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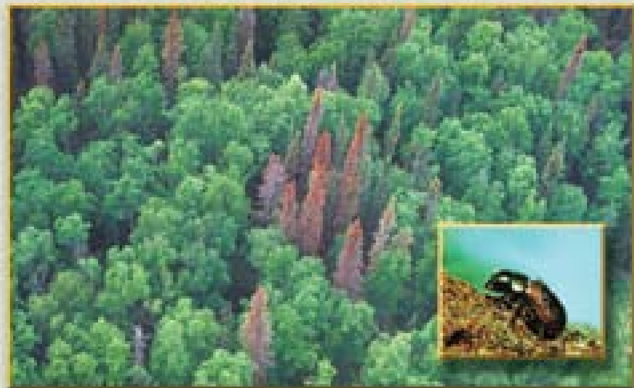
Insects and Diseases of Alaskan Forests



Cover photos clockwise from top:

Spruce bark beetle damage (inset spruce bark beetle)
Chicken of the woods conks
Hemlock fluting and wood decay
Wood wasp

Insects and Diseases of Alaskan Forests

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Preface

The U.S. Forest Service publication, Identification of Destructive Alaska Forest Insects (91), dealt mainly with the damaging forest insects of Southeastern Alaska. Insects and Diseases of Alaskan Forests (137, 138) included disease agents and were a logical statewide expansion of Hard's (1967) earlier insect work. Since then, our information on forest insects and diseases of Alaska has increased tremendously (279). In April 2001, a substantially revised and expanded Insects and Diseases of Alaskan Forests was printed (141). The popularity of the handbook and the need for minor revisions has resulted in this 2009 reprint.

This handbook is divided into insect and disease sections, each with its own illustrations, and host index. Literature cited, glossary, and a general index follow at the end of the book.

Handbook Organization

Not every insect or disease in Alaska is covered in this handbook. Some are omitted because of limited distribution or minor importance, and others are awaiting more comprehensive surveys and information on their economic or ecological importance.

Few chemical suppression measures are included for the organisms covered in this manual because many new control measures are quickly outdated or discarded with new advances, recognition of environmental hazards, or lack of benefit/cost effectiveness. Please refer to the nearest office of the Alaska Cooperative Extension Service or State and Private Forestry, U.S. Forest Service for information concerning specific control measures.

A discussion of the forests of Alaska and invasive pests follows the introduction. A short description of insects and diseases affecting general parts of a plant follows next and directs the reader to the appropriate insect or disease section. For each insect or disease, a summary of its hosts, distribution, identification, damage, remarks, and references are provided. A specific index of insect or disease by host plant follows each respective section. The handbook concludes with a glossary, bibliography, appendix for submitting insects or diseases for identification, photography and illustration credits, and finally a general index.

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Introduction

The sciences of forest entomology and pathology or the study of forest insects and diseases are relatively new to Alaska. Even though insect and disease surveys have been undertaken for over eight decades, some pests have only recently been identified. Alaska's forests are important in terms of wood production, wildlife habitat, and recreation. Forest resource management cannot be practical in Alaska until forests are adequately protected from insect, disease, and fire losses. Forest managers should be able to determine which pests are detrimental and which are not to forest resource management. Likewise, private land managers and homeowners should learn to identify pests that invade and attack their trees and shrubs.

We must not underestimate the effects of forest pests whose damage can occur during every stage of forest growth. Nationally, insects kill twice as much timber as do disease-causing organisms, and seven times the amount killed by fire. But, on an annual basis, the loss of potential growth and decay caused by disease exceeds the more spectacular damage caused by fire and insects. There was the risk of forest insect and disease mortality on 23.5 million hectares of forested land in the United States in 2006 (249). The annual volume and monetary loss attributed to insects and diseases are unknown in Alaska.

Some documented insect outbreaks in Alaska include 4 million hectares of Sitka spruce–western hemlock forests of southeast Alaska defoliated by larvae of the black-headed budworm in 1953, 1.6 million hectares of western hemlock in southeast Alaska defoliated by hemlock sawfly larvae in 1953, 200,000 hectares of white spruce infested by the spruce beetle in the Copper River drainage in 1959 and one million hectares in 1975 defoliated by larvae of the spear-marked black moth in interior Alaska. Spruce beetles infested more than 1.3 million hectares of Alaska spruce forests from 1990–99.

Unlike some of the spectacular insect outbreaks, tree diseases are often chronic and pervasive in the forests of Alaska. They may often go unnoticed, yet diseases can cause fundamental ecosystem change and huge economic loss to timber resources. Heart rot fungi cause substantial defect; nearly $^{1}/_{3}$ of the gross volume of live trees in old-growth coastal forests is decayed. Dwarf mistletoe causes growth loss and tree mortality but also contributes to wildlife habitat in hemlock forests. Over 200,000 hectares of yellow-cedar forests have high concentrations of dead trees caused by yellow-cedar decline. Root diseases and heart rot fungi cause substantial growth loss and mortality of spruce and hardwoods.

While insect and disease agents can cause substantial impacts, not all are negative. Ecologically, these agents alter forest structure and composition, and are essential to nutrient cycling, habitat diversity, forest succession, and carbon sequestration. With such a range of potential impacts, wise decisions for insects and diseases can be made when they are based on the best information.

Forests of Alaska

The forests of Alaska stretch thousands of kilometers and encompass 51.4 million hectares. The three major forested zones in the state are the coastal rain forests of Southeast Alaska, transitional forests of South-central, and the boreal forests of the Interior.

The temperate rain forests of Southeast Alaska are dominated by western hemlock and Sitka spruce, but Alaska yellow-cedar, western redcedar, shore pine and mountain hemlock are also important components. Wind is the major agent of large-scale disturbance in Southeast Alaska causing uprooting and bole breakage. The most susceptible forest type is mature spruce-hemlock

Figure 1. *Old-growth spruce hemlock forests of Southeast Alaska.*

on productive, wind-exposed sites. Bole breakage is common in decadent old growth forests. Uprooting also occurs, resulting in soil churning, which expedites nutrient cycling and increases soil permeability. Even-aged forests develop following large-scale catastrophic wind events. Old-growth forest structure develops in storm-protected landscapes. In these areas, small gap-forming events dominate.

South-central Alaska is a transition zone between the coastal marine climate of Southeast and the continental climate of the Interior. Forest vegetation is comprised mainly of white spruce, black spruce, paper birch, trembling aspen, and cottonwood. In the most southern areas of this zone, western hemlock, mountain hemlock, and Sitka spruce grow on favorable sites. In locations where Sitka spruce and white spruce overlap, the Lutz spruce hybrid is common. Fire is a factor in the forested landscapes of South-central, but these fires are mostly

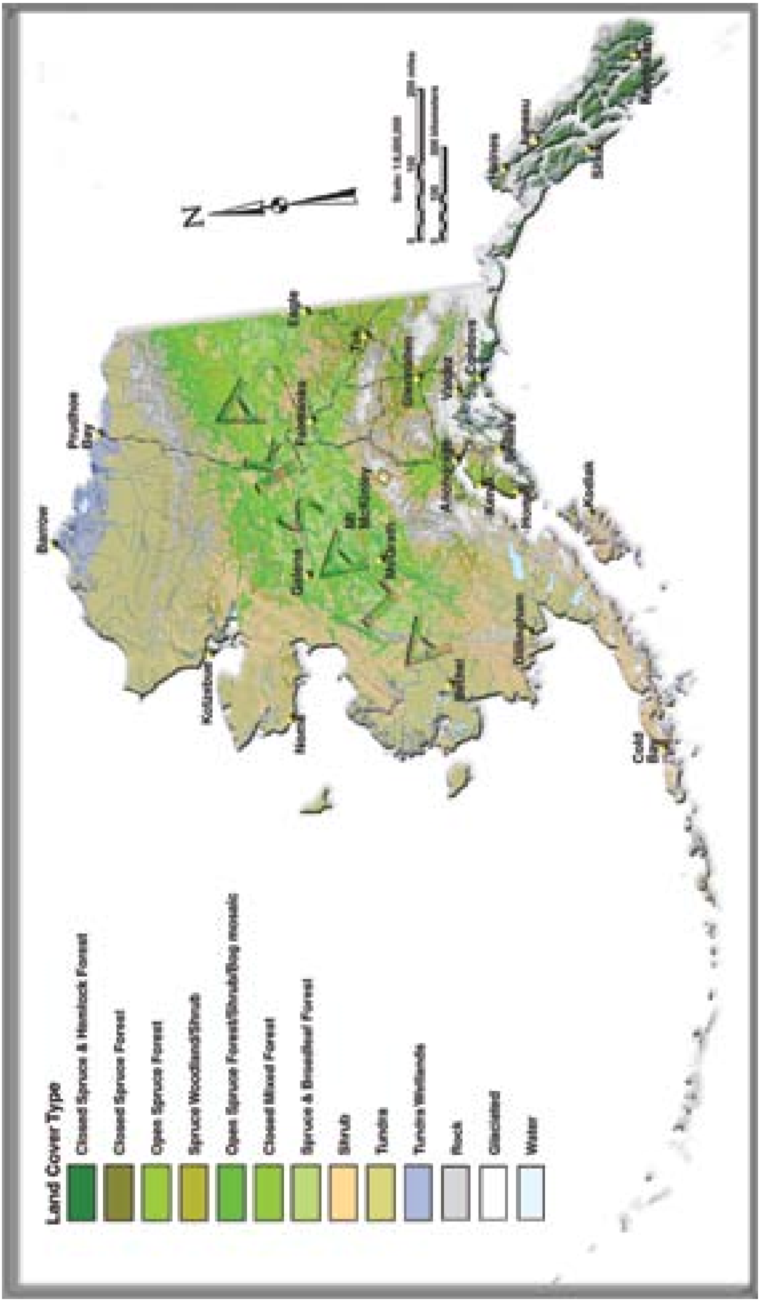
2.471 acres equal one hectare; 5 board feet equal one cubic foot; and 35.32 cubic feet equal one cubic meter.

Figure 2. *Mixed hardwood and spruce forests are prevalent in South-central Alaska.*

the result of human activity as lightning strikes are uncommon in this region. Major disturbances affecting forests in the past century have been human activity and spruce beetle caused mortality. Earthquakes, volcanic eruptions, and flooding following storm events have also left significant signatures on the landscape.

The boreal forests of Interior Alaska are comprised of white spruce, black spruce, eastern larch, paper birch, trembling aspen and cottonwood. Distribution of forested areas across the landscape is determined by fire history, slope, aspect, and the presence or absence of permafrost. Fire is the major disturbance agent; lightning strikes are very common north of the Alaska Range. Tree species in the Interior are susceptible to damage by fire, and all are fire-adapted, to some degree.

Figure 3. *The boreal forest of Interior Alaska is a mosaic of spruce, aspen, and birch.*



Map courtesy of Alaska Department of Natural Resources, Division of Forestry

Figure 4. *Alaska land cover type map.*

Invasive Pests

Invasive pests (introduced non-indigenous plants, animals, and microbes) are among the most serious threats to biological diversity in the forest ecosystems of the United States. Likewise, the movement of native insects and pathogens from one area of the United States to another where they do not naturally occur is also problematic. It has been estimated that 10.8% of the plants and 3.5% of the invertebrates in the United States are established exotics (38). It has also been estimated that, of the $97 billion in losses from invasive pests during 1906–1991, $92 billion was from insects (179). Recent estimates suggest potential losses to the U.S. from forest insects and forest pathogens exceeds $4.2 billion annually (187).

Introduced insects and pathogens can create enormous ecological damage for several reasons. First, native vegetation is not equipped with genetic resistance to these introduced organisms because they did not co-evolve together. Native trees have had time to develop levels of resistance to organisms that they have been exposed to and this limits the virulence of attack. Lacking any genetic resistance, native trees can be overwhelmed by these newly introduced organisms. Second, some of the introduced insects and pathogens are mortality agents to trees. As tree killers, they are disturbance agents and can severely modify the forested landscape. Third, insects and pathogens are highly mobile and are not limited to transportation corridors. They can essentially march across host types and invade some of our most pristine natural areas. Alaska has few tree species, and we cannot afford to lose any one of them.

Because North America contains many plant genera common to Eurasia and east-central Asia, we can expect, and have seen, cross-regional exchanges of plant-feeding organisms. Likewise, given increasing global markets, technological advances in transportation, and mobility of humans, rates of introductions will continue to increase. For example, in a ten year period, the U.S. Agricultural Plant Health Inspection Service (APHIS) intercepted insects on various wood products on nearly 5,900 occasions. Since 1985, there has been a steady increase in the number of insect interceptions on wood products from China at U.S. ports. The volume of commodities imported annually from China with associated wood crating, dunnage, and pallets is estimated to be in the millions of shipments.

Figure 5. *European gypsy moth larva.*

It has been estimated that of 70 major pests of U.S. forests, 19 (27%) were introduced. Some of the more important include: chestnut blight; Dutch elm disease; white pine blister rust; gypsy moth; and recently, sudden oak death, the Asian long-horned beetle and the emerald ash borer. The latter two insects probably traveled to the United States inside solid wood packing material from China or Japan. These beetles have been intercepted at ports, found in warehouses, and found in various cities throughout in the United States. The pathogens came primarily on living plants.

In Alaska few invasive species have been introduced and established into our forested ecosystems. The movement of insects, diseases, and plants into Alaska from the Lower 48 is more of a problem. For example, ornamental mountain ash (*Sorbus* spp.) is established in Southeast Alaska; black knot (*Apiosporina morbosum*), a disease of ornamental trees, such as chokecherry and Mayday, was introduced on imported plant material. The western tent caterpillar (*Malacosoma californicum*) is repeatedly intercepted in Anchorage on nursery stock used as out-plantings. Adult European gypsy moths (*Lymantria dispar*) have been caught in pheromone traps on several occasions in Alaska. It is believed, however, that this potentially devastating forest pest is not established. Likewise, the Sitka spruce weevil (*Pissodes strobi*), a serious insect pest of young spruce throughout the Pacific Northwest and British Columbia has been introduced into the Anchorage Bowl on at least three occasions. It appears that this weevil can complete its life cycle in South-central Alaska. Whether this insect is established is not known.

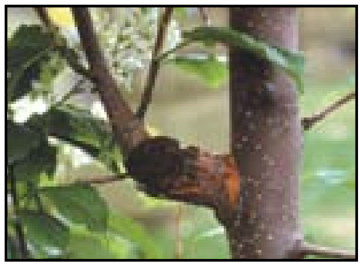


Figure 6. *Black knot.*

The amber-marked birch leaf miner (*Profenusa thomsoni*) is one exotic invasive that we were unable to prevent from establishing in the state. This leaf mining sawfly originated from Europe, entered eastern North America around 1900, spread westward, and eventually reached Alaska probably through Haines in the mid-1990s. From 1996, when it was first discovered in Anchorage, to now, the amber-marked birch leaf miner has spread across the entire Matanuska-Susitna Valley, Fairbanks, Haines, Skagway, and a large part of the Kenai Peninsula. This insect pest will likely continue to spread throughout Alaska's South-central and Interior birch forests.

White pine blister rust was found in Ketchikan in 2004 on an ornamental white pine tree. It may have been introduced with the planting of the pine, or more likely was brought in when infected ornamental gooseberry was planted in the same yard. Fortunately, the pathogen is not capable of spreading beyond ornamental plants because it requires the white pine host and these trees are not native in Alaska. It does, however, illustrate the pathways of introduction of insects and pathogens by the trade of ornamental plants.

We can expect increased introductions of non-native species as well as accidental introductions of native species of the U.S. from one part of the country to another due to expansion of world trade. Another concern is the movement of insects, plants, and microbes from the continental U.S. into Alaska's forested ecosystems in light of climate change and increased commerce. Weather records from the Kenai Peninsula in South-central Alaska, have indicated that annual temperatures have increased by 3–5° F in the last forty years. Such a warming trend could increase the probability that insects accidentally introduced into Alaska can become established. Most introduced insects, plants and microbes arrive without corresponding parasites and predators. Likewise, trees and shrubs native to Alaska have not evolved defensive systems to minimize damage from these introduced pests. Consequently, if established, introduced pests can explode in population numbers and potentially bring about widespread ecological change to our forested ecosystems.

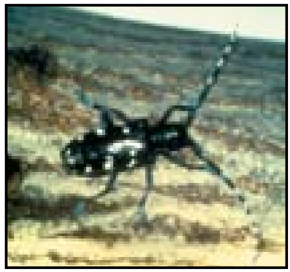


Figure 7. *Adult Asian long-horned beetle.*

It is inevitable that we are going to see more and more introduced pests coming into Alaska. If we are not prepared to expend efforts to safeguard our ecosystems, Alaska will be poorer in terms of resources and biological diversity. USDA APHIS, State of Alaska Division of Agriculture and Forestry, Alaska Cooperative Extension (ACE), and the U.S. Forest Service, Forest Health Protection (FHP) already have small programs to detect these introductions. Inadequate funding and support, however, have limited the scope and implementation of these programs. Alaska residents, resource professionals and land managers need to "keep a sharp eye out" for potential introduced pests, learn to distinguish them from our native species, and quickly contact ACE, APHIS, or the Division of Agriculture, their local Cooperative Extension office if any are found. If introduced pests are quickly identified, the probability of successful eradication is increased.

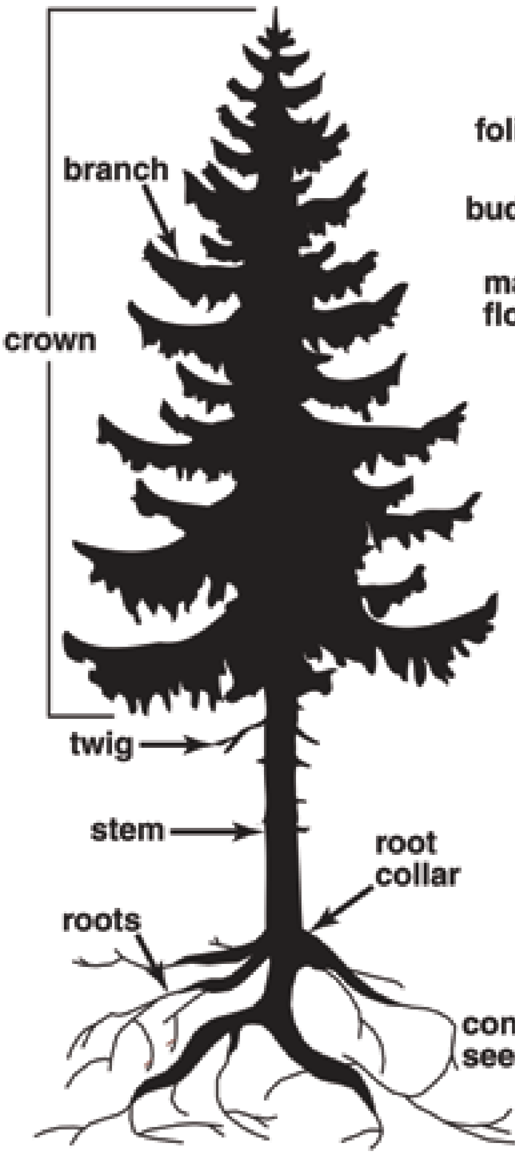
Forest management can help ensure fewer deleterious effects if insects or pathogens are introduced. Managing forests for species diversity is insurance against complete destruction of the forest. Insects and pathogens are typically host-specific and will only attack a narrow group of related hosts. Thus, by creating forests with a mixed tree species composition, some forest trees will remain even in the worst case scenario of an introduced insect or pathogen.

References: 38, 179, 187, 207, 254

Guide to the Forest Pests

Damage confined to Leaves, Buds, and Shoots:

Damage primarily on Cones and Seeds:



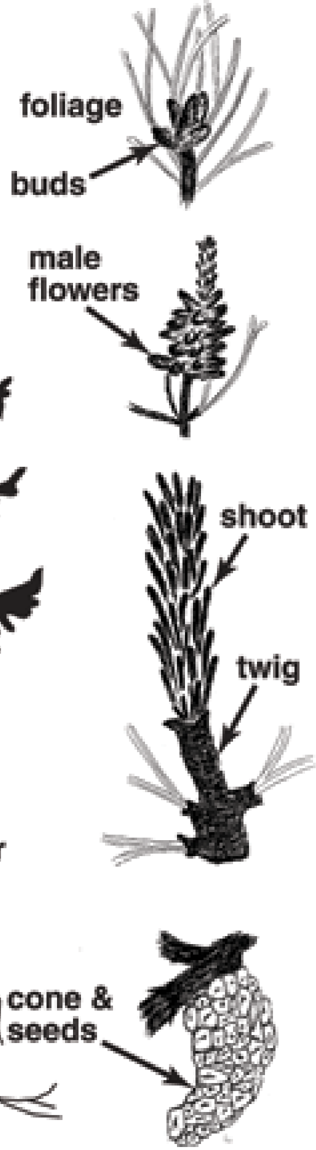


Figure 8. *Parts of trees commonly affected by forest pests.*

Figure 9. *Specific parts of a tree affected by forest pests.*

Damage confined to Branches and Stems:

Witches' Brooms. On hemlock; large or small brooms or swellings commonly on branches, less commonly on stems; needles retained on live brooms; small yellow or red leafless plant may be present on affected tissue (Hemlock Dwarf Mistletoe)..138

On spruce; large or small brooms, current year's needles may appear orange, yellowish, or pale green; fruiting bodies of fungi may be present on needles; broom needles are shed in fall and broom appears dead until spring (Spruce Broom Rust)...142

Galls Caused By Diseases. Round, woody galls on branches or stem of pine. Insects generally not present in the galls. (Gall Rust)....................144

Cankers or Animal Damage. Large patches of dead bark on live trees, sometimes exposing wood; often on main tree bole; fruiting bodies of fungi may be present...146, 148, 199

Wood Decay and Stain. Wood is hollow, pitted, spongy, breaks into crumbly pieces, or is stained in color. Fruiting bodies of fungi may be present. Older trees, or those physically injured in the past usually affected...159

Bark Beetles. Insect activity characterized by boring dust and resin on bark and around base of trees. Galleries commonly found under bark and usually less than 0.6 cm in width, at times into the sapwood, rarely penetrating the wood. Boring dust reddish to light brown and fine.........71

Wood Borers. Larval borings are usually granular. Galleries penetrate into the sapwood and, at times, into heartwood of weakened or recently killed trees or logs..86

Abiotic Disorders. Deeply incised vertical grooves or ridges on live hemlock trees (Hemlock Fluting); globe-shaped, large, woody growths or swellings on branches or stems of spruce and various hardwoods (Burls)...195, 197

Damage confined to Roots and Lower Stem

Root Diseases. Entire crown shows signs of stress (yellowing foliage, needle or leaf loss, stress cone crop) or dies as a unit; wood or root tissues are killed or decayed and may have fungal structures; fruiting bodies of fungi may be present at base of tree or on the ground nearby; trees may die standing, snap at the lower bole, or uproot with a characteristic small root ball and extensive decay in the broken stubs of primary roots; fallen trees in disease centers tend to lie in a random pattern.....................152–158

Windthrow. Individual or patches of trees exhibit stem breakage or uprooting with a large soil plate and primary roots attached; fallen trees typically lie parallel to one another in a similar direction as the wind storm; signs of disease agents may be present..204

Abiotic Disorders. Dead and dying trees found in small or large groups, not usually solitary trees. Entire crown of tree shows signs of stress and dies as a unit as in root diseases. Fruiting bodies of pathogenic fungi usually absent, but weakly pathogenic and saprophytic fungi (those restricted to dead tissues) and secondary insects may be present. Death of coarse and fine roots precedes crown symptoms. Necrotic lesions may spread from dead roots vertically up the main bole (Yellow-cedar decline)..193

Damage confined to Wood Products on Land.

Carpenter Ants and Bees. Galleries in soft or moist wood of buildings...110, 112

Powder Post Beetles. Small holes in finished wood products...............113

Decays and Stains. Wood is hollow, pitted, spongy, breaks into crumbly pieces, or is stained in color. Fruiting bodies of fungi may be present..159

Forest Defoliators

Defoliator insects eat the leaves or needles of forest trees and shrubs. Defoliators are found throughout Alaska and on all tree types. Bark beetles are often considered the more significant disturbance agents in boreal Alaska (due to the high potential for causing tree mortality). Even so, defoliators can have a significant affect on both coniferous and deciduous trees, and can cause tree mortality with several seasons of defoliation. In maritime ecosystems where conifers dominate, such as Prince William Sound and Southeast Alaska, defoliators tend to be the more significant agents of change. If complete defoliation of a conifer occurs before midsummer, the trees will not have formed buds for the following year and the tree could be killed.

In a defoliator outbreak where insect populations are at epidemic levels, vast acreages can be affected. During an outbreak, nearly every tree can be affected to varying degrees. This defoliation often results in a variety of biological and ecological impacts, but there are socioeconomic impacts as well. Some of the impacts associated with a defoliator infestation include, but are not limited to:

Impacts on wildlife habitat. Wildlife may be positively or negatively affected by defoliator outbreaks. Larvae are a necessary food source to fledgling chicks, but bird habitat may be negatively affected by the decrease in cover. Conversely, predatory birds may benefit from the cover change. The added light to the forest floor will result in an increased ground cover of herbaceous plants, benefiting browse animals such as deer. Spruce budworm defoliation can kill the tops of a spruce tree and eliminate its ability to produce cones. Thus squirrels, white-winged crossbills, etc. and their predators may be greatly reduced in these forested areas.

Impacts on aquatic systems. Aquatic systems may also be positively or negatively affected. Nutrient cycling is accelerated as foliage and insect waste enters the aquatic system. Larvae may drop into streams and can serve as a food source for fish. In addition, the loss of overstory cover can increase sunlight exposure to the stream, affecting the aquatic environment.

Economic concerns. Heavy defoliation will decrease the growth rate of trees resulting in the delayed harvesting of merchantable trees. In addition to growth loss, repeated and or heavy defoliation events can cause top kill and, in some cases, tree death.

Aesthetics and recreation. The visual impact of a defoliated stand in the midst of an outbreak can be quite alarming and often will lose attractiveness for recreation. Large numbers of larvae can be a nuisance in picnic grounds and campgrounds. Dead tops and dead trees pose a hazard in recreational areas. However, the effect is often short term, and the following year, scenic quality usually returns to “normal.”

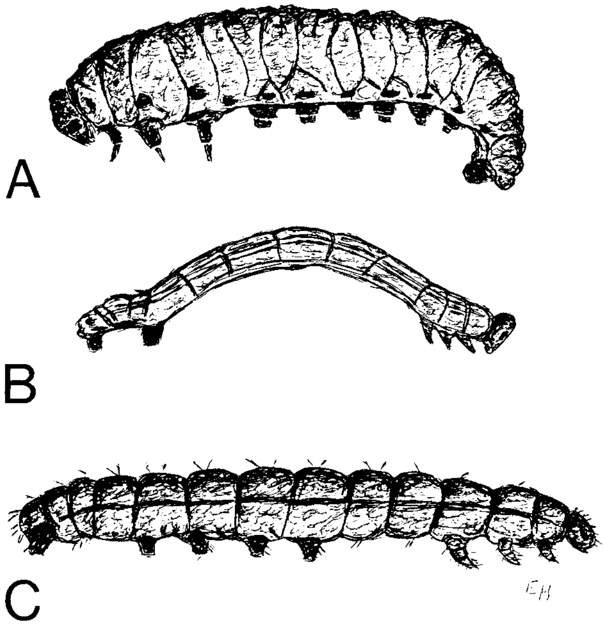


Figure 10. *Defoliators: A. Sawfly larva (Hymenoptera); B. Looper (Lepidoptera: Geometridae), C. Budworm (Lepidoptera: Tortricidae).*

Defoliator outbreaks tend to be cyclic and closely tied to climatic conditions. The synchronization of larval emergence and tree bud break is closely related to population increases. The better the synchronization of insect and host throughout larval development, the more likely that an epidemic will occur.

The effects of defoliation, however, can be viewed positively. The opening of the forest canopy allows greater light penetration to the ground level. This increased light results in new seedlings and increased ground cover of herbaceous plants and more rapid soil nutrient recycling. These changes can result in greater forest and browse production through increased plant growth.

All species of trees are not equally susceptible to damage from defoliation (85). Hardwood species are more resilient. These species can usually withstand several years of defoliation with little tree mortality because hardwoods store large food supplies and may refoliate in the same year. Conifers are more likely to die after complete and repeated defoliation.

In this text, defoliators are grouped by their feeding habits:

- Leaf Chewers, that consume all leaf tissues (succulent tissues, veins, and midrib). They are the most damaging defoliators.

- Leaf Miners, that feed upon the succulent tissues while tunneling between the upper and the lower epidermal layers of the leaf.
- Skeletonizers, that eat all the leaf tissue except for the veins and midrib.
- Sap-Suckers, that feed on needle sap.

The most important tree-defoliating pests are sawflies (Hymenoptera suborder Symphyta: Tenthredinidae, Diprionidae), leaf beetles (Coleoptera: Chrysomelidae), caterpillars (Lepidoptera: Tortricidae, Geometridae, Nymphalidae, Sphingidae, Lymantriidae, Arctiidae, Noctuidae, Gracillariidae, and Lyonetidae), and aphids (Homoptera: Aphididae).

Western Black-headed Budworm

Lepidoptera: Tortricidae

***Acleris gloverana* (Walsingham)**

Hosts: Western hemlock, mountain hemlock, Sitka, Lutz and white spruce.

Distribution: Throughout maritime forests of Southeast Alaska, South-central, and Southwest Alaska. It is also found throughout British Columbia and south to California.

Identification: The larval head is black during the first four larval stages and tan-orange in the last stage. During early development stages, budworm larvae are cream-colored. Their body color changes to green as they develop. Mature larvae are 17 mm long. Pupae are green or brown and are approximately 7 mm long. Adults are small brownish gray moths with variable brown, black, orange, and white markings. Eggs are yellow, flat, and are laid singly on the underside of host needles.

Damage: The western black-headed budworm is one of the most destructive forest insects in coastal Southeast Alaska. An outbreak in the late 1940s to mid-1950s affected host trees on almost every forested hectare in Southeast Alaska. Localized outbreaks have occurred sporadically since then. Larval feeding strips host foliage and can bring about a reduction in growth, top kill, and at times, tree mortality.

Remarks: Western black-headed budworms overwinter in the egg stage on host foliage. The eggs hatch in June and feeding begins. Budworm and hem-

Figure 11. *Hemlock defoliation, Calder Bay, Southeast Alaska.*

lock life cycles are closely synchronized; young larvae feed within the protection of unopened hemlock buds. As the shoots begin to elongate the larvae feed on the new needles. Larvae usually confine their feeding to new growth. In large concentrations, larger larvae will feed on older needles, thus bringing about complete defoliation.

Each mature larva ties live and cut needles together and pupates within this shelter. Adults emerge in late August through October. Mated females lay flat, yellow eggs singly on the underside of host needles. Mean fecundity of a population is 80 eggs per female (205).

Budworm populations are characterized by sporadic spectacular increases in number followed two to three years later by equally rapid declines. Only 16 species of budworm parasites and predators have been identified in Alaska compared to 48 species in coastal British Columbia (234). Adverse weather may be an important controlling factor for Southeast Alaska budworm populations.

To date, no suppression actions have been taken as budworm populations disappear as rapidly as they appear. However, the budworm is a definite threat to young stands.

References: 3, 9, 73, 91, 94, 153, 203–205, 234, 259

Figure 12. *Western black-headed budworm larva,* A. gloverana.

Figure 13. *Western black-headed budworm adult,* A. gloverana.

Spruce Budworm

Lepidoptera: Tortricidae

***Choristoneura fumiferana* (Clemens), *C. orae* Freeman and *C. biennis* Freeman**

Hosts: Sitka, white, and Lutz spruce.

Distribution: Throughout Alaska. Populations of *C. fumiferana* are found in vicinity of Fairbanks and east; *C. orae* populations are found from Fairbanks south into South-central Alaska. These species may hybridize in Lutz spruce stands. The species can only be told apart reliably by mtDNA sequences.

Identification: Mature larvae are approximately 3.2 cm long, with brownish head, green to orange body, and prominent ivory-colored spots. Adults are predominantly gray-brown moths and have a wingspread of 22 to 28 mm. Eggs

***Figure 14.** Spruce budworm larva,* Choristoneura *spp.*

***Figure 15.** Adult spruce budworm.*

are light green and are laid in shingle-like masses on the underside of needles.

Damage: Larvae destroy buds, host foliage, cones and seeds. Reduction in radial growth is evident during severe infestations and top-kill is common.

Remarks: Similar to *A. gloverana* in biology. However, the spruce budworm over-winters as larvae in silken shelters beneath bark scales and old male flowers. Larvae enter and feed upon buds in May or June, then attack new foliage. An extensive outbreak of *C. fumiferana* occurred in the early 1990s and lasted for about five years. More than 50,000 hectares of white spruce were heavily defoliated along the Tanana and Yukon Rivers as far west as Ruby. Spruce coneworm (*Dioryctria reniculelloides*) populations simultaneously increased resulting in heavy defoliation as well as a widespread reduction in cone and seed production. Heavy top-kill is associated with outbreaks, resulting in reduction of cone-feeding vertebrates and eventual predisposition to bark beetle attack.

References: 73, 93

Large Aspen Tortrix

Lepidoptera: Tortricidae

***Choristoneura conflictana* (Walker)**

Host: Aspen.

Distribution: Principally in Interior and in South-central Alaska. This insect was first recorded from Alaska in 1966 when it reached outbreak conditions on more than 2,023 hectares of aspen near Fairbanks.

Identification: Larvae are gray-green to black with dark head capsules. The forewings of the moths are gray with brownish markings. Green eggs are deposited in masses.

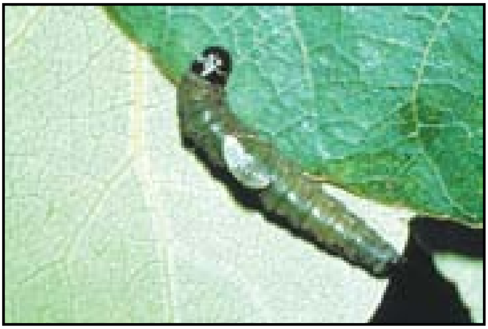


Figure 16. *Large aspen tortrix larva,* C. conflictana. *Note the parasitic fly maggot feeding on the larva.*

Figure 17. *Large aspen tortrix adult,* C. conflictana.

Damage: Larvae skeletonize both upper and lower leaf surfaces.

Remarks: Eggs are deposited on upper leaf surfaces. First instars are active until mid-August, and feed gregariously within rolled leaves where they skeletonize both the upper and lower leaf surfaces. The larvae then migrate to protected areas, spin a shelter, molt to second instar, and overwinter. The overwintered larvae become active during the first two weeks of the following May and mine into buds. Complete destruction of leaves can occur before bud burst. Larger larvae feed in the open. Pupae are formed within rolled leaves of the host plant and understory vegetation. The adults are active from late June to July.

As with many defoliators, large aspen tortrix populations rapidly increase to epidemic levels. Aspen stands are usually completely denuded for two consecutive years. Populations then subside. Large aspen tortrix populations require a pure diet of aspen to maintain outbreak levels. Complete stripping of aspen foliage before the last instar will reduce population numbers due to widespread starvation. Tortrix larvae cannot survive the two or more weeks required by aspen to refoliate and thus are forced to feed on plants that do not provide proper nutrition for larval development and egg production.

Weather, starvation, and parasitism are most effective in reducing *C. conflictana* populations.

References: 11, 13, 14, 17

Leaf Rollers

Lepidoptera: Tortricidae

***Epinotia solandriana* (L.)**

Hosts: Typically Alaska birch and alder; can be found on willow, aspen, and black cottonwood.

Distribution: Recurring problem in South-central, Interior, and Southeast Alaska.

Identification: First instar larvae are pale-green. Later instars are a blue-gray turning to a pale yellow-cream prior to pupation. Pupae are brownish and are approximately 8.0 mm long and 2.5 mm wide. Adult moths vary in forewing pattern. The most common pattern (approximately 65 percent) is one of subdued grays and browns. Wingspan ranges from 1.5 to 2.0 cm. Eggs are approximately 0.96 mm long by 0.71 mm wide, oval in shape and a reddish-orange.

Figure 18. *Mature birch leaf roller larva.*

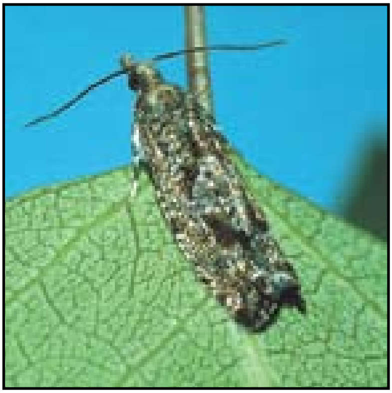


Figure 19. *Birch leaf roller adult.*

Figure 20. *Birch leaf roller damage,* Epinotia solandriana.

Damage: Larvae roll leaves that are skeletonized, curl, brown and drop prematurely. Branch dieback and tree mortality sometimes occurs.

Remarks: Birch leaf rollers have one generation per year in Alaska, and overwinter in the egg stage. Larvae hatch in mid-May to early June and begin feeding in buds and later in leaf rolls. Last instars vacate leaf rolls and pupate in fragile cocoons between the humus layer and the mineral soil. The adults emerge from late July through August. After mating, eggs are laid singly on previous year's twigs, usually on the roughened bud stalks.

Birch leaf rollers are the most common leaf rollers on birch. However, other genera, including *Clepsis,* are commonly associated with birch. Drastic and repeated defoliation by these insects results in minor growth reduction and occasional branch dieback. Large populations of leaf rollers are reduced by adverse weather, parasites, predators, and disease.

References: 142, 169

Western Hemlock Looper

Lepidoptera: Geometridae

***Lambdina fiscellaria lugubrosa* (Hulst)**

Hosts: Sitka spruce (preferred host in Alaska), western hemlock, western redcedar, and Alaska yellow-cedar.

Distribution: The only recorded looper outbreak in Alaska occurred from 1965 to 1966 about 30 km southeast of Wrangell where approximately 200 hectares of Sitka spruce were heavily defoliated.

Identification: Mature larvae are 2.8–3.2 cm long and brownish gray with various patterns of lines, stripes, and spots giving them a mottled appearance. Pupae are approximately 1.3 cm long, mottled greenish brown. Adults are light buff with a wingspan of 3–5 cm. Forewings are marked with two wavy lines

Figure 21. *Western hemlock looper larva.*

Figure 22. *Western hemlock looper adult.*

and hind wings with one wavy line. Eggs are minute (about 0.6 mm long) and grayish green.

Damage: This insect tends to kill many needles because it is an inefficient feeder. Severe defoliation causes reduction in tree growth, and at times, tree mortality.

Remarks: Eggs are deposited on the upper bole and branches and understory shrubbery where they overwinter. The larvae are loopers, and hatch in late spring and early summer and begin feeding on young needles in the crown. Later in the larval development old foliage is eaten. Often only a few bites are taken out of each needle.

Mature larvae pupate in the forest litter or in bark crevices. The pupal period is approximately two weeks. Adults emerge in late fall to mate and lay eggs. There is one generation per year.

Outbreaks build up rapidly and generally last for three years. A single complete defoliation at midsummer can cause tree mortality. Some trees can withstand 50 percent defoliation and even 75 percent defoliation is not fatal unless other insects such as bark beetles subsequently attack the trees.

The most important natural controls are a viral disease and heavy rains during fall moth dispersal. Eight species of parasites have been reared from looper pupae.

References: 3, 41, 91, 93, 153, 235, 236

Spear-Marked Black Moth

Lepidoptera: Geometridae

***Rheumaptera hastata* (L.)**

Hosts: Alaska paper and Kenai birch, alder, and willow.

Distribution: South-central and Interior Alaska. From 1974–75, epidemic populations of the spear-marked black moth infested 1.1 million hectares of paper birch in Interior Alaska.

Identification: Newly hatched looper larvae are 2.5 mm long and have grayish-green bodies and light-brown heads. Mature larvae are about l6 mm long and have black bodies with a whitish pink spot on the side of each body segment and dark brown heads. Pupae are shiny brown and about 11.0 mm long and 3.5 mm wide.

Adults are black moths with white markings on the wings, approximately

***Figure 23.** Spear-marked black moth larva.*

Figure 24. Spear-marked black moth adult.

Figure 25. *Birch defoliation caused by spear-marked black moth.*

9–11.5 mm long with a wingspread of 26–30.5 mm. Similar species also found in Alaska: *Rheumaptera subhastata*.

Damage: Webbed leaves are heavily skeletonized. Severe defoliation by early August results in a temporary reduction in radial and terminal growth. Branch dieback is quite common. Repeated severe defoliation can result in tree mortality.

Remarks: There is one generation per year. Clusters of eggs are deposited from mid-June to early July on upper leaf surfaces or in folds of leaves that have been rolled by leaf rollers. Emerging larvae feed gregariously on upper leaf surfaces between two leaves that have been webbed together. Damage is often inconspicuous due to the larval behavior of webbing leaves together. Third and fourth instars web one or two leaves together and feed singly. Defoliation becomes readily apparent by early August.

Last instars drop to the forest floor, pupate and overwinter in forest litter. Adult moths emerge from early June to July. Following emergence, large groups of adults seek moisture.

Parasites, predators, disease, and weather are responsible for population declines. During the 1975–76 spear-marked black moth outbreak, parasitism accounted for a 16 and 30 percent reduction of *R. hastata* larval and 55 and 90 percent reduction in pupal populations, respectively. Disease contributed to a 95 percent reduction in third and fourth instar populations in 1975.

References: 91, 260, 262, 263

Green-Striped Forest Looper

Lepidoptera: Geometridae

***Melanolophia imitata* (Walker)**

Hosts: Western hemlock (preferred host), western redcedar and Alaska yellow- cedar.

Distribution: Southeast Alaska.

Identification: Mature green-striped forest looper larvae are deep apple green with white and yellow-green lateral stripes. The head is pale green. Adults are mottled gray-brown moths with a wingspan of 25–40 mm.

Damage: Needle chewing can cause top kill and rarely tree mortality.

Remarks: Not well known in Alaska. However, in British Columbia, this looper overwinters as a pupa in the duff layer. Adults emerge, mate and oviposit from mid-May to mid-June. Eggs are deposited on tree branches and trunks. Larvae feed on all foliage, but one year old foliage is preferred. Feeding is heaviest in the upper crown. Mature larvae drop to the ground and pupate in late summer.

References: 73, 93, 130

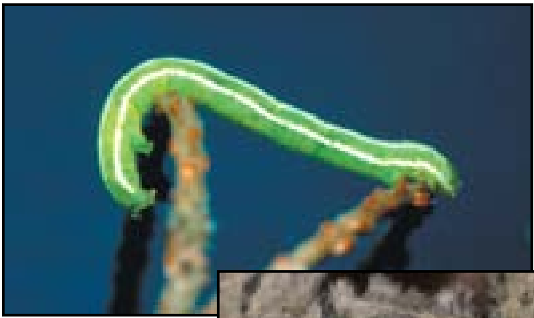


Figure 26. *Green-striped forest looper larva.*

Figure 27. *Green-striped forest looper adult.*

Saddle-Backed Looper

Lepidoptera: Geometridae

***Ectropis crepuscularia* (Denis & Schiffermuller)**

Hosts: Western hemlock (preferred host), western redcedar and Alaska yellow- cedar.

Distribution: Southeast Alaska.

Identification: Mature larvae are loopers with brownish and reddish diamond-shaped marks on the back. The mottled, light-gray moth has a wingspan of 30 mm.

Damage: Needle chewing can cause top kill and rarely tree mortality. This looper is commonly found in association with the hemlock sawfly. In 1969, this looper caused moderate to severe defoliation, and some mortality of western hemlock on 100 hectares near Ketchikan.

Remarks: Biology is not well known in Alaska. However, in British Columbia, the moths emerge in May and lay eggs. Recently emerged larvae feed first on the ground cover and understory, later moving up into trees. Mature larvae drop to the ground in August where they pupate and overwinter.

References: 73, 93, 172

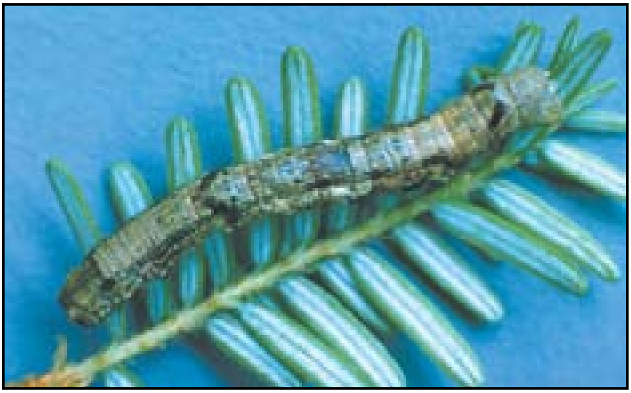


Figure 28. *Saddle-backed looper larva.*

Mourning Cloak Butterfly

Lepidoptera: Nymphalidae

***Nymphalis antiopa* (L.)**

Hosts: Willows (preferred host), poplars, and other hardwoods

Distribution: Throughout Alaska but more prevalent in the South-central and Interior portions of the state.

Identification: Mature larvae are 2.0 to 3.0 cm long and are blackish with red and white dots and are conspicuously spinney. Pupae are 2.0 to 3.0 cm long and are attached to twigs by silk threads and hang downward. Adults are brownish-black butterflies with yellow wing edges and a row of blue dots lining the inner edge of the yellow bands. Wingspread is 50 to 70 mm. A similar species, the Compton's tortoiseshell (*Nymphalis vaualbum*), has become common in the Interior. Larvae are brown and spined, adults are similar in size to *N. antiopa* but brown with a conspicuous white square marking on the hind wing.

Damage: Severe defoliation can result in a temporary reduction in radial and terminal growth. Shrub and tree mortality is rare.

Remarks: In northern latitudes, there is one generation a year. Adult butterflies emerge in late summer and overwinter. In early spring, orange-brown eggs are deposited in masses on limbs and twigs. Larvae feed in groups from the leaf margin inwards. Leaves may be silk-spun together. Pupae are formed in June or July. Control is seldom necessary.

References: 5, 73

Figure 29. *Mourning cloak larva.*

Figure 30. *Mourning cloak adult.*

Hawkmoth

Lepidoptera: Sphingidae

***Hyles galii* (Rottenburg)**

Hosts: Fireweed and other perennials

Distribution: Throughout Alaska

Identification: Larvae, often called hornworms, are quite large, (8 cm long), green or black in color with a red head and pale spots on the body. A conspicuous horn or spine-like process occurs on the dorsal surface of the eighth abdominal segment. The adult hawkmoth or sphinx moth is a good flyer with a pale band down the middle of the forewing and a red band on the hind wing. Wing span is approximately 6 cm. Pupae are brown, 2–3 cm long.

Damage: Complete defoliation of fireweed and other perennials can occur.

Remarks: These moths are strong flyers with a very rapid wing beat; most are active at dusk. Moths feed like hummingbirds, hovering in front of a flower and extending their proboscis into it. Adults are seen from May to August. Larvae feed on fireweed until late fall then over winter as a pupa in the leaf litter. This hawkmoth is also known as the bedstraw hawkmoth as it feeds upon bedstraw (*Galium* spp.) across boreal and montane North America from the east coast to Colorado and California, north to Canada and Alaska.

References: 28, 247

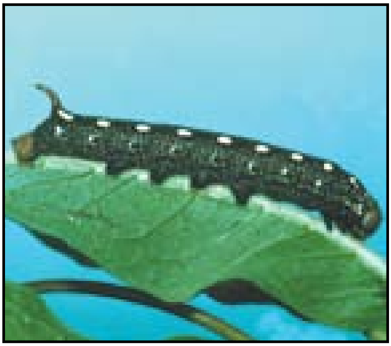


Figure 31. *Hawkmoth larva.*

Figure 32. *Hawkmoth adult.*

Rusty Tussock Moth

Lepidoptera: Lymantriidae

***Orgyia antigua* (L.)**

Hosts: Conifers, hardwoods and shrubs.

Distribution: Throughout South-central, Southwest, and Interior Alaska.

Identification: The dark hairy caterpillar is about 2.8 cm long with four yellow "tussocks" of hair along the back, two tufts of dark hair near the head and one more at the rear. The adult male is an erratic-flying rusty-brown moth with a white dot and a light brown band on each forewing. The female is sedentary, wingless, and about 12 mm long.

Damage: The caterpillars consume the leaves of trees and shrubs. When larval populations are high, large areas can be defoliated.

Remarks: The caterpillars hatch from overwintering eggs in the spring and feed on whatever suitable host is available. Pupation occurs in August with the adults emerging several weeks later. Eggs are laid on host material prior to the winter months. There is one generation per year.

References: 73, 207

Figure 33. *Rusty tussock moth larva.*

Figure 34. *Rusty tussock moth adult.*

Spotted Tussock Moth

Lepidoptera: Arctiidae

***Lophocampa maculata* (Harris)**

Hosts: Blueberry and Sitka alder.

Distribution: Southeast Alaska.

Identification: Larvae are thickly covered with tufts of black and bright yellow to whitish hairs, and have a row of short tufts (some think these look like tussocks) down the middle of the dorsum. Full-grown larvae (also known as woolly bears) are about 30-mm long and dull black above. Pupae are within hairy cocoons. The adult moth is pale yellow with long brown-spotted fore-wings and has a wingspread of 37 to 50 mm.

Damage: Moderate to heavy defoliation of alder and blueberry is sporadic. Larvae are solitary feeders except during outbreaks.

Remarks: This moth is in the tiger moth family not the tussock moth family: Lymantriidae. The tussock hairs of Lymantriidae moths can be irritating to the skin, but not so for Arctiidae moth hairs. Moderate to heavy defoliation of alder and blueberry was observed during the summers of 1997 and 1998 from Wrangell Island south to Ketchikan. There is probably one generation with the pupa overwintering in a cocoon in the leaf litter. Adults emerge the following spring, mate, and deposit eggs. The larval stages found during the summer months.

References: 245, 247

Figure 35. *Spotted tussock moth caterpillar.*

Figure 36. *Spotted tussock moth adult.*

Leaf Blotch Miner

Lepidoptera: Gracillariidae, Lyonetidae

***Phyllocnistis populiella* (Chambers), *Phyllonorycter nipigon* (Freeman), *Lyonetia alniella* (Chambers), and *Lyonetia saliciella* Busck**

Hosts: Aspen, balsam poplar, black cottonwood, birch, and alder.

Distribution: South-central, Southeast, and Interior Alaska.

Identification: Larvae are minute (approximately 5 mm long), white, very flat, and are found within meandering mines. Adults are minute moths with lanceolate wings.

Damage: Meandering mines produced in epidermal layers on underside of leaves. Such mining reduces the photosynthetic area of the affected leaves. Heavy repeated attacks could reduce tree growth and cause branch dieback.

Remarks: Winter is spent as adults under bark scales of conifers and hardwood trees. Adults emerge early June and deposit eggs singly on the leaf edge then slightly fold the leaf edge to form a protective covering for the egg until larval emergence. The newly hatched larvae bore and feed between epidermal leaf tissues. After the fourth instar, pupation occurs within the leaf mines. Adult emergence occurs prior to or sometimes after the leaves drop in late August and early September.

References: 11, 28, 65, 73, 153

***Figure 37.** Larval galleries of the aspen leaf miner,* Phyllocnistis populiella.

***Figure 38.** Leaf blotch miner on cottonwood,* Lyonetia *sp.*

Willow Leaf Miner

Lepidoptera: Gracillariidae

***Micrurapteryx salicifoliella* (Chambers)**

Hosts: Most species of willow with the exception of felt leaf willow, *Salix alaxensis*.

Distribution: Interior Alaska; predominantly in the upper Yukon River Flats area.

Identification: Later instars are pale yellowish in color and are approximately 4.4–6.5 mm long. Mandibles have four distal teeth. Adults are small (wingspans of 10.5–11.2 mm) grayish moths with mottled areas of dark and lighter areas on the forewings, emerge in August. Antennae are about as long as forewings. Eggs (pale green in color, 0.4 by 0.3 mm) are laid solitarily on the undersides of leaves.

Damage: Most leaf mining Gracillariidae create necrotic blotches, either on the upper surface (as does *M. salicifoliella*) or on the lower surface. Willows can be completely defoliated for many consecutive years. Mortality as a result of heavy defoliation has been observed. Most willows, however, respond well (resprout) to disturbances whether insect induced, fire, or flooding. The long

Figure 39. *Willow leaf miner damage along Yukon River.*

term nutritional effect on large herbivores such as moose is unknown but warrants investigation.

Remarks: Fourth and fifth instar larvae create necrotic, reddish blotches that often cover the entire upper leaf surface. Mature larvae exit through slits made on the undersides of leaves and spin silken coverings on the leaf surface before pupating. Adults emerge in late July and August and over-winter in that stage. Ten species of willow have been observed infested with the exception of felt leaf willow (*S. alaxensis*). Felt leaf willow is probably not infested due to its protective felt-like mat of hairs that prevent attachment of eggs to the leaf epidermis. A willow leaf miner outbreak infested hundreds of thousands of hectares in drainages of the Yukon and Kuskokwim Rivers from 1991–1999.

Birch Leaf Miners

Hymenoptera: Tenthredinidae

***Profenusa thomsoni* (Konow), *Fenusa pumilla* Leach, *Heterarthrus nemoratus* Klug**

Hosts: Native and exotic birch species, alder.

Distribution: One or more of these sawfly species has been associated with premature browning and early defoliation of birch trees in the Anchorage Bowl, the Fairbanks area, Haines, Skagway, and along roads on the Kenai Peninsula as far south as Soldotna. The most abundant species is the amber-marked birch leaf miner, *P. thomsoni*, but much about the roles, relative impacts, and distributions of the other two leaf miner species is unknown.

Identification: Full grown *P. thomsoni* larvae are flattened, about 6 mm long, white to pale green, and marked with black spots. Adult sawflies are about 3 to 5 mm long and look like black flies with smoky wings and yellow legs. Males are extremely rare. Females reproduce parthenogenetically. Leaf mining sawfly larvae look similar to other leaf mining caterpillars.

Damage: The larvae of these leaf-mining sawflies eat the chlorophyll of a leaf between the epidermis layers, causing leaves to die, trees to defoliate, and trees across entire urban landscapes to turn brown. Affected trees are obvious and homeowners commonly enquire about this condition. Severity is unevenly distributed across urban areas. Impacts to urban trees include decreased aesthetic values and cost of applying relatively expensive pesticides. Thousands of dollars each year are spent on using pesticides to suppress miner populations.

Remarks: The amber-marked birch leaf miner is considered an important exotic invasive insect in Alaska. This insect was introduced to the east coast of North America from Europe in the early 1900s, spreading westward through Canada, to Alaska around 1990. It was first reported from Haines, Alaska in 1992, and was probably present there since at least 1989.

Damage is usually apparent beginning in midsummer. Heavy defoliation can occur during a warm and dry spring/summer. Eggs are deposited on the leaves and emerging larvae immediately enter the leaf. Mature larvae drop to the ground to overwinter. Larvae pupate and adults, the overwintering stage, emerge the following spring. There is probably one generation per year.

Figure 40. *Birch leaf miner larvae inside a leaf.*

References: 73

Hemlock Sawfly

Hymenoptera: Diprionidae

***Neodiprion tsugae* (Middleton)**

Hosts: Primary host is western hemlock, secondary host is mountain hemlock.

Distribution: Hemlock sawflies occur throughout Southeast Alaska. However, sawflies are more abundant and outbreaks are longer lasting in southern Southeast Alaska where widespread damage is usually confined to the area south of Frederick Sound and west of Clarence Strait, the warmest areas in Southeast Alaska. The largest and earliest recorded outbreak occurred in 1952–3 on two million hectares from Frederick Sound to the south end of Prince of Wales Island.

Identification: Newly emerged larvae are nearly all black, but later instars turn dark green. When larvae are nearly full grown, longitudinal stripes appear. Larvae of all instars have black head capsules. Mature larvae are 15–20 mm long. Adult sawflies are small, thick-waist wasps about 5–8 mm long. Females are larger than males, have serrated antennae, and are olive green, whereas males are black and have plumed antennae.

Damage: Larvae feed on old foliage resulting in a reduction in host radial growth. Some top-kill is evident.

Figure 41. *Hemlock sawfly larva.*

Figure 42. *Hemlock sawfly adult.*

Remarks: Adults emerge and are active in September and October. Sawflies normally overwinter as eggs on host foliage, but will rarely overwinter in cocoons in forest litter. Eggs are deposited singly in characteristic pockets cut into edges of hemlock needles. Eggs hatch in June and larvae feed gregariously on old foliage. Larvae pupate in capsule-like cocoons on foliage or in litter during August and September.

Most sawfly outbreaks do not cause tree mortality, but some trees are top-killed and radial growth is temporarily reduced. Tree mortality becomes more apparent when sawfly and black-headed budworm populations coincide. This is due to the feeding habits of the two defoliators: the budworm feeds on current year's foliage, whereas sawflies consume old foliage, thus causing complete defoliation. Many female sawfly larvae cannot successfully complete development on the current year's foliage alone.

Natural controls usually reduce epidemic sawfly populations within a few years. Wetter than normal summers help reduce sawfly populations by favoring conditions for fungal growth. Fungi readily infect and kill sawfly larvae under warm, damp conditions. Likewise, low summer temperatures help reduce sawfly populations. The apparent widespread collapse of sawfly populations in Southeast Alaska in 1974 was associated with lower than normal 1973 temperatures. Low temperatures delay sawfly development and reduce the opportunities for successful oviposition. Starvation and poor nutrition brought about by a depletion of host foliage contribute to population collapse by reducing sawfly health (increasing effectiveness of fungal infection) and fecundity (the number of eggs laid).

References: 92, 93, 95, 96

Larch Sawfly

Hymenoptera: Tenthredinidae

***Pristiphora erichsonii* (Hartig)**

Hosts: Eastern larch (tamarack) and ornamental Siberian larch

Distribution: Interior Alaska; South-central Alaska.

Identification: Late instars have shiny black heads with bodies that are gray green along the back and a whitish colored underside. Tough, papery cocoons are brown in color and approximately 13 mm long. Adult females are 10 mm long with black antennae and black bodies. The abdomen of females has a broad orange band and tapers sharply towards the rear. Males have yellow antennae and an orange abdominal band, but the abdomen is cylindrical and rounded at the rear. Eggs are translucent and about 1.5 mm long.

Damage: Sawfly larvae eat the needles on the older parts of twigs. Heavy defoliation may cause a significant loss in growth. Larch growing on poor sites that have been defoliated for consecutive years may die outright, or are predisposed to attack by the larch beetle. Siberian larches withstand consecutive years of defoliation better than native larch.

Figure 43. *Larch sawfly larvae.*

Remarks: Larch sawfly was present in detectable numbers by the mid-1960s. Significant larch sawfly defoliation was not observed in Alaska until the mid-1990s. Large outbreaks (>150,000 hectares) developed in Interior Alaska and lasted for more than five consecutive years. Scattered larch mortality was especially apparent on poorer sites. Adults emerge in early to late spring. Less than 2 percent are males. Reproduction is largely parthenogenic. Each female lays 20–200 eggs, depositing them under the bark of current year twigs. Recently emerged larvae move back to the foliage on older twigs and generally feed in groups. Mature larvae drop to the ground, enter the duff, and spin cocoons where they spend the winter.

Larch sawflies were introduced into South-central Alaska (Mat-Su Valley and Anchorage Bowl) in 1999 on Siberian larch, a common and highly desirable ornamental.

References: 58, 73, 246, 247

Striped Alder Sawfly

Hymenoptera: Tenthredinidae

***Hemichroa crocea* (Geoffroy)**

Hosts: Alder.

Distribution: Southeast, Interior, and South-central Alaska

Identification: Larvae are gregarious and chew holes through the leaf from the underside. When disturbed while feeding, larvae often assume a fishhook posture with the posterior end curled under and upward. Full grown larvae are 20 mm long with a black head and a yellow-amber body marked by dark brown lateral stripes. Eggs are laid in a row on the underside of the leaf petiole.

Damage: Repeated defoliation can cause some host growth reduction.

Remarks: Biology is not well known in Alaska. In British Columbia there are two generations per year.

References: 73, 81, 93

Figure 44. *Striped alder sawfly larvae.*

Alder Woolly Sawfly

Hymenoptera: Tenthredinidae

***Eriocampa ovata* (L.)**

Hosts: Sitka, red and thinleaf alder

Distribution: Southeast and South-central Alaska

Identification: Little is known of the life stages other than all instars are covered with a white woolly secretion, except the last instar.

Damage: Larvae skeletonize all leaves on alders. Damage is mostly cosmetic.

Remarks: Biology is not well known in Alaska. This is a European species that is now established from British Columbia to Alaska. Larvae feed throughout the summer months and overwinter as pre-pupae in cocoons in the soil. Adults emerge the following spring. There is probably no more than one generation per year in Alaska. Eggs are laid on underside of the leaf along the midrib. Larvae feed on the undersurface of the leaf.

References: 73, 246

***Figure 45.** Alder woolly sawfly larvae.*

***Figure 46.** Alder woolly sawfly adult.*

Leaf Beetles

Coleoptera: Chrysomelidae

***Chrysomela walshi* Brown, *C. falsa* Brown, *C. interrupta* (F.), *Phratora* sp., and *Macrohaltica bimarginata* (Say)**

Hosts: Balsam poplar, black cottonwood, aspen, birch, alder, and willow.

Distribution: Throughout Alaska.

Identification: Newly hatched larvae are flattened, dark grubs with well-developed legs. Adults are variously colored, either brown, green, reddish brown, yellowish green, and with or without black spots. They are approximately 0.5 cm long and oval. The eggs are yellowish red.

Damage: Adults feed on tender shoots. Larvae first skeletonize and later chew holes in the leaves. On cottonwoods, damage is usually most severe near the top of the tree.

Remarks: Leaf beetles overwinter as adults in leaf litter. Adult leaf beetles become active in early spring and feed on tender shoots. Eggs are deposited on the upper and undersurface of leaves. Newly emerged larvae feed gregariously during the first three instars. Larvae have been found quite late in the summer on alder and may do substantial feeding just prior to leaf fall. There is probably one generation per year in Alaska.

References: 138

Figure 47. *Leaf beetle larvae.*

Figure 48. *Leaf beetle adult.*

Bud and Shoot Insects

Bud and shoot insects are part of a larger group of insects that feed on meristematic tissue. Bud and shoot insects seldom kill a tree, but their damage can reduce the rate of terminal growth or cause deformities that affect the growth and merchantable value of timber and ornamentals. Fortunately, there are few bud and shoot insects attacking Alaska trees.

Figure 49. *Spruce bud midge damage.*

Spruce Bud Midge

Diptera: Cecidomyiidae

***Rhabdophaga swainei* Felt**

Hosts: White, Lutz, black, and possibly Sitka spruce.

Distribution: Recurrent problem in South-central, Interior, and possibly Southeast Alaska.

Identification: Full grown larvae are pale pink, 1.5 to 2.2 mm long and 0.5 to 1.0 mm wide. Pupae are 1.5 to 2.5 mm long and are enclosed in a delicate, transparent case. The adult is a small (2.5 mm) reddish-brown midge. The female has a reddish-brown thorax, but its abdomen and ovipositor are bright orange-red. The pale orange-pink eggs are 0.4 to 0.5 mm long and oval shaped.

Damage: The attacked bud becomes rosette-like due to drying and recurving of the bud scales. These galls are most numerous on the sunny sides and tops of open-grown spruce, which are from 1.5 to 3 m tall. Galls are commonly formed on the terminal buds of branches. The attacked bud is killed; elongation of lateral buds the following year causes bushy growth. When the terminal shoot is attacked, a crook develops. In some cases multiple leaders result.

Remarks: The biology of the spruce bud midge is not fully understood in Alaska but is believed to be similar to that in Canada. Eggs are deposited between the young needles of developing shoots in early May. Newly hatched larvae burrow into the soft tissue of the developing bud. The insect overwinters in the larval stage. By the following May, pupae are formed and the galled bud becomes rosette-like. Adults emerge from mid-May. There appears to be one generation per year.

References: 36, 73

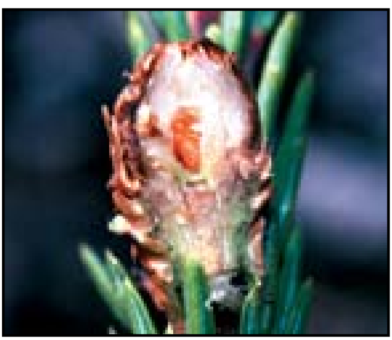


Figure 50. *Spruce bud midge larva.*

Spruce and Larch Budmoth

Lepidoptera: Tortricidae

***Zeiraphera canadensis* Mutuura & Freeman, *Z. confusana* Ferris & Kruse, *Z. fortunana* (Kearfott), *Z. griseana* (Hubner), *Z. improbana* (Walker), and *Z. vancouverana* McDunnough.**

Hosts: White and Sitka spruce and eastern larch (tamarack).

Distribution: South-central, Southeast, and Interior Alaska, Kodiak and Afognak Islands, Prince William Sound, and Yakutat Forelands.

Identification: Larvae are 10–20 mm long, pale brown to greenish gray and the head and pronotum are yellowish-brown. Adults are small, grayish to brownish moths, with a wingspread of about 14 mm. Identification to species needs to be done by specialists.

Damage: New buds are mined by developing larvae.

Remarks: In 1976, the larch budmoth was responsible for the defoliation of 239,000 hectares of larch in Interior Alaska. The trees did not die because defoliation occurred in the spring and the infested larch refoliated soon after. The larch budmoth overwinters as eggs under bark scales of twigs and branches of tamarack trees. Newly emerged larvae feed within a webbed tube constructed from several newly formed needles. Fourth and fifth instars live in lightly spun silken shelters along the branch axis and travel along the branch feeding on new and old needles. Larvae drop to the ground on silken threads and pupate in the forest litter. Females emerge and deposit eggs in late July. There is one generation per year.

References: 42, 43, 73, 142, 262

***Figure 51.** Spruce and larch budmoth larvae.*

***Figure 52.** Spruce/larch budmoth adult.*

Sap-Sucking Insects and Mites

Sap-sucking insects and mites are more important pests in orchards, gardens, or to shade trees than they are in the forest. Hosts are injured in two ways: (1) Directly by sapping the host of part of its food supply and water, producing necrotic spots in host tissue, and (2) Indirectly by introducing plant diseases.

The mouthparts of these insects and mites are formed into beak-like structures that are used to pierce host tissues and suck the sap. Damage by sap-sucking insects is often mistakenly regarded as disease caused. A few of the sap-sucking insects are able to kill their hosts outright, but damage usually results in reduced growth rates and a general weakened condition. Trees injured by these insects may succumb to secondary insects or fungal diseases. Signs of sap-sucking insect damage consist of enlarged growths or galls, leaf curling, bleaching, or yellowing of foliage. Conifers are more severely injured than hardwoods.

In Alaska, there are several sap-sucking insects that cause noticeable damage to trees and shrubs. These pests can cause appreciable problems to urban woodlands and parks. Use of a hand-lens will help in detection and identification, as these organisms are quite small.

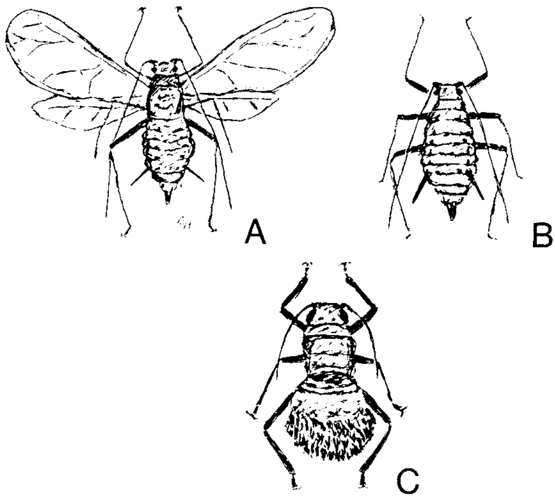


Figure 53. *Aphids: A. adult; B. nymph; C. Woolly aphid nymph.*

Spruce Aphid

Homoptera: Aphididae

***Elatobium abietinum* Walker**

Hosts: Feed on most species of spruce, but are most damaging to Sitka spruce.

Distribution: Spruce aphid populations have infested several areas in Southeast Alaska and occasionally Kodiak Island causing severe defoliation and limited tree mortality. Serious damage has sporadically occurred near Sitka where many trees have been killed. The more severely defoliated trees were weakened and attacked by bark beetles that had built up in adjacent windthrows. In recent years, the needle aphid has been a recurring urban problem around Sitka, Craig, Juneau and Ketchikan.

Identification: Nymphs are oval, green and wingless, approximately 0.5–1.4 mm long. Adult aphids may be either wingless or winged. Wingless adults are about 1.5 mm long, oval, green, with a yellow-green head and dull red eyes. Winged adults are bright green with translucent legs. The transparent wings are longer than the body that is approximately 1.0–1.8 mm long. In most of Europe and Alaska, female aphids parthenogenetically (reproduction without fertilization) give birth to live young (viviparous). Eggs have not been found in Alaska, so the life cycle continues without males or fertilized females (anholocyclic).

Figure 54. *Spruce aphid damage on Sitka spruce, Sitka, Alaska.*

Damage: Partial or complete defoliation and occasional tree mortality. Spruce occurring along tidewater areas that are in "fringe areas" or in other "stressed" locations (urban plantings) are susceptible to aphid damage.

Remarks: This insect was introduced from Europe into the North American Pacific Northwest in the early 1910s. Spruce aphids are abundant and most damaging in early spring and again in fall. Some limited feeding can occur in summer and winter. Population increases in spring and fall are due to a variety of factors. An increase in soluble nitrogen in spruce foliage at these times favors aphid increases. At bud break, around the first week of June, nitrogen levels drop and is followed by a decrease in aphid reproduction. Likewise, mild winter temperatures, minimums that do not go below about 0°F, contribute to aphid buildups. Epidemic aphid populations will usually remain high for only a few years, and then collapse to previous low levels. Factors causing declines include intraspecific competition for food and low winter temperatures. Temperatures well below freezing, when overwintering aphids are emerging en masse, and snowfall (snowfall protects overwintering adults from freezing) are the most important controlling factors. Since the 1970s, aphid defoliation has occurred on thousands of hectares per year except for a few years when late winter temperatures were limiting emerging aphids.

Control of spruce aphids on ornamentals can be done with commercially available insecticides labeled for aphid control.

References: 18, 46, 51, 93, 133, 156

Figure 55. *Spruce aphids.*

Giant Conifer Aphids

Homoptera: Aphididae

***Cinara nigripes* Bradley and *C. piceae* (Panzer)**

Hosts: White and Sitka spruce.

Distribution: Throughout Alaska.

Identification: These aphids have long legs. The giant conifer aphid on white spruce is believed to be *Cinara nigripes*. This aphid is black with a body length of approximately 5 mm. The species on Sitka spruce is believed to be *Cinara piceae*, brown colored with a body length of 3.4 mm long. Sometimes they are lightly covered with a powdery wax. The eggs are blackish, laid singly or in rows on the needles.

Damage: Large aphid populations can cause yellowing of the foliage and reduce tree growth, especially on young trees. Black sooty mold, growing on the honeydew exuded by the aphids, is common.

Remarks: The life cycle of these aphids is complex; up to six generations a year can occur in Canada. All species overwinter in the egg stage. Most *Cinara* feed gregariously and are usually attended by ants that feed on the honeydew. Males occur in the fall generation.

Control is seldom necessary. However, contact insecticides may be used on heavily infested, ornamental spruce.

References: 24, 73, 195

Figure 56. *Giant conifer aphids.*

Spruce Gall Aphids

Homoptera: Adelgidae

***Adelges abietis* (L.), *Pineus similis* (Gillette), and *A. cooleyi* (Gillette)**

Hosts: Sitka, white, and Lutz spruce.

Distribution: Throughout Southeast, South-central, and Interior Alaska.

Identification: The galls are light green to dark purple while developing in the first year but become reddish brown the second year after the aphids have vacated the galls. Galls range in length from 1 to 5 cm long. Adults are oval, reddish brown, and 1 mm long. Nymphs are oval, reddish to yellowish brown and sometimes covered with a white woolly material.

Damage: These aphids cause the tree to form conspicuous cone shaped galls on spruce twigs. Repeated attacks by the insect can result in dead twigs and a ragged appearance of the foliage.

Remarks: The life history of gall aphids on spruce is not well known in Alaska. Both the ragged spruce gall aphid *Pineus similis* and the eastern spruce gall aphid *Adelges abietis* are believed to be the causal agents in white spruce. Both these aphids have no alternate hosts and can have two generations per year. In Sitka spruce the Cooley gall aphid *Adelges cooleyi* is believed to cause the characteristic galls. Eggs are laid by the overwintering aphids in May. The eggs give rise to three types of aphids, two of which cause galls to form. The galls increase in size during the summer until they open, releas-

Figure 57. *Spruce gall aphid damage on white spruce.*

ing the winged adults. These adults lay eggs in July, which produce the new overwintering generation.

Removing and burning green galls is an efficient control for high value trees if done before aphid adult emergence in the summer. A systemic insecticide applied as the buds begin to swell in the spring can provide control.

References: 42, 45, 73, 132, 153, 195

Figure 58. *Galls from the ragged spruce gall aphid,* Pineus similis.

Woolly Adelgids

Homoptera: Adelgidae

***Adelges tsugae* Annand, *Pineus similis* (Gillette), and *A. cooleyi* (Gillette)**

Hosts: Western hemlock, Sitka, white, and Lutz spruce. Also has been identified on transplanted Douglas-fir in Sitka, Alaska in 1990.

Distribution: Throughout Alaska.

Identification: Young aphids are broadly ovoid, 0.3 mm to 0.6 mm long; yellowish-brown. Later stages are dark brown to black, covered with white, waxy wool.

Damage: Woolly tufts on needles and twigs. Woolly aphids are of little consequence in the forest but large populations can seriously weaken and sometimes kill ornamental trees. Infested foliage becomes yellowish-brown. After severe infestations, the foliage may turn brown and fall from the branches.

Figure 59. *Woolly aphids on white spruce.*

Remarks: The hemlock woolly adelgid, *Adelges tsugae*, has a one-year life cycle and feeds only on hemlock. Populations probably consist only of females that are able to reproduce asexually.

The biology of woolly adelgids on spruce is not fully understood in Alaska. The aphids are believed to be either the ragged spruce gall aphid (*P. similis*) or the eastern spruce gall aphid (*A. abietis*). Immature stages of these aphids produce waxy wool. There is the possibility that a monotypic population of *A. coolleyi* is responsible for the waxy wool on spruce. Asexual populations of this aphid live on spruce year around producing woolly tufts but not galls.

If chemical control is necessary, strict attention to timing of spray applications is essential. In general, chemical control is more effective when directed at the immature stages, particularly in the spring. Both systemic and contact insecticides can provide control.

References: 45, 73, 132, 153

Spruce Bud Scale

Homoptera: Coccidae

***Physokermes piceae* (Schrank)**

Hosts: White, Lutz, and possibly Sitka spruce

Distribution: Bud scale insects have only been collected from the Anchorage area. However, they probably occur in Interior Alaska as well.

Identification: The mature bud scale, which is frequently mistaken for a bud, is yellowish to reddish brown, semi-globular, and about 1.5 to 3 mm long and 3 mm in diameter. The female adult scales very closely resemble spruce buds and consequently, often go unnoticed.

Damage: Urban ornamental trees are more commonly infested than those in forested settings. Heavily infested trees are weakened which causes needle loss. Lower branches may be killed. Sooty mold, growing on the honeydew exuded from the scales, is common.

Remarks: The biology is not well known in Alaska. There is one generation a year in Canada and the Lake States. Immature individuals overwinter in clusters around terminal buds. They resume feeding in the spring and mature in early summer. Eggs are laid under the adult female scale. The young crawlers move to the tips of twigs where they feed until late fall.

When control is necessary, a systemic insecticide applied in early August or a contact insecticide applied from late June to late July should prove effective.

References: 73, 195, 275

Figure 60. *Spruce bud scales.*

Birch Aphid

Homoptera: Aphididae

***Euceraphis betulae* (Koch.)**

Hosts: Alaska birch.

Distribution: Large aphid populations on Alaska birch causes concern in Interior and South-central Alaska. Browning of birch foliage covered more than 50,000 hectares near Chickaloon and along the Matanuska River in the mid-1970s. The next summer, various species of aphids were present in high numbers in mixed hardwood/spruce stands covering nearly 120,000 hectares near Palmer urban areas. Aphid defoliation was responsible for large amounts of honeydew, leaf-curling and browning on ornamental birch in both cities.

Identification: Small, greenish brown aphids; both winged and wingless forms may be present.

Damage: Leaf-curling and browning.

Remarks: The lifecycle is not well documented in Alaska. Other aphids, such as *Ericosoma* sp. and *Mordwilkoja* sp. generally cause some leaf-curling, browning, and some limited dieback on aspen and spruce throughout Interior Alaska. They are commonly encountered in the field although their damage is of minor concern.

References: 9, 11, 142

Figure 61. *Birch aphids.*

Figure 62. *Birch aphid damage.*

Hardwood Gall Insects

Diptera: Cecidomyiidae

***Rhabdophaga rosaria* (H. Loew), *R. strobiloides* Walsh.**

Hymenoptera: Tenthredinidae

***Pontania s-pomum* (Walsh)**

Hosts: Willow spp., aspen, cottonwood.

Distribution: Throughout Alaska.

Identification: A variety of minute insects are involved, from small fly maggots to wasps. Galling is a response by the host to insect feeding.

Figure 63. *Willow rose gall.*

Figure 64. *Willow gall wasp.*

Figure 65. *Pine cone gall on willow,* Rhabdophaga *sp.*

Damage: Galling can result in limited growth reduction. The appearance of galled leaves is an aesthetics concern of some homeowners.

Remarks: The life cycles of these insects are complex and not well known in Alaska. Control is seldom necessary. Early spring applications of systemic insecticides provide adequate control.

References: 5, 37, 40

Spittlebug

Homoptera: Cercopidae

***Aphrophora* sp.**

Hosts: Sitka spruce seedlings, hardwoods, and ground vegetation.

Distribution: Southeast and South-central Alaska.

Identification: Both the adult and nymph feed on plant fluids; only nymphs make spittlemass that serves as a protective covering. Young nymphs are red and black; older nymphs are brown. Adults are brown to black and similar to nymphs but with wings. Eggs are teardrop in shape.

Damage: Dead tops, flagged branches, wavy and slanted stems, shortened stem and branch internodes.

Remarks: Biology is poorly known in Alaska.

References: 46, 275

Figure 66. *Spittle mass with spittle bug nymph.*

Spider Mites: Acarina

Acari: Tetranychidae

***Oligonychus ununguis* (Jacobi), *Tetranychus urticae* Koch**

Hosts: Conifers.

Distribution: Throughout Alaska; prevalent in urban areas.

Identification: Adults are 0.5 mm long with a globular body, four pairs of legs, and no antennae. The spider-like adults are greenish to reddish-brown. Nymphs are similar to adults but have only three pairs of legs.

Damage: Fading (brown) host foliage falls prematurely.

Remarks: Biology of the red spider mite is unknown in Alaska. Generally spider mites overwinter as eggs or adults. There are many generations per year. Females can lay from two to four dozen eggs. The presence of mites can be detected by webbing on the foliage that contains considerable debris. Adults, due to their small size, can be detected with a hand lens.

References: 3, 275

Figure 67. *Spider mite damage.*

Eriophyid Mites

Acariformes: Eriophyidae

***Eriophyes* spp.**

Hosts: Willow, alder, mountain ash, and birch.

Distribution: Throughout Alaska.

Identification: Eriophyid mites are very small (200 microns) and observation requires a hand lens or microscope. Unlike the familiar form of spider mites, eriophyid mites are elongated, worm-like, and have only two pairs of legs instead of the usual four pairs.

Damage: Eriophyid mite feeding causes plant abnormalities such as galls and felt-like mats. Most damage is primarily cosmetic as eriophyid mite feeding induces leaf edge rolling, or causes the leaf surface to blister. Growth of the host may be reduced if the tree is heavily infested for many years.

Remarks: The life cycle is fairly simple. Within a growing season, the mites develop through four stages: egg, first nymph, second nymph, and adult, which is the overwintering stage. Eriophyid mites travel between hosts by air currents, or by hitching rides on insects or birds.

References: 20, 73, 207

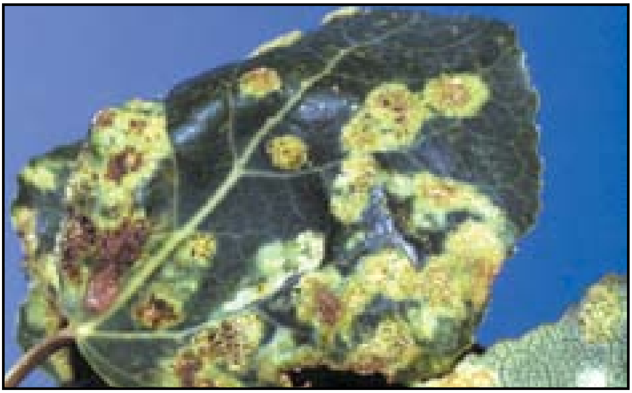


Figure 68. *Eriophyid mite damage.*

Bark Beetles

Bark beetles are common in Alaska where more than 50 different species are known to occur (76). Only a few of these are actually pests of forest trees. In fact, most bark beetles are usually positive components of the ecosystem, where they help break down woody debris, catalyze nutrient cycling, create structural diversity in otherwise continuous forest stands, enhance aesthetic values of the forest, and provide other important ecosystem services.

Sometimes, however, beetles kill living trees and cause socioeconomic or ecological damage or both. Some beetle-caused impacts include: 1. Loss of merchantable value of killed trees, 2. Long-term stand conversion, 3. Positive and negative impacts to wildlife habitat, 4. Impacts to scenic quality, 5. Increased fire hazard, 6. Impact to fisheries, 7. Impact to watersheds, and others.

As a group, certain traits and habits are common to all Alaska's bark beetles:

- Adults excavate egg galleries in bark phloem.
- Most bark beetles prefer weakened host material.
- All bark beetle life stages are spent in the phloem, inner bark and bark, except when adults fly to new hosts.

Bark beetles prefer to breed in weakened host material. However, with abundant host material and during favorable climatic periods for beetle development, populations may build rapidly, reaching levels high enough to overwhelm tree defenses and infest and successfully colonize neighboring healthy trees. Bark beetles disrupt downward translocation of food by girdling the phloem.

Some of the bark beetles, notably those of the genus *Dendroctonus*, have a symbiotic relationship with blue-stain fungi. Blue-stain fungi can completely penetrate the sapwood within a year, occluding the outer conducting tissues in the xylem, and halting upward water translocation. This action in combination with bark beetle feeding presumably causes the death of a host tree.

Crowns of heavily infested trees turn from green to yellow to reddish brown. This color change may occur from one to two years after being attacked, depending on temperature, moisture, and beetle density. Inspection of infested boles might show globules of resin, holes in the bark surface, and reddish boring dust in bark crevices and/or at the base of the tree. The removal of bark from infested trees will reveal two types of galleries. Egg galleries created by adult beetles that are more or less uniform in width. Larval galleries created by feeding larvae that gradually increase in width as the larvae grow in size, and originate at right angles from the egg gallery. Differing gallery patterns are often used to distinguish among the different bark beetles species.

References: 77

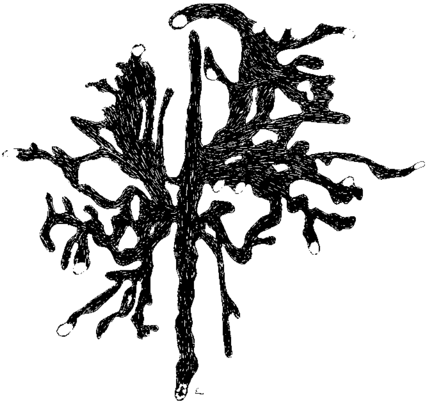


Figure 69. *Spruce beetle galleries.*

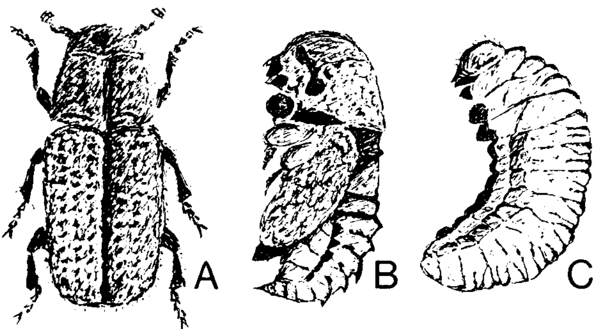


Figure 70. *Spruce beetle life stages: A. adult; B. pupa; C. larva.*

Spruce Beetle

Coleoptera: Curculionidae, Scolytinae

***Dendroctonus rufipennis* (Kirby)**

Hosts: Lutz, white, Sitka, and at times, black spruce.

Distribution: Wherever spruce is present, especially in South-central Alaska.

Identification: Adult spruce beetles are dark brown to black, cylindrical in shape, approximately 5 mm long and 3 mm wide. The larvae are stout, white, legless grubs, 6 mm long at maturity. The pupae are white, soft-bodied, and adult shaped.

Damage: Kills standing trees.

Remarks: The spruce beetle generally has a two-year life cycle, but this can be shortened to one-year if climatic conditions (warm and dry spring and summer) are favorable and there is an abundance of suitable host material. Adult and larval activity begins in May when daytime temperatures under bark reach 6.7° C (47° F) (263). Adult beetles disperse in late May and early June when daytime ambient temperatures reach 16° C (62° F) and above . Dispersing adults can fly as far as 11 kilometers nonstop, but dispersal distance is usually much shorter than this. Females are initially attracted to windthrow and other downed material and initiate attack; males arrive later.

Spruce beetles prefer to attack on the sides and bottoms of downed host material. Attacking female beetles release pheromones that attract other male and female beetles. The monogamous females deposit approximately 80 eggs in niches along the sides of the vertical egg gallery in standing trees. Egg galleries are packed with frass and boring material, and often have a fan shape. Most eggs hatch by August.

Figure 71. *Spruce beetle adult, lateral view.*

Spruce beetles typically overwinter as larvae during the first year, and pupate the following summer. Pupation lasts 10–15 days. Most newly formed adults migrate to, and overwinter under the bark in the snow-covered base of the trees in which they developed. During the cold of winter, the snow that covers the base of infested trees insulates the beetle's domain. The following spring (approximately two years after attack) adults emerge from the tree and attack new host material.

Most *D. rufipennis* outbreaks in standing timber have originated in windthrown trees or large diameter logging residue. In the Rocky Mountains, and probably Alaska also, host susceptibility decreases in the following order: (1) large diameter trees along creek bottoms, (2) trees in better stands on benches, (3) trees in poorer sites on ridges and benches, (4) stand mixtures of spruce and other species, and (5) stands of immature trees.

References: 7, 74, 87, 93, 140, 189–192, 198, 261, 264, 266, 267, 277

Figure 72. *Spruce beetle larvae.*

Figure 73. *White spruce killed by the spruce beetle.*

Figure 74. *Spruce beetle boring material (frass) at the base of an attacked tree.*

Figure 75. *Unacceptable right-of-way cleanup.*

Figure 76. *Acceptable right-of-way cleanup.*

Eastern Larch Beetle

Coleoptera: Curculionidae, Scolytinae

***Dendroctonus simplex* LeConte.**

Hosts: Tamarack (Eastern larch)

Distribution: Interior Alaska. Historically, larch beetle infestations have been reported across the entire range of tamarack in Alaska. Outbreaks have exceeded 215,000 hectares.

Identification: Adults and larvae are very similar to the spruce beetle (see figure 71) although somewhat smaller. Adults are reddish brown to black.

Damage: Attacks weakened tamarack and subsequently causes host mortality.

Remarks: Adults are active from the last week of May through the second week of July. Pitch tubes occur rarely on infested tamarack because of the host's weakened condition at the time of attack. Trees can be weakened by successive years of larch sawfly defoliation, drought, or smoke damage from frequent wildfires in the black spruce wetlands where tamarack is most commonly found.

Egg galleries are vertical and approximately 20–25 cm in length. Larval tunnels occur in groups of 3–6 or more and do not cross. Larch beetles usually overwinter as adults under host bark at the base of the tree and emerge in the spring.

References: 9, 10, 142, 277

Engravers

Coleoptera: Curculionidae, Scolytinae

***Ips perturbatus* (Eichhoff), *I. tridens* (Mannerheim), *I. borealis* Swaine, *I. concinnus* (Mannerheim), *I. pini* (Say), and *I. latidens* (LeConte) spp.**

Hosts: White, black, Lutz, and Sitka spruce.

Distribution: Throughout Alaska, but more prevalent in the Interior. These beetles are known for their opportunistic use of trees damaged by fire, drought, flooding, and human development activities that alter forest stands.

Identification: Adults are small (0.3–0.6 cm long), cylindrical, reddish brown, and black beetles. The head is not visible when the insect is viewed from above. A distinguishing feature of all *Ips* is a pronounced declivity (concave area) on the posterior end, which is margined with three or four pairs of tooth-like spines.

Larvae are segmented, soft-bodied, whitish, elongate cylindrical, legless grubs. Head color is tan, and the thoracic segment is enlarged.

Damage: Cause mortality to saplings, pole-sized, and mature trees.

Remarks: Several engraver species live in Alaska. Most are similar in size, coloration, and habits. The first evidence of *Ips* attack is the presence of fine, yellow-red boring dust in bark crevices. Unlike spruce beetle damage/injury, pitch-tubes of *Ips* are rarely formed in response to *Ips* infestations. Adults disperse to new host material as early as mid-April. Preferred host material

Figure 77. Ips *adult, lateral view.*

Figure 78. *Engraver frass.*

Figure 79. *Engraver galleries.*

includes freshly cut logs, and tops of weakened trees. Dispersal is temperature-dependent, and can occur from early May through early August, depending on the species.

Ips are polygamous. Males *Ips* initiate tree attacks, after which male and female adults aggregate in response to pheromones (and some host chemicals) in the initial galleries. Engravers and spruce beetles commonly occur at the same site, but the former prefer sunnier and drier host material.

After boring into the bark, males construct an enlarged chamber called a nuptial chamber in the inner bark adjacent to the entrance hole. Adults females construct egg galleries which radiate from the nuptial chambers. In contrast to those produced by spruce beetles, *Ips* egg galleries are kept clear of frass and boring dust.

Preventive measures are the best suppression measure for *Ips* buildup. By preventing slash accumulation or by burning infested *Ips* material or scattering slash in very sunny locations help reduce engraver buildup. Direct control operations generally are not used against *Ips* as outbreaks develop and disappear rapidly, usually within three years.

References: 3, 16, 31, 73, 78, 79, 86, 91, 134–136

Hemlock Hylesinus

Coleooptera: Curculionidae, Scolytinae

***Pseudohylesinus tsugae* (Swaine)**

Hosts: Western hemlock.

Distribution: Southern Alaska, especially the Southeast portion of the state.

Identification: Adult beetles are stout, oval bark beetles 3.2 to 4.5 mm long and reddish brown.

Damage/Injury: Larval galleries reduce host tree vigor.

Remarks: The hemlock hylesinus breeds in felled or weakened western hemlock and can sometimes kill healthy trees. Before infesting slash, female beetles make short feeding galleries on live trees, but abandon these galleries within one or two weeks. This phenomenon has been observed in numerous thinned stands on Prince of Wales Island. Egg galleries of this beetle are similar to those made by *Scolytus* spp.

References: 73, 91, 153

Figure 80. *Hemlock hylesinus gallery.*

Cedar Bark Beetle

Coleoptera: Curculionidae. Scolytinae

***Phloeosinus cupressi* Hopkins, *P. punctatus* LeConte, and *P. sequoiae* Hopkins.**

Hosts: Western redcedar and Alaska yellow-cedar.

Distribution: Southeast Alaska.

Identification: Adults are commonly reddish to dark brown and approximately 2 to 4 mm in length. The head is visible from above; antennal clubs are conical, and the eyes are deeply notched.

Damage: Weakened standing trees may be killed in rare cases.

Injury: Feeding adults cause twig and branch dieback. In rare cases, weakened hosts are killed.

Remarks: *Phloeosinus* spp. is composed of a group of 25 species in the U.S. and Canada often referred to as the cedar bark beetles. Members of this group are rarely aggressive enough to kill healthy trees. Attacks usually occur on stressed or recently dead trees, and on debris from harvested or pruned trees. Newly emerged adults feed on twigs, sometimes causing flagging in the crown of infested trees. *Phloeosinus cupressi*, the cedar bark beetle, only infests large branches and main boles of Alaska yellow-cedar in advanced stages of decline. Infested trees become susceptible to the stem rot fungus *Coryneum cardinale*, which is often found fruiting on infested trees. *Phloeosinus punctata*, the western cedar bark beetle, has been reported in Alaska only a few times. The host is western redcedar. *P. punctuata* is considered to be of relatively low significance, causing little damage or concern. Adults are 2 to 3 mm long with reddish brown elytra and a black shiny body. *Phloeosinus sequoiae*, the redwood bark beetle, infests both western redcedar and Alaska yellow-cedar. Host mortality has sometimes occurred. Infestations have been correlated to poor sites. Apparently, *P. sequoiae* is more aggressive, and adults much larger, than the other Alaskan *Phloeosinus* species.

References: 3, 53, 55, 73, 93, 105, 153, 252

Four-Eyed Bark Beetle

Coleoptera: Curculionidae, Scolytinae

***Polygraphus rufipennis* (Kirby)**

Hosts: Sitka, white, Lutz, and black spruce and lodgepole pine.

Distribution: Throughout Alaska wherever suitable hosts are found.

Identification: Adult beetles are stout, cylindrical, approximately 2 to 3 mm long, and reddish brown to black. The two compound eyes are each restricted giving the impression of four eyes.

Damage: Often found feeding beneath the bark in dry and small branches of stressed or dead trees. The four-eyed bark beetles are not important pests in Alaska.

Remarks: *P. rufipennis* adults actively disperse in search of downed logs or dead trees from June to early July, taking flight whenever temperatures exceed 16° C (61° F). Females select the host. Mating takes place in a nuptial chamber in the inner bark. Females excavate egg galleries and lay approximately twenty eggs, then emerge and initiate a second or third egg gallery in the same or a different host. Egg galleries are usually full of frass. One generation occurs each year. Breeding adults overwinter and resume breeding the following spring, which is rare among bark beetles.

References: 16, 53, 78, 79

Coleoptera: Curculionidae, Scolytinae

***Dryocoetes confusus* Swaine, *D. affaber* (Mannerheim), *D. autographus* (Ratzeburg), *D. caryi* Hopkins**

Hosts: Subalpine fir, Sitka spruce, white spruce, Lutz spruce, western hemlock, and lodgepole pine.

Distribution: Throughout Alaska wherever susceptible host material is found.

Identification: Adults are 2.5 to 5.0 mm long, blackish with a distinguishable tuft of "hair" on the head.

Damage: These beetles cause little or no economic impact. Larval galleries are found under the bark of dead and weakened host material.

Remarks: Biology of these species is poorly known in Alaska. However, biological information from Canada and the contiguous United States indicate that beetles disperse to new host material during July. *Dryocoetes* spp. is usually found with dead, stressed, or downed trees. They are polygamous, usually three or four females associated with one male that initiates attack. Egg galleries are irregular in shape. Eggs are laid in niches cut into the gallery wall and are covered with frass. Larval galleries twist and cross frequently showing little orientation with respect to the wood grain. There is one generation per year.

References: 16, 31

Figure 81. Dryocoetes *adult, lateral view.*

Willow Bark Beetle

Coleoptera: Curculionidae, Scolytinae

***Trypophloeus striatulus* (Mann.)**

Hosts: Primarily felt leaf willow.

Distribution: Interior Alaska.

Identification: Adult beetles are brown to black in color and about 2.0 mm long with scaly elytra, especially toward the rear. Larvae have three instars. The third instar is snow white, approximately 3.0 mm long. Eggs are translucent white, oblong, and 0.7 x 0.4 mm. Pupae are white and eyes and mandibles turn blackish-brown when mature.

Damage: Adults attack the larger stems and trunks of decadent, overmature willow. Stems are re-attacked many times over a number of years resulting in stem death.

Remarks: New adults appear in August, probing the host bark for a site to bore a chamber in which they spend the winter. Adults emerge from overwintering sites in the spring and construct a brood chamber under the bark where they mate and construct an egg gallery. Emerging adults usually do not disperse far, preferring to re-attack the same stem for several generations, thereby conserving a limited resource.

References: 31, 72, 73

Figure 82. *Infested willow stem with adult entrance and exit holes.*

Figure 83. *Willow bark beetle eggs and gallery.*

Wood Borers

This group consists of several orders (Lepidoptera, Hymenoptera, and Coleoptera) and families which bore into the sapwood and, at times, the heartwood of weakened, recently felled or dead hardwoods and conifers. Included here are the long-horned beetles or round-headed borers (Coleoptera: Cerambycidae), flat-headed or metallic woodborers (Coleoptera: Buprestidae), horntails (Hymenoptera: Siricidae), ambrosia beetles (Coleoptera: Curculionidae), the ghost moths (Lepidoptera: Hepialidae), and pitch moths (Lepidoptera: Sesiidae). Most of these borers normally attack only freshly cut, injured, dying, or recently dead hosts. However, under certain circumstances, they can cause substantial economic losses in the form of wood degrade and volume loss.

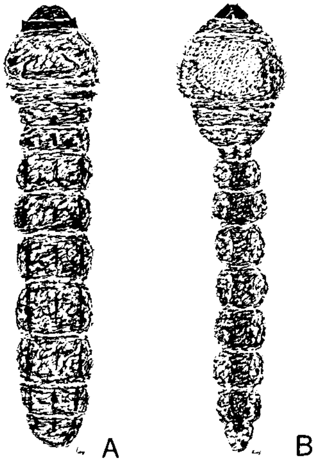


Figure 84. *Wood borer larvae: A. round-headed borer (*Cerambycidae*); B. flat-headed borer (*Buprestidae*).*

Round-headed Borers or Long-horned Beetles

Coleoptera: Cerambycidae

The larvae of this group of insects live as borers in the tissues of trees and other woody plants and are at times serious pests. Smaller trees are sometimes girdled and killed. The sapwood and heartwood of larger trees are riddled and weakened and become susceptible to wind breakage or death. Round-headed borers reduce both grade and volume in logs and pulpwood and also introduce stain-causing fungi that degrade lumber values. Adults may emerge from bark beetle-killed timber used as house logs after the log house has been constructed.

Those round-headed borers that require moist, sometimes decayed dead wood are generally beneficial. They are considered the most prominent insects involved with decomposition of slash, stumps, and dead and dying trees in north temperate forests.

Round-headed borer larvae are characterized by a whitish-elongate-robust to slender body. They are soft, fleshy, and cylindrical to somewhat flattened in shape, with the head slightly flattened. Adult beetles are cylindrical, oblong-elongate to somewhat flattened, sometimes brightly colored. The antennae are long and slender, usually 11-segmented, and as long as or longer than the body. Some species make squeaking noises when disturbed, and the larvae of the “sawyers” produce a loud noise while boring.

White-spotted Sawyer

Coleoptera: Cerambycidae

***Monochamus scutellatus* (Say)**

Hosts: White, Lutz and occasionally, black spruce.

Distribution: Inland forests of Interior and South-central Alaska.

Identification: Full grown larvae are approximately 50 mm long, whitish, elongate and cylindrical with a soft, legless body, and dark brown mandibles. The head is slightly flattened. Adults are stout, dull black beetles, 2.5 cm long with gray-white markings on wing covers; tooth-like projections on sides of prothorax. Female antennae are longer than its body; male bodies are larger and stouter than the female with antennae over twice as long as its body.

Damage: The larvae bore into dead or dying trees and often introduce wood rotting fungi. Adults sometimes feed on the bark of branches and the foliage. Flagging of lateral twigs and foliage occurs when wood borer populations are high, e.g. during harvest operations and on the fringes of burned areas. Flagging is the result of adult maturation feeding.

Remarks: Sawyer beetles are strong fliers and can travel several kilometers. The beetles need to feed on twigs of healthy trees in order to mature and breed. This so-called maturation feeding causes minor damage to the twigs. Female sawyers emerge in early June to mid-August and deposit eggs under the bark scales of dying trees. Newly developed larvae feed in the cambium and heavily scour the sapwood surface. Coarse, splintery larval frass, characteristic of cerambycids, is usually present on or in infested material. Larvae tunnel into and overwinter in the sapwood. The second year is spent in the larval stage with pupation and adult emergence occurring the following spring.

References: 53, 73, 79, 91, 175

Figure 85. *White-spotted sawyer.*

Coleoptera: Cerambycidae

***Xylotrechus undulatus* (Say)**

Hosts: White and Lutz spruce.

Distribution: Interior and South-central Alaska.

Identification: Adults are stout and cylindrical from 12–19 mm long with antennae only slightly longer than combined length of head and thorax. Wing covers are black and sharply outlined with white crescent shaped markings.

Damage: The larvae bore into dead or dying trees and often introduce wood rotting fungi.

Remarks: The biology is not well known in Alaska.

References: 73, 79

Figure 86. Xylotrechus *adult.*

Other Alaska Cerambycidae:

***Acmaeops p. proteus* (Kby.)**

***Phymatodes dimidiatus* (Kby.)**

***Pogonocherus mixtus* Hald.**

***Pogonocherus penicillatus* LeC.**

***Arhopalus productus* (LeC.)**

***Elaphidion* sp.**

***Neacanthocinus pusillus* (Kby.)**

***Pachyta lamed* (LeC.)**

***Gnathacmaeops pratensis* (Laich.)**

***Grammoptera subargentata* (Kby.)**

***Neoclytus m. muricatulus* (Kby.)**

***Callidium cicatricosum* Mann.**

***Judolia m. montivagans* (Cooper)**

***Pronocera c. collaris* (Kby.)**

***Tetropium cinnamopterum parvulum* (Csy.)**

***Tetropium velutinum* LeC.**

Hosts: White, Sitka, Lutz, and black spruces.

Distribution: Throughout Alaska.

Remarks: The biologies are not well known in Alaska.

References: 77, 78

Metallic or Flat-Headed Wood Borers

Coleoptera: Buprestidae

Unlike the cerambycids, the buprestids almost never develop in decayed wood; they are restricted to recently weakened or killed material. The buprestids are destructive in that they sometimes kill living trees and often reduce the value of lumber through their attacks. The winding larval galleries, present in the sapwood and heartwood, are characteristically tightly packed with boring material.

Adults are flattened, frequently brightly colored, iridescent beetles with short antennae. Females oviposit in bark crevices, and developing larvae construct long, winding, oval galleries in the bark and/or the wood. Adults of many species can successfully attack and develop in pitchy fire scars on living trees and in trees weakened by root decay, or in unseasoned lumber, milled wood, wood placed in storage, and wood in use. Buprestid larvae are easily recognized by a greatly expanded head and thorax and a long, slender abdomen.

The prevention of fire scars and other injuries to standing trees and the prompt utilization of diseased and felled trees can greatly reduce buprestid damage.

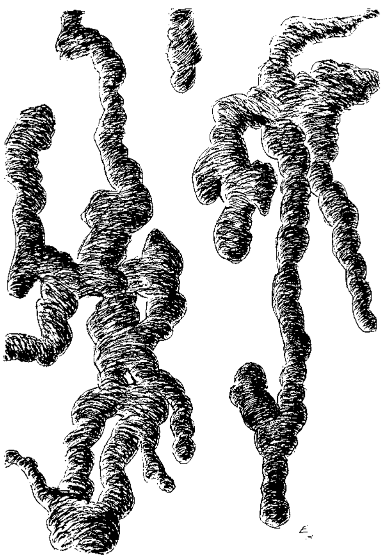


Figure 87. *Flat-headed fir borer gallery characteristically packed with boring material.*

Flat-Headed Fir Borer

Coleoptera: Buprestidae

***Melanophila drummondi* (Kirby)**

Hosts: Western hemlock.

Distribution: This borer has caused severe, but localized, damage on western hemlock in Southeast Alaska. In the late 1960s, periodic flooding of western hemlock stands on the Salmon River near Hyder brought about a general decline in stand health. Samples taken at tree diameter contained as many as twelve larvae per 90 cm^2 of bark surface. Salvage logging was employed as a suppression measure.

Identification: Adults are approximately 1.3 cm long and are metallic bronze or black with an iridescent sheen. Larvae are creamy white grubs with thorax and head greatly expanded and abdomen long and slender. Buprestid galleries differ from those of round-headed borers by being packed tightly with fine, dark excrement and wood particles.

Damage: Attacks damaged or weakened trees.

Remarks: Little is known concerning the biology of this insect in Alaska. Investigations into the host selection behavior of *M. drummondi* have demonstrated that adults are attracted to acetone and to a variety of substances associated with conifers including terpenes, scolytid pheromones and ethanol. *M. drummondi* overwinters in the larval stage within the host bark.

References: 43, 91, 209

Figure 88. *Adult* Melanophila drummondi.

Bronze Birch Borer

Coleoptera: Buprestidae

***Agrilus anxius* Gory**

Hosts: Aspen and Alaska birch.

Distribution: Interior Alaska.

Identification: Adults are olivaceous brown-black, approximately 1.3 cm long. Larval galleries are winding, about 6 mm wide and always tightly packed with boring dust.

Damage: Attacks confined to individual ornamental trees, trees in open stands or exposed branches in fully stocked and stagnating stands; repeated attacks can reduce host tree vigor until death.

Remarks: Adults emerge in late spring and summer and select sunny portions of trees for egg laying. Eggs are deposited on the bark surface of branches and upper parts of trees, especially those on poor sites. Larvae leave the phloem region at intervals and bore into the sapwood to molt. Larvae pupate in the host bark in autumn. Adults may feed, upon emergence, on host foliage. There is only one generation per year in over mature, slow growing trees.

Silvicultural measures are the most practical to suppress *A. anxius* infestations. The best way to avoid attack is to maintain stands as healthy as possible. If birch regeneration is considered, only good sites should be utilized. Care should be taken not to leave host material directly exposed to the sun, as *A. anxius* prefers sunny locations for oviposition sites. To avoid vulnerability to exposure, stands should be clearcut or by cutting in groups, maintaining adequate shading for the remaining trees.

References: 3, 86, 142, 257

Figure 89. *Stem swellings, an indication of bronze birch borer activity.*

Other Alaska Buprestidae

***Melanophila fulvoguttata* (Harris)**

***Chrysobothris trinervia* (Kby.)**

***Buprestis nuttalli* (Kby.)**

Hosts: White spruce.

Distribution: Interior Alaska.

References: 79

Figure 90. *Flat-headed borer,* Chrysobothris trinervia.

Figure 91. Melanophila fulvoguttata *adult.*

Ambrosia Beetles

Ambrosia beetles are important pests of forest products because they riddle the sapwood and heartwood of unseasoned logs and poles. The entrance holes and small larval galleries are inoculated with dark brown or black stain fungi. Ambrosia beetles do not feed directly on the host tree, but obtain nutrients that have already been processed by the introduced fungi. Each ambrosia beetle species has a close symbiotic relation with a specific wood staining fungus. The beetles have specialized structures, mycangia, used for transporting the fungus from one host to another.

The living requirements are very exacting for ambrosia beetles; unseasoned wood is suitable for attack whereas dried seasoned lumber is immune to attack. Damage is usually greatest where mild winters allow favorable temperatures and moisture conditions for extended periods of beetle activity.

Suppression of ambrosia beetles is a matter of prevention. Logs, which are cut in the summer or fall, should be removed from the woods as quickly as possible and either placed in fresh water or processed at the mill. Prompt use of timber is about the only satisfactory solution for preventing ambrosia beetle damage.

Figure 92. *Ambrosia beetle adult.*

Figure 93. *Ambrosia beetle gallery; note staining.*

Ambrosia Beetles

Coleoptera: Curculionidae, Scolytinae

***Trypodendron lineatum* (Olivier), *T. betulae* Swaine**

***T. retusum* (LeConte)**

Hosts: Western hemlock, Sitka, Lutz and white spruce, yellow-cedar, birch, and aspen, depending on ambrosia beetle species.

Distribution: Southeast, South-central, and Interior Alaska.

Identification: Adults are small, stubby, dark beetles with a smooth, shiny body often with lighter colored longitudinal stripes.

Damage: Sapwood and heartwood of unseasoned logs and poles are riddled with larval galleries. Symbiotic fungi produce a brown to black stain in and around the larval galleries. Fortunately, most of the damage is confined to the sapwood, but galleries may extend into the heartwood. Ambrosia beetle damage is difficult to eliminate because populations breed in stumps, fallen trees, and trees whose tops are broken from ice and snow.

Remarks: *T. lineatum* adults overwinter in the litter on the forest floor. In the spring females select host material and initiate boring. Additional attacks are promoted by an aggregating pheromone. Galleries penetrate directly into the wood a short distance before branching into one of three egg galleries where adults then lay eggs. After the eggs hatch, the larvae enlarge these niches into larval cradles, and feed on ambrosia fungi introduced by the parent adults. In late summer, the brood matures, and adults emerge and disperse to hibernation sites in the litter on the forest floor. When they emerge and attack in the spring, striped ambrosia beetles show the strongest preference for logs cut in the previous fall and winter (Oct. through Feb.). Research conducted in Washington indicates buildup of ethanol in freshly cut trees in the winter makes them highly attractive to ambrosia beetles. In Southeast Alaska, material felled after March will probably not be attacked that year, but will be susceptible to infestation in the following year if it is still on the ground.

References: 31, 41, 53, 79, 91, 93

Clearwing Birch Borer

Lepidoptera: Sesiidae

***Synanthedon culiciformis* (L.)**

Hosts: Birch

Distribution: South-central and Interior Alaska

Identification: Adult borers are day-flying moths which mimic bees and wasps in their coloration. They have narrow interlocking wings that are usually transparent and un-scaled. Larvae are naked and ivory white, except for brownish markings on the thorax.

Damage: Damage to infested trees occurs in several ways. First, the destruction of phloem by larval feeding can seriously reduce the tree's ability to transport nutrients. Second, the tree becomes stressed and is more susceptible to additional insect and disease attacks. Wounds that are infested and re-infested do not heal, and provide entries for decay-causing fungi. Trees that have been infested for consecutive years are quite susceptible to stem breakage.

Figure 94. *Clearwing birch borer larva.*

Figure 95. Clearwing birch borer adult.

Remarks: Adult clearwing borers fly in late spring through midsummer and are most active during the warmer daylight hours. Clearwing moths rarely injure healthy trees. When birch, however, is used as landscape trees, environmental stress factors such as soil compaction, moisture deficiency, and wounding can weaken them. Such trees are more susceptible to borer attack. Adults are attracted to fresh wounds near the base of the tree. Eggs are laid singly near these wounds. Young larvae immediately bore through the bark and begin feeding on the phloem tissue. Larvae continue feeding throughout the summer and hibernate beneath the bark through the winter. The following spring, larvae transform into adult moths. Wounded areas can be re-infested in successive years resulting in almost complete girdling of the tree.

References: 73, 139, 207

Ghost Moths

Lepidoptera: Hepialidae

Sthenopsis quadriguttatus **Grote**

Hosts: Black cottonwood, alder, aspen and willow.

Distribution: Throughout South-central and Southeast Alaska, less common in the Interior.

Identification: The adult moth is very large (35–100 mm wingspan), brownish tan, and heavy bodied. Forewings are mottled with tan, brown, and orange, with one or two silver spots at base of cell. Adults are in flight from late-June to mid-August. Moths fly at dusk, swiftly and close to the ground. Eggs are smooth and unornamented.

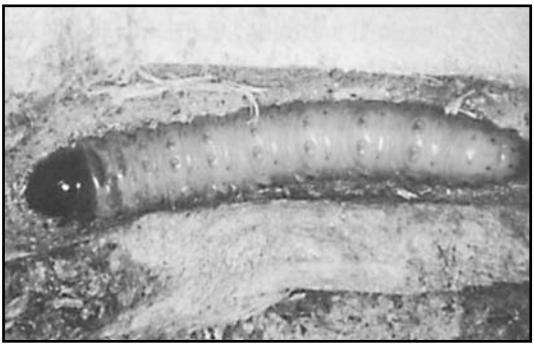


Figure 96. *Ghost moth larva.*

Figure 97. *Ghost moth adult.*

Larvae are unornamented, cream colored with a reddish brown head and at maturity reach a size of 57 mm long.

Damage: Ghost moths have only been found to attack small diameter (<8 cm) shrubs and regeneration. Larval burrowing in the basal area of the tree trunk and lower roots causes heavy decline in tree growth and usually results in death of the host.

Remarks: One-half to 2 hectare areas of cottonwood and alder mortality have been observed in riparian zones bordering the Lowe River near Valdez. Almost every small tree and shrub has been killed by larval mining of the phloem and xylem. Larvae burrow in the xylem along the long axis, usually into the center of the roots. Pupation occurs within the larval galleries. Larvae take 1 to 2 years to develop.

References: 73, 229

Wood Wasps

Hymenoptera: Siricidae

Wood boring wasps or horntails are responsible for more damage than is usually ascribed to them. Wood wasps are especially abundant in fire killed forests. Trees killed by spring fires are more susceptible to attack. These borers may continue to work in sawed lumber taken from infested logs. Kiln drying usually kills larvae in sawed material. Fresh water treatments of saw logs and prompt utilization of are the best ways to prevent damage.

Figure 98. *Wood wasp ovipositing in white spruce,* Urocerus gigas flavicornis.

Horntails

Hymenoptera: Siricidae

***Urocerus gigas flavicornis* (F.), *Sirex juvencus* (L.), *S. cyaneus* F., *Xeris spectrum* (L.)**

Hosts: Sitka, white, Lutz and black spruce, firs, and yellow-cedar (*S. juvencus*).

Distribution: Throughout Alaska.

Identification: The most common siricid, *Urocerus*, is a menacing looking, but stingless, thick-bodied, black and yellow wasp (Fig. 98). The female bears a hornlike ovipositor sheath projecting beyond the abdomen. The female inserts her ovipositor through the bark and deposits from one to three eggs. The larvae are white, legless grubs, cylindrical in form with a dark spine on the end of the abdomen.

Damage: Attacks weakened or fire damaged trees, downed timber, or saw logs.

Remarks: Larvae construct round galleries in cross section, which penetrate into the wood. The galleries increase in size as the larvae mature. Horntail larvae consume wood that passes through their digestive tract and is packed tightly behind them. As with most siricid species, the larvae require from one to two seasons to complete development. The larvae construct pupal chambers in the outside layers of the sapwood. Pupal chambers are usually constructed on the upper side of logs.

References: 73, 79, 85, 153

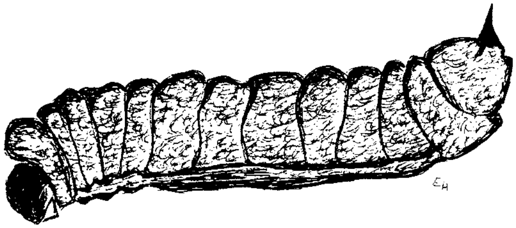


Figure 99. *Horntail larva.*

Cone and Seed Insects

Cone and seed insects are relatively unimportant economically in a natural forest. The amount of seed produced by forest trees under natural conditions usually far exceeds the number of seeds destroyed by these insects. When good seed years occur in succession, cone and seed insects may build up to exceptionally high numbers. Consequently, the seed crop produced the second year may be almost completely destroyed (86, 153). In some seasons, insects and red squirrels may destroy all the spruce seed in certain localities.

Destruction of forest seeds may be caused by insects that feed on buds, flowers, or immature cones, as well as by insects that actually destroy seeds. In many cases, the cones show no outward sign of damage, but the seeds may be infested. Many of the insects (budworms and coneworms) that feed upon buds and green tips also attack immature cones indirectly. The most injurious groups of cone and seed insects in Alaska are the seed moths and coneworms (Lepidoptera), seed worms and midges (Diptera), and true bugs (Hemiptera). In Alaska, the true bugs feed exclusively on birch, alder, and aspen seeds. The other species feed on spruce and hemlock cones and seeds.

To date, few seed and cone insects have been associated with Alaska conifers, particularly in Southeast and South-central Alaska although *Dioryctria reniculelloides* are known to attack Sitka, white and Lutz spruce cones heavily during good cone crop years.

Seven species of insects injurious to white spruce cones and seeds near Fairbanks were identified: Spruce Coneworm, *Dioryctria reniculelloides*; Spruce seed chalcid, *Megastigmus piceae* Felt; Spruce cone-axis midge, *Dasineura rachiphaga* Tripp; Gall midge, *Phytophaga carpophaga* Tripp; and cone maggots, *Hylemia* sp.

Spruce Coneworm

Lepidoptera: Pyralidae

Dioryctria reniculelloides **Mutuura and Munroe**

Hosts: White, Lutz, and Sitka Spruce

Distribution: Principally in Interior and South-central Alaska.

Identification: The forewings of adults are bluish gray with zigzag darker cross markings. The hindwings are dusky white with darker borders. Adult wingspan is about 25 mm. Eggs are creamy white, turning cinnamon before hatching and are 1.0 by 0.7 mm. Mature larvae are 17 to 20 mm long, naked, and greenish red to amber brown above and light colored below.

Damage: First instars mine one or two needles. Larger larvae mine and attack spruce cones. Up to 100% cone mortality can occur. They also mine expanding buds and shoots. Infested cones and surrounding shoots are enveloped in coarse frass and webbing; severely infested cones are hollowed out. Damage can be confused with the spruce budworm and many times both insects are present on the same host during outbreak conditions.

Remarks: There is usually one generation per year. Eggs are deposited in bark cracks and fissures of stems, and on twigs and needles. In the early 1990s, a defoliator outbreak was aerially detected along the Tanana and Yukon Rivers from Fairbanks to Ruby and encompassed more than 75,000 hectares. This outbreak was originally attributed to defoliation by the eastern spruce budworm, *Choristoneura fumiferana*. It was later determined that at least 50% of the damage was do to *D. reniculelloides*.

References: 73, 243, 246

Figure 100. *Spruce coneworm larva.*

Spruce Seed Moth

Lepidoptera: Tortricidae

***Cydia youngana* (Kearfott)**

Hosts: Sitka, Lutz, and white spruce, western hemlock.

Distribution: Distributed throughout Alaska. Damage to spruce cones can exceed 300 percent.

Identification: Adult insects are small, inconspicuous moths. Last instars are about 1.4 cm long.

Damage: Larvae bore into the cone scales and feed from seed to seed.

Remarks: Adults emerge from infested cones from May to June and oviposit on young cones. The eggs hatch about mid-June and each young larva crawls to the base of a cone scale to enter a seed. The larvae develop through four instars, feeding from seed to seed. Frass is packed in the tip of the gallery and in the mined seed. Usually only one larva reaches maturity in a single cone. An exit hole is made near the base of the cone, attended by a short, silk tube leading to the outside between the cone scales. This tube, which is made just before pupation in the fall, is diagnostic for this insect and is the only evidence of cone attack. The last instar overwinters in the cone. Pupation occurs the following May. There is usually one generation per year, but generations may overlap.

References: 9, 103, 104, 275

Figure 101. *Spruce seed moth larva.*

Spruce Cone-Axis and Gall Midges

Diptera: Cecidomyiidae

***Dasineura rachiphaga* Tripp, *D. canadensis* Felt**

Hosts: White and Lutz spruce.

Distribution: South-central and Interior Alaska.

Identification: Adults are small, dark midges approximately 3 mm long. The mature larva is yellow.

Damage: Larvae burrow in and around the cone-axis and indirectly damage the seed.

Remarks: Little information concerning these species has been collected in Alaska. In British Columbia, *D. rachiphaga* is probably the most abundant insect in white spruce cones. The larvae burrow in and around the cone-axis. Since the larvae do not feed on or adjacent to the seeds, they do not damage them directly. *D. canadensis* is usually secondary in importance. Each larva creates a small gall in cone scales. This species causes little, if any damage to spruce seed.

References: 104, 258

Spruce Cone Maggot

Diptera: Anthomyiidae

***Hylemia* sp.**

Hosts: Mountain hemlock, Sitka, white, Lutz, and black spruce.

Distribution: Throughout Alaska.

Identification: Adult flies are shiny black and approximately 6 mm long. The larvae (maggots) are white, about 8 mm long, having two large, black hooks on the head.

Damage: Larvae consume seed.

Remarks: Adults emerge from pupal overwintering sites in forest litter. Eggs are deposited between cone scales and maggots tunnel about the radius, eating through the scale bases and consuming the seed. After three weeks of feeding, the larvae emerge from the cone and drop to the ground where they overwinter as pupae.

There is very little evidence of damage on infested cones. Usually one maggot completes development in each infested cone and may destroy up to 50 percent of the seed.

References: 104, 153, 258

Figure 102. *Spruce cone maggot damage.*

Yellow-cedar Gall Midge

Diptera: Cecidomyiidae

***Chamaediplosis nootkatensis* Gagne and Duncan**

Hosts: Yellow-cedar

Distribution: Southeast Alaska.

Identification: Adults are small dark midges. The mature larva is orange.

Damage: Larvae burrow in the tips of branches. Small galls are formed; each gall contains one larva, but sometimes two, or rarely three.

Remarks: As for the spruce gall midge, little is known about the yellow-cedar gall midge. Infested trees are usually trees that have been planted in residential settings or seed orchards. Only a small percentage of the buds are affected. Damage is usually restricted to low elevations.

References: 103, 258

Insect Pests of Wood Products

To date, there have been few problems with insect pests of wood products in Alaska. In the southern latitudes wood products insects cause tremendous losses. It has been estimated that the loss from these insects is about 1–5 percent of the annual cut. However, climatic conditions effectively bar many of these wood destroyers from the more northerly latitudes. Only 13 species of insects have been associated with wood products in Alaska, and few have caused structural damage to wooden buildings. Some woodborers have previously been discussed, others are described below.

Insects of wood products either attack moist or dry seasoned wood (85). Those insects that attack moist, seasoned wood are usually symbiotically associated with protozoa, fungi, and bacteria that aid the insects in the digestion of cellulose and lignin.

Some of these insects do not obtain their food from the wood. They tunnel into the wood to secure a sheltered base for foraging expeditions and a nursery for the young. Those insects attacking dry, seasoned wood also live in a symbiotic relationship with other microorganisms. These insects can breed successfully in wood with water content as low as six percent.

The suppression of insects injurious to forest products is largely a matter of damage prevention. Kiln dried lumber is more or less resistant to insect attack, but a few species attack kiln dried material.

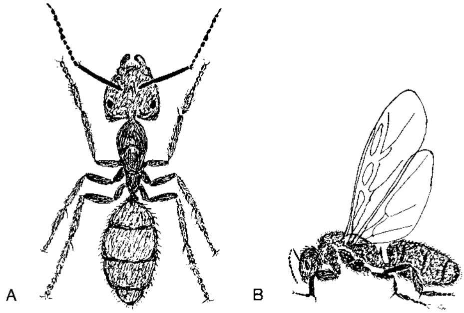


Figure 103. *Carpenter ants: A. worker; B. king.*

Carpenter Ants

Hymenoptera: Formicidae

Camponotus herculeanus **(L.)**

Hosts: White and Lutz spruce.

Distribution: Throughout Alaska.

Identification: Ants have elbowed antennae, large heads with constrictions between the thorax and head, and the thorax and abdomen. When wings are present, they are translucent with prominent venation. The adult carpenter ant is shiny black and large. There are three labor castes: (1) queens, 15–20 mm long; (2) kings, 10 mm long; and (3) workers, 6–10 mm long, which are sexually imperfect females. Only the queens and kings have wings. The egg is elongate, translucent white, and gourd-shaped. The pupae are creamy-white in papery, light brown cocoons.

Damage: In the northern temperate zones, carpenter ants can cause extensive structural damage to buildings. These ants build their nests in several types of wood. They attack moist heartwood of living trees, or they hollow out logs, house timbers, structural wood or other soft, wood materials that are wet or moist. In Alaska, carpenter ants damage standing white spruce and house logs. Carpenter ants tunnel into wood for shelter and brood rearing, but do not eat the wood. They forage from these shelters and consume both animal and vegetable material.

Figure 104. *Carpenter ant worker.*

Remarks: Males and females swarm and mate in May and June. After this mating flight, females either reestablish an old colony or establish a new nest. The young queen seeks out a small cavity in a tree or timber. She seals herself in, deposits her eggs, and does not feed until her first brood is mature. The young workers feed the queen and cut parallel, concentric galleries in a vertical direction throughout the wood.

The presence of carpenter ants can be detected by piles of “sawdust” at the base of posts, along sills, or elsewhere. Unused nest openings are sometimes sealed with plugs of wood. Carpenter ants do their greatest economic damage to houses where wood timbers are in contact with the ground. Prevention is the best control. Moist wood is attractive; so measures to prevent wood in structures from becoming wet are very important. Building sites and adjacent areas should be cleared of stumps and partially decomposed logs. Buildings should be placed on concrete or masonry foundations or on treated timbers. This will greatly reduce attack by carpenter ants. Lumber and debris in basements is attractive to carpenter ants and may provide nesting sites. Badly damaged timbers may need replacement. Suppression measures may need to be taken if ants are foraging, especially during the winter months, within a house, or other structure.

References: 86, 197

Figure 105. *Carpenter ant damage.*

Carpenter Bees

Hymenoptera: Xylocopidae

***Xylocopa* sp.**

Hosts: White, Lutz, and black spruce.

Distribution: South-central and Interior Alaska.

Identification: Carpenter bee adults are 1.5–2.5 cm long, robust, and resemble bumblebees. Females are greenish-black; males are often yellow with pale hairs. Larvae are typical hymenopteran grubs; legless, head globular with small mouthparts, and thoracic segments smaller than those of the abdomen. Pupae are robust, pale, and always found inside silken, leathery cocoons.

Damage: Carpenter bees, like the carpenter ants, cause structural weakening in house timbers where their galleries are concentrated. Carpenter bees have been reported to attack and burrow into wood houses and other wood structures in Alaska. Often, carpenter bees merely take over the galleries of other wood-boring insects.

Remarks: Adults emerge in the spring, and after mating, the females disperse and burrow into wood that is not eaten, but discarded. Eggs are deposited and larvae are fed pollen and nectar collected by the adults. Tunnels penetrate inwards for a few centimeters or so and then turn and parallel with the wood grain. Galleries are divided into individual cells, about 2 cm long, by means of cross walls that consist of cemented, compacted, chewed wood. There is one larva per cell. New adults escape through entrance holes constructed by parents. There is usually one generation per year.

Controls are seldom needed, but coating the wood with varnish or paint is effective in preventing attacks.

References: 3, 73

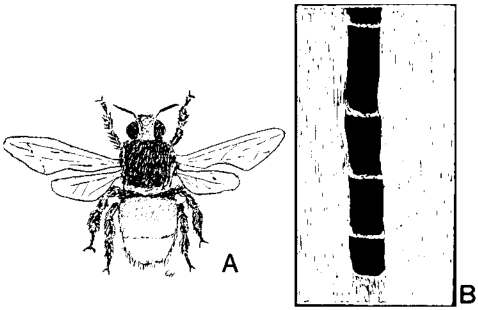


Figure 106. *Carpenter bee: A. adult; B. chambered galleries.*

Powder Post Beetles

Coleoptera: Lyctidae

***Lyctus cavicollis* LeConte**

Hosts: Sapwood of seasoned hardwoods with moisture content between 6 and 30 percent.

Distribution: Throughout Alaska.

Identification: Beetles are 0.6 cm long, with a flattened, elongated body, and are brown to black. Larvae are small, whitish, cylindrical grubs with three-segmented pairs of thoracic legs.

Damage: *Lyctus* are the most injurious of the powder post beetles in North America. Severely infested wood is reduced nearly to powder, but remains somewhat covered by nearly intact but, holey, exterior shell. Furniture and hardwood lumber dealers often discover these pests. Axe and shovel handles may be destroyed, and infested hardwood flooring may be installed without knowledge of the beetles' presence. When adults emerge, the wood exhibits numerous small, round exit holes. In Alaska, museum displays of wooden snowshoes and other wood products have been infested by powder post beetles.

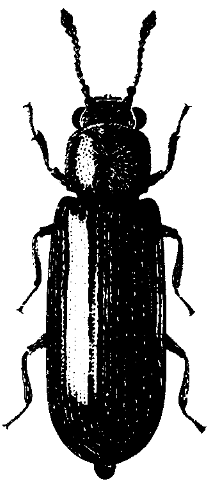


Figure 107. *Adult powder post beetle.*

Remarks: Mated females deposit eggs in wood pores approximately 0.3 cm deep, and new larvae bore through the wood in all directions. Overwintering larvae pupate at the end of larval galleries. Adults emerge through round, 0.2 cm exit holes. There is usually one generation per year, but two years or more maybe required to complete development under unfavorable conditions.

Preventive measures are the best control. Protecting susceptible wood by painting with linseed oil, varnish, or paint effectively prevents oviposition. Stored heartwood and sapwood lumber should be separated where possible, and inspected frequently. Infestations can be detected by the small quantities of fine boring dust on and in the vicinity of the infested material.

References: 3, 73, 86

Parts of an Insect

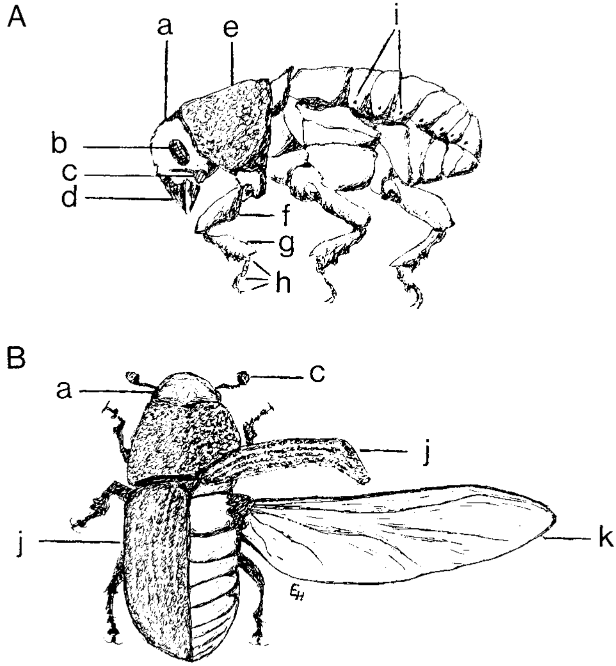


Figure 108. *External insect morphology: A. side view of a bark beetle with wings and wing covers removed; B. dorsal view. Legend: a. head, b. compound eye, c. antenna, d. mouthparts, e. pronotum, f. femur, g. tibia, h. tarsus, i. spiracles, j. elytra (wing covers), and k. membranous wings.*

Index to Insects by Host Plants

Spruce, Lutz (*Picea x lutzii* Little)

Willow (*Salix* sp.)

Diseases

Tree Diseases

Tree diseases in Alaskan forests can fundamentally change the ecosystem and lead to huge economic loss to the timber resource. But unlike typically dramatic insect outbreaks, diseases are often chronic and insidious and may go unnoticed.

Most of the countless disease agents in Alaskan forests are fungi, and most of those do not seriously threaten the life of the tree or cause significant changes to the ecosystem. Diseases of leaves and needles are a good example; they discolor trees but the attacks generally do not continue for long and infected trees usually recover. This type of disease is often only a problem if the appearance of the tree is important.

The tree diseases of greatest concern in Alaska are internal wood decays of live trees (heart rot, stem decay fungi), hemlock dwarf mistletoe and several root diseases. These are among the diseases that can kill trees or greatly influence tree growth, wood production, and ecological processes.

The amount of disease is usually related to the age of trees or the forest in general. Young forests that regenerate after clearcutting or natural disturbance generally are not seriously affected by disease although some pathogens, such as the needle fungi and root diseases mentioned above, may be present. But as forests age several diseases, particularly the heart rots, become much more abundant. These diseases progress slowly until they eventually begin to alter forest dynamics. In some cases diseases such as heart rots and root diseases influence stand development or plant succession by selectively killing trees or tree species.

Without disturbance from logging or natural causes such as fire or windstorms, forests can develop to an old-growth stage. Disease can help maintain old growth by killing trees in a scattered manner rather than catastrophically disturbing forests. Such is the case in Southeast Alaska, where large old trees are often killed by heart rots and dwarf mistletoe. The death of these dominant trees creates an opening in the forest, a “canopy gap,” where new trees can regenerate.

A healthy forest is one that meets the goals of resource managers, which could mean very little or very abundant disease, depending on the management goals for that forest. Forests managed for wildlife habitat and resources other than wood can benefit from heart rot and dwarf mistletoe, diseases that contribute to structural and biological diversity. Where timber production is favored, these same diseases are detrimental to the timber resource and usually do not help meet management goals. Moderate disease levels may be the goal for forests managed to meet multiple resource objectives. Most tree diseases respond in a predictable way to harvest treatments and can be managed to particular levels with confidence.

Other Agents

The severe decline of yellow-cedar in Southeast Alaska does not appear to be caused by any biological agent, which means it may not be considered a true forest disease. Still, the effect on the ecosystems can be considerable, particularly changes in forest composition and plant succession that are a result of yellow-cedar mortality.

Animal damage is also a factor in the condition of Alaskan forests. By removing the bark during feeding, porcupines can create large wounds, top kill, or completely kill trees. In several places in Southeast Alaska, brown bears frequently wound the lower bole of yellow-cedar trees, producing infection courts for wood decay fungi.

Other non-disease factors, such as hemlock fluting and injury from weather events, are also described.

Spruce Needle Rust

Chrysomyxa ledicola Lagerh.

Hosts: Sitka, white, and black spruce and Labrador tea

Distribution: Throughout Alaska on spruce where the ranges of spruce and Labrador tea (*Ledum* spp.) coincide.

Identification: A heterocyclic rust with one stage of its life cycle on spruce and the other on Labrador tea (*Ledum* spp.). Spores produced on Labrador tea infect current-year's spruce needles. Pustules produced by the rust fungus are orange or yellow with dry spore deposits. The rust disease occurs on spruce only on boggy sites where the alternate hosts are found, but can occur solely

Figure 109. *Spruce needle rust.*

on Labrador tea outside the range of spruce. Spruce trees have a distinct orange tinge when the rust is fruiting on the needles in summer.

The closely related *C. weirii* Jacks. is microcyclic (no alternate host) and causes chlorotic (yellowing) bands on one-year-old needles of Sitka spruce where it fruits in early spring. This rust fungus is less damaging and conspicuous than *C. ledicola*.

Injury: Causes a premature defoliation that could influence tree growth. Little damage usually occurs unless the tree is infected for several consecutive years.

Remarks: Removal of alternate hosts in the vicinity of spruce or spraying with fungicides in the spring can reduce infestation to some extent but this is not often economically justified except for high value trees where appearance is important. Spruce nurseries should not be established in boggy areas with a history of spruce needle rust.

References: 29, 71, 126, 232, 244, 278

Figure 110. *Spruce needle rust with current year's needles infected.*

Figure 111. *Labrador tea is the alternate host for spruce needle rust.*

Figure 112. *The closely-related* Chrysomyxa weirii *on one year old spruce needles.*

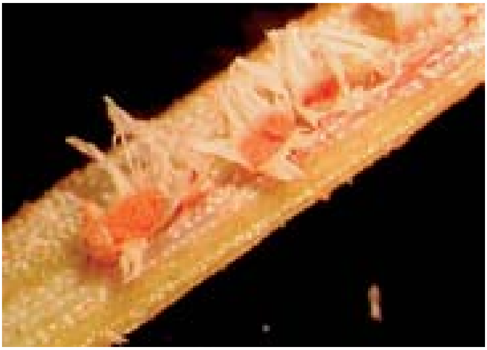


Figure 113. *Close-up of* Chrysomyxa ledicola *on an infected needle.*

Hemlock Needle Rust

***Naohidemyces vaccinii* (Wint.) Sato, Katsuy et Hiratsuka**

***(=Pucciniastrum vaccinii* (Rab.) Joerst.)**

(=Uraecium holwayi)

Hosts: Western hemlock and blueberry species.

Distribution: Southeast Alaska.

Identification: A heterocyclic rust with one stage on hemlock needles (rarely on cones) and the other stage on several species of blueberry (*Vaccinium* spp.). Another needle rust of western and mountain hemlocks, *Melampsora epitea* f. sp. *tsugae*, is also present in Alaska. Its alternate host is willow.

Current-year hemlock needles become infected from spores produced in pustules on blueberry leaf. Orange or yellow pustules form on the underside of hemlock needles. Infected needles turn yellow, but hemlocks are not usually heavily infected, thus branches have a scattering of yellow needles with most needles remaining uninfected and green.

Injury: Infected needles turn yellow and die, but the incidence of the disease on hemlock needles is usually low. Infected needles are shed prematurely. Injury to infected trees is negligible, perhaps slightly reducing growth.

Remarks: The generally low occurrence of this rust is surprising given the great abundance to western hemlock and blueberries in coastal Alaska. Control is not usually warranted, as injury to trees is typically very minor.

References: 1, 199, 232, 278

Figure 114. *Hemlock needle rust on western hemlock.*

Figure 115. *Pustules of the rust fungus on the underside of infected needles.*

Hardwood Leaf Rust

***Melampsora epitea* Thuem, *M. medusae* Thuem**

***Melampsoridium betulinum* Kleb**

Hosts: On willow: several races of *M. epitea* (alternative hosts: hemlock and true firs); on aspen and cottonwood: *M. medusae* (alternative hosts: true fir, spruce, hemlock, and pine); on birch: *Melampsoridium betulinum*.

Distribution: Hosts range in Alaska.

Identification: These rust fungi appear as orange or yellow spots on the upper or lower surfaces of live hardwood leaves. Some of these rust fungi alternate between hardwood and conifer hosts to complete the life cycle. Rust spores produced on hardwood leaves can alternate to either hardwoods or conifers , while rust spores produced on conifers can only infect the hardwood host. The rust fungi that do not require an alternative host can overwinter in buds and readily reinfect hardwood trees in successive years.

Injury: Damage can be more important on conifer host. Hosts are not usually killed by leaf rust infestations, but trees may be prematurely defoliated or growth may be slowed if trees are heavily infected. Infected ornamental plants may become less attractive.

Remarks: Each of these rust fungi infects a small range of hardwood hosts; therefore, planting resistant species or varieties on highly valued sites known to have rust problems can minimize losses.

References: 29, 71, 278

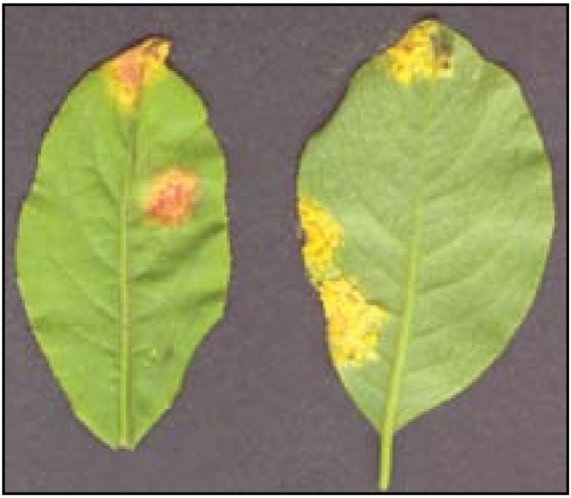


Figure 116. *Rust pustules of* Melampsora epitea.

Cedar Leaf Blight

***Didymascella thujina* (Durand) Maire**

(= *Keithia thujina* Durand)

Host: Western redcedar.

Distribution: Host range in Southeast Alaska.

Identification: The fungus produces small dark brown fruiting structures on the upper side of cedar foliage. Usually one to three spherical or oval structures are formed just under the epidermis. At maturity in summer, a flap of epidermis is pushed aside when conditions are moist and the spores are forcibly ejected into the air. After spore discharge, the fruiting structure falls out and leaves a black cavity or hole in a dead brown foliage scale resembling an "exit hole" from insect feeding. Foliage on cedars severely infected first appears reddish and later gray.

Injury: Seedlings can be killed by the fungus. Older trees often have the lower crowns heavily infected, resulting in growth loss and a reduction of vigor.

Remarks: This disease is very common on western redcedar in the forest and in ornamental trees, but does not cause mortality. Control is not necessary in the forest but may be accomplished by the use of fungicides in nurseries or for ornamental trees.

References: 4, 29, 71, 126

Figure 117. *Scattered infection of cedar leaf blight on western redcedar.*

Spruce Needle Blight

Lirula macrospora (Hartig) Darker

Lophodermium picea (Fckl.) V. Hohn

Rhizosphaera pini (Corda) Maubl.

Hosts: Sitka, white, and black spruce.

Distribution: Host ranges in Alaska.

Identification: These three diseases occur on the needles of spruce. Fruiting bodies are small, black and elliptical for *Lophodermium*, black and elongated for *Lirula*, and microscopic and emerging from stoma for *Rhizosphaera*. All three occur along the underside of diseased needles.

Symptoms appear in needles one year old or older. *Lirula* actually makes its infection in spring on new needles as they emerge during bud break, but the infected needles do not show any symptoms for one year. For *Lirula*, infected needles turn a reddish-brown color in the spring one year after infection and become tan in color two years after infection. The elongated black fruiting body appears on the underside of these two-year-old tan needles and opens in spring to release its spores to infect new needles. *Lophodermium* may also infect new needles, but symptoms typically appear in older groups of adjacent needles. Infection could be systemic in twig tissue. *Rhizosphaera* is

Figure 118. *Spruce needle blight,* Lirula macrospora*, on Sitka spruce.*

Figure 119. *Fruiting bodies of* Lirula macrospora *on two-year-old spruce needles.*

Figure 120. Lophodermium picea *on spruce needles.*

Figure 121. Rhizosphaera pini *on older needles of Sitka spruce.*

less common than the other two pathogens and can only be identified using a microscope because the clear, bubble-like fruiting bodies are so small.

Injury: Fungi, such as these needle blight species, are not damaging to spruce trees unless there are several successive years of attack. *Lirula* is the most commonly observed of the three needle diseases. Outbreaks are triggered by weather patterns that usually do not repeat several years in a row; therefore, epidemic levels of these fungi do not typically occur. Given the microscopic shape of spores (extremely elongated), dispersal of *Lirula* and *Lophodermium* spores may be by rain splash. Also, infections often take place in the lower, less important, portion of the crown. Infected trees are often localized; a few trees in an area may be heavily attacked while other nearby trees are nearly uninfected, suggesting a genetic disease resistance in spruce.

Remarks: *Lirula* is the most common of these needle blight fungi, frequently attacking spruce in young-growth forests of coastal Alaska. Control is not usually necessary, but fungicides have been shown to be effective if applied during or just after bud break when new needles are being exposed and the fungus is sporulating.

References: 29, 71, 107, 111, 126, 232

Sirococcus Shoot Blight

***Sirococcus tsugae* (Rossman, Castlebury, D.F. Farr & Stanosz)**

(=*Sirococcus strobilinus* (Dearn.) Petr.)

Hosts: Western hemlock, mountain hemlock, and occasionally Sitka spruce

Distribution: Southeast Alaska

Identification: This is a fungal disease of young lateral or terminal shoots. Initial infection occurs on juvenile needles, later growing into the developing shoots. Small cankers sometimes appear and stem growth is retarded on one side of the shoot causing it to bend into a characteristic hook shape. Death of the shoot or terminal leader follows and small black circular fruiting bodies

Figure 122. *Numerous dead shoots of western hemlock caused by* Sirococcus tsugae.

appear. Mature spores are disseminated by the splashing of water drops. Microscopically, the spores are distinctive in having a slight constriction at the single septum (crosswall). Development of the fungus is favored by high atmospheric moisture, mild temperatures, and low light intensities—conditions typical of dense young growth forests in Southeast Alaska.

Injury: *Sirococcus* causes a wilting and dieback of the shoot tips and occasionally seedling and sapling mortality. Mature trees suffer little damage. Growth reduction may occur on heavily infected trees. Ornamental mountain hemlock trees are often heavily infected and can die.

Remarks: The new species name, *Sirococcus tsugae*, is now formally described and applies to the species found in Alaska. The type specimen was collected from a mountain hemlock tree in the Mendenhall Valley near Juneau. Thinning may be the best management of the disease in younger stands since it changes high humidity levels that favor the pathogen; control is unnecessary in older stands. Fungicides are available for control in nurseries or for ornamental trees.

References: 69–71, 185, 196, 220, 232, 253, 274

Yellow-cedar Shoot Blight

***Apostrasseria* sp.**

Host: Yellow-cedar

Distribution: Southeast Alaska

Identification: Infection by this fungus causes dieback of branches or the terminal leader. The small black fruiting bodies of the causal fungus can be found in spring when infection has just killed shoot tissues. The disease is restricted to seedlings and saplings of yellow-cedar and has not been found in mature trees.

Injury: Shoots of seedlings and saplings are killed by *Apostrasseria*. Small seedlings are often killed by this pathogen. Infection of larger seedlings or saplings is serious when terminal leaders are killed; this can result in yellow-cedar not being competitive with surrounding vegetation. Injury may appear similar to spring frost damage.

Remarks: This fungus may limit the success of yellow-cedar regeneration, whether seedlings establish naturally or are planted. Browsing by deer and spring frost injury are generally more substantial threats, however.

References: 106

Figure 123. *Yellow-cedar shoot blight.*

Shepherd's Crook

***Venturia macularis* (Fr.:Fr.) E.Müller & Arx., *V. populina* (Vuill.) Frabic.**

Host: On aspen: *V. macularis*; on balsam poplar: *V. populina*.

Distribution: Hosts range in Alaska.

Identification: Angular black spots are formed on leaves and twigs in spring and early summer. Infected leaves curl, turn black and die. The adjoining twigs then become withered, blackened and hooked at the tip. New shoots may be killed as they start to grow. Wet or damp weather favor these fungi, which remain dormant during hot dry summers. Trees with insect injury are more susceptible to infection.

Injury: *V. macularis* primarily causes stunting and malformation of terminal shoots of aspen seedlings and saplings. *V. populina* infects terminal and lateral shoots of balsam poplar. Mature trees suffer little damage.

Remarks: Where practical, blighted twigs may be pruned on ornamental trees to help improve their appearance and reduce future infection.

References: 34, 49, 71, 126, 128, 129

Figure 124. *Sheperd's crook on aspen.*

Hemlock Dwarf Mistletoe

Arceuthobium tsugense (Rosendhal) G.N. Jones

Hosts: Western hemlock, Sitka spruce (uncommon), mountain hemlock (rare)

Distribution: Southeast Alaska, south of Haines

Identification: Dwarf mistletoe is caused by a small seed bearing plant. Only one species of dwarf mistletoe occurs in Alaska. The parasitic plants are small, leafless, and yellow-green or sometimes other colors. They are incapable of producing enough food for their own support and exist only as a parasite (i.e., obligate parasite) growing in twigs, branches, and boles of living trees. The "roots" of the dwarf mistletoe plant are endophytic (growing inside live plant tissues) and occur as feeding structures in the cambial area and sapwood of swollen tree tissues. The short aerial shoots (about 5 to 13 cm tall) are produced solely for the purpose of reproduction. Female and male flowers occur on different dwarf mistletoe plants.

Sticky mistletoe seeds are forcibly discharged (up to 30 ft) from female plants

Figure 125. *A female plant of hemlock dwarf mistletoe with mature fruits.*

in late summer or early autumn. Seeds that hit and attach to hemlock foliage or twigs over winter as seeds. Seeds removed from branches during winter may significantly reduce infection rates in Alaska. The next spring, seeds germinate and penetrate young twig tissue with an infection peg to begin infection. Twig swelling is the first symptom of mistletoe infection, and generally appears two years after infection. After 3 to 4 years, dwarf mistletoe shoots may emerge from the enlarged swelling and produce either male or female flowers. Female flowers are pollinated and produce the single-seeded fruits after another year to complete the life cycle. Inoculation studies in Alaska suggest that the life cycle may take longer to complete here than for the same disease further south. Endophytic roots (inside hemlock tissue) of dwarf mistletoe plants are viable for many years and may produce large swellings and many successive years of aerial shoots. Aerial shoots, flowers, and fruits occur on infections with adequate light, usually occuring high in tree crowns where they cannot be readily observed.

***Figure 126.** Western hemlock tree severely infected with hemlock dwarf mistletoe.*

***Figure 127.** Swelling and aerial shoots of hemlock dwarf mistletoe on a small branch.*

Injury: Dwarf mistletoe interferes with tree hormones causing increased growth in the hemlock tissues that are infected. Infections result in branch or twig swellings, large disfiguring burls on main bole infections, and most noticeably, witches' brooms–portions of tree crowns with branch proliferations. Witches' brooms and swellings can adversely affect height and diameter growth, and also reduce tree vigor, which can make infected trees more susceptible to insects and other diseases. The degree of growth loss is directly correlated to the intensity of infection (the number and size of infections). Lightly infected trees have no measurable growth loss, but severely infected trees lose about 40% of their potential growth. Severely infected trees may die. Bole infections may reduce wood quality and frequently provide infection courts for wood decay, leading to significant heart rot.

Remarks: Hemlock dwarf mistletoe is one of the most important diseases of western hemlock in Alaska, infesting an estimated 405,000 hectares of forest land. It is more common at low elevations, another indication that snow may limit reproduction, overwintering of seeds, or infection. The disease is favored by small-scale disturbance (gap formation) that occurs in old-growth forests where mistletoe seeds can infect new trees that regenerate in small gaps. Clearcut logging of infected stands serves as a form of disease control. As an obligate parasite, dwarf mistletoe is killed and will not reproduce on hemlock slash or downed logs. Infected residual old-growth trees (left after logging), advanced regeneration, and old-growth trees on the perimeters of harvest units are sources of inoculum for spread to young-growth forests. But the disease generally does not flourish in even-aged forests because trees grow too rapidly in height and the parasite cannot spread vertically as fast. Dwarf

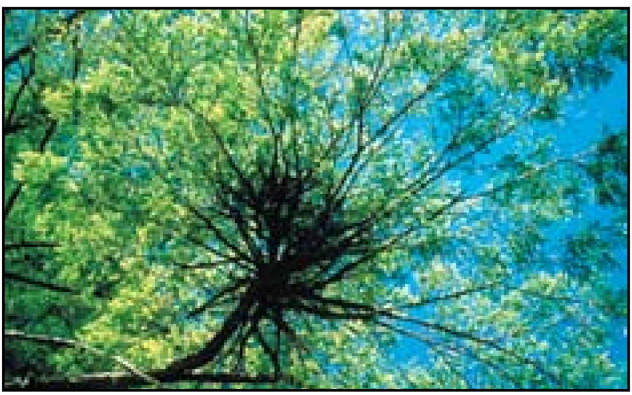


Figure 128. *Young broom of hemlock dwarf mistletoe.*

mistletoe often will eventually die out as stands grow beyond 40 years of age or so. Partial harvests of old, infected hemlock forests can lead to varying amounts of dwarf mistletoe, with the amount dependent upon the number of large hemlocks that remain, their infection level, and their spatial distribution. Moderate mistletoe levels may be desirable where management objectives include sustaining wildlife habitat, however, little is know about actual wildlife use of dwarf mistletoe brooms in Alaska.

Large or dead mistletoe brooms could be removed from infected trees in recreation areas to prevent injury or property losses because these brooms sometimes break out of trees during winter.

Reference: 1, 52, 100, 101, 121, 143, 160, 177, 212, 213, 219, 225–227, 232, 256

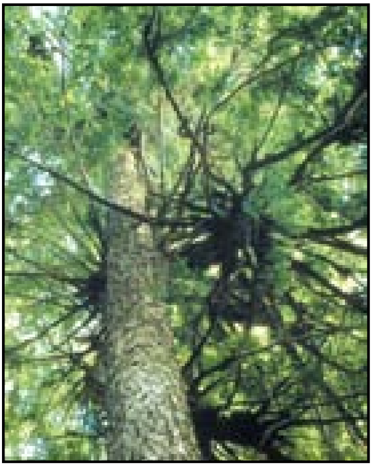


Figure 129. *Large brooms caused by hemlock dwarf mistletoe.*

Figure 130. *Large burl on western hemlock caused by an old bole infection of hemlock dwarf mistletoe.*

Figure 131. *Dead western hemlock tree with numerous hemlock dwarf mistletoe infections. Tree death resulted in a canopy gap.*

Spruce Broom Rust

Chrysomyxa arctostaphyli **Diet.**

Hosts: White, Sitka, and black spruce

Distribution: Across Alaska where the range of spruce and bearberry (*Arctostaphylos uva-ursi* (L.) Spreng.) coincide. Sitka spruce is not affected throughout most of Southeast Alaska, but populations have been found on Kuiu Island and in Glacier Bay.

Identification: Spruce trees infected by the rust fungus develop dense perennial witches brooms. In summer, spores are produced on current year's needles giving the brooms an orange or yellowish coloration. The needles are shed in the fall and the brooms appear dead until spring. The fungus causes a purple-brown leaf spot on the alternate host, bearberry. The rust fungus cannot

Figure 132. *Perennial broom on white spruce caused by spruce broom rust.*

complete a life cycle unless both host types (spruce and bearberry) are present. Spores produced on the bearberry infect spruce.

Injury: Loss of height and diameter growth, bole deformation, and mortality are associated with the presence of the fungus on spruce. Rust brooms can serve as entrance courts for decay fungi such as *Phellinus pini*.

Remarks: Brooms by this rust fungus may be confused with brooms caused by hemlock dwarf mistletoe. Where practical, pruning of brooms on ornamentals and on trees in recreation areas can reduce losses and hazards. Ecologically, large brooms on spruce provide important winter denning and nesting sites for wildlife, particularly flying squirrels in Interior Alaska.

References: 1, 29, 71, 126, 176, 278

Figure 133. Chrysomyxa arctostaphyli *sporulating on the needles of a live broom.*

Western Gall Rust

***Peridermium harknessii* J. P. Moore**

(= *Endocronartium harknessii* (J. P. Moore) Y. Hirat.)

Host: Shore pine

Distribution: Nearly all shore pine stands throughout Southeast Alaska.

Identification: A rust fungus that can infect directly from pine-to-pine without an alternate host. As with other rusts, the fungus is an obligate parasite and depends on a living host for its survival. Infection causes typically globose galls, sometimes hemispherical or pyriform in shape, on the branches and main stem of shore pine. In spring when the fungus is fruiting, the bright orange spores give the galls a distinctive orange coloration. Airborne spores infect nearby pines on young tissue.

Injury: Galls are produced when the pathogen controls the tree's growth hormones, causing extra tissue growth at the point of infection. The disease can cause growth loss and stem deformation of infected trees. The rust galls are often colonized by an opportunistic fungus, *Nectria macrospora*. This fungus produces tiny, red, spherical fruiting bodies. It kills the gall, which in turn kills the branch outwardly from the gall. Infection by gall rust and this secondary pathogen on the main stem can kill the top of the tree in this way. Thus, upon finding dead branches (or a dead top) on shore pine, look carefully and you will usually find a gall that has been killed in this manner. Pines with numerous reddish or brown branches are a common sight in Alaska.

Remarks: Western gall rust is the most commonly observed disease of pine in Alaska. Faster growing trees are more susceptible than slow-growing or suppressed trees. Many galls may represent infections from the same year, indicating ideal weather conditions for sporulation and infection during the spring

Figure 134. *Western gall rust sporulating on shore pine.*

Figure 135. *Dead top of shore pine caused by secondary infection of western gall rust by* Nectria macrospora.

of that particular year (i.e., "wave year"). Control is possible by removing infected trees, especially those with main stem galls. Infected branches could be pruned from ornamental pines before or after they are colonized by *Nectria*.

References: 2, 29, 33, 109, 126, 278

Cankers of Spruce and Hemlock

Discocainia treleasii (Sacc. in Sacc., Peck, and Trel.) J. Reid & Funk, *Botryosphaeria picea* (Funk), *Xenomeris abietis* (Barr) *and Aleurodiscus* sp.

Hosts: *Discocainia treleasii, Botryosphaeria picea, and Aleurodiscus* sp. all cause branch or stem cankers on Sitka spruce. *Xenomeris abietis* and *Discocainia treleasii* are two fungi that cause cankers on western hemlock.

Distribution: Hosts range in Alaska.

Identification: Cankers can occur on branches or main stems. They often appear as swollen, sunken, resinosus, or callusing. Cankers are caused by the fungi listed above, but the same symptoms are sometimes caused by animal feeding, mechanical damage, or extreme weather. The only way to determine if fungi are responsible for causing cankers is to collect and identify their small fruiting bodies found on or adjacent to damaged tissue.

Injury: Many cankers on spruce and hemlock eventually heal and are not very damaging unless they are numerous, are located on the main stem, or occur on seedlings. Cankers on main stems of trees create an open infection court for decay fungi to cause heart rot, but this appears uncommon for conifers in Alaska.

Remarks: Most canker diseases of conifers in Alaska are typically minor diseases that do not need control. Several heart rot fungi (*Phellinus hartigii* and *P. pini*) can act as canker fungi by killing the cambium and sapwood of living trees. This can result in dead portions of the main stem and resemble a canker disease. An apparent canker disease on Sitka spruce that does not produce fruiting bodies and is of unknown cause is visible in areas around Juneau in late summer. Trees have scattered dying (yellow) branches in their crowns, but the situation does not progress to the point of affecting tree health.

A canker disease of western hemlock, known as "hemlock canker" is periodically found causing lesions, callusing cankers, dead branches, or outright mortality on hemlocks near roads in several areas of Southeast Alaska. Road dust may aggrevate this problem, but the disease is sometime observed away from dusty roads. Lower branches of large hemlocks near roads are killed and small to medium-sized hemlocks can be killed. The actual role that dust plays in branch or tree mortality has not been determined.

References: 70, 126, 232

Figure 136. *Hemlock canker disease found along roads in Southeast Alaska.*

Cankers of Hardwoods

***Ceratocystis fimbriata* Ell. & Halst**

***Cryptosphaeria lignyota (Fr.: Fr.)* Auersw (=*Cryptosphaeria populina* (Pers.:Fr.) Sacc.)**

***Cytospora chrysosperma* Pers. ex. Fr.**

***Encoelia pruinosa* (Ell.& Ev.) Torkelson & Eckblad (=*Cenangium singulare* (Rehm.) Davidson and Cash)**

***Nectria galligena* Bres. in Strass.**

***Valsa melanodiscus* G.H. Otth (*anamorph Cytospora umbrina*)**

Hosts: On alder: *V. melanodiscus*; on aspen: *E. pruinosa*, *C. fimbriata*, *C. lignyota*, *C. chrysosperma*; on balsam poplar: *E. pruinosa*, *C. lignyota*, *C. chrysosperma*; on cottonwood: *C. lignyota*, *C. chrysosperma*; on paper birch: *N. galligena*, on willow: *C. chrysosperma*.

Distribution: Host range in Alaska.

Identification: Infection biology and identifying features of mature cankers differ among these fungi. Perennial cankers develop on the main stem or branches, although the canker form varies from subtle, diffuse, and elongated to distinctly target shaped with flaring bark. *E. pruinosa* produces elongated sooty black cankers, often over 10 feet in length, and frequently mistaken for fire scars. Cankers produced by *C. lignyota* are long, narrow, spiraling snake-like around the tree, with a black stringy inner bark. Infection by *C. fimbriata* and *N. galligena* results in target-shaped cankers with prominent concentric rings, callus folds, and flaring dead bark and are commonly initiated at dead

Figure 137. Cryptosphaeria lignyota *on aspen.*

branches or twigs. Stem cankers caused by *C. chrysosperma* appear as subtle sunken bark areas, with a slight target shape, typically originating at the base of dead twigs. *V. melanodiscus* produces diffuse cankers that are elongated areas of sunken bark, irregular in outline.

Injury: *E. pruinosa* is considered the most lethal canker pathogen of aspen, capable of girdling and killing a tree in as few as 3 years. *V. melanodiscus* is a primary cause of mortality of alder in Alaska, particularly riparian thin-leaf alder, *Alnus tenuifolia*. Stain, decay, and mortality are associated with infection by *C. lignyota*, with wounded trees of all ages potentially attacked. Damage from *C. fimbriata* and *N. galligena* consists mainly of trunk deformity; mortality is uncommon as tree diameter growth generally exceeds canker enlargement. Canker infection also can result in premature stem breakage.

Remarks: With the exception of *V. melanodiscus*, infection by these fungi occurs primarily through wounds on stressed trees. Control is possible through prevention of wounds, pruning out branch cankers, maintaining vigorous stands, and shortened harvest rotations. *V. melanodiscus*, however, typically infects alders without wounds. Trees with large *C. lignyota* cankers probably have associated decay and should be carefully evaluated for stability in recreation areas. The term "diamond willow" refers to distinctly shaped depressions of willow stems caused by the canker fungus *C. chrysosperma*. "Diamond willow" is sought after by wood carvers who prize the reddish diamond shaped depressions that develop after fungal infection.

References: 1, 27, 30, 34, 35, 50, 70, 89, 126–129, 146, 155, 230, 276

Figure 138. *A large* Nectria galligena *canker on paper birch.*

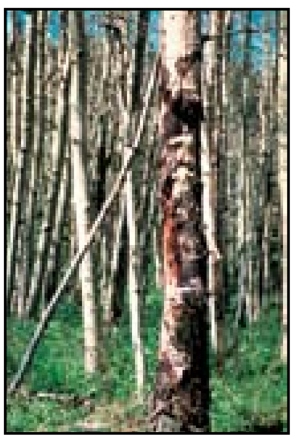


Figure 139. *Sooty bark canker,* Encoelia pruinosa *on aspen.*

Figure 140. *Long diffuse* Valsa melanodiscus *canker on alder.*

Figure 141. *Aspen stand severely infected with* Ceratocystis fimbriata.

Figure 142. Ceratocystis fimbriata *on aspen.*

Figure 143. Cytospora *canker on aspen.*

Rough Bark of Alder

***Didymosphaeria oregonensis* (Goodd.)**

Hosts: Red alder and Sitka alder

Distribution: Throughout the range of alder hosts in Alaska

Identification: Roughened bark in distinct horizontal bands on branch or main stem of alder trees. These bands encircle the branch or stem and are somewhat swollen. Moss is often abundant in these zones. The tiny (1-mm diam.) fruiting bodies of the causal fungus can be found in these bands. Ascospores are greenish in color.

Injury: Although the infection encircles the branch or main stem, there is little physiological injury to infected trees. The periderm and outer bark are disrupted, but the transporting phloem tissue is apparently not harmed. The disease appears to be more common on younger trees. Alder trees do not die from these infections.

Remarks: This disease is a curiosity because of its unusual appearance, but it causes little harm to infected alder trees.

References: 1, 70, 84

Figure 144. *Rough bark of alder caused by the fungus* Didymosphaeria oregonensis.

Annosus Root Disease

***Heterobasidion annosum* (Fr.) Bref. (=*Fomes annosus* Fr.)**

Hosts: Western hemlock, Sitka spruce

Distribution: Southeast Alaska, possible elsewhere in Alaska.

Identification: Conks are uncommon; often hidden by litter at the base of infected trees or in hollow logs or stumps. Conks are perennial, irregular in outline, shelf or crust-like, woody or leathery. Upper surface concentrically ringed dark brown to black. Lower surface is white to tan with angular-shaped pores and a sterile margin (no pores). Pores are larger and more angular-shaped than those of *Fomitopsis pinicola*, a similar appearing, but much more abundant conk in Alaska. Contex (interior) white or cream-colored. The lower surface has a reflective sheen when moved about under direct light. This fungus also has an asexual spore stage, but it is nearly microscopic and not normally observed.

Wood with incipient decay is pinkish to dull violet but the color varies somewhat with host species. Incipient decay remains hard and firm. Sometimes the perimeter of the stained region is outlined by a dark line. Decayed wood has small elongated pockets with or without small black flecks in the white fiber filling the pockets. The white pockets eventually coalesce leaving a spongy white mass with black flecks. In the final stage, only a hollow in the roots or butt is left.

Figure 145. *Annosus root disease.*

Injury: Annosus root and butt rot is a major disease in many forests of the temperate world, usually becoming more destructive as forest management intensifies. In Southeast Alaska, it occurs as a root and butt rot of old-growth trees, particularly in western hemlock. Losses are due to butt rot (i.e., cull) and tree mortality by uprooting and bole breakage induced by wood decay in roots and the lower bole.

Remarks: The role of *H. annosum* as a root disease in young growth hemlock–spruce stands appears minimal but it is a potentially important disease. There are two distinct genetic forms of the fungus in western North America. The form found in Alaska, is the less aggressive form. It causes wood decay of live trees but not a lethal root disease. In old-growth forests of Southeast Alaska, *H. annosum* is the third most important cause of heart rot of western hemlock. This estimate comes from the Kimmey (1956) study of heart rot and is based on the appearance of decayed woood in dissected trees, and did not involve confirmation by culturing fungi or modern genetic tools. In other regions, thinning increases the incidence and damage of this fungus. Airborne spores, either basidiospores from conks or the asexual spores can infect retained trees through wounds made during thinning; however, stumps

***Figure 146.** White rot caused by* Heterobasidion annosum.

are often the primary source of infection for adjacent live trees in some forest ecosystems. Spores of *H. annosum* germinate on the surface of freshly cut stumps, colonize the stump's root system, and then attack and the roots of an adjacent live tree. Research suggests that the infection of thinning stumps by *H. annosum* in this manner is rare and colonization of wounds on trees is also fairly infrequent in Southeast Alaska; thus, the disease poses little threat to young-growth management.

References: 1, 12, 29, 57, 62, 63, 114, 126, 143, 157, 158, 182, 183, 211, 214, 215, 232

Figure 147. *Conk of* Heterobasidion annosum.

Armillaria Root Disease
Honey Mushroom or Shoe String Root Rot
Armillaria spp.

Hosts: All tree species in Alaska.

Distribution: Hosts range in Alaska.

Identification: A honey-colored mushroom occurring in clusters at the base of infected trees and stumps in late summer or autumn. Mushrooms sometimes have dark brown scales on top. The white gills are attached to both stalk and cap, and a ring may occur around the stem, a short way below the gills. Considerable variation exists among different mushroom collections. Rhizomorphs and mycelial fans are generally used to identify *Armillaria* since they are more abundant than mushrooms and occur year-round.

In the incipient (early) stage of decay, the wood appears faintly water soaked, then changes to a light brownish color. In the advanced stage of decay, the wood is light yellow or white, soft and spongy (stringy in conifers) with many fine black zone lines. There may be white fan shaped mycelial felts between the bark and wood, or black shoestring like rhizomorphs between the bark and wood and on the surface of the roots or in the soil. In conifers there may be an abnormal resin flow from the root collar of infected trees. Hardwood trees may exhibit "collar crack," longitudinal cracks that appear at the root collar and extend a distance up the stem.

Injury: *Armillaria* causes growth loss, butt and root rot, and mortality. *Armillaria* can quickly colonize root systems of recently dead or dying trees. In

Figure 148. *Gilled mushrooms of* Armillaria sinapina.

most environments, the fungus rarely kills trees that are not under some sort of stress. For example, *Armillaria* occurs on the roots and root collars of about one half of trees dying from yellow-cedar decline. It is not the primary cause of tree mortality, but probably speeds the process of tree death. *Armillaria* also occurs as an important heart rot fungus of conifers in Southeast Alaska where it is a leading cause of the wood decay of live trees, especially of western hemlock and, to a lesser extent, Sitka spruce.

Remarks: *Armillaria* has many roles in forests. Its rhizomorphs are common in woody debris and soil duff, where the fungus often occurs as a decomposer of woody debris. Thus, it is important as a nutrient recycler of many of the wood plant species in Alaska. Different species of *Armillaria* vary greatly in their aggressiveness. Generally, *Armillaria* species in Alaska tend to be the unaggressive wood decomposers or that are involved in tree death only when trees are already suffering some form of stress. Decaying wood by *Armillaria* occasionally glows in the dark, a process known as bioluminescence.

References: 1, 29, 34, 60, 62, 66, 126, 143, 157, 158, 183, 210, 211, 215, 216, 218, 232, 255

Figure 149. *Rhizomorphs (shoestring-like structures) under the bark of dying or dead trees are diagnostic of* Armillaria.

Figure 150. Amillaria *fans exposed beneath cedar bark.*

Tomentosus Root Rot

***Inonotus tomentosus* (Fr.:Fr) S. Teng**

Hosts: Spruce, lodgepole pine; rarely larch

Distribution: Host range in South-central and Interior Alaska. Sitka spruce is not affected throughout most of Southeast Alaska, but populations have been found near Skagway.

Identification: Annual fruiting bodies are produced in the fall, developing on the ground near the base of infected trees. Fruiting bodies are leathery and small (usually less than 4 inches in diameter) with a central stalk. The upper surface is tan to rust-brown and velvety. The lower surface is cream to yellow-brown with small round pores that extend part way down the stalk.

The early stage of root decay is characterized by a red-brown to pink stain in the heartwood. Wood with advanced decay contains elongated spindle shaped pits, with poorly defined margins, separated by red-brown firm wood. The cross section of infected roots with advanced decay appears honeycombed. Stump surfaces of infected trees often exhibit stain and honeycombing.

Injury: Damage includes outright mortality, butt decay of up to one third of the gross volume, premature uprooting from loss of structural roots, and growth reduction. Host trees are susceptible to infection at any age. The fungus efficiently spreads through root contacts between infected and healthy roots, thus diseased trees occur in groups and mortality results in stand openings. Following death of an infected tree, the fungus may remain alive for decades. Spruce trees planted or growing within active tomentosus root rot centers become infected through root contact with diseased stumps/roots and may be

Figure 151. *Extensive root rot caused by* Inonotus tomentosus.

killed outright.

Remarks: Avoid planting spruce trees in root disease centers as infected stumps and roots serve as inoculum sources for succeeding generations of spruce trees. Losses can be mitigated by establishing less susceptible species (e.g. hardwoods) on infected sites, and planting susceptible species (e.g. spruce) at least 3 meters from known inoculum sources. Lodgepole pine, *Pinus contorta*, though not a native tree in Alaska, is occasionally planted in South-central and Interior, is susceptible to tomentosus root rot, and should not be planted in root rot centers. Thinning infected stands may increase the incidence and damage of this root disease. Careful diagnosis through root inspection is important because advanced decay can be mistaken for other pocket rots, particularly *Phellinus pini*.

References: 1, 19, 83, 90, 144, 163–168, 206, 270–273

Figure 152. *Honeycombed advanced decay of spruce roots.*

Figure 153. *Leathery annual fruiting bodies of* Inonotus tomentosus.

Wood Decays and Stains

Wood decay causes the greatest disease-related loss of timber volume to live trees in Alaska. The effects are particularly acute in old-growth forests in coastal Alaska where, on average, 31% of the volume of live trees is defective. Along with the direct cause of wood volume loss, decay fungi also increase logging and milling costs and complicate management by introducing errors in yield and cruise computations. On the other hand, wood decay is critically important to the normal functioning of forest ecosystems and has key roles in nutrient cycling, soil development, small-scale disturbance, wildlife habitat, and biological diversity. For example, the spruce beetle mortality of millions of spruce trees annually on the Kenai Peninsula through the 1990s precipitated research on the fate and decomposition of these dead trees.

Many decay fungi listed here cause heart rot of living trees, others decay the wood of dead trees, and some grow on both live and dead trees. Most of these decays do not actually interfere with the normal growth of live trees. They can affect tree structure, however, and contribute to wind-breakage and windthrow. Other specialized fungi (e.g. *Phellinus* and *P. pini*) may attack the sapwood and cambium of live trees after existing as a heart rot fungus. Many of the fungi that are normally found on dead trees can grow on live trees that have large stem wounds or broken tops (e.g., *Fomitopsis pinicola*). Root rot fungi also cause wood decay, particularly in the lower bole. Several common root diseases in Alaska are discussed in the previous root disease section.

The management of decay fungi on live trees is generally simple because decay levels are so highly correlated with tree age and tree injuries. These disease levels can be reduced greatly by limiting tree age (e.g., managing on shorter rotations) and reducing tree wounds during treatments. In multiple resource management where the beneficial roles of wood decay need to be maintained, decay levels of trees can be manipulated by creating forests with mixtures of tree ages and influencing the amount of tree injuries. Thus, tree injuries from logging wounds, animal feeding, or weather events can have beneficial ecological effects.

Each wood decay fungus decomposes wood in one of two ways: by white rot where cellulose and lignin are degraded, or by brown rot where cellulose is consumed but lignin is left largely intact. These two modes of wood decay have different outcomes affecting such things as habitat for wildlife and carbon sequestration. Some wood decay fungi produce mushrooms or other fruiting bodies that may be considered to be edible. Be absolutely certain about the identity of any fungus that you pick for consumption. Call the Poison Center (907-563-3393) for emergencies or more information.

References: 66, 97, 110, 116, 157

Pini Conk or Red Ring Rot

***Phellinus pini* (Thore : Fr.) *Pilat* (=*Fomes pini* Thore : Fr.)**

Hosts: Western and mountain hemlock, Sitka, white, and black spruce, western redcedar, and lodgepole pine.

Distribution: Host ranges in Alaska.

Identification: The perennial conk is common on live trees. The conk is woody and typically shelf-shaped with a sharp edge. The upper surface is dark brown, hairy (when young), with concentric ridges and a narrow velvety, light brown to golden margin. Lower surface is dark brown with pores that are variable in size and shape. Conk interior is stratified, yellow brown when young and dark brown when old. Blind conks or punk knots (swollen knots filled with golden-brown mycelium) are common. The early stage of decay

Figure 154. Phellinus pini *conk on hemlock.*

Figure 155. *Conks of* Phellinus chrysoloma *(*P. cancriformans*).*

Figure 156. *Resinous punk knots (blind conks) of* Phellinus pini.

Figure 157. *White pocket rot and punk knots caused by* Phellinus pini.

appears as a discoloration of the heartwood. In white spruce, the discoloration is light purplish to gray, later changing to reddish brown. In western redcedar the discoloration is a narrow bluish to reddish brown band along the margins of the more advanced decay. The advanced decay consists of elongated spindle shaped pockets or cavities parallel to the grain and sometimes separated by apparently sound wood that may be resin soaked. Decay pockets may be empty or filled with a mass of white fibers. Fine black to brown zone lines may be present.

Injury: This fungus causes a white pocket rot that can extend the entire length of the tree bole. It is particularly common on mountain hemlock wherever the tree grows in Alaska, but western hemlock is also commonly infected. The fungus infects and decays the heartwood of living trees, but does not continue decaying dead trees long after they die. In living trees, *P. pini* can grow into sapwood after decaying heartwood and thereby kill trees. A closely related species, *Phellinus chrysoloma* (*P. cancriformans* (M. Lars. et al.) M. Lars & Lomb.), can cause cankers or dead portions of the bole in addition to extensive heartwood decay. Sporophores of *P. chrysoloma* are smaller and closely stacked on top of one another.

Remarks: As with other heart rot fungi, this disease can be managed by harvesting trees of susceptible species before they reach old age. Live, infected trees may serve as valuable habitat for cavity nesting animals.

References: 1, 12, 22, 29, 60, 64, 66, 82, 83, 90, 110, 126, 157, 182, 183, 240

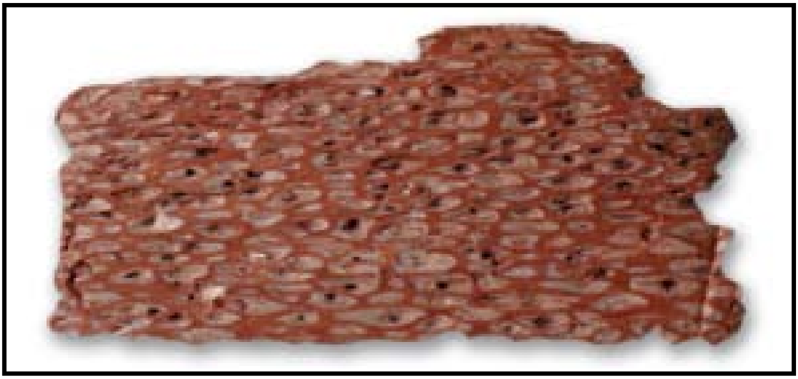


Figure 158. *White pocket rot caused by* Phellinus pini.

Pinicola Conk or Red Belt Fungus

Fomitopsis pinicola (Swartz ex Fr.) Karst

(=*Fomes pinicola* (Swartz ex. Fr.)

Hosts: Sitka, white, and black spruce; western and mountain hemlock; lodgepole pine; and occasionally western redcedar and birch.

Distribution: Throughout Alaska.

Identification: Fruiting bodies very abundant, perennial, hard, woody, flat to hoof-shaped. Upper surface zoned, smooth, gray to black, usually with a reddish band near the margin. Lower surface creamy white with minute pores. Contex (tissue inside) layered and light buff in color.

Wood in the incipient stage of decay is stained a light brown or yellow brown. Wood in the typical advanced stage of decay is reddish or yellow brown, cubical, and crumbly. Conspicuous mycelial felts often form in the cracks in the decayed wood.

Injury: *F. pinicola* causes a brown cubical decay of both live and dead trees. Infection of live trees probably occurs through wounds. Fruiting bodies on live trees are often found on these large wounds. By causing loss of structural support in the decay of live trees, heart rot fungi such as *F. pinicola* contribute to trees dying when their boles collapse or break.

Remarks: This is the most commonly seen conk in the conifer forests of Alaska. It is relatively common on wounded live trees, but is very abundant on the wood of dead conifer trees whether standing or down. Thus, the fungus is remarkably important as a decomposer in conifer forests where it converts

Figure 159. Pinicola *conks on dead hemlock.*

Figure 160. *Two pinicola conks, one showing the "red belt" on the upper surface. Genetic control of color variation is not understood.*

Figure 161. *Brown cubical rot and white mycelial felts of* Fomitopsis pinicola.

wood to a stable structure known as partially modified lignin. Given the enormous inputs of this material, it is undoubtedly important in soil formation in coastal forests. In live trees of Southeast Alaska, *F. pinicola* causes more decay than all other fungi combined for Sitka spruce and is the third leading decay for western hemlock. Timber in service is susceptible to decay from this fungus. Management of *F. pinicola* is by limiting tree age (short timber rotations), controlling the wounding live trees, and the prompt salvaging of dead trees.

References: 1, 12, 22, 29, 60, 62, 63, 66, 83, 90, 110, 116, 126, 143, 158, 183, 222

Chicken of the Woods or Sulfur Fungus

***Laetiporus sulphureus* (Bull. ex Fr.) Bond. et Sing.**

(=*Polyporus sulphureus* Bull. ex Fr.)

Hosts: Sitka spruce, hemlock, cottonwood, and poplar

Distribution: Hosts range in coastal Alaska

Identification: The fruiting body of this fungus is annual and emerges during the mushroom season in Alaska (e.g., August in many areas). Upper surface lemon yellow to orange. Lower surface sulfur yellow with small pores often in clusters. Contex (tissue inside) yellow, broad, watery and soft when fresh. The annual conk turns white when it dies and often falls to the ground. This dead, white stage is the way it is found during most of the year.

Injury: Incipient wood decay is a brown to reddish brown discoloration. Wood with advanced decay is dark reddish brown, cubical, brittle, and crumbly. In longitudinal section, the wood sometimes has a rippled look. Thick mycelial felts usually occur in the cracks. This decay closely resembles other

Figure 162. *Fruiting bodies of chicken of the woods.*

brown rot decay caused by *Fomitopsis officinalis* but the mycelial felts are not bitter to the taste.

Remarks: This fungus causes a brown cubical rot of live and dead trees. Timber losses can be managed by using shorter rotations and controlling the wounding of live trees. Trees with fruiting bodies are potentially hazardous around homes or recreation areas and should be evaluated for removal. The fruiting body is edible when fresh, hence the name chicken of the woods. Be absolutely certain of the identity of any mushroom or fungus that you consume and do not select old fruiting bodies.

References: 1, 12, 22, 29, 63, 66, 83, 110, 126, 157, 182, 183

Figure 163. *Remnants of old conks of* Laetiporus sulphureus.

Velvet Top Fungus

***Phaeolus schweinitzii* (Fr.) Pat. *(=Polyporus schweinitzii* Fr.)**

Hosts: Sitka spruce, white spruce, and western hemlock.

Distribution: Southeast and South-central Alaska

Identification: Fruiting bodies normally occurs on the lower bole or arise from the soil near the base of the tree where they are decaying wood in roots. Fruiting bodies are bracket-like when occurring on the bole and circular, stalked, and with a sunken center when arising from the soil. Although large, fruiting bodies are annual. They are dark brown, with yellow brown margin, hairy, soft and spongy when fresh, brittle and dark brown when dead. The undersurface has large irregularly shaped pores and is greenish turning deep red brown if bruised when fresh.

Wood with incipient decay is light reddish brown or yellowish brown. Advanced decay is red- to yellow-brown, cubical, brittle, and crumbly and has a turpentine odor. Thin resinous mycelial felts may occur in the cracks of decayed wood.

Injury: The fungus causes a brown cubical butt rot of conifers. Mature trees with this heart rot sometimes die through collapse or breaking of the bole due to loss of structural support. Thus, *P. schweinitzii* is an important agent in tree mortality or small-scale disturbance in old forests.The role of this fungus in causing a root disease on young trees is unknown in Alaska but it does not appear to be significant; elsewhere in the world it can be destructive to young-

Figure 164. Phaeolus schweinitzi *on a hemlock.*

growth stands.

Remarks: Effects of this heart rot fungus can be managed by preventing injury to trees and by reducing rotation length. Fruiting bodies on or near the base of trees indicate a potentially hazardous condition near homes or in recreation areas; infected trees should be evaluated for removal.

References: 1, 12, 29, 63, 66, 83, 90, 110, 126, 157, 182, 183

Figure 165. *Older fruiting body of velvet top fungus.*

Artist's Conk

***Ganoderma applanatum* (Pers.: Wallr.) Pat.**

Hosts: Commonly on hardwoods including paper birch, aspen, cottonwood, alder, willow; also found on western and mountain hemlock, white and Sitka spruce.

Distribution: Host range in Alaska.

Identification: The perennial conk is woody and shelf-like. The upper surface is smooth, concentrically ridged, tan gray to grayish black, often covered with a tan dusting of spores. The margin, when fresh, is typically white. The under surface is white when fresh, turning yellowish with age, with small round pores. When fresh, the underside turns brown immediately when scratched or marked, hence the common name of the "artist's conk." The interior of the conk is dark reddish brown, layered, with tubes in older layers sometimes overgrown with white mycelium.

The early stage of decay, in most host species, is characterized by bleached areas encircled by a dark brown stain. In western hemlock, the areas are violet to lilac. In the advanced stage, the wood is whitish to cream, mottled, soft and spongy, and usually with fine black zone lines.

Injury: This fungus causes a white mottled heart rot of living and dead trees. Infection of living trees apparently occurs through wounds and broken tops. *G. applanatum* also attacks timber in use.

Remarks: Management of this fungus can be achieved through removal of infected trees and wound prevention on residual trees. Trees with *G. applanatum* conks have extensive associated decay and, in recreation areas, should be carefully evaluated for stability.

References: 1, 29, 34, 60, 83, 126, 182, 183

Figure 166. *Artist's conk on paper birch. This fungus also invades conifers.*

Figure 167. Ganoderma *conk on alder.*

Lacquer Conk or Varnish Conk

***Ganoderma tsugae* Murr. (=*Ganoderma oregonense* Murr.)**

Host: Western hemlock

Distribution: Southeast Alaska

Identification: Upper surface of fruiting body is distinctly varnish- or lacquer-like, and shiny reddish brown. Lower surface is white. Conks may be several centimeters to half a meter wide and are attached by a lateral stalk.

Decayed wood is wet, spongy, straw-colored or white, and may have large black spots scattered throughtout. Red-brown zones may be present in decayed wood.

Injury: This fungus is not known to grow on live trees.

Remarks: *G. tsugae* is not common. Conks have an unusual appearance and are generally found on large, old stumps or logs that have been down for a considerable number of years.

References: 29, 83, 126, 182, 183

Figure 168. *Lacquer conk on an old hemlock log.*

Figure 169. *Young lacquer conk.*

Indian Paint Fungus

***Echinodontium tinctorium* (Ell.& Ev.) Ell. & Ev.)**

Hosts: Mountain hemlock, perhaps western hemlock

Distribution: Northern Southeast Alaska near Haines and Skagway; and South-central Alaska within the limits of mountain hemlock's range.

Identification: Hard, woody hoof-shaped conks grow on or under branch stubs. The upper surface is dull black, rough and cracked, the undersurface consists of coarse grey teeth or spines, the context is brick red to bright orange and is diagnostic.

The early stage of decay appears as a light brown stain in the heartwood. In the advanced decay stage, heartwood is reduced to a rust-red or brown, stringy, fibrous mass.

Injury: This fungus causes a brown stringy heart rot of live hemlocks. The presence of fruiting bodies on live trees indicates substantial heartwood decay.

Remarks: Infection of hemlocks occurs through small dead branchlets, often while trees are small and suppressed. Significant decay develops later, after infected trees are stressed through wounding or other factors. Volume losses may be reduced by shortening harvest rotations. Trees with conks have extensive associated decay and, in recreation areas, should be carefully evaluated for removal.

References: 1, 29, 64, 66, 83, 126, 182, 183

Figure 170. Echinodontium tinctorium *on mountain hemlock.*

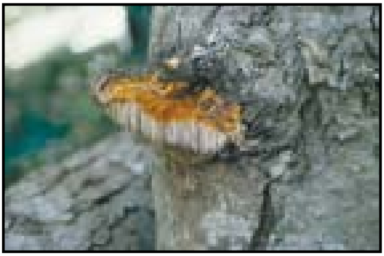


Figure 171. Distinctive spines and orange color inside an Indian Paint conk.

Quinine Conk

Fomitopsis officinalis **(Vill.:Fr.) Bond & Sing.**

(=*Fomes officinalis* Vill.:Fr.)

(=*F. laricis* (Jacq.)Murr.)

Hosts: Sitka spruce, shore pine, hemlocks.

Distribution: Host range in Alaska.

Identification: Fruiting bodies are variable in size; sometimes huge; hoof-shaped to long and cylindrical. Upper surface zoned, white, and turning gray, brown, or sometimes greenish when colonized by algae. Lower surface white with small regular pores. Context white, soft, cheesy, then becoming chalky with age. The conk has a bitter taste.

Wood in the incipient stage has a light yellowish, reddish discoloration. The advanced stage of decay appears as brown cubes that are easily crumbled and there are thick, bitter tasting mycelial felts in the shrinkage cracks.

Injury: The fungus causes a brown cubical rot. A single conk on the bole indicates substantial decay and loss of commercial wood value.

Remarks: As with other heart rot fungi, shortened rotations may serve to reduce timber losses in forests. Trees with conks in recreation areas are potentially hazardous because of the large amount of decay indicated by each conk. Historically, fruiting bodies of this fungus were collected, carved into figures, and placed on the graves of Tlingit shamen.

References: 1, 26, 29, 83, 90, 126, 182

Figure 172. *Quinine conk.*

Hartig's Conk

***Phellinus* (Allesch. & Schnabl) Bond.**

(=*Fomes hartigii* (Allesch. & Schnabl) Bres.)

(=*Polyporus hartigii (*Allesch. & Schnabl.0

Host: Western and mountain hemlock.

Distribution: Host range in Alaska.

Identification: Brown perennial fruiting usually located on the underside of limbs or branch stubs, but sometimes occurring directly on the bole. Upper surface dark brown to black and cracked. Under surface rusty brown to brown with very small regular pores. Tissue inside conk is yellow- to rusty-brown with streaks of white mycelium.

Incipient decay appears as a brown to purple discoloration in irregular patches. Advanced decay has a light bleached look and appears laminated on radial sections because of differential decay of spring and summerwood. There are light buff to brown horizontal streaks on tangential sections. Brown zone lines are common.

Injury: This fungus causes a white rot of sapwood and heartwood of living trees. Decay is usually confined to the side of truck where infection occurred and normally extends only a few feet above and below the conk. Decay of the sapwood causes a sunken canker where the side of a tree is killed.

Remarks: Management can influence the abundance and effects of this fungus by altering the length of timber rotations. This fungus is sometimes confused with and referred to as *Phellinus robustus*. Hartig's conk is named after Robert Hartig, a 19th Century German forest scientist who is generally regarded as the father of forest pathology.

References: 1, 22, 29, 60, 82, 83, 110, 126, 157, 182, 183

Figure 173. *Hartig's conk on a dwarf mistletoe broom.*

Borealis Conk

***Climacocystis borealis* (Fr.) Kotl. & Pouz.**

(=*Polyporus borealis* Fr.)

Host: Sitka spruce, western hemlock and mountain hemlock.

Distribution: Southeast Alaska.

Identification: Fruiting body annual, shelving, white, fleshy. Upper surface shaggy, lower surface with large pores, interior tissue is white.

Decayed wood is a yellowish white and shows white flecks in cross section. Tangential and radial faces have white patches around small pinholes and cross-grain white streaks. Thoroughly decayed wood fractures in a cubical pattern.

Injury: This fungus causes a white mottled wood rot of living trees and continues decay in wood of dead trees.

Remarks: As with other decay fungi, managers can reduce losses of the timber resource by using shorter rotations.

References: 29, 63, 83, 126, 182, 183

Figure 174. Borealis *conks on a log end.*

Purple Conk

***Trichaptum abietinus* (Dicks:Fr.) Ryvarden**

(=*Hirschioporus abietinus* (Dicks.:Fr.) Donk

(=*Polyporus abietinus* (Dicks.:Fr.) Donk)

Hosts: Sitka and white spruce; western hemlock

Distribution: Host range in Alaska.

Identification: Fruiting body is annual, small, thin, shelving, and sometimes crustlike. Upper surface is hairy, zoned, and gray, may become greenish with age and algae. Lower surface is purplish when young, turning brown with age. Pores vary from regular to irregular in shape and are conspicuous.

Decayed wood in the incipient stage has a faint yellowish to tan color. The wood becomes honeycombed with small pockets in the advanced stage of decay. The pockets are filled with whitish fibers initially but become empty later as the wood becomes spongy or corky.

Injury: This fungus is restricted to dead trees and does not harm live trees.

Remarks: The fungus causes a white pocket rot of dead coniferous sapwood. Both woody debris in forests and wood in use are attacked. Dry and well-ventilated conditions reduce incidence of the fungus on wood in use.

References: 1, 12, 29, 60, 83, 126, 182

Figure 175. *Upper surface of* Trichaptum abietinum *conks.*

Figure 176. *Violet colored lower surface of the purple conk.*

Yellow Cap Fungus or Scaly Cap Mushroom

Pholiota spp.

Host: Spruce, hemlock, cottonwood, birch, aspen

Distribution: Host range in Alaska.

Identification: Fruiting body is an annual mushroom, typically produced in clusters. The upper surface of the mushroom cap is yellow-brown and usually scaly and/or sticky. Young specimens may be flagrantly scaly while older specimens may become sticky and lose their scales. Gills on the lower surface are yellow at first, later turning brown. The stem (i.e. stipe) may or may not have a ring and may be scaly. Mushrooms may develop at the base of the tree or on the stem, particularly at wounds.

Incipient wood decay appears as light yellowish areas in the heartwood. Wood with advanced decay is yellow-white with yellow or yellow-brown streaks. Thin strands of yellow-brown mycelium, occur along the grain. If the strands of mycelium are pulled from the wood, irregular channels, resembling insect tunnels, remain.

Injury: *Pholiota* species cause a white rot of wood in live trees, typically invading through wounds. Mushrooms on a living tree indicate extensive decay. Some species are root rot fungi while others cause stem decay.

Remarks: There are many species of *Pholiota* found in Alaska, only some are capable of decaying live trees. For exact determination of any specific specimen, a key for *Pholiota* must be used. Managers can reduce effects of wood decay fungi by limiting tree ages through shorter rotations and by reducing trunk wounds.

References: 1, 12, 29, 126, 145, 224, 251

Figure 177. Pholiota *mushrooms on aspen.*

Coniophora Brown Rot

Coniophora arida (Fr.) Karst, *C. olivacea* (Fr.:Fr.) Karst

C. puteana (Schum.:Fr.) Karst

Hosts: Spruce, hemlock, and occasionally hardwoods.

Distribution: Hosts range in Alaska.

Identification: The fruiting bodies are annual flattened, crust-like, principally olive or very light brown in the center and white towards the margins, lacking pores, gills, or teeth. Fruiting bodies are uncommon and difficult to find because they occur in a live tree within decay columns or on the lower side of downed logs.

Wood in the advanced decay stage becomes uniformly cubical with frequent longitudinal cracks. Decayed wood varies from purple brown to light or dark brown. A thin brown mycelium may develop on cube faces and within the longitudinal cracks of the wood.

Injury: These fungi cause a brown cubical heart rot of live trees typically

Figure 178. *Brown cubical rot of white spruce caused by* Coniophora *spp.*

invading thru wounds. Presence of a fruiting body indicates considerable decay. These fungi are particularly common in mature white spruce stands in Interior Alaska.

Remarks: As with other heart rot fungi, shortened rotations will help reduce timber losses from these pathogens. Live trees with extensive decay may provide important habitat for cavity nesting birds and mammals.

References: 183, 251

Figure 179. *Crust-like fruiting body of* Coniophora puteana.

Redcedar White Ring Rot

***Ceriporiopsis rivulosa* (Berk. & Curt.) Gilbn. & Ryv.**

(=*Poria rivulosa* (Berke and Curt.) Cooke)

(=*P. albipellucida* Baxt.)

Host: Western redcedar.

Distribution: Southeast Alaska, south of Sumner Straits.

Identification: Fruiting bodies are annual, white, thin, and crustlike with pores. Margins are thin and appear water soaked. Fruiting bodies are rare.

The incipient stage of decay is an irregular or crescent-shaped yellowish to brownish discoloration sometimes surrounded by a blue to red zone. In the advanced stage, the decayed wood is crumbly, white or yellowish with radial cracks, small pockets, and laminations.

Injury: This fungus is the leading causes of heart rot in living western redcedar trees. It causes a white rot.

Remarks: Mature western redcedar trees frequently have a considerable amount of internal wood decay. Along with the two white rot decays mentioned here (*Ceriporiopsis rivulosa* and *Phellinus weirii*), the brown rot fungus *Postia sericeomollis* (=*Poria asiatica*) contributes to this decay. External indicators of decay are often not helpful in allowing forest workers to judge decay levels and none of these fungi produces a common or conspicuous fruiting body. Management of decay levels can be achieved by limiting tree age where that is desirable.

References: 1, 29, 32, 83

Figure 180. *White rot of western redcedar caused by* Ceriporiopsis rivulosa.

Yellow Ring Rot

***Phellinus weirii* (Murr.) Gilbn. (=Poria weirii Murr.)**

Host: Western redcedar

Distribution: Southeast Alaska, south of Sumner Straits.

Identification: Fruiting bodies are uncommon and difficult to find because they occur on the bottom of down logs, along root crotches, or inside decay columns. Fruiting bodies are dark brown or yellow brown perennial layers. The layers crack with age. Conk margins are buff to white when fresh. Context is layered and brown.

The incipient stage of decay is yellow to reddish brown and often crescent shaped or irregular in cross section. In the advanced stage of decay, the wood is yellow or light colored, stringy, with small pockets. The decayed wood separates (i.e., delaminates) at the annual rings with brown mycelium forming between the resulting laminations and in the pockets.

Injury: This fungus causes a white rot of the roots and lower bole of western redcedar. The incidence and amount of decay are associated with tree age.

Remarks: Management can reduce timber loss by using shorter rotations for western redcedar. Another form of this fungus, which may be classified taxonomically as a separate species, causes a serious root disease of many species of conifer in forests of western North America. This form is not present in Alaska, however.

References: 1, 12, 29, 32, 63, 82, 83, 90, 126, 157, 183

Figure 181. *Laminated decay of western redcedar caused by* Phellinus weirii.

Figure 182. *Crust-like fruiting body of* Phellinus weirii.

Cedar Brown Cubical Pocket Rot

Postia sericeomollis* (Romell) Julich *(=Oligoporus sericeomollis, Poria asiatica)

Hosts: Mainly western redcedar, but also yellow-cedar and other conifers

Distribution: Southeast Alaska

Identification: Fruiting bodies are white, annual, and about 6 inches wide. They are rarely encountered, but may be found on dead trees. Typically, there are no outward signs that trees are infected.

Early or incipient decay is tan to yellow brown. Decay typically occurs in discrete pockets with apparently unaffected surrounding wood. But these pockets of decay can coalesce, leading to larger areas of decay. Advanced wood decay is brown, brittle, and breaks apart in cubical chunks.

Injury: This is the most common brown rot of western redcedar.

Remarks: Western redcedar has a surprising level of heart rot for a tree species that produces such decay resistant wood. This is one of three fungi able to overcome cedar heart wood chemistry and cause extensive decay. In Idaho, birds are known to use decayed pockets by this fungus in live redcedar trees as nesting habitat.

References: 1, 29, 32

Figure 183. *Cedar pocket rot.*

Oyster Mushroom

***Pleurotus ostreatus* (Jacq.:Fr.) Kumm.**

Hosts: Alder, aspen, cottonwood, birch

Distribution: Host range in Alaska.

Identification: Fruiting body is a fleshy annual mushroom that grows in clusters. Upper surface is smooth, white, or grayish. Lower surface has prominent gills that extend onto the stalk.

Early decay of heartwood and sapwood is characterized by a brown discoloration. Advanced wood decay is white and flaky, with black flecks scattered throughout.

Injury: This fungus causes a white flaky rot of hardwoods; both sapwood and heartwood are decayed.

Remarks: Sporophores on logs indicate substantial wood decay. This species of mushroom is edible, but be absolutely certain about the identity of any mushroom that you consume. For specific determinations, a key for the genus should be used.

References: 29, 34, 126, 183

Figure 184. *Oyster mushroom on aspen.*

Coral Fungus

***Hericium abietis* (Weir:Hubert) K. Harrison**

Hosts: Western hemlock and Sitka spruce.

Distribution: Host range in Alaska.

Identification: Fruiting bodies are annual, soft, fleshy, white, coral-like and composed of many hanging spines. Fruiting bodies are found usually in the fall on the sides and ends of down logs or logs in decks and on scars on standing trees. The size of fruiting bodies is quite variable with some approaching 1 meter in diameter.

The early stages of decay appear in the heartwood as a yellowish to brown stain, which later changes to long spindle-shaped yellow spots. In the advanced stage of decay, the wood is riddled with long spindle-shaped pockets that may or may not contain a yellowish mycelium. In this stage, the wood is very splintery, fibrous, and has a honeycombed appearance in cross-section.

Injury: This fungus causes a white rot that affects the bole of either living or dead trees.

Remarks: Managers can reduce decay levels in forests by controlling the wounding of living trees, scheduling the early harvest of damaged trees, and limiting tree ages. The fruiting body of this fungus is edible, but be certain about the identity of any fungus that you consume. There are other closely related species on both hardwoods and conifers (i.e., coral fungi), thus, the use of detailed keys and guides are recommended for precise species identification.

References: 12, 29, 90, 126, 183

Figure 185. *Coral fungus.*

Tinder Conk

Fomes fomentarius **(L:Fr.) Kichx.**

Host: Paper birch

Distribution: Throughout the range of birch in Alaska.

Identification: The perennial conk is woody and distinctly hoof-shaped with a concentrically zoned, smooth, gray or gray-brown to black upper surface. The lower surface is brown with small regular pores; conk interior has dark brown tubes that are somewhat stratified and partially filled with or incrusted with white mycelium.

In the early stage, decayed wood is brownish and firm while in the later stage it is soft, spongy, yellow white, with narrow brown to black zone lines and small radial cracks.

Injury: This fungus causes a white rot of both sapwood and heartwood in living and dead trees. Presence of a conk indicates little usable heartwood.

Remarks: Infection occurs through wounds. The conk is common on dead trees or dead portions of live trees. Some control of this fungus may be achieved by removal of infected trees bearing conks, minimizing damage to live trees, and shortened rotations. Traditionally, the fungus has been used as fire starting material and, as early as the fifth century B.C., Hippocrates wrote about its use for medicinal purposes.

References: 1, 29, 83, 126, 182, 208

Figure 186. *Tinder conk on paper birch.*

False Tinder Conk

Phellinus igniarius (L.:Fr.) Quel. (=*Fomes igniarius* L.:Fr.)

P. tremulae (Bord.) Bond et Boriss

Hosts: *P. igniarius* on paper birch,alder, and other hardwoods ; *P. tremulae* on aspen and cottonwood.

Distribution: Host range in Alaska.

Identification: The fruiting bodies are similar for these *Phellinus* species. Conks are perennial, hoof-shaped, with an upper surface that is zoned, greyish black to black, becoming cracked and cinder-like with age. Lower surface is brown with small circular pores. Context layered and rusty brown with many tubes in older layers filled with white mycelium. The upper and lower surfaces of *P. tremulae* conks are at angles of about 45° from horizontal, whereas the lower surface of *P. igniarius* conks are close to horizontal.

Wood in the incipient decay stage is yellowish white or with white spots, streaks, or large areas of heartwood surrounded by a yellowish green to brownish black zone. In the typical decay stage, the wood is lightweight, soft, and whitish with fine black zone lines throughout.

Injury: These fungi cause a white trunk rot. Presence of a conk indicates considerable decay.

Remarks: Infection by these fungi is typically through dead branch stubs or wounds. Volume losses increase with tree age, thus removal of infected trees,

Figure 187. Phellinus igniarius *conk on paper birch.*

prevention of wounding of uninfected trees, and shortened rotations help reduce timber losses from these pathogens. Trees with conks could be hazardous and should be carefully evaluated in recreation areas and near homes.

References: 1, 29, 34, 82, 83, 126, 128, 180, 182, 194

Figure 188. Phellinus tremulae *on aspen.*

Cinder Conk

***Inonotus obliquus* (Pers.:Fr.) Pilat (=*Poria obliqua* (Pers.:Fr.) Karst.)**

Host: Paper birch, rarely on cottonwood.

Distribution: Hosts range in Alaska.

Identification: Perennial sterile conks are the most conspicuous sign of infection by this fungus. The sterile conk is a cinder-like mass of fungal tissue with a rough, black exterior. The interior tissue is yellow-brown to rust brown with a punky texture. Inconspicuous, short-lived fertile conks may break through the bark after the tree dies. The fertile conk is thin, resupinate (flattened), with a gray to red-brown pore surface. The fertile fruiting body quickly deteriorates and is usually difficult to find.

Incipient decay appears as yellowish white streaks and spots in the wood. Wood in advanced decay is white, soft, with fine black zone lines throughout, and a mottled appearance on radial surfaces.

Injury: The fungus causes a white trunk rot similar to that caused by *Phellinus igniarius*. Presence of a conk indicates substantial decay.

Remarks: Infection by this fungus occurs commonly through wounds and dead branches. Volume losses from this pathogen may be reduced through removal of infected trees, preventing wounds, and shortened rotations. Trees with conks could be hazardous and should be carefully evaluated in recreation areas. Historically, the fungus has been used as fire starting material and for medicinal purposes.

References: 1, 12, 25, 29, 83, 126, 151, 182, 183, 223, 238

Figure 189. *Sterile conk of* Inonotus obliquus *on paper birch.*

Figure 190. *Young cinder conk on birch.*

Birch Conk

Piptoporus betulinus **(Bull.:Fr.) Karst.**

(=*Polyporus betulinus* Bull.:Fr.)

Host: Paper birch.

Distribution: Host range in Alaska.

Identification: Fruiting body is annual, leathery, shelving with or without a short lateral stalk. Conks have a distinctive thickened margin, incurved, projecting below the lower surface. The upper surface ranges from mouse-colored to whitish, yellow-brown or brown. Upper surface may be smooth or broken up to give a pitted or scaly appearance. Lower surface is white at first then turning yellowish or tan and with thick-walled pores. Interior tissue is firm, white, and corky in texture with a distinct pore layer that readily peels off in fresh specimens.

Initially both sapwood and heartwood decay is light yellowish-brown, cracking into cubes with thin white mycelial felts in the cracks. In advanced stages the wood is reduced to a fine crumbly mass.

Injury: The fungus causes a brown cubical rot of dead trees and dead portions of living trees. After colonization of dead tissues, the fungus may occassionally spread a short distance into the main stem of living trees.

Remarks: This fungus was carried on the wrist of Otzi, the 5,000 year old man whose body was recovered from ice in Italy in 1991. Historians speculate that he consumed the fungus to treat intestinal parasitoids.

References: 1, 12, 29, 83, 126, 182, 184

Figure 191. Piptoporus betulinus *conk.*

Rainbow Conk

***Trametes versicolor* (L.:Fr.) Pilat. (=*Polyporus versicolor* L.:Fr.)**

Hosts: Hardwoods, occasionally on conifers.

Distribution: Hosts range in Alaska.

Identification: The fruiting body is annual, thin, tough, and leathery. Upper surface is hairy and with multicolored zones or bands that vary from white or greyish to brownish, blackish, or purple. Lower surface is white with small pores. Conk interior is white.

The early stages of decay are unnoticeable. Wood with advanced decay is uniformly white, soft, brittle, and much reduced in weight.

Injury: The fungus causes a white spongy rot of dead hardwood trees, slash, stored logs, and wood in service.

Remarks: Clean, dry and well-aerated conditions or treatment with a preservative will control the fungus on wood in service.

References: 12, 29, 83, 126, 182

Figure 192. *Rainbow conk.*

Blue Stain

***Leptographium abietinum* (Peck) Wingfl.**

Hosts: White, and Sitka spruce, Lutz spruce; likely on black spruce

Distribution: Hosts range in Alaska.

Identification: Infection results in a grayish, dark blue, or blackish discoloration of the sapwood. In cross section the discoloration typically appears as streaks, irregular areas, or wedge-shaped sectors. Stain patterns occur because of colonization of both tracheids and rays in the sapwood.

Injury: Sapwood discoloration is the principle injury. If conditions remain favorable for the fungus, the entire sapwood may become blue-stained. Pathogenicity tests suggest that *L. abietinum* is saprophytic or only weakly pathogenic to the host.

Remarks: Most wood properties are not significantly altered by blue stain fungi, thus the wood may be used for many purposes provided the discoloration itself is not objectionable. Since conditions favoring blue stain also favor rot development by wood decay fungi, stained wood should be carefully examined for indications of decay. In Alaska, this fungus is commonly associated with spruce beetle (*D. rufipennis*) galleries, however the symbiotic association between the beetle and the blue stain fungus is poorly understood.

References: 29, 98, 188, 228, 265

Figure 193. *Blue stain of white spruce sapwood.*

Black Stain of Yellow-cedar Heartwood

***Sporidesmium* sp., *Phialophora melinii* (Nannfeldt) Conant.**

Hosts: Yellow-cedar

Distribution: Southeast Alaska

Identification: Stained patterns in yellow-cedar heartwood are dark colored, usually black with a bluish-greenish color. In cross section they appear as arcs with a width of about 1-inch. In longitudinal section, they are elongated vertically. A wood decay is associated with some stained patterns and insect galleries. Corpses of woodwasp larvae (*Sirex* sp.), which are believed to transmit the fungus to cedar trees, may be found. Tiny wounds are also associated with many of the stain pattern.

Injury: The stain can represent a serious reduction in the value of infected wood but, unless the associated wood decay is present, the stain may not influence the strength of wood. Black stain in heartwood appears to have little to no influence on the physiology of the tree.

Remarks: *Sporidesmium*, *Phialophora melinii*, and other fungi have all been isolated from stained wood. *Sporidesmium* is the most consistently isolated and its color when grown in culture looks very similar to the green-blue-black color of stained wood. Research on the identity of these fungi continues. These fungi infect the wood when it is sapwood. As the infected sapwood is converted to heartwood, the stain occurs there and is overgrown by new sapwood. The causal fungus eventually dies, but the stain persists in the heartwood in crescent shapes with widths equal to the sapwood width (i.e., about 1 inch). There is some evidence that the stain fungus is vectored to trees by woodwasps. The small wounds and insect galleries in stain patterns appear to represent feeding by these insects.

References: 106, 173, 246

Figure 194. *Black stain of yellow-cedar heartwood.*

Noninfectious Disorders

Disease-like processes which are not caused by living agents (pathogens) and which are noninfectious are referred to as abiotic disorders. These problems may be caused by many different nonparasitic factors in the environment, such as weather, air pollution, deficiencies or excesses of soil minerals, and misuse of chemicals. We include animal damage to trees in this section even though the causal agent (i.e., the animal) is biotic. In many instances the symptoms of abiotic disorders closely resemble those of some parasitic diseases making it difficult to determine the cause. Many of the noninfectious injuries serve as an entry way for pathogens, such as those that cause cankers and wood decay.

In this section, we have also included forest tree problems (i.e. yellow-cedar decline) which are widespread and probably caused by changing climate conditions.

Figure 195. *Yellow-cedar decline.*

Yellow-Cedar Decline

Affected Trees: Yellow-cedar, also known as Alaska-cedar or Alaska yellow-cedar

Distribution: On about 200,000 hectares throughout Southeast Alaska from northwestern Chichagof Island to Portland Canal, and also extending about 161 kilometers south into north coastal British Columbia.

Identification: Trees are dead or dying in small patches of less than one hectare to expansive areas stretching for several kilometers. Mortality is usually associated with boggy (muskeg) conditions. Affected stands have a mixture of trees that died long ago, died more recently, are currently dying, and appear relatively healthy. On average two thirds of the mature yellow-cedar is dead and standing in declining forests. Yellow-cedars that have been dead for up to 100 years (when the problem began) are often still standing but their bark and limbs and all sapwood have deteriorated away. Affected cedars die quickly, with their entire compliment of foliage turning red and then brown over 2 or 3 years, or die slowly (e.g., 15 or more years) with crown slowly thinning and terminal foliage the last to die. Cedars with thin or off-green crowns frequently have vertical lesions of dead cambium on the lower bole.

Injury: Yellow-cedar decline appears to represent a form of freezing injury, most likely to superficial roots that are forced to grow close to the soil surface because of saturated soils (i.e., in boggy and semi-boggy conditions). These areas also exibit rapid temperature changes due to less canopy cover. Yellow-cedars are cold hardy in fall and early winter, but they deharden in late winter and early spring and are then vulnerable to freezing injury. The health of yellow-cedar forests is highly associated with snow patterns: forests are dead and dying where snow does not protect roots from late winter-early spring freezing but forests appear healthy at higher elevations and areas close to the mainland in Southeast Alaska where snow persists through March or April. Yellow-cedar trees also appear healthy where the mix with western hemlock and other tree species on well-drained soils. The organisms (i.e., fungi, insects, and nematodes) that are associated with dying cedars lack the capability of killing a healthy, unstressed tree. *Phloeosinus* bark beetles, *Armillaria* spp., and other fungi that are frequently found on dying or recently dead trees have been shown to not be the primary cause of tree death.

Remarks: The early onset of the problem in about 1880 to 1900 in remote, relatively pristine sites suggests that yellow-cedar decline may have been initiated as a natural process at the end of the Little Ice Age. The problem accelerated in the later half of the 1900s, apparently the result of less snow, extended growing season in the spring, and periodic cold events. Death of overstory yellow-cedar trees results in plant succession that favors other conifer tree species. Because of the remarkable decay resistance of yellow-cedar wood, the recovery of wood from dead yellow-cedars often produces a valuable product. Yellow-cedar is a high elevation tree throughout most of its natural range. It is no longer adapted to low elevation, wet, open areas with today's climate. Forest management of this valuable tree species can continue with planting and thinning in areas where snow persists into spring or on better drained soils where roots can grow more deeply.

References: 48, 88, 108, 112, 113, 115, 116, 118–120, 123–125, 150, 221

Figure 196. A tree that died from yellow-cedar decline.

Hemlock Fluting

Affected Trees: Western hemlock.

Distribution: Southeast Alaska, most commonly within close proximity to beaches.

Identification: Main stems of western hemlock have deeply incised vertical grooves and ridges. Grooves appear to originate at dead branches and extend vertically down the stem. The occurrence of fluting all the way up boles to the live crown of trees distinguishes bole fluting from other characteristics such as a flared root collar. Disturbances, rapid growth, and coarse branching of young western hemlock are factors that seem to trigger bole fluting.

Injury: Technically, trees are not injured by bole fluting, and fluting may contribute to their survival by making them more windfirm. Fluting can significantly reduce the economic value of logs because of bark inclusions and irregular grain.

The degree to which hemlock trees are fluted varies with tree age. Fluting can begin when trees are about 10 years old and intensify while trees are growing rapidly. Flutes generally initiates below branches that decline in growth from shading. Flutes from vertically aligned branches coalesce and produce long grooves that spiral downward.

With time, as dead branches deteriorate and the bole overgrows the branch

Figure 197. Hemlock fluting.

stub, the tree can develop a round bole to the point where flutes are no longer visible. These trees may have bark trapped in the internal wood, however.

Remarks: By creating conditions that trigger fluting, thinning western hemlock stands on sites where fluting has been a problem in the past will likely exacerbate the problem. Planting or favoring Sitka spruce and other species during thinning can help reduce losses.

References: 147–150

Figure 198. *Log end showing deep incisions of hemlock fluting as well as hollow caused by heart rot.*

Burls

Affected Trees: Sitka and white spruce; various hardwoods

Distribution: Hosts range

Identification: These globe-shaped, large, woody swellings or growths are quite striking and have long been phenomena of interest on plants. Burls occur on branches or stems of trees either singly or in groups and may be locally abundant. These woody growths apparently originate at a single cell or small group of cells near the pith in the first year of growth, and enlarge throughout the life of the tree. Burls of spruce can reach enormous proportions, frequently larger than the diameter of the stem. Buds or sprouts may develop on the surface of a burl.

Injury: Trees with burls appear to grow normally, with the stem bark generally the same color and texture as that of the burled area. Wood from burls is usually sound, lacking stain or decay. Recent research suggests that aspen trees with woody black stem galls tend to have less stem decay than those lacking galls. Research continues on identifying and characterizing inhibitory compounds produced by the microflora in the galls.

Remarks: The cause of burls in spruce has not been proven. Possible factors include injury from freezing temperatures, mutation, or genetic predisposition to burl formation in response to unknown environmental factors. Genetics are

Figure 199. *Large burls on Sitka spruce.*

suspected to be involved as spruce burls tend to be found in patches within a localized area or watershed. Large burls on aspen can be induced by the poplar budgall mite and are characterized by red mite-containing tissues on the surface. Other burls of aspen, those that are generally globose with a rough, black, fissured surface, have an unknown cause. Burl formation on paper birch and other hardwoods is unexplained. Burls on hemlock can be induced by hemlock dwarf mistletoe stem infections. The highly figured wood of cut burls is prized by fine woodworkers. Alaskans use burled trees as signposts and for a variety of home decorative purposes. At the end of the 1,000–mile Iditarod sled dog race, mushers and their teams pass under a quentesentially Alaskan burled arch in Nome.

References: 29, 39, 268, 269

Animal Damage

Affected Trees: All tree species in Alaska.

Distribution: Throughout tree range in Alaska.

Identification: Severed stems, stripped bark, scratched bark, holes in the bark, clipped buds, twigs, and cones, seed and seedling destruction. Most injury occurs as a result of the direct feeding by animals, an exception being bears sometimes scratching trees. Brown and black bear, moose, porcupine, sapsucker (birds), vole, shrew, snowshoe hare, squirrel, and deer cause most of the injury in Alaska.

Animal feeding that results in the bark of live trees being removed usually leaves teeth marks or grooves on exposed wood. The width of these teeth marks can give an indication of which animal is responsible. Grazing by animals such as moose, deer, and snowshoe hare leave plants with the appearance that lateral and terminal branches been clipped off.

Injury: The actual injury to plants by animal feeding is quite variable. Serious injury occurs when bark is removed from large areas, grazing removes a significant amount of the photosynthetic tissues, or seedlings are destroyed. Porcupines and bears cause significant damage to trees by creating large bole scars or by feeding on the entire circumference the bole. Large wounds are colonized by wood decay fungi and complete girdling of stems causes top kill or entire tree death. Snowshoe hare feeding can result in death of the terminal branch and subsequent decay of the stem.

Remarks: Porcupines damage high value trees, such as crop trees left after thinning in Southeast Alaska. In winter, they climb to feed on the inner bark along the bole of young trees and feed at the base of large trees (usually western hemlock in the latter case). Removing damaged trees before significant decay develops, or favoring species, such as cedars, that pocupines do not

Figure 200. *Large wound at the base of a Sitka spruce caused by porcupine feeding.*

prefer, will reduce losses.

Brown bears cause extensive wounding to the boles of yellow-cedar. More than one half of the yellow-cedar trees are scarred in some stands on Baranof and Chichagof Islands in Southeast Alaska. Scars occur on the lower boles, but the entire bole is rarely girdled. They appear as old callusing wounds or fresh with detached bark and teeth marks in exposed wood made when brown bears pulled bark away. Obvious signs of feeding are not evident on scars; the reason that bears scar cedars is not known.

References: 23, 34, 61, 117, 170, 171, 240, 241

Figure 201. *Yellow-cedar tree wounded by a brown bear. Note the teeth marks in the exposed wood.*

Figure 202. *Girdling of paper birch caused by feeding of red squirrels.*

Other Abiotic Disorders

Winter Drying (Red Belt) and Needle Discoloration

Drought-like conditions in the winter are the cause of winter drying and much of the needle discoloration seen in spring. Sudden warm spells or warm winds that occur during the winter may cause a marked increase in transpiration, killing foliage and buds. If the soil is frozen when this occurs, water is not available to replace that which has transpired. Under these circumstances the tree reacts as it would in a period of drought and injury is expressed by browning and dying of the foliage when warm weather comes in the spring. If the warm wind occurs high along the side of the valley the damage is displayed as a sharply defined reddish belt of affected trees, thus the common name for this phenomena is "red belt." Fortunately, affected trees are usually not permanently damaged. This injury may be difficult to distinguish from direct freezing injury to tissues.

Purple to red needle discoloration of conifers is often noticed in spring on exposed trees in urban environments. Typically these trees have suffered from winter needle dessication. Foliage within unopened buds at the time of warm winter winds is usually unaffected and foliage on the sides of trees facing the

Figure 203. *Red belt (winter drying).*

winds will display the greatest damage. Discolored needles could be caused by many biotic and abiotic factors including drought, misapplied chemicals, infection by needle fungi, root disease agents, and planting trees that are poorly adapted trees to Alaskan conditions. Proper diagnosis for the cause and control of needle discoloration requires careful observation for signs and symptoms of fungal infection (i.e fruiting bodies on the underside of needles or on twigs). Without signs of biotic agents, the damage is typically attributed to abiotic influences.

Drought

Drought conditions occur whenever soil moisture drops below the level required by trees. Chronic injury results from long-term exposure to low water supplies and is expressed by growth loss and increased susceptibility to parasitic fungi and insects. Chronic injury can be difficult to diagnose. Acute injury occurs when an extreme water deficiency occurs and is expressed by significant growth loss or death. Symptoms of drought damage include

Figure 204. *Modest and severely drought stressed alder foliage.*

wilting, discoloration of foliage, premature leaf fall, death of tree from top of crown down and outside of crown in. The roots are usually the last portion to die. Symptoms can be similar to trees suffering root disease, except roots die before the foliage for trees with root disease.

Freezing Injury

Death of foliage, buds and twigs, leading to a growth loss and a general weakening of the tree, may occur as the result of either an early (fall) or late (spring) frost. Injury in mid-winter is less frequent because tissues are often resistant to temperatures below record lows and dehardening is governed largely by photoperiod (i.e., daylength). Early frost injury takes place before the trees are hardened for the winter, but this form of damage is not as common as late

Figure 205. Freezing injury of spruce.

Figure 206. Yellow-cedar seedling with frost damage.

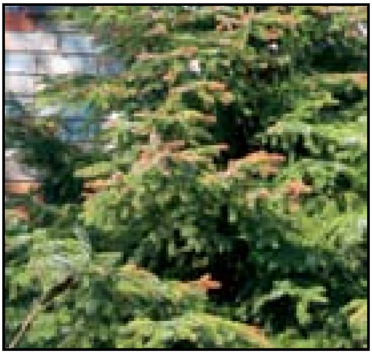


Figure 207. Frost damage on the tips of Sitka spruce foliage.

winter or spring damage. Spring frosts causing foliar injury are particularly common in conifers. Needles in exposed areas or on one side of the tree are killed when they experience warm weather, deharden and lose cold tolerance, and are then injured during subsequent cold weather. Young, newer foliage (e.g., produce the prior year) is often more vulnerable to this injury than older foliage. The actual damage is a result of intercellular and/or intracellular formation of ice crystals that cause cellular deformation and death. Injury can be sudden and acute, perhaps occurring during one day at dusk during a rapid transition from the warmth of day to the cold of night.

Windthrow

Single trees or patches of trees are uprooted with full root plates or broken off at the bole as the result of strong winds. Windthrown trees in patches often lie parallel to one another in the same direction as the windstorm. Old-growth hemlock-spruce forests in Southeast Alaska are particularly susceptible, where damage most commonly occurs in the fall or winter months. Heavy rains which saturate soils accompany gale-force southerly winds contribute to windthrow at that time. Many of the patches of windthrown trees that are now visible resulted from one storm on November 28, 1968. Storms in the 1880s gave rise to many even-aged forests in Southeast Alaska. Most windthrow is not associated with human activity, but patches of windthrown trees on the perimeters of clearcutting units are common, particularly on the leeward side

Figure 208. *Windthrow.*

or in V-shaped or square corners of clearcuts. In Southeast Alaska, windthrow is commonly associated with south-facing slopes, productive soils, and low elevations—all conditions which support tall old-growth trees. Root and stem rot increases the incidence of wind damage. During strong winds, trees with stem decay tend to snap while trees with root disease tend to uproot with only a minor complement of roots attached.

Sulfur Dioxide Emissions

Emissions of chemical pollutants in the form of gases from industrial plants, including SO_2, can damage trees. Chronic injury, which results from continued low level emissions of noxious gases, is expressed as a general yellowing of trees and growth loss. On conifers, the internodes and terminals are shorter and the needles are smaller with a shorter life and retention. On broad-leaved trees, the leaves are discolored with irregular flecks and patches before becoming entirely yellowish. Acute injury occurs when a tree is exposed to high concentrations of noxious gases. Needles on conifers with acute injury first appear water-colored then turn tan or reddish-brown as the tissue dies. Either the entire needle or just the distal portion may be affected. On broad-leaved trees the leaf margins are affected first then the tissue between the veins. In many instances all of the leaf tissue with the exception of the veins may be killed.

References: 1, 29, 99, 126, 143, 161, 178

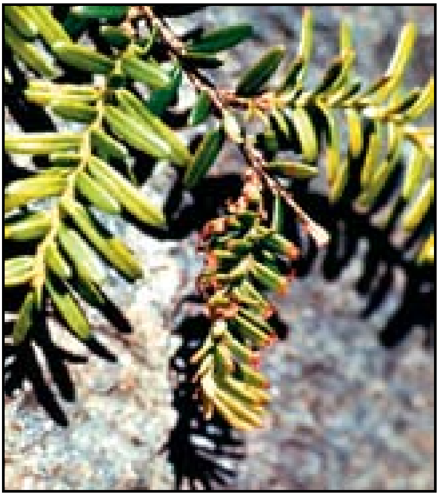


Figure 209. *Damage to western hemlock foliage by sulfur dioxide emissions.*

Index to Pathogens by Host Plants

Willow (*Salix* spp.)

Diseases

Decays

Glossary

Abdomen: Posterior part of the insect's main body divisions.

Abiotic disorder: Interference of the normal functioning of a plant that is caused by some non-living factor (e.g., weather) and not by an organism (pathogen or insect); symptoms may be similar to true disease. Weak pathogens may be present.

Adult: Full-grown, sexually mature insect; usually with wings in contrast to larvae which lack wings.

Alternate host: One of the two dissimilar plants infected by a heterocyclic fungus, i.e., some rust fungi.

Arthropod: Largest phylum in the animal kingdom including insects, crabs, spiders, etc.

Blind conk: An overgrown knot filled with old conk material or the beginning of a new conk, also called punk knot, reliable indicator of the presence of some wood decay fungi, i.e., *Phellinus pini*.

Brown Rot: Brownish, dry, crumbly decay of wood, caused by fungi decomposing cellulose and leaving the lignin in a modified state; may occur in areas surrounded by sound wood. Decayed wood typically brakes into cubical shapes.

Boring-dust: Reddish-brown to tan, pulverized bark excavated by the adult bark beetle as it bores through the outer bark; often found in small piles in bark crevices and around base of tree.

Callus: Healing tissue of trees on branches, boles, or roots that attempt to grow over scars or wounds.

Cambium: Layer of cells between xylem and bark, forms additional xylem and phloem elements.

Canker: Localized, dead, sometimes sunken, portion of the cambium and bark of branches or the bole of a tree, often caused by a pathogen. Many layers of dead callus folds surround some cankers as the tree repeatedly attempts to heal the dead portion, only to have the pathogen kill the callus folds.

Chlorosis: (adj. chlorotic) An unseasonable yellowing of the foliage, may occur in bands on needles.

Conk: Fruiting body of a wood-attacking fungus, often hoof or bracket-shaped and perennial, although some are annual; other than a mushroom.

Context: Interior tissue of a fruiting body.

Cornicle: Dorsal tubular processes on the posterior portion of the abdomen; common on aphids.

Cortex: Rind or outer layer.

Crop tree: Tree left after thinning, often because of superior quality or species and lacking defect or disease.

Decay: Rot, destruction or decomposition of plant material by fungi, typically separated into brown or white rot depending on the wood compounds consumed.

Dioecious: Male flowers and female flowers on different individual plants, as in hemlock dwarf mistletoe.

Disease: A disturbance of a plant caused by a pathogen (not an insect) that interferes with the plant's normal growth, structure, or reproduction. See also abiotic disorder.

Endemic: typical, non-epidemic population

Endophytic: An organism living within tissues of a live plant.

Epidemic: Large scale temporary increase in an insect or disease population.

Fecundity: Ability to produce young.

Flag: Dying or recently dead branch contrasting in color with the normal green color of a living tree.

Frass: Solid insect excrement, usually in small pellets; many times mixed with boring dust.

Fruiting Body: A general term for any fungal spore-producing structure. See also conk or mushroom.

Fungus: (plural = fungi) An organism incapable of producing its own food supply by photosynthesis, usually having microscopic thread-like feeding structures (hyphae) and reproductive spores. Most tree diseases, especially of conifers, are caused by fungi.

Galls: An abnormal growth of plant tissue, stimulated by insect or fungal activity.

Genus: A group of closely related species. Similar genera are grouped in a family.

Girdle: The act of damaging the cambium completely around the circumference of the stem, root or branch, typically causing death of the tree or tissue beyond the point of girdling.

Gregariously: Insects tending to feed or remain in groups.

Grub: Thick-bodied larva, usually sluggish, good fishing bait.

Heartwood: Central mass of tissue in tree trunks, with no living cells and no longer functioning in water conduction; contributes to mechanical support.

Heart Rot: Decay, typically caused by fungi, that is characteristically confined to the heartwood

Heterocyclic: Fungi that requires two different hosts to complete their life-cycle; i.e., some rust fungi.

Honeydew: Sugary liquid excretion of aphids or scale insects.

Instar: The stage of an insect between successive molts.

Lanceolate: Spear-shaped, tapering at each end.

Larva: Immature form of an insect such as a caterpillar, grub, or maggot.

Molt: Process of shedding the exo-skeleton, the insect "skin."

Monogamous: Mating with only one individual.

Mushroom: Fleshy fruiting body of a fungus, may have gills or pores.

Mycangia: Structure found on some insects used for the transportation of symbiotic fungi from one host to another.

Mycelium: (hyphae) The vegetative feeding structure of a fungus.

Mycelial Fan: a fan shaped mycelial mat forming under the bark and wood of roots or lower trunks; often associated with *Armillaria* spp.

Mychorrhizae: Association between plant rootlets and specialized fungi that are beneficial to their tree associate by assisting in nutrient and water uptake.

Necrotic: Dead plant cells or tissues.

Nuptial Chamber: Mating site.

Nymph: Immature form of an insect resembling the adult except for incomplete wing development.

Obligate Parasite: An organism capable of existing only as a parasite on a live host.

Oviposit: Lay or deposit eggs.

Ovipositor: Egg-laying apparatus.

Parasite: An organism living in or on, and getting its food from, a live host. May be harmful (i.e., pathogen) or beneficial (e.g., mycorrhizae)

Parthenogenetic: Reproducing by eggs that develop without being fertilized.

Pathogen: An organism or virus capable of causing disease on a host. Most pathogens of forest trees are fungi.

Perennial: Lasting for several years or more.

Perfect Stage: The stage of the life cycle of a fungus where spores are formed during sexual reproduction (meiosis).

Pheromone: Chemicals which are produced by one individual to affect or alter the behavior of another individual of the same species.

Phloem: Vascular tissue that conducts synthesized foods through the plant, located adjacent to the outside of the cambium in trees, essentially the inner bark.

Pitch-Tubes: A tubular mass of cream colored resin mixed with bark, wood borings, and insect excrement that forms on the surface of the bark at beetle entrance holes.

Plumed: Feather-like.

Polygamous: Mating with several individuals

Pronotum: The dorsal plate of the prothorax.

Prothorax: The anterior of the three thoracic segments.

Pupa: Inactive stage of an insect; transitional stage from larva to adult.

Radial Growth: One-half the diameter growth of a tree.

Rain forest: Forest in which factors other than fire are the main catastrophic disturbance forces.

Rhizomorph: a cord-like structure of some fungi, i.e., *Armillaria* spp., composed of white hyphae and often covered by a black rind.

Rot: deterioration of organic material through the enzymatic activity of microorganisms; decay.

Rust: A disease caused by one of the rust fungi, highly specialized pathogens that are obligate parasites, frequently require two different types of hosts to complete their life cycles (heterocyclic), and produce orange, yellow, or brown spores.

Saprophyte: An organism living in and getting its food from dead organic material.

Sapwood: Outer region of xylem of tree trunks, containing some living cells and functioning in water conduction, food storage and mechanical support.

Serrate: Saw-toothed edge.

Slash: Debris such as logs, bark, branches left after cutting timber.

Spore: A microscopic reproductive body of a fungus used for dissemination.

Sporophore: Fruiting body of a fungus that produces spores (i.e., mushroom or conk).

Stomata: Breathing pore in the epidermis (outer layer) of a plant.

Sub-cortical: Below the bark.

Symbiotic: An intimate association between two species which benefits both.

Systemic: Throughout the plant host tissues, usually surviving from year to year.

Terminal Growth: Height growth of a tree.

Terpenes: Unsaturated hydrocarbons occurring in plant oils and resins, common in conifers.

Thorax: The body region of an insect behind the head, which bears the legs and wings.

White Rot: White to tan decayed wood, caused by fungi decomposing both lignin and cellulose; may occur in areas surrounded by sound wood. Decayed wood is often fibrous or spongy in texture, and may contain distinctive pockets. In advanced stage, may create a large hollow in a tree.

Windthrown: Trees uprooted by wind. The term sometimes is applied to trees whose stems are snapped by the wind.

Witches' Brooms: Abnormal proliferations of shoots or branches caused by a pathogen (e.g., from dwarf mistletoe).

Xylem: Vascular tissue that conducts water and mineral salts, taken in by roots, throughout the plant, essentially the woody part of the stem or trunk.

Zone Line: Black to brown lines in decaying wood formed by fungi.

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Appendix

Submitting Insects and Diseases for Identification

People interested in obtaining positive identification of insect and disease specimens should submit samples to specialists. The following procedures for the collection and shipment of specimens should be followed.

Specimen Collection:

- Adequate material should be collected. Collect both healthy and injured material.
- Adequate Information: The value of an insect or disease specimen depends on the information regarding its collection.
- Where the specimen was collected; nearest post office or town, elevation, aspect.
- When the specimen was collected.
- Who collected the specimen.
- Host description (age, species, and general appearance).
- General condition of the surrounding area (fire, blowdown, logging, and so forth).
- Personal opinion of the problem: the collector's opinion can be very helpful.

Shipment of Specimens:

- General: Pack specimens in such a manner that breakage will be minimal.
- Insects: Specimens sent through the mail should be packed to withstand rough treatment.
- Larvae and other soft-bodied insects should be shipped in small screw-top vials or bottles containing at least 70 percent isopropyl (rubbing) alcohol. Make certain that the bottles are sealed well. Include in each vial adequate information, or a code, relating the sample to the written description and information. Labels inserted in the vial should be written on with pencil or India ink. Do not use ballpoint pen.
- Pupae and hard-bodied insects can be shipped either in alcohol or in small boxes. Specimens should be placed between layers of tissue paper in the shipping boxes. Pack carefully and make certain that there is

very little movement of material within the box. Do not pack insects in cotton.

- Adult moths, butterflies and fragile insects should be folded between paper before packing in the tissue paper.
- Conks or mushrooms: ship immediately or air-dry thoroughly, then ship.
- Needle Diseases: Do not ship in plastic bags. Sprinkle lightly with water before wrapping in newspaper.

Shipping:

- Ship as quickly as possible. If samples can't be shipped as soon as possible, store them in a refrigerator.
- Include address inside shipping carton.
- Mark "Fragile: Insect—Disease Specimens Enclosed" and "For Scientific Purposes Only—No Commercial Value."
- Specimens from Alaska should be sent to:

Anchorage:

Forest Health Protection
State and Private Forestry, U.S. Forest Service
3301 "C" Street, Suite 202
Anchorage, AK 99503–3956

Juneau:

Forest Health Protection
State and Private Forestry, U.S. Forest Service
2770 Sherwood Lane, Suite 2A
Juneau, AK 99801–8545

Fairbanks:

Forest Health Protection
State and Private Forestry, U.S. Forest Service
3700 Airport Way
Fairbanks, AK 99709

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