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Forest
Service

**Southwestern
Region**

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Field Guide to Insects and Diseases of Arizona and New Mexico Forests

Ips galleries and armillaria mycelial fans

Pinyon ips

Pandora moth caterpillar

Southwestern dwarf mistletoe broom on fire

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Field Guide to Insects and Diseases of Arizona and New Mexico Forests

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Preface

Our knowledge of forest insects and diseases continues to evolve and some organisms have only recently been identified or found to cause significant damage. This guide is designed to be practical for the field. Not every forest insect or disease of the Southwest is covered, but we have attempted to include those having significant ecological and/or economic impacts on forest resources such as recreation, wildlife, wood production, or watershed quality.

This field guide is divided into insect and disease sections, each with its own description, illustrations, and host index. Literature cited, glossary, and general index are at the end of this field guide.

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Roles of Forest Insects and Pathogens

Most forest insects and pathogens in the Southwest are naturally occurring components of ecosystems and play an important role in dynamic processes. They affect short- and long-term vegetative structural diversity, provide food and habitat for animals, and contribute to biological diversity. These organisms, along with fire, are among the major disturbance agents in the Southwest. Outbreaks of forest insects and diseases can result in shifts in forest composition and structure. The degree of shift depends upon the particular insect and/or disease and on the condition of the ecosystem affected.

The actions of insects are often easily observed as their populations can quickly expand under favorable climatic conditions. Some insects are significant natural disturbance agents, capable of altering forest succession. For example, bark beetle populations can increase dramatically under drought conditions and cause large-scale tree mortality. In contrast, indigenous tree pathogens increase gradually and their presence and effects may go relatively unnoticed. Although most people see dwarf mistletoe in our forests, few realize that it is the primary agent of growth loss and will gradually kill trees. Insects and pathogens often interact, as is seen when diseased trees are attacked by bark beetles.

A key to insect and disease damage is provided in the "Guide to Forest Insects and Diseases" section, directing the reader to the appropriate insect or disease section. There is also a host index in the back of the book. A description for each insect and disease includes hosts, damage, symptoms, biology, and effects or impacts. A list of references is also provided.

Please refer to your local Forest Service, Forest Health zone office, State Forest Health Specialist, Cooperative Extension Agent, or State Forester for information concerning specific control measures.

References: 17, 51, 59, 99, 100, 106

Invasive Pests

Similar to the rest of the Nation, Arizona and New Mexico's forests and grasslands are threatened by invasions of exotic species of insects, disease pathogens, and plants. Over the past 200 years, several thousand foreign plant and animal species have been introduced in the United States. About one in seven of these species has become invasive.

Two invasive pest species that were introduced into the United States in the early 1900s have become established in forested lands of New Mexico and Arizona. White pine blister rust, caused by *Cronartium ribicola*, was discovered in southern New Mexico in 1990, and found throughout most of the range of its host in the Sacramento and adjoining White Mountains. Based on the apparent age of cankers, the rust first became established around 1970, but it is not clear how the fungus was introduced. Infected white pines were later found in nearby Capitan Mountains and Gallinas Peak, and by 2005, a population was observed on the Gila National Forest in far western New Mexico. The disease was not observed in Arizona until 2009, where it is currently restricted to the east-central mountains. Over time the disease will have a major impact on white pines in the Sacramento Mountains and some other parts of the Southwest.

Figure 1. Adult spruce aphid

The second species introduced in the region is spruce aphid, *Elatobium abietinum*. This was first reported in 1976 on an ornamental tree in the city of Santa Fe, New Mexico, and in a natural forest setting in the late 1980s. Its distribution extends from the San Francisco Peaks in northern Arizona, to the Sacramento Mountains of southern New Mexico. The damage caused by this insect in the

Southwest is much greater than that observed elsewhere in the United States, which may be due to variations in the insects' behavior. Research in the Southwest found that spruce aphid populations increase in the fall, have a sexual life cycle, and a greater cold-hardiness, all factors that may be contributing to the insect's success.

Figure 2. White pine blister rust on ribes

The Animal and Plant Health Inspection Service (APHIS) is responsible for regulating the movement of plants and plant materials that may carry pest organisms, and for detection and eradication of new pest introductions. The USDA Forest Service, the Bureau of Indian Affairs, and other Federal land managing agencies are responsible for reducing the impact of invasive exotic plants on lands they manage. Despite the efforts, we expect increased introductions of nonnative 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 and national trade. Early detection and rapid response are important to minimizing invasive species establishment and subsequent resource damage.

References: 14, 57, 106

Guide to Forest Insects and Diseases[1]

Damage confined to leaves, buds and shoots:

[1] *Adapted from "Insects and Diseases of Alaskan Forests" (Holsten et al., 2001)*

Damage primarily on cones and seeds:

Galls Caused by Insects. Abnormal, misshapen, swollen, or spherical growth in the cones or seeds. Insect larvae or frass present inside the galls. --99

Moths and Midges. External evidence of insect activity is difficult to see. Galleries are small in diameter and are commonly found within the cone axis, cone scales, and seeds. Boring dust is reddish to light brown and fine. ---94

Cone Rust. Enlarged cones on Chihuahua pine, with orange spores under papery outer covering. -----------------------------------175

Damage confined to branches and stems:

Witches' Brooms. Prolific sprouting of adventitious buds on branches infected with mistletoe or fungi.

Needles retained on those caused by dwarf mistletoe. ----177

Needles cast on those caused by fungi, only to reappear the next year. ---123

Cankers and/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. -----------------------147

Strips or sections of bark removed by animals, fungi follow wounding. ---213

Stem Decay. 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. ---132

Bark Beetles. Insect activity characterized by boring dust and/or 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. ---55

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. ------------------------------87

Abiotic Disorders. Globe-shaped, large, woody growths or swellings on branches or stems of ponderosa and various hardwoods (burls). --212

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. ---189

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 of the windstorm; signs of disease agents may be present (e.g. root disease). ---209

Noninfectious 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 similar to damage by root disease. Fruiting bodies of pathogenic fungi usually absent, but weakly pathogenic and saprophytic fungi (those restricted to dead tissues) and secondary insects may be present. ----------------------204

Forest Insect Defoliators

Defoliating insects damage trees by eating leaves or needles, removing the photosynthetic tissue critical for plant maintenance and growth. A significant loss of leaves or needles results in growth loss, increased susceptibility to attack by other insects and pathogens, and sometimes tree mortality.

The impact of defoliation on individual trees is dependent on a variety of factors. Tree species vary in their tolerance to defoliation. In general, hardwood species can sustain repeated defoliation events over several years because they store large food supplies and can refoliate in the same year. The timing of the defoliation relative to seasonal growth phenology is also important. For example, late season defoliation of hardwoods has a lower impact than does late season defoliation of conifers. A single late season defoliation of pines often results in tree mortality. Trees that are healthy and growing vigorously will generally survive defoliation better than stressed trees.

Historically, the two most destructive defoliators in the Southwestern Region were the western spruce budworm and the Douglas-fir tussock moth. Both of these defoliators can cause severe growth loss, top-kill, increase susceptibility to bark beetles, and cause outright tree mortality. Other defoliators are observed, but are not typically as widespread. Beginning in the early 1990s, the exotic spruce aphid and the native Janet's looper caused high levels of mortality in the spruce-fir forest type in the White Mountains and Pinaleño Mountains of Arizona. Two different looper species have been observed in the Sacramento Mountains of southeastern New Mexico in the early 2000s, causing tree mortality in the mixed conifer and subalpine fir types.

Many other defoliating insects that have the potential to cause localized problems are not included in this guide. Consult Federal or State forest health personnel for assistance on insects not described in this guide.

References: 41, 68, 73, 109

Western Spruce Budworm
Choristoneura freemani (Razowski)
(*C. occidentalis* Freeman)

Hosts: Douglas-fir, true firs, and spruce

Symptoms/signs: Adults are a mottled orange brown and have a wing span of 22 to 28 mm. Eggs are white to light green in color and are laid in shingle-like masses on the underside of needles. Newly hatched larvae are cream colored with brown heads. Full-grown larvae are 25 to 32 mm long with brownish head and body and prominent ivory colored spots. Pupae are 12 to 16 mm long, broad at the head and tapering toward the tail. Signs of feeding include current foliage being partially or fully chewed over the entire tree; expanding buds mined and evidence of feeding on second and third year shoots possible; and shoots webbed into feeding shelters giving the tree a reddish-brown appearance.

Figure 3. Adult western spruce budworm with pupal case.

Figure 4. Egg mass of western spruce budworm on underside of needle. Note shingle-like feature.

Biology: Eggs are laid in July and August and hatch in about 10 days. The initial larvae do not feed, but spin silken shelters (hibernacula) under bark scales or lichens where they will hibernate. The next spring larvae mine old needles until the buds swell and then bore into the buds and feed on the expanding needles. Later they web the growing tips together and feed on the new needles. The larvae pupate in June and July. Adults begin to appear in July and start egg laying for the next generation.

Figure 5. Late instar larva of western spruce budworm feeding on foliage.

Effects: Defoliation by western spruce budworm can cause growth loss after 1 or 2 years. Repeated heavy defoliation (4 or 5 years) can cause a significant decrease in growth, tree deformity, top-killing, and ultimately tree mortality, particularly in seedlings and saplings.

Figure 6. Defoliation of Douglas-fir tree caused by western spruce budworm.

Similar Insects and Diseases: The white fir needleminer, *Epinotia meritana*, feeds inside the needles of true fir. Mined needles are a bleached yellowish color and do not have a chewed appearance. The mature larvae are much smaller (8mm) than western spruce budworm and yellowish green to cream colored. The adult moths have wings that are dusty gray with alternating bands of dark scales. Wing spread is 11 mm. Repeated defoliation by white fir needleminer can cause branch mortality, deterioration of tree crowns and increased susceptibility to fir engraver.

References: 20, 24

Figure 7. Near view of western spruce budworm defoliation to Douglas-fir.

Forest Insect Defoliators

Douglas-fir Tussock Moth
Orgyia pseudotsugae **(McDunnough)**

Hosts: Douglas-fir, white fir and spruce

Symptoms/signs: The caterpillar of the Douglas-fir tussock moth is grayish with brightly colored tufts of hair and a shiny black head. There are also two long horns of black hairs behind the head and another at the rear of the body. In the Southwest, feeding often causes severe or nearly complete defoliation, which often leads to top kill or tree mortality. Small cocoons and egg mass cases are attached to the underside of twigs and branches.

Figure 8. Adult male (left) and female (right) Douglas-fir tussock moth.

Figure 9. Adult female Douglas-fir tussock moth on egg mass. Note that female moth is wingless.

Figure 10. Egg mass and early instar larvae of Douglas-fir tussock moth.

Biology: Eggs hatch from mid-May to early June and caterpillars feed on the current year's developing foliage. Young larvae are 4 to 7

Forest Insect Defoliators

Figure 11. Douglas-fir tussock moth late instar larva (a) and pupa (b).

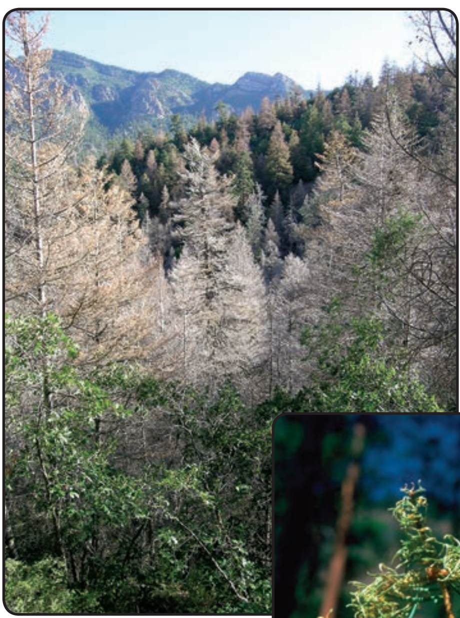


Figure 12. Douglas-fir tussock moth-caused damage to white fir in the Sandia Mountains, New Mexico.

Figure 13. Near view of Douglas-fir tussock moth-caused damage.

mm long and covered with long, thin body hairs that later develop into tufts. Because the female moth is wingless, the primary means of dispersal from tree to tree is by windblown larvae. Young larvae congregate on the tops of defoliated trees and drop by silken threads that may be over 3 meters long. These threads eventually break from the tree and give a ballooning effect to the larvae. Mature larvae are about 20 to 30 mm long with a gray or brown body and a shiny black head. Two long hair pencils project forward from behind the head and another occurs at the rear of the body. Four tufts of brown or cream-colored hairs and red spots occur on the first four and last abdominal segments. Some people develop an itchy rash from exposure to the frequently airborne caterpillar hairs. After the caterpillars are about half-grown, they feed on all age classes of needles throughout the crown. Pupation occurs inside a thin, silk cocoon spun on the undersides of branches from late July to the end of August. Adults emerge shortly afterwards and the flightless female deposits egg masses on twigs and branches.

Effects: Severe outbreaks can cause significant mortality of both overstory and understory trees relatively quickly (1 or 2 years). Top-kill occurs in less severe outbreaks. Bark beetle epidemics can occur in tussock moth defoliated areas.

Similar Insects and Diseases: Early damage and webbing in trees may be similar to that caused by western spruce budworm; however, the larvae are very distinct.

References: 9, 24, 112

Pine-feeding Needleminers
Coleotechnites spp.

Hosts: Ponderosa pine and piñon

Symptoms/Signs: Adults of pine-feeding needleminers are small, narrow-winged, mottled, silvery-gray moths with a wingspan of about 10 mm. Eggs are too small, 0.2 mm in diameter, to be noticeable. Larvae are brown, 8 mm long when fully developed, and usually found mining within current year's needles. The pupae are elongate, cylindrical black, and about 6 mm long. Needles inhabited by third and fourth instar larvae turn a faded yellow-brown in color and have several tiny holes in them for frass disposal and larval exit.

Figure 14. Silhouette of Coleotechnites *larvae feeding inside ponderosa pine needle.*

Biology: Adult moths emerge and fly in June and July. Eggs are laid inside previously mined needles. Larvae begin hatching in July, crawl to and mine into previously uninfested needles and overwinter. Pupation occurs in late spring.

Effects: Persistent infestations can cause severe discoloration, defoliation, and reduced growth of stems, shoots, and needles.

Figure 15. Closeup of needle damage caused by Coleotechnites *feeding on ponderosa pine.*

Similar Insects and Diseases: Similar symptoms, i.e., discoloration and defoliation, can result from scale insects, aphids, and needle cast diseases. However, only the needleminers leave telltale holes in the mined needles.

References: 24, 97

Figure 16. Needle damage caused by Coleotechnites *feeding on ponderosa pine.*

White Fir Needleminer
Epinotia meritana (Heinrich)

Host: White fir

Symptoms/Signs: Larvae mine the needles, resulting in bleached-yellow needles from late spring to early fall. Mature larvae are about 8 mm long, yellowish-green to cream colored, with brown to black heads. Pupae are orange to dark brown, about 5.5 mm in length, and can often be seen protruding from the hole in the mined needle prior to emergence. The adults are 11 mm dusty gray moths. They can be seen swarming around host trees in late June and July.

Biology: The white fir needleminer has one generation per year in New Mexico and Arizona. Eggs are deposited, usually one per needle, in late June and July. Eggs hatch in August and September. Young larvae immediately bore into the needle where they overwinter. As weather warms in the spring, feeding begins. Each larva can mine several 1-year-old needles. Two- and three-year-old needles are also mined during outbreak conditions when insect populations are high. Two to six needles are usually webbed together

Figure 17. Defoliated white fir caused by the white fir needleminer.

Figure 18. Closeup of white fir needleminer defoliation to white fir.

and remain on the tree for the duration of the summer. Pupation occurs within the last mined needle in June or early July. Adult moths emerge in 10 to 14 days after pupation. Mating occurs within 2 to 3 days of emergence.

Effects: After several consecutive years of heavy defoliation, a high proportion of limb mortality and widespread tree mortality may occur. This can give individual trees or even entire stands a silvery appearance. These heavily defoliated stands decline in vigor and may be predisposed to attack by fir engraver beetle.

Similar Insects and Diseases: Similar defoliation may be caused by western spruce budworm or Douglas-fir tussock moth; however, the larvae of white fir needleminer only mine inside the needles.

References: 24, 110

Pandora Moth
Coloradia pandora **(Blake)**


Figure 19. Adult pandora moth.

Hosts: Ponderosa pine

Symptoms/Signs: Adult pandora moths are very large and heavy bodied, about 2.5 to 4.0 cm long, with a wingspread of 7 to 11 cm. The forewings are brownish gray and hindwings are light pinkish gray, each marked with a black dot and a dark wavy line. The males are distinguished by having large, feathery antennae. The globular eggs, bluish green to bluish gray, are deposited in clusters of 2 to 50. Early instar larvae are about 5 mm long. They have shiny black heads and black to brownish bodies that are covered with short, dark hairs. Fifth instar larvae grow to about 6 to 8 cm long and are brown to yellowish green. Pupae are dark purplish brown, 2.5 to 3.5 cm long, and have a tough shell.


Figure 20. Early instar larva of pandora moth.

Biology: The pandora moth has a 2-year life cycle. Adults emerge between late July and late August. The moths mate and females deposit their eggs within a few days. The egg stage lasts at least 40 days and most larvae emerge in October. Larvae are gregarious and extremely cold hearty. They feed in groups on the foliage on warm days throughout the winter. Fifth instar larvae leave the host trees in late June and enter


Figure 21. Late instar larva of pandora moth.

the ground where they pupate. They remain in the pupal stage for the next 12 to 13 months.

Effects: During outbreaks, defoliation can be severe over large areas. Due to the 2-year life cycle, however, defoliation occurs only during alternate years. Outbreaks on the Kaibab Plateau have

Figure 22. Pupae of pandora

Figure 23. Defoliation of ponderosa pine caused by pandora moth on the Kaibab NF, Arizona.

subsided without causing any lasting damage. However, some growth loss and even mortality can occur especially if trees are severely stressed from additional factors such as drought or heavy dwarf mistletoe infections.

Similar Insects and Diseases: May be confused with sawfly larvae and defoliation. However, sawfly larvae have smooth bodies, are smaller, 18 to 25 mm long, and have eight pairs of leg-like appendages on the abdomen. Defoliation caused by sawflies usually occurs on an individual or small group of trees and is not widespread like that of a pandora moth outbreak.

References: 10, 24, 86

Pine Butterfly
Neophasia menapia (Felder and Felder)

Host: Ponderosa pine

Symptoms/signs: Newly hatched pine butterfly larvae are gregarious feeders on older foliage and then move to the new foliage as they mature. Mature larvae are approximately 2.5 cm long, dark green in color and have light green heads. The body is covered with fine hairs and has two white lateral stripes on the side. Adult moths are white with black markings.

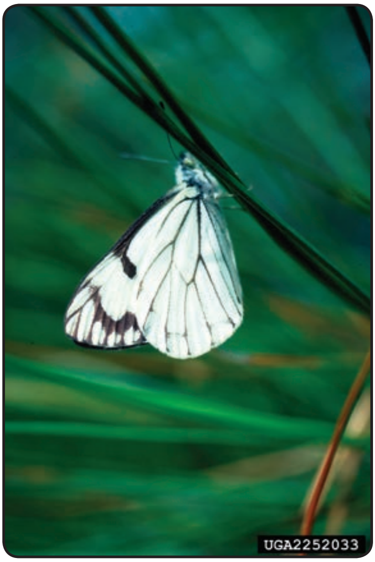


Figure 24. Adult pine butterfly.

Biology: Adults fly and lay their green eggs from July through October. The eggs overwinter and the larvae hatch the following June or about the time new foliage appears. The small larvae feed in clusters with their black heads oriented toward the tip of the needle. As the larvae mature they feed singly. They pupate in July for approximately 15-20 days.

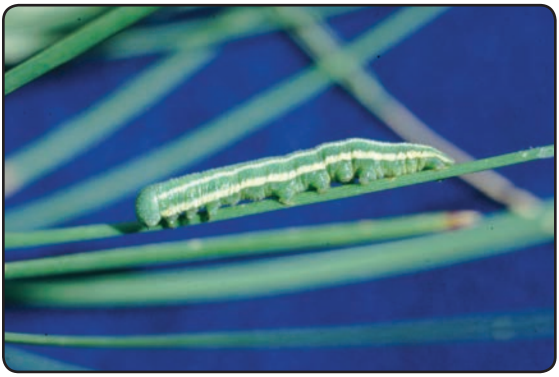


Figure 25. Larva of pine butterfly.

Effects: This insect has caused spectacular defoliation in the Pacific Northwest, however, it causes little defoliation in the Southwest.

Similar Insects and Diseases: The pine butterfly adult resembles the common cabbage butterfly. In addition, the young larvae feeding in groups may be confused with other gregariously feeding larvae such as sawflies. These would include *Neodiprion* spp. and *Zadiprion* spp. of sawflies. Pandora moth is also a defoliator of ponderosa pine. This insect has a 2-year life cycle. Mature larvae are distinctly larger, brown to yellowish green in color and possess stout, branched spines on each body segment.

Figure 26. Pupa of pine butterfly.

Reference: 24

Pine Sawflies
Neodiprion spp., *Zadiprion* spp.

Hosts: Ponderosa pine, piñon

Symptoms/signs: Pine sawfly larval appearance varies by species and by larval instar, but most are green or yellowish green in color with black, tan or orange head capsules. Larvae are found in either spring-summer or fall-winter feeding gregariously on older foliage, consuming only the outer needle tissue while leaving the central ribs intact. The central ribs later turn yellow brown and break off. Later instar larvae feed singly and consume most of the needle. Eggs are laid in slits cut in the edge of living pine needles. A papery cocoon covers the pupae. Adults are broad waist wasps. Infested trees have sparse foliage and thin crowns.

*Figure 27. Adult female pine sawfly (*Neodiprion *spp.) ovipositing on ponderosa pine.*

Figure 28. Needle with row type egg cluster and newly hatched pine sawflies on ponderosa pine.

Figure 29. Late instar of Neodiprion gillettei *feeding on ponderosa pine.*

Effects: Eight species of sawflies infest pines in the Southwest, five of those are found on ponderosa pine. Different species have different preferences for the size of host attacked, and location on the host where they feed. Pine sawflies in the Southwest typically attack open-grown trees or areas where pine is growing at a low density. The same trees are frequently defoliated year after year. In general, defoliation causes slower growth. Repeated defoliation can result in top-kill and tree mortality.

Similar Insects and Diseases: See pandora moth and pine butterfly.

References: 12, 19, 24, 64, 67, 69

Figure 30. Zadiprion rohweri *larvae on piñon pine. Note the regurgitated resin droplets that are used as a defense mechanism against attacking predators and parasitoids.*

Figure 31. Late instar larvae of Zadiprion townsendii *feeding on ponderosa pine.*

Figure 32. Pine sawfly defoliation of ponderosa pine needles showing both early and late instar feeding.

Tiger Moth
Lophocampa ingens (Edwards)
(=Halisidota ingens)

Hosts: Ponderosa pine, white pines, and piñon

Symptoms/Signs: Larvae feed on foliage and make large silken webs (tents) in the upper branches of host pines. Mature caterpillars are about 4 cm long, reddish brown to black in color and have tufts of black and yellow hairs on their back. Adult moths have dark forewings with large, white splotches and white hindwings.

Figure 33. Adult tiger moth.

Figure 34. Larvae of tiger moth.

Biology: The tiger moth has one generation per year in the Southwest. Adult moths emerge and lay eggs in August. During September and October caterpillars hatch from eggs, begin feeding on pine needles and producing webbing. Larvae overwinter in the webs in groups. In April and May, larvae resume feeding and expand their webs. At this point the insects and the webs become very noticeable. In June pupation occurs.

Tiger moths are also found feeding and forming tents on Douglas-fir and white fir during outbreaks.

It is believed that populations of this insect usually remain at low levels due to the action of predators, parasites, diseases, and cold winters.

Effects: Larvae feed gregariously in webs primarily on young piñon and ponderosa pine. Although the webs and larvae can be very noticeable in spring, this insect causes minor defoliation. Permanent tree injury rarely results from feeding that is usually limited to the upper foliage.

Figure 35. Tents and damage of ponderosa pine caused by tiger moth.

Similar Insects and Diseases: Tents are similar to those formed by tent caterpillars such as the western tent caterpillar; however, *L. ingens* is the most common moth to make large tents on piñon, ponderosa, and white pines. Another species of tiger moth, *L. argentata subalpina,* feeds primarily on juniper and occasionally on piñon in the Southwest.

References: 24, 105

New Mexico Fir Looper
Galenara consimilus (Heinrich)

Hosts: Douglas-fir and white fir

Symptoms/Signs: Larvae feed on the foliage often stripping its host of needles. The immature stages of this insect have not been described. The forewings of the adults are light gray overlain with grayish-brown and brownish-black scales.

Figure 36. Larva of New Mexico fir looper.

Biology: Little is known about the biology of this insect. Outbreaks of this occasional pest occurred in 1924, 1928, 1951, 1958, 1974, 1977, and 2002 in New Mexico, the only state in which this insect is known to occur.

Effects: This insect can cause heavy defoliation of Douglas-fir and white fir resulting in growth loss and top-kill. Several years of heavy defoliation can result in high levels of tree mortality.

Figure 37. Damage of fir caused by New Mexico fir looper.

Reference: 24

Figure 38. Near view of damage of fir caused by New Mexico fir looper.

Janet's Looper
(*Nepytia janetae* (Rindge))

Figure 39. Adult Nepytia janetae.

Figure 40. Larva of Nepytia janetae.

Hosts: Engelmann spruce, corkbark fir in Arizona; Engelmann spruce, corkbark fir, Douglas-fir, ponderosa pine, and southwestern white pine in New Mexico

Symptoms/signs: The taxonomic status of this species is uncertain as there is considerable variation in body coloration and host feeding between Arizona and New Mexico. Studies are attempting to determine if there are two separate species or two subspecies. Larvae feed on foliage, chewing needles of all ages. Early instar larvae scrape or score the outer surface of needles, while later instars consume, partially consume, or clip needles. Partially consumed or clipped needles accumulate beneath defoliated trees. Mature caterpillars are approximately 2.5 cm in length. The upper surfaces of larvae are gray with dark brown and green markings in a herringbone pattern and with irregular pale cream lateral stripes. The head capsule is mottled with a distinct black stripe above the mouthparts. Larvae can be seen in the foliage, hanging from silken threads, beneath the tree on ground or snow and climbing up the bole of the tree. Adults are small light gray moths that can be seen flying singly through the woods or flying in large numbers around the tops of host trees. Pale green (Arizona) to mottled brown and cream (New Mexico) colored pupa can be seen on the foliage wrapped in webbing.

Biology: *Nepytia janetae* has one generation per year. Adults appear in late June, peak flight is reached in early July.

Eggs hatch in late September. Larvae feed throughout winter and spring. Soome larvae are present until early July and there can be considerable overlapping of life stages.

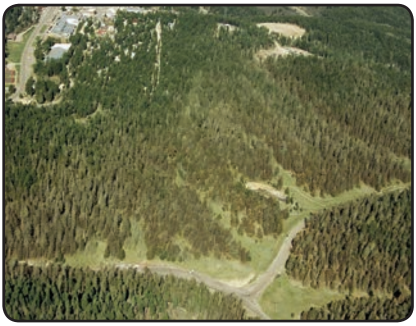


Figure 41. Defoliation of mixed conifer trees by Nepytia janetae *near Cloudcroft, New Mexico.*

Effects: Outbreaks develop rapidly, last 2 to 3 years, and collapse due to starvation, parasites, and disease. During outbreaks, heavy defoliation results in growth loss and, with multiple years of defoliation, tree mortality. Mortality can be due to defoliation alone or due to secondary infestation by bark beetles. This insect caused extensive damage and mortality to spruce and corkbark fir in the White Mountains and Pinaleño Mountains of Arizona in the late 1990s. Associated spruce beetle mortality occurred only in the Pinaleño Mountains. During the mid-2000s, an outbreak also occurred in the mixed conifer forest type of the Sacramento Mountains, New Mexico. All conifer species in the impacted area were defoliated.

Figure 42. Partially consumed white fir needles by Nepytia janetae.

Similar Insects and Diseases: See New Mexico fir looper. Another species of looper (Mountain girdle, *Enypia grisiata*) has caused heavy defoliation to spruce-fir in the White Mountains of Arizona. Similar insects in other regions (e.g. western hemlock looper and western false hemlock looper) have not been observed in the Southwest.

References: 57, 81

Fall Webworm
***Hyphantria cunea* (Drury)**

Figure 43. Adult and pupa of fall webworm.

Hosts: Willow, alder, ash, chokeberry, cottonwood, madrone, and walnut

Symptoms/signs: Larvae feed on foliage, forming large webs in the branches of trees. Webs are noticeable in the fall when larval feeding takes place. There are two races: a blackheaded or northern race and a redheaded or southern race. Larvae of the southern race are yellowish-tan with red or orange colored heads and brownish hair that arises from reddish-brown tubercles. Larvae of the northern race have a black head with a pale yellowish or greenish body that has a dark stripe on the back, and long white hairs rising from red or black tubercles. The black-headed race predominates in the West. Adults are white in color with orange markings on the body and legs. The wings have some black spots and a wing expanse of approximately 30 mm.


Figure 44. Larva of fall webworm.

Biology: Fall webworm has one generation per year. Adults appear and lay eggs in late June and early July. The eggs hatch and the small larvae feed on both leaf surfaces while larger larvae will consume the whole leaf. Larval feeding continues until mid-September. The insect overwinters in the pupal stage in a transparent cocoon in the soil, leaf litter, or on tree trunks.

Effects: This insect causes minor defoliation in most forested situations. It can cause loss of visual quality in ornamental plantings.

Similar Insects and Diseases: The western tent caterpillar is sometimes confused with the fall webworm, due to both having dark heads and dark stripes down their backs. However, the western tent caterpillar feeds in the spring while fall webworm feeds in the fall.

References: 16, 24

Figure 45. Webbing and feeding damage on Arizona walnut by fall webworm.

Western Tent Caterpillar
Malacosoma californicum **(Packard)**

Figure 46. Adult western tent caterpillar and egg mass.

Hosts: Aspen, willows, cottonwoods, and mountain mahogany

Symptoms/signs: Western tent caterpillar is an early season defoliator with feeding damages typically occurring between May and June. Symptoms include moderate to complete defoliation of trees; large silken tents on branches; and presence of larvae in and around the tents. Trees repeatedly defoliated will have sparse foliage, minor branch dieback, and in some cases, tree mortality.

Mature larvae are 4 to 5 cm long and vary widely in coloration. Their heads are blue to black and body color patterns are mixtures of black, orange, and blue. Larvae are usually quite hairy.

Biology: Larvae overwinter as first instars inside egg masses glued around twigs. Larvae emerge from egg masses in spring and construct silken tents on branches that are used for shelter and molting during the daytime. At night, caterpillars feed outside of the tents. As the larvae mature, they disperse and become solitary feeders. Moths emerge from cocoons and following mating, glue egg masses to live twigs that are less than 2 cm in diameter.

Figure 47. Larva of western tent caterpillar.

Effects: Heavy defoliation of aspen for a number of years will cause growth loss and branch dieback. Some mortality may also occur during prolonged outbreaks. Outbreaks, however, are generally short lived, generally lasting 2 to 3 years.

Similar Insects and Diseases: See fall webworm, large aspen tortrix and foliar diseases of aspen.

References: 3, 16, 24

Figure 48. Tent of western tent caterpillar on aspen.

Figure 49. Western tent caterpillar larvae and defoliation of aspen on the Carson NF, New Mexico.

Large Aspen Tortrix

Choristoneura conflictana **(Walker)**

Host: Aspen

Symptoms/Signs: Presence of flat egg masses on the upper surface of foliage, partially eaten rolled-up leaves in which small, green to black larvae are feeding or pupating, incomplete defoliation before the buds have expanded in the spring.

Figure 50. Adult large aspen tortrix.

Biology: Pale green egg masses are laid in large, flat masses on the upper surfaces of the foliage in June and July. Second-instar larvae overwinter in silken hibernacula in bark crevices and other out-of-the-way places. The small larvae begin to migrate up the stems of aspen on warm days in early spring. The larvae mine the buds, sometimes causing complete defoliation before the buds open. Later stage larvae roll the leaves into shelters within which they feed and eventually pupate. The moths have a wingspread of 25 to 30 mm. The forewing

Figure 51. Closeup of damage caused by large aspen tortrix and larva.

is grayish with basal, middle, and outer brownish patches. There is one generation annually.

Effects: During outbreaks, this insect can completely defoliate aspen stands. Outbreaks characteristically last 2 to 3 years and can result in growth loss and some twig and branch dieback.

Similar Insects: Larvae and pupae are similar to those of the western spruce budworm. However, the larvae of the large aspen tortrix are green to grayish-black with a black head capsule while the western spruce budworm larvae are white to grayish-tan with a tan head capsule and feed on Douglas-fir, true firs, and spruce.

References: 4, 24

Figure 52. Large aspen tortrix defoliation of aspen in Colorado.

Alder Flea Beetle

***Macrohaltica ambiens* (LeConte = Altica ambiens)**

Figure 53. Adult alder flea beetle.

Hosts: Alder

Symptoms/signs: Larvae are skeletonizers, meaning that they feed on the tissue between the veins, but leave the veins intact. Adults chew holes in the leaves. Adult beetles are dark shiny blue, and about 5 mm long. The mature larvae are a little longer and narrower than the adults, brown to black above and yellowish below.

Biology: One generation is reported per year. Adults hibernate during the winter in duff at the base of trees and in other sheltered places. They emerge in early spring to resume feeding. Eggs are laid in clusters on foliage. Larvae hatch and begin feeding within a few days. One source reports that larvae mature in August; but in the Southwest they mature earlier in the season.

Figure 54. Early instar larvae of alder flea beetle on underneath side of alder leaf.

Effects: No long-term effects are documented. Outbreaks are generally short lived and sporadic with heavy defoliation. Trees tend to recover quickly.

Similar Insects and Diseases: Although other defoliators feed on alder, outbreaks of these other insects have not been reported.

References: 24, 46

Figure 55. Late instar larvae of alder flea beetle on defoliated alder leaves.

Figure 56. Defoliation of alder caused by alder flea beetle in Arizona.

Sap-Sucking Insects, Gall Formers and Mites

The majority of sap-sucking insects are in the orders Hemiptera (true bugs) and Homoptera (aphids, leaf and plant hoppers, and scales). Most of these insects are relatively small in size and injure the host in two ways: (1) directly by sucking 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 mistaken as a pathogen induced disease. A few of the sap-sucking insects are able to kill their hosts outright, but most reduce growth rates and weaken the tree. Trees injured by these insects may succumb to secondary insects or fungal diseases. Signs of sap-sucking insect injury consist of enlarged growths or galls, leaf curling, bleaching, or yellowing of foliage. Conifers are more severely injured than hardwoods.

In the Southwest, there are several sap-sucking insects that cause noticeable damage to trees and shrubs, but they have not affected forests at the landscape scale. Their impacts are typically more important to shade trees and ornamentals. However, a spruce aphid, *Elatobium abietinum*, has been severely impacting spruce forests and ornamentals in some areas of the Southwest since the 1990s.

Use of a hand lens will help in detection and identification, as these organisms are quite small.

References: 24, 41

Sap-Sucking Insects, Gall Formers and Mites

Aphids
Aphidida

Hosts: Hardwoods and conifers, particularly ponderosa pine and spruce.

Symptoms/signs: The best evidence of infestation is the insects themselves or shiny leaves from the honeydew. Honeydew is a clear, sugary, sticky liquid that aphids excrete as they feed. It accumulates on the foliage, twigs, trunk and ground. Honeydew attracts ants, and often the presence of ants on a tree may indicate that aphids are there. It is also a good growth medium for sooty mold, which grow on affected portions of the tree. Aphids are small soft-bodied gregarious insects. Adults may be winged or wingless. Nymphs are wingless. They vary in color by species, but may be nearly colorless to green to black.

Figure 57. Cinara aphids on pine host.

Figure 58. Eggs of aphids on pine needle.

Biology: Typically aphids produce several generations per year, most are parthenogenetic. The last generation is usually sexual, and then winter is spent in the egg stage. Different aphids feed on different parts of their hosts, including the foliage, twigs, trunk, and roots. All aphids have piercing mouthparts that they use to feed on sap from their host plants.

Effects: Feeding can result in formation of small necrotic spots. Heavy feeding by some species can cause early leaf drop, yellowing of foliage, and reduced growth. In general, these insects are not considered economically important in forest situations. In urban areas, the honeydew can accumulate on walkways and vehicles and attract the attention of the public.

Similar Insects and Diseases: Damage caused by aphids may resemble that caused by needle midges, other sucking insects, or needle diseases.

Reference: 24

Figure 59. Aphid damage to conifer host.

Sap-Sucking Insects, Gall Formers and Mites

Spruce Aphid
Elatobium abietinum (Walker)

Hosts: Engelmann spruce and blue spruce

Symptoms/signs: The spruce aphid is a small green, soft-bodied insect about 1 to 1.5 mm in size. Both winged and wingless forms occur. Spruce aphids feed by inserting their needle-like mouthparts into host foliage and sucking the sap from the needles. First symptoms of feeding are yellow patches on the needles. If the population increases, discoloration intensifies and affected needles turn brown and drop prematurely.

Figure 60. Adult spruce aphid.

Biology: Like other aphids, the spruce aphid bears live young with females producing females. Nymphs mature within 3 weeks. During favorable years, large colonies develop during the winter and feed during mild periods. Populations reach a low point during the summer and may be very difficult to find. In the fall, aphids may reappear and begin feeding on the current year's foliage. Greatest population increases generally occur from late winter into early spring in northwestern North America and Europe, however, the highest population densities in the Southwestern United States occur in the fall.

Effects: Since populations decline prior to needle flush in late spring and early summer, the new foliage is unaffected by the overwintering population of aphids. Current year's foliage is not affected until aphids begin building up again in the fall. Defoliation is usually partial, but in some outbreaks trees are completely defoliated. Heavy defoliation can result in tree mortality, especially if trees are also infected with dwarf mistletoe. All age classes of spruce are infested. Outbreaks are sporadic, usually short-lived, and associated with dry winter and spring conditions (i.e. outbreaks begin in the fall).

References: 55, 56, 58, 114

Figure 61. Spruce aphid defoliation of Engelmann spruce on the White Mountains, Arizona.

Figure 62. Closeup of defoliation caused by spruce aphid.

Sap-Sucking Insects, Gall Formers and Mites

Cooley Spruce Gall Adelgid

***Adelges cooleyi* (Gillette)**

Hosts: Spruce and Douglas-fir

Symptoms/signs: Cone-like galls, 12-75 mm long, are formed on spruce branch tips as a result of feeding by the nymph stage of this insect. In late spring, galls are light green to purplish in color and the nymphs may be found inside. In late summer and fall, galls dry up and open and the nymphs emerge, flying to Douglas-fir to complete the next phase of their life cycle. The galls may persist on the branches for several years.

Figure 63. Galls on spruce caused by Cooley spruce gall adelgid.

On Douglas-fir the insect feeds on the sap of new needles, new shoots, and developing cones. Nymphs are oval and black with a white waxy fringe. Adults are dark brown and covered with white, wooly wax. Feeding on Douglas-fir does not cause galls to form but rather yellowing and twisting of the needles.

Figure 64. Cross section of gall showing nymphs of spruce gall adelgid on spruce.

Figure 65. Waxy filaments (“cotton”) created by Cooley spruce gall adelgid on Douglas-fir branch.

Biology: The entire life cycle requires 2 years. There are six stages in addition to the eggs and crawlers when both host trees are present.

Effects: This insect has a very complex life cycle involving two hosts, spruce and Douglas-fir. On spruce, galls are unimportant in forest situations. However in nurseries, plantations, and on ornamentals, galls are a concern since they kill branch tips and can stunt and deform trees.

On Douglas-fir, infested needles turn yellow and become twisted. Heavy infestations on poor sites result in defoliation.

Similar Insects and Diseases: Damage on Douglas-fir is similar to that caused by needle midges or needle cast.

Reference: 24

Sap-Sucking Insects, Gall Formers and Mites

Pinyon Needle Scale

Matsucoccus acalyptus **(Herbert)**

Host: Piñon

Symptoms/Signs: Pinyon needle scale is most easily recognized by finding cotton looking egg masses in spring, black bean-shaped nymphs in fall, or emerged adults in April.

Figure 66. Adult pinyon needle scales appear like small, dark, bean-shaped objects on piñon needles. Piñon needles damaged by pinyon needle scale have a chlorotic (yellow) appearance.

Biology: Adults emerge during middle to late April. Adult females are wingless and flightless and males are winged. After mating, females lay clusters of yellow eggs covered with white, cottony webbing around the root collar, undersides of branches, branch crotches, or crevices in rough bark. Sometimes egg masses are found several meters away from piñon trees on a rock or log. Crawlers emerge about 5-6 weeks after eggs are laid. They climb to the ends of branches and settle on the previous year's new growth. After inserting their piercing sucking mouthparts into a needle, they become immobile. The body becomes covered with wax and turns black in color. This occurs in the Southwest by early June. By October, the larva resembles a small black bean 1.5 mm long. They overwinter in this stage.

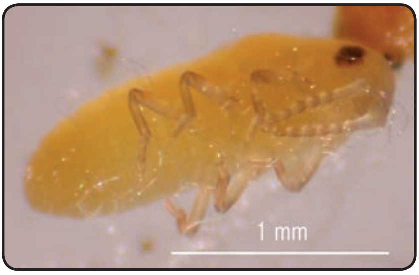


Figure 67. Crawler stage of pinyon needle scale.

Figure 68. Egg masses of pinyon needle scale which are found at or near the base of infected piñon.

Effects: Infestations can cause needles to yellow and drop. Repeated attacks cause reduced new growth and stunted needles. In severe outbreaks, small trees may be killed outright and larger trees can be predisposed to attack by bark beetles.

Similar Insects and Diseases: Symptoms of needle scale may look similar to needle cast caused by fungi, but fruiting bodies will be embedded in needles rather than external.

References: 8, 24

Figure 69. Damaged piñon caused by pinyon needle scale.

Sap-Sucking Insects, Gall Formers and Mites

Prescott Scale

***Matsucoccus vexillorum* (Morrison)**

Host: Ponderosa pine

Symptoms/signs: The most noticeable symptom is the appearance of branch flagging in spring. Upon closer inspection old egg masses can often be found on flagged twigs, often at branch nodes.

Biology: In April and May, flightless but mobile females and winged males emerge from overwintering pre-adults. Following mating, eggs are laid, often at branch nodes. Eggs are laid in groups, covered with a fluffy white wax, which makes them look like tiny cotton balls. During May and June first stage larvae, called crawlers, settle in temporary feeding spots. The second stage larvae settle in permanent feeding locations in July and August. They feed beneath scales at the base of needles and in cracks and crevices of twigs, particularly around the first and second nodes. During fall the third or pre-adult stage develops and then overwinters. The life cycle is completed in 1 year.

Affected twigs exhibit lesions, brownish areas in the phloem. A fungus, *Cenangium* spp., is sometimes associated with the lesions.

Apparently the principal factor in natural control is branch dieback. Few natural enemies have been found outside of a species of ladybird beetle and a green lacewing.

Figure 70. Waxy filaments ("cotton") created by Prescott scale in Arizona.

Figure 71. Branch damage ("flagging") caused by Prescott scale in the White Mountains, Arizona.

Effects: Branch flagging is the most common symptom. It occurs primarily in younger trees, less than 75 years old and is most conspicuous in dense stands. Both lateral and terminal shoots can be affected. Mortality rates averaged 1-2 percent in past outbreaks.

Similar Insects and Diseases: Bark beetles known as twig beetles also cause twig dieback in ponderosa pine. However upon close inspection one can find the galleries of these insects either in the inner bark or the pith of affected branches.

References: 24, 63, 65

Sap-Sucking Insects, Gall Formers and Mites

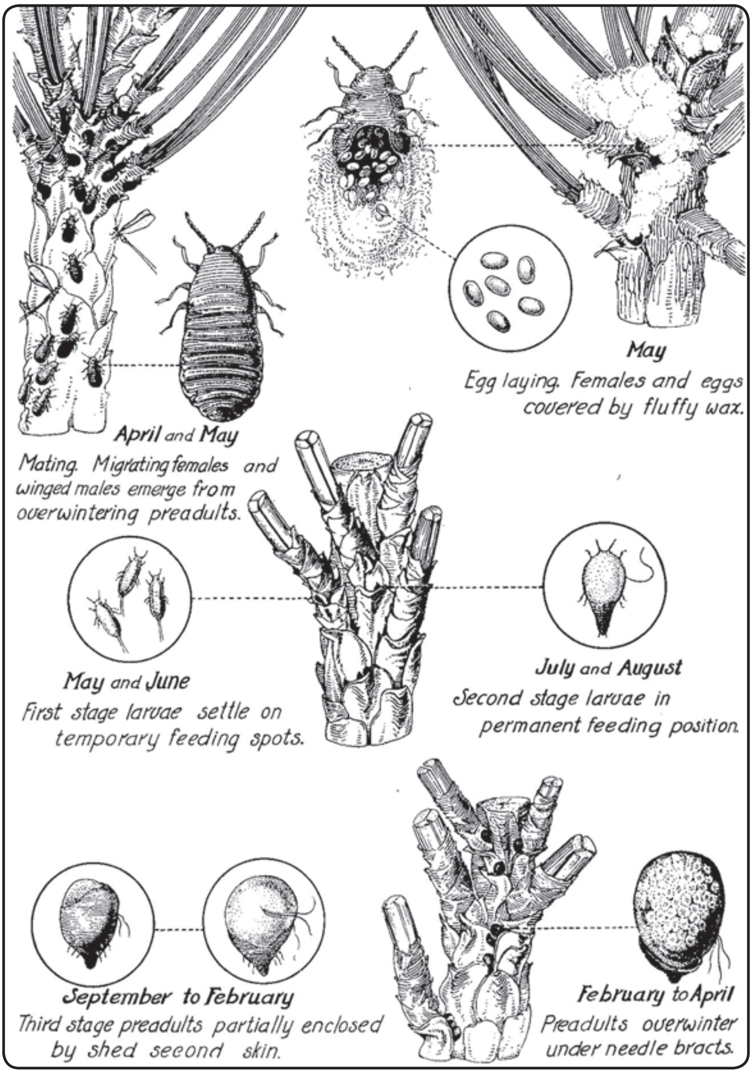


Figure 72. Seasonal life history of Prescott scale.

Pine Needle Scale
Chionaspis pinifoliae (Fitch)

Hosts: Most pines, spruce, Douglas-fir

Symptoms/signs: Damage is especially noticeable on ornamental pine and spruce trees growing along dusty roads. Insects feed by sucking sap from needles, causing the needles to yellow and eventually drop.

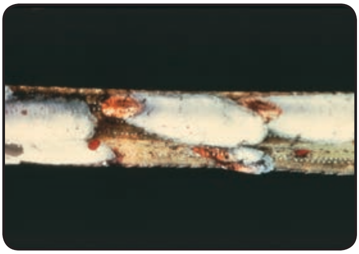


Figure 73. Closeup of pine needle scale.

Biology: The pine needle scale has two generations per year. The 3.5 mm long mature female scales are most conspicuous. They are almost pure white, slender at the front with a wider rear end. Males are smaller and slender and rarely seen. Twenty to 30 eggs are laid in the fall and winter beneath the dead female scale. Eggs hatch in May and the nymphs, or "crawlers", move to new green needles to feed. Nymphs mature by early July, adults mate, and new clusters of eggs are laid. Scales of this second generation mature by fall and lay the overwintering eggs.

Effects: Heavy infestations over several years can kill young trees and severely weaken larger trees, predisposing them to attack by other pests.

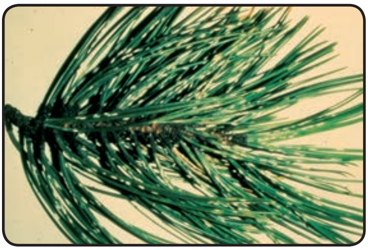


Figure 74. Ponderosa pine branch with pine needle scale.

Similar Insects and Diseases: Damage may be similar to that caused by other agents that discolor needles such as black pineleaf scale, pine needle casts, winter desiccation, drought, and aphids. If scales are present, diagnosis is assured.

References: 8, 33

Sap-Sucking Insects, Gall Formers and Mites

Gouty Pitch Midge
Cecidomyia piniinopis (Osten Sacken)

Host: Ponderosa pine

Symptoms/signs: The first signs of injury are noticeable in early summer when the new shoots start to droop, the foliage turns yellow and the shoot dies. Larvae are red in color and feed in pits under the bark of the current year's shoots, causing twig deformities. Adult midges are small delicate flies, which resemble mosquitoes. They possess long antennae that are beaded in appearance along with a much reduced wing venation.

Figure 75. Closeup of gouty pitch midge damage.

Biology: The gouty pitch midge has one generation per year. Larvae overwinter in pits under the bark. In the spring, they make their way to the surface where they spin cocoons on needles.

Figure 76. Larva and pupa of gouty pitch midge.

Effects: Although yellowing and shoot death can be significant, these effects are not considered to be commercially important in most situations.

Similar

Insects and Diseases: Twig beetle (*Pityophthorus* spp.) feeding may cause similar death of small twigs and branches on pines. In addition, tip moths, ponderosa pitch nodule moths, and shoot feeding weevils (*Magdalis* spp) also cause flagging damage to shoots of young ponderosa pine.

References: 24, 46

Figure 77. Flagging damage to branches of ponderosa pine caused by gouty pitch midge.

Sap-Sucking Insects, Gall Formers and Mites

Pinyon Spindlegall Midge
***Pinyonia edulicola* (Gagné)**

Figure 78. Gall on piñon caused by pinyon spindlegall midge.

Host: Piñon

Symptoms/Signs: Presence of spindle-like swellings at the base of needles that are about 1 cm long with tiny, orange maggots inside.

Biology: Adults lay eggs on needles in late June and early July. Larvae hatch soon afterward and mine into the current year's needles near the base. The plant forms a gall around the feeding larvae. Each gall contains 5 to 40 small, orange legless maggots. The larvae overwinter in the galls and pupate in the spring

Effects: This is a common forest insect that rarely causes serious damage. However, heavy infestations in urban settings cause serious defoliation when needles drop prematurely.

References: 8, 24

Figure 79. Orange-colored maggots of pinyon spindlegall midge.

Sap-Sucking Insects, Gall Formers and Mites

Spittlebugs
Aphrophora spp., *Clastoptera* spp.

Hosts: Oak, juniper, pines, and southwestern dwarf mistletoe

Symptoms/signs: The most conspicuous evidence of infestation is the spittle-like froth that surrounds the feeding nymphs.

Figure 80. "Spit" caused by spittlebug nymphs feeding on pine.

Biology: Adults usually lay eggs just under the bark of twigs in summer. Eggs overwinter and hatch in spring. Nymphs feed on twigs and leaves and cover themselves with spittle. The spittle protects nymphs from drying and discourages natural enemies. Nymphs migrate to foliage in July and August where they transform to adults. Nymphs and adults feed on the sap of their hosts via their piercing mouthparts. The main natural controls include hot, dry weather that can desiccate the nymphs and a variety of natural enemies including wasp and fly parasites, ants, spiders and birds.

Effects: When these insects are abundant, their feeding can cause discoloration and sometimes mortality of infested twigs.

Similar Insects and Diseases: The juniper twig girdler, *Styloxus bicolor*, causes twig dieback and flagging on junipers, but may be distinguished from spittlebugs by looking closely at affected twigs. The twig girdler bores inside the twigs, leaving them hollow inside.

References: 24

Sap-Sucking Insects, Gall Formers and Mites

Spider Mites
***Oligonychus* spp.**

Hosts: Conifers and hardwoods

Symptoms/signs: Spider mites suck plant juices with needle like mouthparts, which cause spotting, yellowing, fading, and premature drop of foliage. When populations are heavy, cast skins, webbed foliage, eggs, and other mite activity can be found. Adult spider mites are tiny greenish to reddish colored arachnids with black heads.

Figure 81. Adult spider mites.

Biology: There can be several generations per year. Spider mites have five stages and all but the egg stage bear legs.

Effects: Spider mites are mainly an ornamental tree problem and often go unnoticed in forested situations. Outbreaks of spider mites generally last 1 year and are kept under control by natural enemies, such as predatory mites.

Similar Insects and Diseases: Aphid feeding can have the same symptoms of yellowing, spotting or fading foliage. Adult aphids have winged and wingless individuals. In general, aphids are larger in size and have three pairs of legs instead of four.

Leaf injury from compounds such as ozone may have similar symptoms such as yellowing, spotting, or fading.

Figure 82. Damage to juniper caused by spider mites.

References: 24, 46

Bark Beetles

Bark beetles are one of the most destructive insects in western coniferous forests. It has been estimated that 90 percent of insect-caused tree mortality and more than 60 percent of the total insect-caused loss of wood growth in the United States is due to bark beetles. In the Southwest, bark beetle killed trees were scattered over more than 2 million acres between 2001 and 2003.

The Southwest has a large complex of bark beetles composed of many genera and species. Frequently, several species are found attacking the same host tree and, therefore, it may be difficult to discern what species initiated the attack. Although species of *Dendroctonus* are the most notorious tree killers in the western United States, *Ips* species also play a very important role in pine forests of the Southwest.

Bark beetles derive their name from their habit of living and mining between the bark and wood of trees and shrubs. Adults excavate egg galleries in bark phloem. All bark beetle life stages are spent in the phloem, inner bark and bark, except when adults leave the tree in which they developed to fly to new host material. Bark beetles feed on the phloem during adult and larval stages.

Most bark beetles are considered secondary mortality agents because they prefer weakened host material. However, during environmental conditions favorable for beetle development, populations may build up rapidly and successfully attack healthy trees. Most bark beetles have a symbiotic relationship with blue-stain fungi. The blue stain fungi can completely penetrate the sapwood within a year. The fungi occlude the outer conducting tissues in the xylem that halts upward water translocation. This action, plus that of the bark beetle feeding, causes the death of a host tree.

Bark beetles produce chemical compounds called pheromones that are used to communicate with other beetles. Aggregation pheromones cause beetles to congregate in certain

Bark Beetles

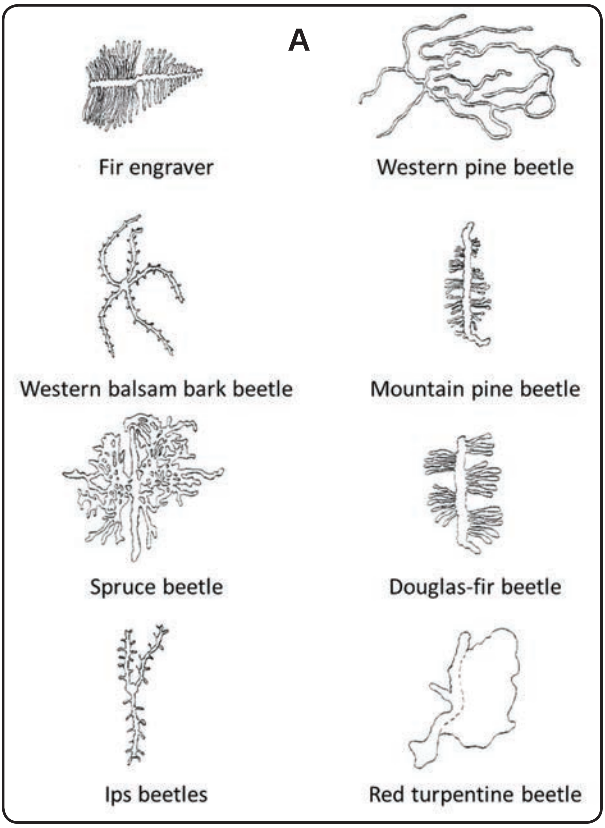
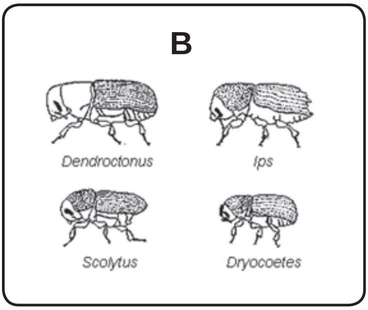
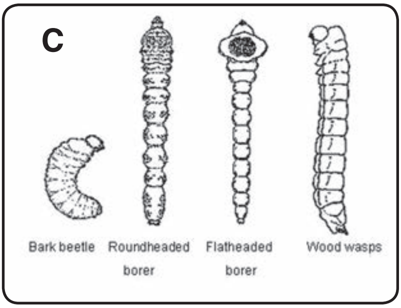


Figure 83. Bark beetle gallery patterns (a), adult beetles (b), and larvae (c) compared with woodborer larvae.





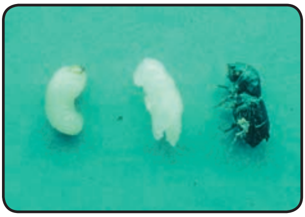


Figure 84. Life stages of bark beetles (adult, pupa, larva).

Figure 85. Adult Arizona five-spined ips *(top) and western pine beetle (bottom). Note differences in the elytral declivity between the species.*

Figure 86. Exit holes of bark beetles emerging from ponderosa pine.

areas and mass-attack trees. Anti-aggregation pheromones cause beetles to disperse to neighboring trees or other areas. Pheromones of many bark beetles have been identified and synthetically produced. Both aggregation and anti-aggregation pheromones have been effective to mitigate impacts caused by some bark beetles in the western United States.

Crowns of successfully attacked trees turn from green to yellow to reddish brown. This color

Bark Beetles

Figure 87. Small rust-colored pitch tubes are a sign that trees have been attacked by bark beetles.

Figure 88. Boring dust in branch crotches, bark crevices or around the base of trees is a sign that trees have been successfully attacked by bark beetles.

Figure 89. Blue stain fungi introduced during bark beetle attacks on conifers occurs in the sapwood.

change, an indication of a dying tree, may occur from a month to more than 2 years after successful attack depending on the temperature, moisture conditions, and density of beetles in the tree. Close inspection of infested tree trunks will show either small globules of resin, small holes through the bark, or reddish boring dust in bark crevices and around the tree base. The removal of bark from infested trees will reveal two types of galleries, egg and larval. Egg galleries constructed by adult beetles are rather uniform in width. Larval galleries depart at right angles from egg galleries and increase in size as the young grow.

References: 24, 25, 41, 116

Bark Beetles

Pine Engravers
Ips spp.

Hosts: Pines and spruce

Symptoms/signs: In standing trees, fading tops of large trees or whole crowns in small trees can be indicators of *Ips* infestation. Other external evidence consists of accumulations of boring dust in bark crevices and at the base of the tree. Occasionally pitch tubes can be found on the trunk. Characteristic egg galleries may be found under the bark, slightly engraving the sapwood, hence the common name engraver beetle. In slash, look for boring dust and galleries.

Adults are small cylindrically shaped brown beetles a few millimeters in length. They possess a pronounced concavity at the rear end of the elytra that is bordered on either side by three to six tooth-like spines. Larvae are white, legless grubs.

Figure 90. Egg galleries of Ips pini *on fire-damaged ponderosa pine. Note egg galleries radiate outward from centralized nuptial chamber.*

Figure 91. Overwintering adult feeding galleries of Arizona fivespined ips on ponderosa pine log.

Figure 92. Adult Arizona fivespined ips beetle. Note spines along posterior edge of the elytral declivity.

Biology: Beetles produce 2 to 4 generations per year, depending on climate, species, and elevation. In spring, adult beetles emerge from material infested the previous fall and fly to attack new hosts. Beetles prefer fresh debris from logging, construction activity or natural events, but during outbreaks living trees may be attacked.

Figure 93. Frass piles indicating Ips *attacks on fresh ponderosa pine slash.*

Effects: Bark beetles in this genus have the potential to kill thousands of pine trees during short-lived outbreaks in Arizona and New Mexico. Pine mortality is frequently noticed in drought years. Pinyon ips (*I. confusus*) killed millions of drought-stressed piñon across the Southwest from 2002 to 2004. Similarly, the pine engraver beetle (*I. pini*) and the Arizona five-spined ips (*I. lecontei*) killed millions of ponderosa pine during the same time span throughout Arizona. Some outbreaks are associated with human activities that create large amounts of fresh pine debris or that weaken trees. These insects are also beneficial, creating snags and providing a food source for other animals.

Figure 94. Ips *species typically initiate attacks near the top of ponderosa pine causing a characteristic top-down fading pattern.*

Similar Insects and Diseases: Other bark beetles may be found in southwestern pines. They may be distinguished by egg gallery characteristics and adult appearance. Ips egg galleries possess a nuptial chamber—an enlarged excavated area—with one to many galleries radiating from it. The egg galleries are free of frass. *Dendroctonus* galleries vary by species in shape but lack the nuptial chamber and are packed with frass. Ips adults display a pronounced concavity at the rear end of the elytra, which contains three to six spines on either side. *Dendroctonus* adults on the other hand have a rounded declivity with no spines. Frequently, both *Dendroctonus* and *Ips* species occur within the same tree with *Ips* species typically located in the top half of the bole and *Dendroctonus* in the bottom half.

Figure 95. Stand level ponderosa pine mortality caused by Arizona fivespined ips on Prescott NF, Arizona.

Figure 96. Initial construction of egg galleries by pinyon ips on piñon.

References: 25, 49, 53, 62, 76

Figure 97. Adult pinyon ips feeding colonies are frequently found near the base of piñon during the fall through early spring.

Figure 98. Pitch tubes caused by pinyon ips attacks.

Figure 99. Boring dust in bark crevices near base of pinyon ips attacked piñon (left).

Figure 100. Landscape level piñon mortality caused by pinyon ips in New Mexico (right).

Bark Beetles

Western Pine Beetle
***Dendroctonus brevicomis* (LeConte)**

Host: Ponderosa pine

Symptoms/signs: Larval feeding in the inner bark and adult mating and egg laying creates mazelike galleries. Entrance holes, reddish dust in bark crevices, and pitch tubes are indicators of attack. Exit holes are created when the mature beetle leaves the host. Trees, which have been successfully attacked by beetles, are most noticeable when the foliage begins to fade from green to yellow to red to gray. Also, infested trees often exhibit signs of woodpecker feeding activity in the bottom half of the bole. Needles fall off approximately 1 year after the initial attack.

Figure 101. Egg gallery of western pine beetle on ponderosa pine. Note that galleries have a sinuous, crisscrossing pattern.

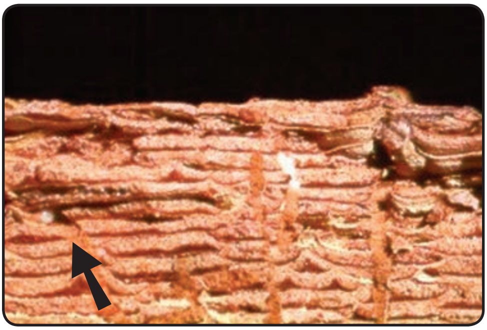


Figure 102. Cross section of bark showing western pine beetle larvae in outer bark.

Biology: Adult beetles usually begin flight and attack of suitable host trees in late spring or early summer and continue until cold weather begins. Females produce from one to three broods a year. Eggs are laid in niches along galleries. When the eggs hatch, the larvae feed in the inner bark working away from the egg gallery.

Effects: The direct effect of successful attack is tree mortality. Usually, the beetles breed in and kill scattered, overmature, slow growing, decadent, or diseased trees and trees weakened by stand stagnation, lightning, fire, or mechanical injury. This tree mortality may be considered part of the normal ecological process of succession during which a forest matures and replaces itself. Epidemics can affect ponderosa pine ecosystems by reducing the density and size distribution of its host, and altering species composition and stand structure.

Similar Insects and Diseases: Other bark beetles attacking ponderosa pine. Western pine beetle egg galleries can be distinguished from other beetles by their maze-like appearance.

Figure 103. Pitch tubes indicating western pine beetle attack are frequently small in size (<1/4 inch, 6.4 mm).

References: 18, 24

Figure 104. Woodpecker activity ("flaking off of bark") on ponderosa pine indicates western pine beetle larvae are in the outer bark.

Bark Beetles

Mountain Pine Beetle
Dendroctonus ponderosae (Hopkins)

Hosts: Ponderosa pine, white pines

Symptoms/signs: External evidence on green infested trees consists of pitch tubes. On successfully attacked trees, these are small and numerous. Pitch tubes on unsuccessfully attacked trees are larger in size (around 2 cm in diameter), typically white, and widely scattered over the trunk. During drought years, infested trees may not produce pitch, and external evidence consists only of boring dust. These are referred to as blind attacks. Later, foliage on successfully attacked trees fades to yellowish green, to sorrel, red and finally brown. Under the bark, egg galleries are straight, vertical, and packed with boring dust. They range from 10 to 122 cm in length. Adult beetles are brown cylindrically shaped beetles about 4 to 7.5 mm long. Larvae are small white grubs with tan head capsules.

Figure 105. Adult mountain pine beetle.

Biology: The beetle produces one generation per year. Adults begin attacking trees in early July and the attack period can extend into September. Females initiate attacks and release pheromones to attract males. Beetles create egg galleries in the inner bark and females lay eggs.

Figure 106. Egg and larval galleries of mountain pine beetle. Note that egg galleries have an initial "crook" or "j" and then run vertically up the bole. Larval feeding galleries are perpendicular to the egg galleries.

In 1 to 2 weeks small larvae hatch. Generally they overwinter as small larvae. Larvae resume development the following spring and when mature, excavate oval cells in which they transform into pupae and then adults. Adults then bore out and attack new trees. In the Southwest on ponderosa pine, this insect is found primarily on the Kaibab Plateau in northern Arizona and in northern New Mexico. It can be found on white pines throughout the Southwest.

Effects: The direct effect of successful attack is tree mortality. Epidemics can affect ponderosa pine ecosystems by reducing the density and size distribution of its host, and altering species composition and stand structure.

Similar Insects and Diseases: Several other bark beetles may be found in Southwestern ponderosa pine, including other *Dendroctonus* species and engraver beetles. These may be distinguished from mountain pine beetle by their egg gallery characteristics and adult appearance. Egg galleries of the western pine beetle are maze-like, and those of the roundheaded pine beetle are vertical and slightly sinuous. Galleries of engraver beetles possess a nuptial chamber with one to several galleries radiating out from it. Engraver beetle egg galleries are free of frass. *Ips* adults display a pronounced concavity at the rear end of the elytra that possesses three to six spines on either side. The elytral declivity on *Dendroctonus* adults is rounded and does not possess any spines.

References: 1, 75

Figure 107. Ponderosa pine mortality caused by mountain pine beetle.

Roundheaded Pine Beetle
Dendroctonus adjunctus (Blandford)

Figure 108. Egg gallery of roundheaded pine beetle. Note that galleries are vertical, but more "snake-like" in appearance than mountain pine beetle egg galleries.

Host: Ponderosa pine

Symptoms/Signs: Reddish brown boring dust is present in bark crevices and numerous pitch tubes are observed on the bark at entrance holes. In heavily attacked decadent trees, pitch tubes are often missing or very small. Later, the foliage fades from green to yellow or bright red, and eventually a dull brown. Woodpecker activity on the trunk is also a good indication that bark beetles have attacked the tree.

Biology: Adult roundheaded bark beetles attack and colonize susceptible trees in October and November. Females initiate the attack producing an aggregation pheromone drawing large numbers of beetles to the tree. The beetles chew through the bark and excavate a chamber in the moist tissue beneath the bark. Males enter the chamber and mating occurs. Female beetles then excavate horizontal tunnels in the inner bark region for 25 to 50 mm and then longitudinally with the grain an average distance of 300 mm. Eggs are laid individually in niches on alternate sides of the egg galleries, which are packed with frass. The larvae mine across the grain in the inner bark until in the third instar and then bore into the outer bark to complete development.

Effects: Roundheaded pine beetles attack, colonize, and kill trees in the southwestern United States and Mexico. Periodic outbreaks have killed large numbers of ponderosa pine in southern New Mexico and southeastern Arizona. In 1950, 16,000 pole and sawtimber-sized trees were infested on 2,500 acres near Cloudcroft and 400,000 pole-sized ponderosa pines were killed on 150,000 acres from Mayhill to Ruidoso in 1971. Similar outbreaks occurred during the 1990s in the Sacramento Mountains in southern New Mexico and the Pinaleño Mountains in southeast Arizona.

Figure 109. Pitch tubes caused by roundheaded pine beetle are typically larger and more cream colored than those formed by western pine beetle

Similar Insects: The roundheaded pine beetle is similar to other *Dendroctonus* beetles, *Ips* beetles, and other members of the subfamily Scolytidae. *Dendroctonus* beetles are distinguished from each other mainly by their unique egg galleries and, in the case of the Douglas-fir beetle and spruce beetles by the host species they attack. *Dendroctonus* beetles are distinguished from *Ips* beetles by their rounded posterior ends and galleries, which are packed with frass. In contrast, the posterior ends of *Ips* beetles are slightly concave with and have several to many small spines and the runways (egg galleries) are free of frass.

References: 8, 24, 61

Figure 110. Ponderosa pine mortality caused by roundheaded pine beetle in the Pinaleño Mountains, Arizona.

Figure 111. Aerial view of ponderosa pine mortality caused by roundheaded pine beetle in the Pinaleño Mountains, Arizona.

Bark Beetles

Southern Pine Beetle and Mexican Pine Beetle
Dendroctonus frontalis (Zimmerman) and *Dendroctonus mexicanus* (Hopkins)

Hosts: Chihuahua, Apache, ponderosa pines

Symptoms/signs: Presence of reddish brown boring dust caught in bark flakes and crevices around tree; numerous pitch tubes on the bark at the entry point of the tunnels. In heavily attacked decadent trees, pitch tubes are often missing or so small they can only be seen up close. Later, the foliage begins to fade, turning from green to yellow or bright red, and eventually a dull brown. Woodpecker activity on the trunk is also a good indication that bark beetles have attacked the tree.

Figure 112. Egg and larval galleries of southern pine beetle. Note that egg galleries are S-shaped that crisscross one another in the inner bark and on the wood surface.

Adults are dark reddish brown, cylindrically shaped beetles approximately 3 mm in length. Larvae are white, legless grubs. The morphology of southern pine beetle and Mexican pine beetle are very similar and, therefore, are difficult to tell apart. Taxonomists use the seminal rod of male beetles as the distinguishing characteristic.

Biology: Although southern pine beetle has many generations in the southeastern U.S., it likely has only one to two generations per year in the Southwest depending on elevation and climate. Adults construct winding galleries in the inner bark, where eggs are deposited in individual niches on each side of the galleries. The larvae mine for a short distance before boring into the outer bark where they pupate. Mexican pine beetle is thought to have a similar biology.

Effects: Southern pine beetle and Mexican pine beetle killed large numbers of Apache and Chihuahua pines throughout 1999-2001 in the Chiricahua Mountains of southeastern Arizona. Pine mortality ranged from single trees to large groups of more than 100. Southern pine beetle has been collected from traps in northern Arizona.

Similar Insects and Diseases: Southern pine beetle and Mexican pine beetle can be distinguished from other pine bark beetles by the shape of egg galleries and beetle morphology. Western pine beetle egg galleries are similar in appearance; however, larval feeding galleries on the inner bark are absent.

References: 104

Figure 113. Chihuahua pine mortality caused by southern pine beetle in Chiricahua Mountains, Arizona.

Red Turpentine Beetle
***Dendroctonus valens* (LeConte)**

Hosts: Pines

Symptoms/signs: The best indicators of red turpentine beetle attack on pines are: large pink-white pitch tubes on the lower bole; accumulations of reddish brown sawdust at the base of the tree and in bark crevices; and accumulations of cream to pink colored crystallized resin granules at the tree base. The egg galleries under the bark are fairly wide and linear to irregular in shape. Galleries extend downward from the entry hole 7 cm to 1 m and may even extend into large roots.

Figure 114. Large pitch tubes at bases of ponderosa pine indicate red turpentine beetle attacks.

Adults are reddish brown, cylindrically shaped beetles approximately 8 mm in length. Larvae are white, legless grubs.

Biology: The number of generations varies from 1 to 2 years in the coldest portions of its range to 2 to 3 generations per year in the warmest areas. Attacks are made in the lower bole of pines. Attacks occur throughout warm weather but peak by midsummer. These beetles often attack trees scarred by fire.

Figure 115. Red turpentine beetle frequently attacks fire-damaged ponderosa pine as indicated by pitch tubes and frass.

Effects: Through repeated attacks this beetle can sometimes kill trees;

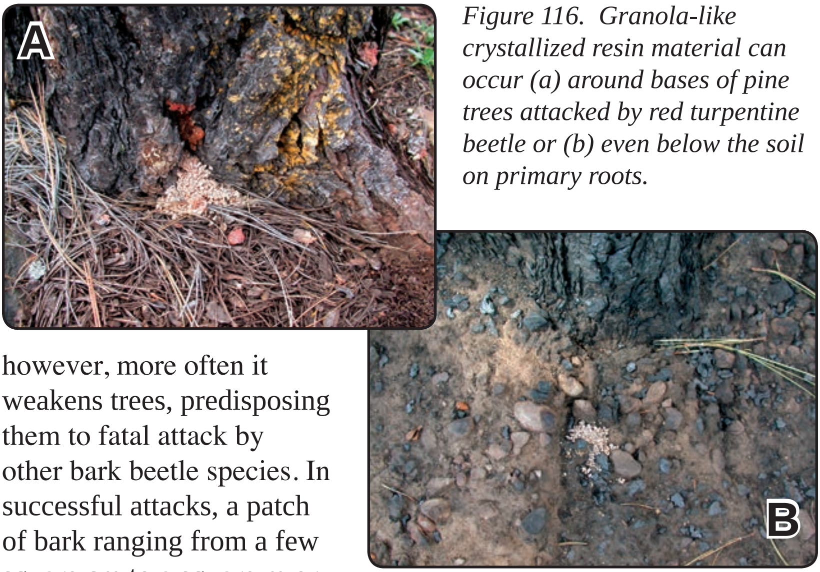


Figure 116. Granola-like crystallized resin material can occur (a) around bases of pine trees attacked by red turpentine beetle or (b) even below the soil on primary roots.

however, more often it weakens trees, predisposing them to fatal attack by other bark beetle species. In successful attacks, a patch of bark ranging from a few square cm to a square m or more may be killed. Red turpentine beetles frequently colonize fire-scorched ponderosa pines.

Similar Insects and Diseases: This beetle is distinguished from other bark beetles by the large size of the pitch tubes, galleries and the beetle itself.

References: 2, 24, 95

Figure 117. Egg and larval galleries of red turpentine beetle. Note that larval feeding occurs in a gregarious fashion.

Spruce Beetle
***Dendroctonus rufipennis* (Kirby)**

Hosts: Engelmann spruce is principal host, blue spruce is an infrequent host

Symptoms/signs: External evidence on green infested trees consists of entrance holes in the bark and occasional pitch tubes. However, pitch tubes are often indicative of an unsuccessful attack. Red boring dust from entrance holes usually accumulates in bark crevices around the bases of infested trees. Woodpeckers frequently remove large sections of bark looking for larvae to

Figure 118. Egg and larval galleries of spruce beetle. Egg galleries are vertical with eggs laid on alternate sides of the gallery.

Figure 119. Fading Engelmann spruce mortality caused by spruce beetle in White Mountains, Arizona.

feed on. About 1 year after attack, needles of infested trees usually turn a yellowish green and fall, though some may remain green until the second year. Needles do not turn a reddish color like those on bark beetle infested pines. Under the bark, egg galleries are vertical and slightly groove the xylem. Egg galleries range from about 6 to 30 cm long. Adult beetles are cylindrically shaped and 4 to 6 mm long. They are generally dark brown to black with reddish brown wing covers; however, older adults are usually entirely black. Larvae are creamy white, cylindrical, legless grubs. Larvae reach a length of about 6 mm. Pupae are creamy white and similar in size to the adult.

Figure 120. Remnants of spruce beetle galleries on a downed log.

Biology: Spruce beetles generally produce one generation in 2 years; however, generation time can take from 1 to 3 years. Adults emerge from May through July and begin attacking new host trees. Eggs hatch and larvae develop during the summer. Broods overwinter as larvae or callow adults and complete development to mature adults by the following August. Spruce beetle attacks standing trees, windthrown trees, or logging residuals. It prefers large diameter, green downed material to standing trees. Populations are affected by a number of factors including the number of susceptible hosts, natural enemies, and extreme cold.

Effects: The direct effect of spruce beetle attack is tree mortality or in some cases strip kill, when only a vertical section of the bole is attacked. Strip attacked trees often die in subsequent years. Spruce beetle epidemics can have both immediate and long-term effects on spruce-fir forests. The immediate effects include changes in stand structure and composition. The longer-term effects come from successional changes that result from microclimate changes as well.

Similar Insects and Diseases: The most common associates are in the genus *Ips*. In New Mexico, *I. pilifrons sulcifrons* is the most common, while in Arizona, *I. pilifrons utahensis* is found most often. *Ips* beetles frequently infest the upper (exposed) portion of downed material, while spruce beetle favors the shaded material. *Ips* egg galleries differ from those of spruce beetle by containing a nuptial chamber and by being free of frass.

Figure 121. Flaking of bark caused by woodpeckers indicates spruce beetle larvae in the outer bark of Engelmann spruce.

References: 42, 87

Bark Beetles

Douglas-fir Beetle

Dendroctonus pseudotsugae **(Hopkins)**

Host: Douglas-fir

Symptoms/signs: Reddish-orange frass is the first sign that a tree has been attacked. At times, the most evident sign of attack is the clear resin exuding from entrance holes on the upper portions of the stem. Pitch flow, however, is not always present on successfully attacked trees. Needles of successfully attacked trees change from green to yellow to sorrel to reddish brown in the year following attack. Egg galleries run parallel to the wood grain and are 20 to 25 cm long. Adult beetles are stout, cylindrically-shaped, and 4 to 6 mm long. The head and thorax are black; the wing covers reddish brown, becoming darker with age.

Figure 122. Egg and larval galleries of Douglas-fir beetle. Note larval galleries occur in alternating groups.

Figure 123. Douglas-fir beetle caused mortality of dwarf mistletoe-infected Douglas-fir on the San Francisco Peaks, Arizona.

Biology: The Douglas-fir beetle has one generation per year. Although adult flight times vary by year, most new attacks occur in late spring to early summer. Broods develop under the bark throughout the summer and early fall. Adult, pupal, or larval life stages can overwinter. Brood that develops to pupae or adults by winter usually emerges between April and June. Overwintering larvae emerge as adults in summer. A small percentage of adults that overwinter will re-emerge from the spring-attacked trees and attack additional trees in

Bark Beetles

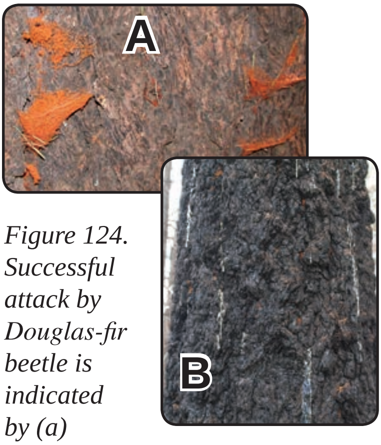


Figure 124. Successful attack by Douglas-fir beetle is indicated by (a) frass (boring dust) in bark crevices, spider webs, or at base of Douglas-fir and (b) pitch streaming.

the middle of summer. Typically, late-season attacks account for less than 20 percent of all attacks in one season.

Effects: The direct effect of successful attack is tree mortality. At low or endemic levels, the beetle infests scattered trees that are infected with dwarf mistletoe and/or armillaria root disease, injured by fire, or stressed by defoliating agents. During outbreaks, groups of 100 or more attacked trees are common. Douglas-fir beetle epidemics can have both immediate and long-term effects on mixed conifer forests. Immediate effects include changes in stand structure and composition. Successional (long-term) changes result from alterations in microclimate.

Figure 125. Galleries of Douglas-fir pole beetle on small diameter Douglas-fir. Galleries are short, longitudinal and often with two branches.

Similar Insects and Diseases: Other bark beetles, *Scolytus monticolae* and Douglas-fir pole beetle (*Pseudohylesinus nebulosus*), often occur in large branches, boles of pole-sized trees and the top of trees killed by Douglas-fir beetle. They may be separated by gallery patterns and characteristics of adult beetles.

References: 24, 90

Western Balsam Bark Beetle
Dryocoetes confusus (Swaine)

Host: Subalpine fir (corkbark fir)

Symptoms/signs: Small entrance holes and boring dust are usually difficult to detect on green standing trees, but pitch flow may be evident. Under the bark, egg galleries lightly etch the surface of the wood. Egg galleries radiate from a central nuptial chamber. Attacked trees generally turn yellow-red within a year. Needles on a beetle-killed fir may remain for more than 4 years. Adults are shiny, dark brown, cylindrical beetles about 2 to 5 mm long. The posterior end of the elytra is abruptly rounded with no spines.

Figure 126. Egg gallery of western balsam bark beetle on corkbark fir. Egg galleries typically have five or more galleries radiating from a nuptial chamber.

Biology: Little is published on the biology of this species; however, it is thought to have a 1- to 2-year life cycle. The lower to mid bole of standing trees is usually selected for attack. This species is

Figure 127. Adult western balsam bark beetle. Note the "crew cut" appearance on front of beetle heads.

moderately aggressive and capable of killing older and/or weakened trees. Occasionally cut or fallen trees are attacked.

Effects: The direct effect of successful attack is tree mortality.

Similar Insects and Diseases: Other bark beetles attack subalpine fir, including species of *Scolytus* and *Pseudohylesinus*. They may be separated by gallery patterns and characteristics of adult beetles. Western balsam bark beetle attacks are frequently associated with fir infected by root diseases.

References: 24, 66, 116

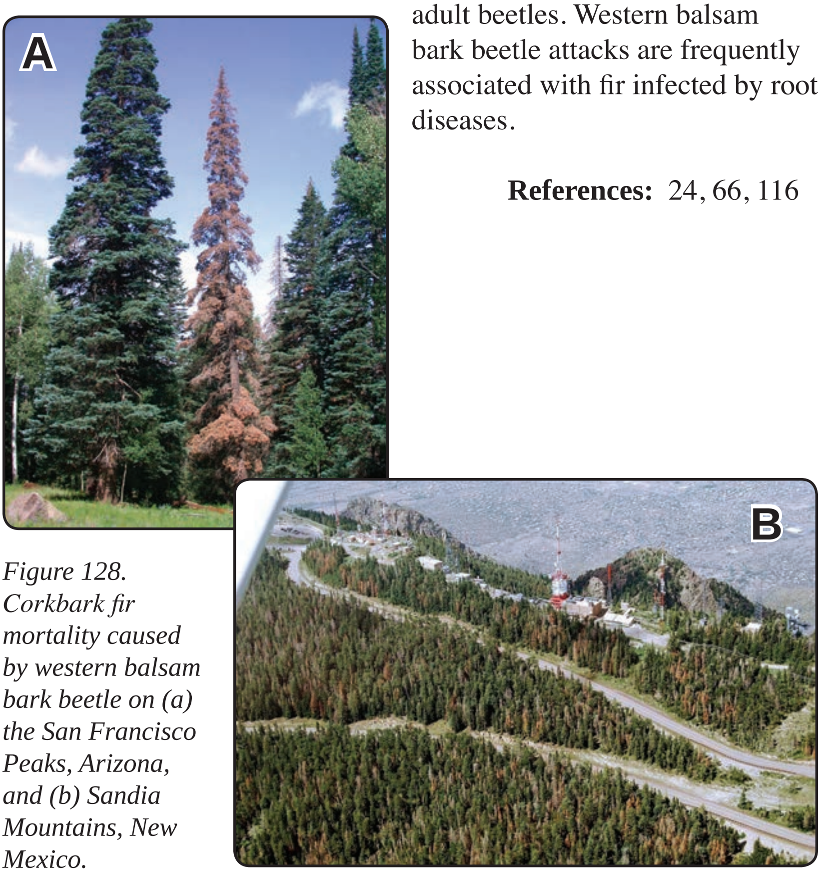


Figure 128. Corkbark fir mortality caused by western balsam bark beetle on (a) the San Francisco Peaks, Arizona, and (b) Sandia Mountains, New Mexico.

Bark Beetles

Fir Engraver
Scolytus ventralis (LeConte)

Hosts: True firs

Symptoms/signs: Freshly attacked green trees have tiny holes in the bark, reddish-brown boring dust in bark crevices, and streams of clear pitch exuding from entrance holes. Needles change from green to yellow-green to sorrel and then red to brown. Larvae, pupae, and egg are found in the inner bark; egg and larval galleries deeply score the wood, creating characteristic horizontal egg galleries and vertical larval galleries. Adult beetles are small, shiny, black beetles about 4 mm long. The abdomen is incurved at the rear.

Figure 129. Egg and larval galleries of fir engraver. Galleries are horizontal with two branches radiating out from entrance point.

Biology: In warm locations, the fir engraver completes one generation and a partial second generation each year. In cooler sites, the beetle needs 2 years to complete its life cycle. Adult flight

Figure 130. Adult fir engraver beetle. Note the "sawed-off" appearance of the beetles' abdomen.

occurs throughout the summer, but peaks in July and August. Fir engravers overwinter primarily as young or mature larvae. In the spring, they feed for a short period and then construct pupal cells at the end of their galleries.

Effects: Fir engravers are a major mortality agent of true firs, usually attacking pole-sized to sawtimber-sized trees. Outbreaks often occur during and following droughts. Root diseases are often associated with attacked trees. The fir engraver can also breed in slash and wind-thrown trees. Flagging (death of branches) may occur on fir trees that have been only partially attacked.

Figure 131. White fir mortality caused by fir engraver on Mormon Mountain, Arizona.

Similar Insects and Diseases: Other bark beetles attack subalpine fir, including species of *Dryocoetes* and *Pseudohylesinus*. They may be separated by gallery patterns and characteristics of adult beetles.

References: 3, 20, 24

Twig Beetles
Pityophthorus spp., *Pityogenes* spp., *Pityoborus secundus*

Hosts: Pines and other conifers

Symptoms/Signs: Trees attacked and colonized by twig beetles exhibit fading needles on twigs and branches, and twig and branch dieback throughout the crown. Tan sawdust is produced around the attack sites. On smaller twigs and branches, most of the cambium is mined beneath the bark. Small, star-shaped egg galleries generally occur under the bark of the larger branches and small trunks.

Biology: Adult twig beetles are about 3 mm long and dark brown. Most species

Figure 132. Pitch tubes of twig beetles on piñon are typically very small (<1/8 inch).

Figure 133. Damage to ends of piñon branches caused by twig beetles. Very small pitch tubes may be present on twigs.

have a rounded rear end, but a few have a pair of short spines. The larvae are fat, white, C-shaped grubs with light brown head capsules and feed under the bark. Most species have 2 to 4 generations per year, depending on local conditions.

Effects: Typically attacks and kills small twigs and branches of drought stressed or otherwise weakened pines and other conifers. Although twig beetles are generally considered of secondary importance, under favorable conditions they may develop in sufficiently high numbers and attack and kill small trees. *Pityogenes carinulatus* killed thousands of young ponderosa pine in 1967 in New Mexico as a result of populations increasing in thinning and logging slash. Twig beetles infested high numbers of young piñon in 2002, 2003, and 2004 across New Mexico and Arizona.

Figure 134. Mortality of piñon regeneration killed by twig beetles near Los Alamos, NM.

Similar Insects and Diseases: See *Ips* discussion. Most twig beetles have elytral declivity and egg galleries that are somewhat similar to *Ips*; however, twig beetles are smaller in size and are typically found in branches and very small diameter trees.

References: 9, 24

Cedar and Cypress Bark Beetles
***Phloeosinus* spp.**

Hosts: Arizona cypress and junipers

Symptoms/signs: External evidence consists of twig killing (called flagging), or whole trees fading. Under the bark, egg galleries are simple and longitudinal, 2 to 7 cm long, usually engraving the wood rather deeply. Egg niches are usually rather large and conspicuous. Larval galleries wander away from the parent galleries.

Adults are reddish brown to black, shiny beetles ranging in size from 2 to 4 mm long. Larvae are small white grubs, with brown head capsules.

Biology: One to one and a half generations are produced per year. Attacks occur in spring and summer. Adults and larvae feed in the inner bark in galleries. Newly emerged adults feed on the pith of

Figure 135. Egg galleries of Phloeosinus *beetles deeply engrave sapwood and are often thermometer shaped with an enlarged chamber. Conspicuous larval galleries radiate away from both sides of egg galleris.*

Figure 136. Juniper mortality caused by cedar bark beetle near Flagstaff, Arizona.

Figure 137. Pitch tubes on Arizona cypress caused by cypress bark beetle near Sedona, Arizona. Note that pitch tubes are frequently absent.

*Figure 138. Adult cedar bark beetle (*Ploeosinus *spp.).*

Figure 139. Mortality of Leyland cypress near Sedona, Arizona, caused by cypress bark beetle (right).

Figure 140. Extensive mortality caused by cypress bark beetle north of Clifton, Arizona.

twigs of living trees prior to constructing egg galleries. Often twigs are hollowed out completely and killed.

Effects: These beetles are typically not aggressive and are generally found attacking branches, trunks, tops, and limbs of weakened, dying, or felled trees. Occasionally outbreaks occur during drought.

Similar Insects and Diseases: This is the main bark beetle genus attacking cypress and juniper. There are some woodboring beetles that attack these trees. Bark beetles are distinguished from woodborers by the shape and location of the galleries and size of the adults and larvae. Galleries of woodborers extend both in the bark and wood. Woodborer larvae and adults are larger than bark beetles.

References: 24, 82

Wood Borers

This group contains insects belonging to several orders (Coleoptera, Lepidoptera, and Hymenoptera) that bore into the sapwood and sometimes the heartwood of weakened, fire-scorched, recently felled, or dead hardwood and conifer trees. In addition, they can cause substantial economic losses in the form of degraded wood and volume. Descriptions here include families belonging to the order Coleoptera: longhorned beetles/roundheaded borers (Cerambycidae), metallic wood-boring beetles/flatheaded borers (Buprestidae) and ambrosia beetlesw (Scolytinae, Playtpodinae). Wood wasps/norntails (Hymenoptera: Siricidae) and clearwinged moths (*Lepidoptera: Sesiidae) are also common wood borers on pines and aspen in the Southwest, respectively.

Figure 141. Egg niches of cerambycid wood borers are oval shaped pits in the bark with a slit in the bottom.

Figure 142. Larva of roundheaded wood borer.

References: 24, 41

Wood Borers
Roundheaded borers, Cerambycidae
Flatheaded borers, Buprestidae

Hosts: Conifers and hardwoods

Symptoms/signs: Larvae are found under the bark of dead and dying trees. These galleries are usually wider than bark beetle galleries and vary in diameter as the larva grows, in contrast to the egg galleries of bark beetles which have a uniform diameter throughout. Roundheaded borer galleries are packed with a coarse boring material while flatheaded borer galleries are packed with fine boring dust. In many species, larvae complete their development in the wood so tunnels extend into sapwood and sometimes the heartwood. Adults emerge through large emergence holes in the bark.

Adult roundheaded borers are medium to large sized, oblong to cylindrical insects. The antennae are often longer than the body, giving them the name "longhorned beetles." Larvae are relatively large, particularly when fully developed, white, cylindrically shaped grubs. The heads are slightly larger in diameter than the body.

Adult flatheaded woodborers are medium to large sized, flattened, compact beetles. Larvae have a very distinctive shape. The first body segment behind the head is much broader than the following body segments and has horny plates on the top and bottom.

Figure 143. Ponderosa pine bark borers (adults of roundheaded borers). Note that antennae are longer than the length of the body.

Effects: These insects primarily attack weakened, dead or dying trees. A few species attack and kill apparently healthy trees, such as the western cedar borer on junipers and *Agrilus* species on *Populus*. They often attack trees already infested with bark beetles and sometimes compete with them. Larval mines penetrate both the cambial region as well as the wood, sometimes mining it extensively. They are important in the process of nutrient cycling by assisting in breaking down woody material.

Reference: 24

Figure 144. Larva of flatheaded wood borer. Note that their flattened heads are usually broader than the body.

Figure 145. Adult metallic wood borer (flatheaded wood borer). Note that antennae are shorter than the body.

Wood Borers

Juniper Borers
***Trachykele blondeli* (Marsuel)**
***Callidium* spp**
***Atimia* spp**
***Chrysobothris* spp**

Hosts: Junipers and Arizona cypress

Symptoms/signs: Exit holes.

Effects: Several roundheaded and flatheaded wood borers are aggressive pests in drought-stressed junipers and cypress. Damage can be extensive before symptoms are apparent. Usually a large portion of the tree or the entire tree dies before the insects' exit holes are noticed.

Biology: *Callidium* spp. larvae bore beneath the bark making very wide tracks that distinctively score the outer sapwood much like a router. Older larvae excavate oval tunnels deep in the wood and overwinter. Adults emerge throughout the warm months of the year. There is one generation per year. Adult beetles are rather short-horned for cerambycids and dark blue or black. These roundheaded borers leave an oval or rectangular exit hole.

Atimia spp. are small roundheaded borers about 6.5 mm long and generally have a 1-year life cycle. These longhorned beetles attack thin bark portions of seriously weakened and dead juniper and cypress.

Figure 146. Larval feeding gallery of a juniper borer.

Trachykele blondeli, the western cedar borer, is 11 to 17 mm long and attacks juniper and Arizona cypress. Females lay eggs under bark scales and branches of living trees. Flatheaded larvae bore from the branches into the main bole. They feed primarily in the heartwood for several years. Adults emerge in the spring, leaving oval or rectangular exit holes.

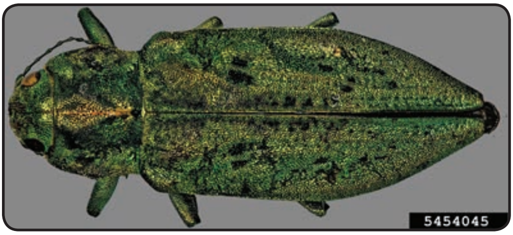


Figure 147. Adult western cedar borer.

Chrysobothris spp. are flatheaded borers of junipers and Arizona cypress. They are medium-sized beetles about 11.5 mm long. Larvae bore into the bark and outer wood of weakened trees.

Similar Insects and Diseases: See cedar bark beetles.

References: 9, 24

Figure 148. Juniper mortality caused by western cedar borers.

Wood Borers

Ambrosia Beetles

***Trypodendron* spp, *Platypus* spp,**
***Gnathotrichus* spp, *Xyleborus* spp**

Hosts: True fir, spruce, Douglas-fir, pine, aspen, poplar, and maple

Symptoms/signs: Entrance holes are small for most species (1.5 mm or less) and are marked by piles of white boring dust. Gallery patterns vary by species, but all tunnels run perpendicular to wood grain. The mines of *Platypus* species penetrate into the heartwood in contrast with most ambrosia beetles in the Scolytinae that mine only the sapwood.

Effects: Weakened, dying, recently cut or dead trees are attacked. Galleries cause defect in logs. Some species can attack freshly cut lumber before it has been dried. Populations can build up in windthrown and fire-killed trees, bases of trees attacked by bark beetles, logging slash, and logs in storage. These beetles are unique among bark beetles in that larvae feed upon a special type of fungus, known as the ambrosia fungus, which grows in the galleries. Larvae do not feed on wood or phloem as in other bark beetles.

Figure 149. White boring dust caused by ambrosia beetles tunneling in the wood of a bark beetle-killed pine.

Biology: Insect appearance varies between beetles. Adult *Trypodendron, Gnathotrichus,* and *Xyleborus* beetles are all dark colored, cylindrically shaped beetles, about 2 to 4.5 mm long (depending on the species). Larvae are white, legless grubs with brown head capsules. All three genera belong to the subfamily Scolytinae. *Platypus* on the other hand belongs to the subfamily Platypodinae, which is closely related to the Scolytidae. Adult *Platypus* are more elongate, cylindrically shaped beetles than scolytids.

Similar Insects and Diseases: May be confused with other bark beetles; however, ambrosia beetles are the only ones that bore straight into the bole producing fine, white boring dust.

References: 24, 33

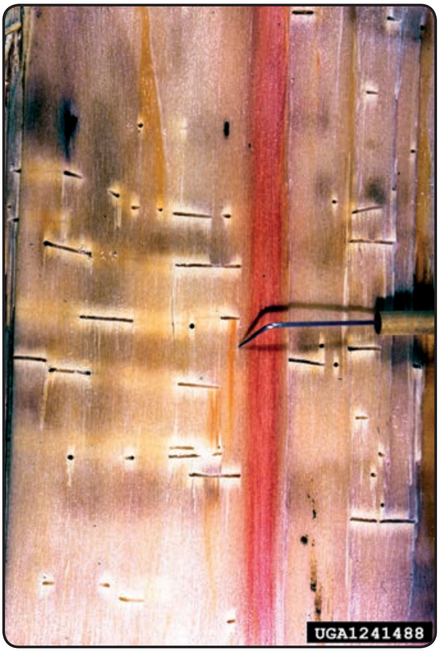


Figure 150. Entrance points of adult ambrosia beetles. Holes are stained by blue stain fungi.

Cone and Seed Insects

Cone and seed insects, also called conophytes, include a variety of moths, flies, bugs, and beetles. Destruction of forest seeds may be caused by insects that attack the buds, flowers, immature cones, and the seeds themselves. Because flower and seed production by forest trees varies dramatically from year to year and by location, so do impacts caused by cone and seed insects. In general, cone and seed insects are relatively unimportant under forest conditions as the amount of seed produced by forest trees usually far exceeds the number of seeds destroyed by these insects. However, they can have economic impacts to seed orchards in which seed production is limited. They can also impact natural regeneration of white pines that are being severely impacted by white pine blister rust. The most injurious groups of cone and seed insects in the Southwest are the seed moths and coneworms (Lepidoptera), seed worms and midges (Diptera), and cone beetles (Coleoptera).

References: 5, 24, 37, 48, 88

Cone and Seed Insects

Cone Beetles
***Conophthorus* spp.**

Hosts: Pines

Symptoms/signs: External evidence consists of pitch tubes at the point of entry on the cone stalk or the base of the cone. Following attack, cones turn brown and wither. If beetles have emerged, small round exit holes may be found on the outside of affected cones. Inside, beetles leave cones riddled with tunnels and frass. Adult beetles are reddish brown to black, shiny bark beetles. Larvae are small white, legless grubs.

Figure 151. Adult boring hole indicating attack on ponderosa pine cone by Conophthorus *cone beetles.*

Biology: One generation is produced per year. Adult beetles bore into the base or stem of immature second-year cones in the spring. A gallery is created along the cone axis, with eggs deposited along its sides. The creation of the gallery severs the conductive tissues of the cone, killing it. Larvae hatch and feed on the scales, seeds, and tissues of the cone. The brood complete development during the summer within the cone and usually overwinter there. Some new adults emerge and may bore into shoots or conelets and overwinter.

Figure 152. Damage to interior ponderosa pine cone caused by larva (arrow) of cone beetles.

Effects: These beetles cause the death of second-year cones. The amount of mortality is highly variable but in some years a large proportion of cones may be attacked.

Similar Insects and Diseases: This insect is best distinguished from other insects that attack developing cones by the presence of the pitch tube on the cone base or stem.

References: 24, 37

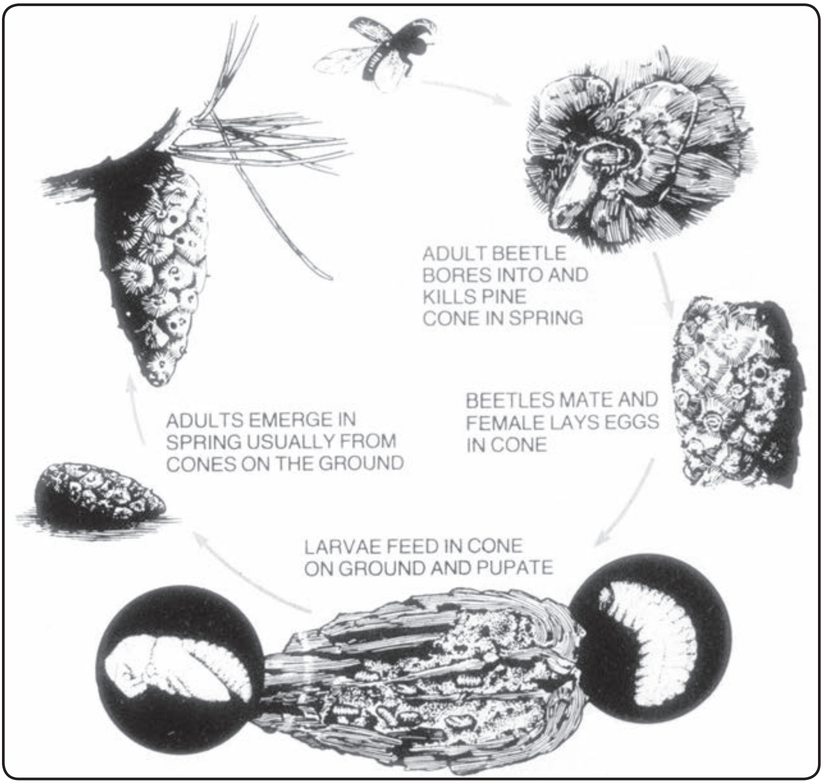


Figure 153. Life cycle of cone beetles.

Cone and Seed Insects

Ponderosa Pine Seedworm
Cydia piperana **(Kearfott)**

Figure 154. Larvae of ponderosa pine seedworm.

Figure 155. Damage of ponderosa pine seed by ponderosa pine seedworm.

Host: Ponderosa pine

Symptoms/signs: There is no external evidence of infestation. Inside the cones, frass and mining can be seen in the cone axis. Seed pairs on the same scales can become fused together by the silk lined tunnels produced by the larvae. Often these seeds tend to stick to the scales and remain in the cones.

Adult moths have a wingspan of 10 to 20 mm. The fore wings are metallic gray with silver bands. Larvae are 10 to 15 mm when mature, white to cream colored, with a mottled head capsule.

Biology: One generation is produced annually. Eggs are laid at the base of cone scales, on the surface of the scale, or on the cone stalk. Newly hatched larvae bore between the cone scales, enter a seed, consume it, and leave it filled with frass. It then moves on to another seed leaving a silk lined trail. As the larva matures, it burrows into the cone axis and overwinters. In spring, the insect pupates. Following pupation, the adult emerges.

Effects: In some years this insect can consume a large proportion of the seed crop.

Similar Insects and Diseases: A number of insects affect cones. This insect is distinguished by the presence of the frass packed seeds, larvae or mining in the cone axis.

Reference: 37

Pine Seed Chalcid
Megastigmus albifrons (Walker)

Figure 156. Larva and seed damage caused by the pine seed chalcid.

Host: Ponderosa pine

Symptoms/signs: Adults are antlike in appearance and range in color from yellow to black or brown. Females have a long, curved ovipositor. The larvae are small, white and legless. The outer seedcoat develops normally and shows no evidence of an oviposited egg. When adults emerge they leave a small round hole in the seedcoat.

Biology: Adult emergence lasts for about a month in spring. Females may mate or reproduce parthenogenetically. Eggs are oviposited through the young scales of developing cones directly into the seed. Usually one egg is laid per seed. The larva matures in the seed, consuming its entire contents. The insect overwinters in the seed and pupates in early spring. Some adults emerge at this time while others may diapause for up to 3 years.

Effects: Pine seed chalcid can cause a large percentage of cull seed in commercial seed production operations. Since it is very difficult to distinguish between healthy and inhabited seed, insects are unknowingly transported.

Similar Insects and Diseases: There are a variety of cone and seed feeding insects in the West. Larvae of the family Cecidomyiidae (Diptera) may cause similar reductions in seed production; however, the larvae are not voracious feeders and damage to cones and conelets results from gall formation on the seed scale which prevents seed dispersal. Other species of insects that feed in seeds and cones of ponderosa pine in the Southwest include ponderosa pine cone beetle (*Conophthorus ponderosae*), pine coneworm (*Dioryctria auranticella*), and the ponderosa pine seed moth (*Laspeyresia piperana*).

References: 3, 15

Cone and Seed Insects

Pine Coneworm
Dioryctria auranticella (Groté)

Host: Ponderosa pine

Symptoms/signs: Entire cones are usually killed by pine coneworms; partially killed cones become distorted and do not open. Larval feeding cavities inside cones are filled with frass and webbing.

Biology: Larvae begin feeding in ponderosa pine cones in late spring. They make an entry hole in the basal portion of the cone and consume seeds and scale tissues. Mature larvae pupate in the cavities in the cones created by feeding activity of the larvae. Adults emerge in middle to late summer.

Effects: This obligate seed and cone insect can be destructive when populations are high. Up to 80 percent of cones can be damaged per year in the Southwest. Coneworms feed on seeds and scales from a cavity inside the cone, severely distorting the cone and preventing extraction.

Similar Insects and Diseases: There are a variety of cone and seed feeding insects in the West. Other species of insects that feed in seeds and cones of ponderosa pine in the Southwest include pine seed chalcid (*Megastigmus albifrons*), ponderosa pine cone beetle (*Conophthorus ponderosae*), and the ponderosa pine seed moth (*Laspeyresia piperana*). This conophyte is distinguished by the entry hole in the basal portion of the cone and larval feeding cavities filled with frass and webbing.

Figure 157. Damage to ponderosa pine cone caused by larva of the pine coneworm.

References: 5, 88

Bud and Shoot Insects

Injury to buds and shoots may be caused by caterpillars, weevils, bark beetles, midges, aphids, or scale insects. Some of these insects also feed on other plant parts such as foliage, cones, and branches. By far the most frequently observed damage to pine shoots is caused by tip moths and shoot borers belonging to the order Lepidoptera (moths and butterflies).

Shoot insects affect trees by damaging terminal or lateral shoots. Such damage typically reduces height growth and deforms the tree. Forked branches or multiple leaders often result from a previous year's insect damage. Seedlings and saplings are most susceptible to damage by shoot insects. Trees above 2 m in height rarely sustain significant injury. Young seedlings are often prevented from growing taller than herbaceous competitors, resulting in mortality.

Most of these shoot insects are important in young, intensively managed stands or replanted forested areas. The susceptible stage of hosts is predictable and managers can plan accordingly to minimize impacts caused by shoot insects.

References: 24, 41, 44, 109

Bud and Shoot Insects

Pine Tip Moths
Rhyacionia spp.

Host: Ponderosa pine

Symptoms/signs: Insect appearance varies between species. *R. bushnelli* adults have a wingspread of 10 to 15 mm; forewings are mottled yellowish gray and reddish brown. Larvae are yellowish with black heads, and about 9 to 12 mm long when mature. *R. neomexicana* adults have a wingspan of about 24 mm. Forewings are irregularly banded with transverse bars of dark gray, blackish and brick-red scales on the inner two-thirds of the wing. Larvae are usually orange in color with dark brown to light tan head capsules and are about 12 to 16 mm long when fully developed.

Figure 158. Adult pine tip moth.

Figure 159. Damage of ponderosa pine shoot caused by pine tip moths.

Biology: Larvae mine inside new shoots in spring and early summer, killing them. Both lateral and terminal shoots are attacked. Larvae initially mine needles and then bore into the shoot. Pitch tents, frass, and silk webbing are all signs of tip moth activity. Once in the shoots, larvae feed between the pith and the bark, eventually hollowing out the shoot.

Effects: Larvae mine in the phloem and xylem of lateral and sometimes terminal shoots. Small trees, those less than 2 m tall are most susceptible. Shoots are killed by the attacks. Repeated attacks slow growth and cause crooks, forks, multiple stems, and spike tops. Tip moths rarely kill established trees outright, but attacks can affect survival of young planted seedlings.

Similar Insects and Diseases: Western pine shoot borer and ponderosa pitch nodule moth.

References: 24, 44

Figure 160. Closeup of damaged ponderosa pine shoot caused by pine tip moths.

Bud and Shoot Insects

Western Pine Shoot Borer
Eucosma sonomana **(Kearfott)**

Host: Ponderosa pine

Symptoms/signs: Adults are moths with coppery-red forewings marked with two bright gray transverse bands and a wingspread of about 20 mm. External symptoms include shortened needles and stunted terminal growth. Following emergence of the larvae, exit holes can be found near the center of the shoot. In the year following infestation, a distinct swelling can be seen around the stem, near the exit hole. Occasionally terminals break off where the stem is weakened by the exit hole.

Figure 161. Damaged (top) and undamaged (bottom) shoots of ponderosa pine caused by western pine shoot borer larvae. Note "bottlebrush" appearance of damaged shoot.

Biology: Eggs are laid on elongating shoots in spring. The larvae feed in the pith of these shoots, vacate in late spring, and drop to the ground to pupate. There they remain dormant through the winter and hatch as adults the following spring.

Effects: Larvae mine only in the pith of the shoot. Usually shoots remain green for at least a year after attack, however, in some cases shoots are killed outright. Most often shoots live, but become stunted. Frequently, lateral shoots overtop affected shoots and a crook or a fork results. The main result of infestation is reduced height growth, about 25 percent of one year's vertical growth per attack. Depending on management objectives, this may or may not be important. The insect occurs at low population levels.

Similar Insects and Diseases: See pine tip moths.

References: 24, 95, 98

Figure 162. Larva of the western pine shoot borer. Note that larval feeding is restricted to the pith region of the shoots.

Pinyon and Ponderosa Pitch Nodule Moth

***Retina (= Petrova) arizonensis* (Heinrich)**
***R. metallica* (Busck)**

Host: Piñon

Symptoms/Signs: Attacks are characterized by fading branch tips and small nodules of pitch formed at the insects feeding sites. The pitch nodules are hollow balls of pitch 13 to 25 mm long, round, smooth, and light purple to red in color. Pitch nodules usually occur at the crotch of two or more twigs.

Figure 163. Damage caused by the pinyon pitch nodule moth.

Biology: Small, rusty-brown moths emerge through holes in the pitch nodule in late June and early July. Eggs are laid on the needle sheaths of the current year's foliage. Newly hatched larvae feed on the young needles before boring into the bark at nodes or whorls of twigs or branches. Full-grown larvae are about 13 mm long, reddish-yellow in color with a black head and a dark area behind the head. Pupation occurs inside the pitch nodule in June. The pupae move just below the pitch surface before they emerge as adults.

Figure 164. Cocoon of ponderosa pitch nodule moth.

Effects: Attacked twigs and branches are killed. Leaders are occasionally damaged and forked trees may result.

References: 9, 24

Bud and Shoot Insects

Bark Moths *Dioryctria* spp. and Pitch Moth *Synanthedon* spp.

Hosts: Piñon, ponderosa pine, and occasionally Douglas-fir and true fir

Figure 165. Damage to piñon caused by D. albovittella *at Sunset Crater NP, Arizona.*

Symptoms/signs: Pitch moth attacks appear as large masses of pitch that form at the wound site, but some species of *Dioryctria* can damage the cone or shoots. The pinyon twig moth, *D. albovittella,* can cause significant damage on young piñon. Bark moths typically produce less pitch.

Effects: Larger branches, limbs, and trunks of young trees are attacked. Repeated attacks can seriously weaken and kill branches. The most severe damage is to trees under 6 m, especially in urban areas. The insects are rarely a problem on larger trees or in the forest environment.

Biology: Pitch moths require 2 years for one generation to mature, overwintering as larvae each winter. Bark moths require only 1 year for a generation to mature, overwintering as eggs or larvae. Eggs are laid in bark crevices or near mechanical wounds on the bark. Newly hatched larvae tunnel under the bark forming irregular galleries or elongated gouges in the sapwood. Pitch moth larvae feed on pitch the tree produces in response to their tunneling. Oozing pitch masses 25 to 75 mm in diameter cover entry holes and conceal larvae and their destructive tunneling. Full-grown larvae are 15 to 25 mm long, dirty white, yellow, orange, green, or light brown. Bark moth larvae feed on the inner bark and when full grown, are marked with rows of dark spots.

Figure 166. Damage caused by pitch moth.

Reference: 9

Bud and Shoot Insects

Juniper Twig Pruner
Styloxus bicolor (Champlain and Knull)

Hosts: Juniper and Arizona cypress

Symptoms/ signs: The juniper twig pruner is a small longhorned beetle (Cerambycidae). The adult is 7 to 11 mm long and has a reddish-orange head and brownish to black body. Larvae are small, white roundheaded borers..

Figure 167. Damage to junipers caused by the juniper twig pruner.

Biology: The life cycle may take as long as 2 years to complete. Eggs are laid on branches, often near an intersection of twigs, 0.5 m from the branch tip. Grubs kill twigs by boring through the centers.

Figure 168. Closeup of damage to juniper shoots caused by the juniper twig pruner.

Effects: Juniper twig pruner causes twig dieback on junipers and cypress growing throughout the Southwest.

Similar Insects and Diseases: Cedar bark beetles and western cedar borer.

References: 9, 43

Figure 169. Exit hole of juniper twig pruner.

Insects of Wood Products

A variety of insects attack trees that are recently dead or dying. Losses from these insects are about 1 to 5 percent of the annual timber harvested. Some of these insects have previously been discussed (e.g., woodborers and ambrosia beetles) and others are described on the following pages.

Insects of wood products can either attack moist or dry seasoned wood. Those 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 will continue to develop in the wood for several years after the wood has been dried and manufactured.

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 6 percent.

References: 15, 24

Carpenter Ants
Camponotus spp.

Hosts: Douglas-fir, pine and true fir

Symptoms/signs: Carpenter ants are large in size, about 5-15 mm long, and black or black and red in color. They tunnel in the wood of stumps, logs, dead standing trees, the interior dead sections of livings trees, and the wooden portions of buildings. These galleries are honeycomb-like in appearance; the walls are sandpaper smooth, free of frass, and run across the grain. The wood borings, which are coarse and fibrous, are pushed out of the tunnels and may accumulate at the base of inhabited trees.

Biology: Mating occurs during mass flights in the spring. The female then lays eggs, which take approximately 2 months to become mature larvae. The larvae then pupate in cells. Each individual will emerge as one of three possible castes: winged males, winged females, or workers. Carpenter ants do not eat wood but excavate galleries for nesting purposes. These insects are general feeders, and will eat animal food (such as caterpillars, meat, or refuse) and sweets (from aphid honeydew, ripe fruit, or sap.)

Figure 170. Boring at base of ponderosa pine caused by carpenter ants.

Effects: The excavations in wood can be so extensive that the structural integrity of the tree is lost, predisposing the tree to wind breakage.

Similar Insects and Diseases: Horntails or "woodwasps" (Siricidae) have similar excavations in host trees. The main differences being that they actually have the wood borings pass through the digestive tract and are packed in the tunnel behind the larva. They usually attack fresh logs or newly dead trees. Adults are generally thick-waist, wasp-like insects that are metallic blue or black in color. Adults emerge in late spring or summer and lay eggs in solid wood (conifers or hardwoods) and the life cycle can range from 1 to 2 years. Pupal cells are found in the phloem and the exit holes from mature adults are round.

References: 15, 24

Figure 171. Cross section of stump with carpenter ant galleries.

Insects of Wood Products

Termites
Order *Isoptera*

Hosts: Most tree species

Symptoms/signs: Termite damage is honeycomb in shape and follows the grain of wood. There are three types:

Drywood termites. Coarse sand-like fecal pellets found outside of finished wood.

Dampwood termites. Typically colonize dead and down trees and untreated wood in contact with the ground.

Subterranean termites. Presence of mud shelter tubes on wood, walls and tree trunks.

Biology: Termites are eusocial insects that have well developed caste systems. Caste consists of primary reproductives, supplementary reproductives, workers, and soldiers. Only the reproductives have wings and they form large flight swarms outside the colony. As their name implies, workers perform most of the work for the colony. They are generally pale in color, lack compound eyes, and have small mandibles. Soldiers are sterile adults with greatly enlarged and armored heads and mandibles. Their sole duty is defense of the colony against invaders. The conversion of cellulose to smaller units by protozoa and bacterial organisms in the guts of termites allow them to digest cellulose from wood and other plants.

Figure 172. Castes (queen, soldier and worker) of termites.

Effects: Termites can be extremely destructive to structures built out of wood. Even houses with a cement block foundation are at risk because subterranean termite tunnels can cross over the cement to wood framing. Damp wood termites attack wood that has high moisture content and do not require contact with the ground.

Similar Insects and Diseases: Termites are sometimes referred to as "white ants"; however they can be differentiated from ants by their soft body, light color, straight beadlike antennae, and broad connection between the thorax and abdomen. Ants are hard bodied, darker in color, elbowed antennae, and have a narrow "waist."

References: 15, 24

Figure 173. Damage to sign post caused by termites.

Foliar Diseases

Hardwood Leaf Diseases

Hardwood leaf diseases in Arizona and New Mexico are most often observed on aspen, Arizona sycamore, cottonwood and willow. Although clonal susceptibility to foliage pathogens is common for aspen and willow; whole areas can become infected during favorable moisture periods. Severe infection can cause premature defoliation and reduced tree growth.

Figure 174. Foliar diseases can cause premature defoliation.

Foliar Diseases

Black Leaf Spot
Marssonina populi (Lib.) Magnus

Hosts: Aspen and cottonwood

Symptoms/signs: Black leaf spot, caused by several species of *Marssonina* is common on aspen and cottonwood. Small brownish spots appear on infected leaves in late July and early August. The spots later enlarge and turn blackish, are of various sizes and irregular in outline, and have a yellowish to golden border. Infected leaves fall prematurely.

Biology: Primary infection occurs soon after leaves emerge in spring, from spores produced on twig lesions or from infected fallen leaves. Additional spores are produced on newly infected leaves, which initiates the repeating cycle of disease that continues with wet weather until leaves fall. Symptoms intensify and seem to ascend trees as the season advances. *Marssonina* spp. survives the winter as tiny stromata in fallen leaves and twig lesions.

Effects: Severe outbreaks may cause foliar browning in midsummer and nearly complete defoliation by late August. Regrowth follows in late summer and early autumn, and twig dieback may follow in winter because late season shoots lack normal cold hardiness. Defoliated trees produce less wood for 1 or more years following an outbreak.

Similar Insects and Diseases: Several agents can cause premature defoliation of aspen including aspen tortrix, western tent caterpillar, melampsora rust, frost, and drought. The irregular brown to black blotches on leaves distinguish black leaf spot from the other agents.

Figure 175. Black leaf spot of aspen caused by Marssonina populi.

References: 39, 93

Ink Spot Leaf Blight
Ciborinia whetzelii (Seaver) Seaver

Hosts: Aspen and cottonwood

Symptoms/signs: *Ciborinia whetzelii* forms brown to black spots, or stromata, in blighted leaves. Infected leaves turn brown and the ink spots, or sclerotia, begin to drop out leaving a circular hole in the dead leaves.

Biology: *Ciborinia whetzelii* infects young leaves in the spring by ascospores produced on fruiting structures that overwintered on fallen leaves. Infected leaves begin to die midsummer, but defoliation may not take place until autumn.

Effects: Ink spot leaf blight is more severe on smaller aspen trees and in the lower crowns of larger trees. As with many aspen diseases, some clones appear to be more susceptible than others.

Similar Insects and Diseases: This fungus may be confused with *Marssonina populi*; however, *C. whetzelii* produces well-defined circular and slightly raised fruiting structures, while those of *M. populi* are irregularly shaped and flattened.

Reference: 39

Figure 176. Black ink spots (sclerotia) on aspen leaf.

Melampsora Rust
Melampsora spp.

Hosts: Aspen, Douglas-fir, willow, and cottonwood

Symptoms/signs: Several Melampsora species occur in the region. *M. Medusae* causes conifer-aspen leaf rust; *M. occidentalis,* causes conifer-cottonwood rust; and *M. epitea,* which causes willow rust. Powdery yellow to yellow-orange spores produced on both sides of leaves or needles.

Figure 177. Rust pustules of Melampsora sp. *on aspen leaves.*

Biology: The life cycle of many rust fungi are very complex. In the early spring, infected dead aspen leaves on the ground release basidiospores that can only infect Douglas-fir. A different spore produced on Douglas-fir is wind disseminated and infects aspen leaves in the summer. Yet another spore, the golden-yellow uridiniospore, appears on both sides of infected aspen leaves within 2 weeks. This is called the repeating stage because these spores germinate to reinfect aspen leaves throughout the growing season. An overwintering spore is produced on the underside of infected leaves in late fall.

Effects: During wet summers this fungus can cause the leaves of highly susceptible clones to shrivel and drop prematurely, reducing growth.

Similar Insects and Diseases: The orange spores are distinct to Melampsora rust on the listed hosts.

References: 39, 93

Foliar Diseases

Shepherd's Crook
Venturia tremulae var. *grandidentatae* (= V. moreletii) (M. morelet)

Host: Aspen

Symptoms/signs: Curling, blackening and dieback of the tips of terminal and lateral shoots on young aspen sprouts.

Biology: Primary infections by *Venturia tremulae* var *grandidentatae* occur in spring on leaf blades, petioles, and young stem tissue. Dark brown to black lesions expand rapidly, causing leaves and shoots to droop, whither, and become brittle. Secondary infections, promoted by wet weather, are initiated throughout the period of shoot elongation by conidia from newly blighted shoots. New shoots frequently grow adjacent to blighted ones and are blighted in turn. Lesions do not extend into woody twigs.

Effects: In wet seasons, *shepherd's crook* can kill virtually all terminal shoots in young susceptible aspen, within the same local. This damage reduces height growth and deforms trees by causing a bend in the stem at the point where a lateral shoot became a new leader following death of the terminal shoot. Successive leaders may be killed during wet favorable summers. Plants less than 3 meters tall are at greatest risk, and damage becomes negligible as trees attain heights greater than 5 meters.

Similar Insects and Diseases: This is the only fungus on aspen causing black lesions on leaves, petioles and stems, which curl and form characteristic shepherd's crooks.

References: 39, 93

Figure 178. Curling and blackening of aspen shoots from Shepherd's crook.

Sycamore Anthracnose
Apiognomonia veneta (Sacc. & Speg.) Höhn

Figure 179. Leaf blight caused by sycamore anthracnose.

Hosts: Arizona sycamore

Symptoms/signs: Sycamore anthracnose has a range of symptoms corresponding to the three phases of this disease. The symptoms include: cankers on buds and twigs; shoot blight following a period of cold spring weather; and leaf blight from direct infection of leaves. Foliar lesions characteristically extend along the veins and involve interveinal tissue. Sometimes large irregular marginal lesions develop.

Biology: *Apiognomonia veneta* enters twigs via petioles during the growing season and remains quiescent until host dormancy, when it colonizes and kills bark and cambium. In the early spring, spores produced in these cankers infect new shoots and leaves. Shoot blight, the second phase of the disease, involves the rapid death of expanding shoots and leaves. This phase tends to develop suddenly during a period of cold spring weather. The third and final phase of sycamore anthracnose is leaf blight, which results from direct infection of leaves. It starts out most severe on low branches, and intensifies

Figure 180. Chronic infection by sycamore anthracnose results in repeated dieback of shoots.

and spreads upward during wet seasons, causing premature leaf drop. Leaves are most susceptible during the first few weeks of growth. Hyphae of the fungus often grow down petioles into the twigs, setting the stage for the next year's damage.

Effects: Repeated twig dieback alters the form of sycamores in two ways. First, when the terminal twig on a branch is killed and a lateral takes over as the new leader. Since infection takes place repeatedly during the life of a susceptible tree, the branch axis changes direction again and again, and crooked branches result. The second altered form is the development of a cluster of twigs around a common point on a branch because of the repeated killing of terminals.

Figure 181. Severe defoliation by sycamore anthracnose.

Similar Insects and Diseases: Sycamore anthracnose may occasionally be confused with injury by late spring frost. However, frost damage may affect several species in the same area and *Apiognomonia veneta* affects only sycamore.

Figure 182. Infected trees refoliate but branch dieback is evident.

References: 93

Foliar Diseases

Conifer Needle Diseases

Although occasional outbreaks appear quite dramatic, long-term damage from conifer needle diseases in the Southwestern Region is usually minor. Sporulation, spread, and infection by these fungi are frequently restricted to a specific season, depending on the pathogen, and successful infection depends on favorable weather conditions. Needle diseases are often more pronounced on younger trees and the lower crowns of large trees, due to more humid conditions favorable to disease fungi.

Figure 183. Conifer needle diseases are most noticeable in the spring before bud break.

Foliar Diseases

Lophodermella Needle Cast
Lophodermella cerina (Darker) Darker

Host: Ponderosa pine

Symptoms/Signs: *Lophodermella cerina* infects the needles of seedlings, saplings, and the lower crown of larger trees. Current year needles become infected and turn brown and die by early summer of the following year. After the next bud break, green current year needles and brown 1 year needles give the tree a distinctive appearance. The brown needles are "cast" prematurely compared to normal needle drop. Repeated infection occurs only with favorable weather conditions and results in thin crowned trees.

Biology: Fruiting bodies are short, oval, light brown, and easily overlooked. The spores mature after the needles have been cast. They infect new needles shortly after bud break. Spores germinate and infect needles directly through the epidermis. Infected needles extend normally and are usually killed by the fungus before the next year's needles emerge.

Effects: Although rare, growth loss is the primary long-term effect of needle cast. Successive years of infection are usually the result of repeated abnormally high rainfall in spring and early summer. Though trees can be

Figure 184. Lophodermella *needle cast on 1-year needles before bud break.*

killed if infection is repeated for several years in a row, they are more often predisposed to other pests.

Similar Insects and Diseases: From a distance, trees with needle cast symptoms may be mistaken for those affected by winter damage, deicing salt damage, or needle miners. On close inspection, needle cast needles are completely brown with dark fruiting bodies present. Winter damage, salt damage, and needle miner needles often have brown needle tips with green bases.

References: 71, 83, 93

Figure 185. Diseased 1-year needles are cast in late summer leaving current year and 2-year+ needles.

Foliar Diseases

Elytroderma Needle Cast

Elytroderma deformans (Weir) Darker

Hosts: Ponderosa pine, piñon, and southwestern white pines

Symptoms/Signs: Needles begin to fade in the fall of the year of infection, and by late winter are lighter in color than uninfected needles. By spring, the infected needles turn straw color as the new needles break bud. The fruiting bodies are elongated (average 10 mm in length) and black when visible on dead needles. Distinctive "witches' brooms" are formed by the sprouting of epicormic buds. Resin cysts can be found in infected twigs.

Biology: Spores initially infect new needles through the epidermis following bud break, but infection can continue into the fall until temperatures are too low for spore germination and growth. There are two types of spores: one spore is spread by water and the other is spread by wind. Discharge of spores occurs during and after a rainstorm, when new needles are probably most susceptible to infection. The fungus spreads throughout the needles and into twigs before the needles are killed. When twigs become infected, the fungus can perennially infect needles on the same twigs. Conditions conducive to needle infection by spores only have to occur once, after which the disease can progress within the infected tree.

Figure 186. Witches' broom formed from Elytroderma infection.

Effects: Although elytroderma needle cast is known as an occasional disease of ponderosa pine in the Southwest, it is common in some areas. In mature trees, if less than one-fourth of the branches are infected there is little or no effect on the tree, but if more branches are infected, needle cast alone can kill a tree or predispose it to attack by bark beetles.

Similar Insects and Diseases: The witches' brooms produced by elytroderma needle cast are similar to those caused by dwarf mistletoe, however, the existence of dead second year needles are indicative of needle cast and not dwarf mistletoe infection. Elytroderma is the only needle cast that is perennial.

References: 11, 83, 84, 93

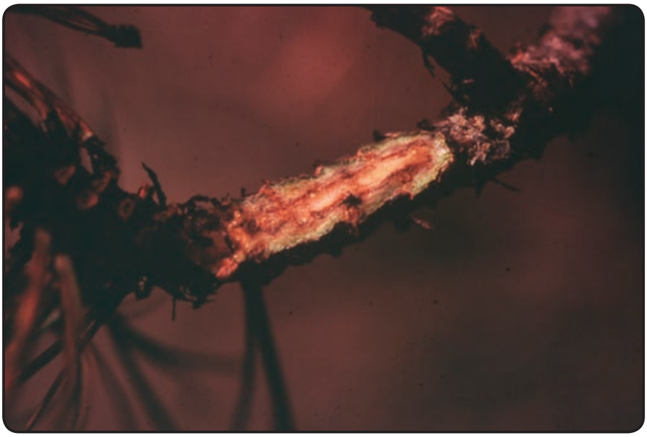


Figure 187. Cambium of infected branch has pockets of dark resin.

Red Band Needle Blight
Mycosphaerella pini Rostr. in Munk
(*Scirrhia pini* Funk & A.K. Parker)
Dothistroma septospora (Doroguine) Morelet

Hosts: Ponderosa pine and piñon

Symptoms/Signs: Symptoms first appear as yellow or tan bands around the needles, which later turn red. Infection of current and second year needles is usually in the lower crown of sapling size trees. Seedlings and large trees are rarely infected. Newly infected needles have green bands that turn red or brown in late summer. These needles die from the tips back. Infected second and older year needles can be cast the same year they become infected.

Biology: Needles are infected during rainy periods by rain-splashed spores. The number of infection cycles depends on the climate. During wet years, several cycles of infection can occur. The *Dothistroma septospora* stage is the asexual, imperfect stage, and the one most commonly found.

Effects: Dothistroma needle cast has been observed on ponderosa, piñon, and Austrian pine in New Mexico. It is most often associated with offsite planting. Several years of severe infection results in reduced growth and death of infected trees.

Similar Insects and Diseases: Infected trees can look like the lower crown was sprayed with herbicides. The death of needles from the tips to fascicle is similar to the affects caused by high concentrations of de-icing salts.

References: 78, 83, 93

Figure 188. Dothistroma blight of Austrian pine.

Rhabdocline Needle Cast
***Rhabdocline* spp.**

Host: Douglas-fir

Symptoms/signs: Tiny chlorotic spots on one or both surfaces of first year and occasionally older needles arise in late summer or early autumn. These lesions enlarge and darken to purplish brown spots and bands that are conspicuous by late autumn to early spring. Numerous lesions coalesce and involve the entire needle except for a short basal portion. Discolored foliage is most conspicuous the following spring.

Biology: Rhabdocline species produce apothecia May through June in needles still attached to the twigs. The apothecia appear as swellings up to several millimeters long and open by splitting the needle surface, usually near the midrib. Ascospores are airborne and penetrate developing needles directly through the cuticle. Only one infection period occurs per year, but it may

Figure 189. Rhabdocline needle cast lesions on 1-year Douglas-fir needles.

last several weeks. Needle colonization increases during the fall as symptoms become apparent. Infected needles drop during the winter, making missing foliage the only noticeable sign of disease.

Effects: This is the most important needle disease of Douglas-fir. Damage can be severe in Christmas tree plantations and ornamental nursery stock. Seedlings infected in nurseries can become foci of subsequent damage in plantations. Occasional outbreaks in forest stands can appear spectacular, but trees usually recover.

Similar Insects and Diseases: The fruiting body of Rhabdocline may be confused with secondary fungi.

References: 83, 93

Figure 190. Needle cast due to rhabdocline needle cast.

True Fir Needle Cast
Lirula abietis-concoloris (Mayor ex Dearn.) Darker

Host: White fir and subalpine fir

Symptoms/signs: Dark brown or black elongate fruiting bodies are found on second year needles. The fruiting bodies extend down the center of the lower needle surface for almost the full length.

Biology: Infection begins on young, developing needles during periods of rainfall. Fruiting structures mature on these needles the following spring and needles turn brown.

Effects: *Lirula abietis-concoloris* occurs sporadically and infects only newly emerged needles. Damage is rare since it takes several years of favorable weather for repeated infection to defoliate trees and affect growth and vigor.

Similar Insects and Diseases: None.

References: 83, 93

Figure 191. Death of 2-year needles caused by true fir needle cast.

White Pine Needle Cast

***Lophodermella arcuata* (Darker) Darker**

Host: Southwestern white pine

Symptoms/signs: This fungus is identified by the dark brown to concolorous, elongate to elliptical, fruiting structures, which develop on previous year's dead and dying needles.

Biology: Fruiting bodies in dead, second year needles open by means of a longitudinal fissure during warm wet weather and release colorless spores that have sticky, gelatinous sheaths. Airborne spores settle and penetrate young, developing needles. The following spring, diseased needles turn reddish brown and by July, they are straw colored.

Effects: *Lophodermella arcuata* infects only the current year's needles, and a single attack results in only partial defoliation of the host. Repeated consecutive infections are rare, but can lead to reduced tree growth and vigor.

Similar Insects and Diseases: This is the only known needle cast disease of white pine in the Southwest.

References: 83, 93

Figure 192. Lophodermella arcuata *cause browning of 1-year needles, which is most noticeable just before bud break of current year needles.*

Figure 193. Fruiting bodies of Lophodermella arcuata *are the same color as the faded needle.*

Pinyon Needle Rust

***Coleosporium ribicola* Arthur (*C. jonesii (Peck) Arth.*)**

Hosts: Piñon; currants and gooseberries (Ribes spp.) are alternate hosts.

Symptoms/Signs: White columnar sacs (aecia) filled with orange spores occur on all surfaces of piñon needles in the spring. On ribes, uredinia appear as small, round, golden yellow pustules during the summer. Telia, which are waxy and darker orange, develop in late summer on the same ribes leaves.

Figure 194. Aecia of Coleosporium ribicola *on piñon.*

Biology: Piñon needle rust must go through five spore stages on two different hosts to complete its one year life cycle. Spores from ribes leaves infect pine needles in late summer to early fall, where the fungus overwinters. Orange droplets form on infected needles in early spring and bright orange aeciospores by late spring. The latter are wind disseminated and infect newly emerged ribes leaves. Urediniospores develop on the ribes and multiply during wet periods. Telia develop in late summer followed by the final spore stage which infects pine needles.

Effects: Affected needles drop prematurely. This disease is encountered infrequently on piñon, but is very common on *Ribes* spp.

Similar Diseases: *Coleosporium ribicola* on ribes can be mistaken for other rusts of ribes, such as white pine blister rust, *Cronartium ribicola*. There is another needle rust of piñon in the region, *Coleosporium crowellii*, which is microcyclic, meaning there is no alternate host. The fruiting structures are more reddish-orange and waxy rather than powdery as in *Coleosporium ribicola*.

Reference: 107

Figure 195. Uredinia and telia of Coleosporium ribicola *on* Ribes cerium, *wax current.*

Stem Decays and Stains

Decay of wood is caused by fungi that utilize the cell wall components of xylem as a source of nutrition. These fungi have both beneficial and damaging influences on forest stands. In living trees, decay fungi break down tissues in branches, roots, and stems of trees. They play an irreplaceable role in the earth's carbon cycle by returning to the atmosphere billions of tons of carbon each year and provide valuable habitat for many species of wildlife. Although vital to ecosystem functioning, decay can render trees useless for wood products and create hazard trees in recreation sites.

Many decay fungi discussed here decay the heartwood of living trees, others decay the wood of dead trees, and some grow on both live and dead trees. Most decay fungi do not interfere with the

Figure 196. A conk, or fruiting body, of a stem decay infection.

normal growth of live trees since they stay in the heart or xylem wood of the host. However, they can affect tree structure and contribute to wind breakage and windthrow as decay progresses. There are some decay fungi that cause mortality. These fungi begin decaying the host as a heart rot and later move into the sapwood and cambium, which cuts off the flow of water and nutrients, girdling the tree. Other fungi decay the wood of dead trees and can also decay dead sections of live trees, such as a dead top or old wound on the bole.

Decay levels in live trees are highly correlated with age. For example, high amounts of decay are typically found in sites where conifer trees are 150+ years old. Susceptibility to stem decay fungi varies with tree species. Some hardwoods—like cottonwood and aspen—are the most susceptible to stem decay in the Southwest, and Douglas-fir, white fir and spruce are in general more susceptible than ponderosa or southwestern white pine. However, susceptibility is also dependent on site quality and host genetics; silviculturists have observed some 70-year-old ponderosa pine sites with high levels of decay.

Stem Decays and Stains

Red Ring Rot
***Porodaedalea pini* (syn. *Phellinus pini*) (Brot.) Murrill**

Hosts: Spruce, true fir, Douglas-fir, pine

Symptoms/signs: *Porodaedalea pini* produces swollen knots where branches were previously shed, irregular bulges with exuding resin, and resin flow from knots. It also produces brown fruiting bodies at branch bases, branch stubs, knots, wounds, and cracks. These fruiting bodies, or conks, are bracket-like with a brownish-black upper surface, concentric furrowed rings and a brown undersurface with spores. Punk knots are common in Douglas-fir, western larch, pines, and some spruces. A punk knot is a mass of tightly packed sterile brown hyphae that extends from a decayed branch stub within the trunk to a local swelling on the surface.

Biology: Decay often begins near the junction of heartwood and sapwood and may extend into sapwood adjacent to wounds. The decay is often confined to the heartwood of mature trees, either in one central column or in several discrete columns that extend from branch stubs.

Figure 197. P. pini *fruiting on an Engelman spruce at many old branch stubs.*

Effects: *P. pini* is thought to be the most common trunk decay fungus of conifers in North America. Decay columns commonly extend 10 meters or more, rendering entire trunks useless for lumber. Decay is much more extensive in old trees in virgin and unmanaged forests than it is in managed forests where trees are harvested at relatively young ages.

References: 28, 31, 93

Figure 198. Closeup of red ring rot conk on Douglas-fir.

Red Rot

Dichomitus squalens **(Karst.) Reid.**

Hosts: Ponderosa and piñon pines

Symptoms/signs: *Dichomitus squalens* produces a flat fruiting body on the underside of dead branches or stems with intact bark. The pore surface is white when fresh and ages to yellow. The red rot fungus causes a white pocket rot. Like other wood decays, it has two distinct stages: incipient and advanced.

Figure 199. Red rot fruiting body on the underside of a dead ponderosa pine branch.

The incipient stage is characterized by a reddish-brown discoloration of the affected wood, unaccompanied by any obvious changes in structure or strength. The advanced stage is characterized by small, often poorly defined, white pockets in the discolored wood, accompanied by progressive changes in structure and reduction in strength. As decay progresses, the pockets become more and more numerous until they merge and give the affected wood the appearance of a fibrous white mass. Eventually, the white lint-like material disappears, leaving the bleached, grayish-brown, decayed wood in either a stringy or a somewhat amorphous condition.

Both stages of red rot are usually visible in a board sawed from a decayed log. At the point where rot started in the trunk heartwood, advanced decay often forms a cavity. Extending in both directions from this point are more or less continuous columns of advanced decay, bordered by incipient decay.

Biology: The spores are dispersed by wind, land in cracked bark crevices of dead branches, and germinate to colonize the area between the bark and wood and eventually the dead wood, provided it has intact bark. The red rot fungus fruits abundantly on the lower side of decaying dead material in close contact with the ground. The flat, white fruiting bodies appear about 4 years after infection and then develop annually during the rainy season for about 6 years.

Effects: *D. squalens* is the most common decay of ponderosa pine in the Southwest. It is a decayer of slash (a saprophyte) as well as a heartrot in live trees. It has been reported to cause a significant amount of cull in live trees 150+-years-old when grown for timber. As with other decay fungi, *D. squalens* provides habitat for cavity nesting birds and other wildlife. Although this fungus is of minor occurrence on living trees in second growth forests, there are reports of extensive decay of young trees (<80 years) in localized areas.

Figure 200. Red rot decay affects the heartwood and is typically associated with old growth ponderosa pine.

Similar Insects and Diseases: Many fungi decay ponderosa pine slash, but *D. squalens* is probably the most common.

References: 28, 30, 52, 93

Indian Paint Fungus

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

Hosts: True fir, and occasionally Douglas-fir and spruce

Symptoms/signs: *Echinodontium tinctorium* produces woody, perennial hoof-shaped conks, 4-20 cm in diameter, usually at the undersides of branch stubs. These fruiting structures sometimes form at wounds or on limbs. The upper surface is dark gray-to-black, rough and cracked. The lower surface is gray-brown to black, composed of thick, blunt, tooth-like spines. The interior tissue is brick red to rust red, from a pigment that extends into the adjacent decayed wood. The common name for *E. tinctorium*, "Indian paint fungus," is derived from the Native American's use of conks in the preparation of red paint pigments.

Biology: The spores of *E. tinctorium* are dispersed during cool, wet weather in the fall. They remain viable during winter, germinating best after a period of freezing temperatures. The fungus enters branchlets between 0.5 mm to 1.5 mm in size and spreads through the pith to the main branch. Here the fungus can remain in a dormant condition for 20, 50, or even 100 years. When the main branch dies or breaks off, the fungus becomes

Figure 201. Indian paint fungus conk showing orange inner tissue.

active again, and decay of the heartwood portion of the main branch begins, eventually spreading to the main stem of the tree.

Effects: This fungus is the main cause of heart rot and volume loss in mature true firs. Conks are reliable indicators of defect and are associated with substantial volumes of decay. One fruiting body usually indicates that the entire cross section of the log is decayed for a distance of 2 m above and 2.5 m below the conk. Decay may also be present in trees that do not bear sporophores. The rot is most common in the mid-trunk but may also extend into the butt or down from the top. In very late stages of decay, the trunk may become completely hollow. Infected trees that break or are windthrown are important sources of hollow logs for wildlife habitat and act as nurse logs for regeneration.

Similar Insects and Diseases: Advanced stages of decay closely resemble equivalent stages of rot associated with *Stereum sanguinolentum*. However, *S. sanguinolentum* fruiting bodies are completely different, as they form thin, crust-like layers with a grey to light brown gilled lower surface that turns blood red when bruised.

References: 22, 30, 93, 101

Red Belt Fungus
***Fomitopsis pinicola* (Swartz:Fr.) Karst.**

Hosts: Conifers and aspen

Symptoms/signs: *Fomitopsis pinicola* forms perennial conks that are corky and shelflike. Its characteristic feature is a red-brown band near the white to cream colored edge. These fruiting bodies form on dead trees and logging slash and not on infected living trees. The decay is a brown cubical rot with shrinkage cracks in which prominent white sheets of mycelium develop.

Biology: This fungus enters living trees with airborne spores colonizing and infecting through wounds and broken tops. It may be introduced into dying or dead trees by insects, as it has been isolated from Douglas-fir bark beetles captured both in flight and from egg galleries.

Effects: *F. pinicola* is one of the most important brown rot pathogens of old-growth western conifers, but it acts slowly and is not considered a major decay pathogen of second-growth forests. However, it is an important component of the coniferous forest ecosystem because it decays dead trees and

Figure 202. Fomitopsis pinicola *on dead Douglas-fir.*

logging slash and leaves a lignin-rich residue that is very stable and is a major component of the organic matter on the forest floor and in the upper layers of soil. This residue enhances water holding and cation exchange capacities of soil and is a favorable habitat for the development of ectomycorrhizae and for nitrogen-fixing bacteria.

Similar Insects and Diseases: Brown rot caused by *F. pinicola* is difficult to distinguish from that caused by *Phaeolus schweinitizii*, a butt rot of Douglas-fir. Since *P. schweinitzii* is a root and butt rot pathogen, it is found in the lower 3 meters of the trunk and in the roots, and it fruits from the roots out through the soil of live trees. *F. pinicola* only fruits on dead wood material so is frequently observed on stumps.

References: 28, 30, 93

Pouch Fungus
Cryptoporus volvatus (Peck) Shear

Hosts: Ponderosa pine and other conifers

Symptoms/signs: *Cryptoporus volvatus* produces small, cream-colored to tan, leathery fruiting bodies. The most distinguishing feature of *C. volvatus* is that it has a fungus sheath with a single hole covering the lower spore-bearing surface. This is not a heart-rot fungus, but causes a grayish white rot of the sapwood of recently killed trees.

Figure 203. C. volvatus *conks have a covered pore surface with a hole in the bottom where insects enter and exit.*

Biology: Insects enter, feed, and then exit fruiting bodies of the pouch fungus, carrying spores to infect recently killed or dying trees. Typically, it occurs only on dead trees and snags within 1 to 2 years after the tree's death.

Effects: Most commonly found on ponderosa pine and Douglas-fir in the Southwest, but can infect other conifers. This is not an aggressive pathogen, but invades a tree within the first 2 years of death and is very common in trees killed by bark beetles.

Similar Insects and Diseases: No other conifer pouch fungus has been identified.

References: 7, 28, 30

Blue Stain Fungi
Ophiostoma spp.
Ceratocystis spp.

Hosts: Conifers

Symptoms/signs: Blue-green discoloration of sapwood (often in wedge shapes) in recently killed trees. Blue stain fungi frequently originate from bark beetle galleries.

Biology: Blue stain fungi are carried by bark beetles and other wood inhabiting insects and are associated with tree mortality. They are mostly blue-staining and primarily from the genera *Ophiostoma* and *Ceratocystis*. The spores germinate and produce a mycelium (thread-like mass) that colonizes the phloem and sapwood, eventually blocking the water-conducting columns of the tree. The formation of a wedge-shaped stain is due to movement of hyphae along the rays from the outside of a log.

Effects: Stain fungi often hasten the death of trees attacked by bark beetles. The stain may result in a reduction in the value of timber or timber products by discoloring sapwood, but does not affect wood strength.

Figure 204. Blue stain fungi invade sapwood and not the inner heartwood.

Similar Insects and Diseases: Another group of sapstaining fungi are wind disseminated, of various colors (blue, brown, or gray) and are from the genera *Aureobasidium* and *Alternaria*. Black stain fungi, which are closely related to blue stain fungi, also block water-conducting columns. However, black stain fungi spread to healthy trees by root-to-root contact.

References: 93, 101

False Tinder Conk
Phellinus tremulae (Bondartsev) Bondartsev & Boresov

Host: Aspen

Symptoms/signs: *Phellinus tremulae* produces woody conks on aspen trunks, typically at branch stubs or scars. The conks are hoof shaped, brown to black, with a rough, cracked upper surface and tan to white pore surface. The conks are usually attached to the host by a granular core of tissue that continues into the decayed branch within the trunk. *P. tremulae* also produces hard, blackish sterile masses of mycelium (sterile conks) at branch scars, hence the name. The yellowish white spongy decay caused by this fungus is usually confined to a central core.

Figure 205. Phellinus tremullae *conk on aspen.*

Biology: Airborne spores of *P. tremulae* infect fresh branch stubs or wounds. The fungus decays the dead or injured area and then gains entry to the heartwood.

Effects: *P. tremulae* is the most common cause of aspen stem decay in the Southwest. It causes less mortality than aspen canker fungi or ganoderma root rot but can create hazard trees in recreation sites.

Similar Insects and Diseases: No other fungi with the characteristics of the fruiting body are found in aspen.

References: 31, 39, 93

Stem Decays and Stains

Oak Heartrot Fungi

Inocutis dryophilus **(Berk.) Fiasson and Niemelå**
Phellinus everhartii **(Ell. & Gall.) A. Ames.**

Hosts: Oaks

Symptoms/signs: Oaks are host to many heartwood decay fungi. Two of the most common are *Inocutis dryophilus* and *Phellinus everhartii*. The former produces an annual fruiting body that degrades quickly following spore dispersal, while the latter produces a perennial fruiting body (conk) that grows a fresh sporulation layer every year.

Figure 206. I. dryophilus *on Emory oak.*

Biology: As with most decay fungi, branch stubs are the most common sites of heartrot infection, but entry also occurs through trunk injuries. Fruiting bodies develop on living trees.

Effects: Either species can create extensive decay in mature trees, resulting in valuable wildlife habitat and/or creating tree failure risks of developed sites.

Figure 207. Heartrot, Phellinus everhartii, *on Gambel oak.*

Similar Insects and Diseases: There are many other fungi that decay the heartwood of living oak trees, but these are the most common.

References: 30, 93

Canker Rot of Oak
Inonotus andersonii (Ellis & Everh.) Cerny

Hosts: Oaks

Symptoms/ signs: *Inonotus andersonii* produces flat, bright yellow to yellow-brown fruiting bodies with peg-like outgrowths beneath the bark or outermost layers of wood. These fruiting bodies degrade quickly, turning dark dull brown to black, as if the wood was burned.

Figure 208. Inonotus andersonii *forms bright orange fruiting structures beneath the bark of infected trees that blacken with age.*

Biology: Branch stubs are the most common sites of infection, but entry also occurs through trunk injuries. *I. andersonii* first invades heartwood causing a white rot, and then moves outward, killing the sapwood and cambium (hence the name, canker rot). Trees often break at these cankers.

Effects: It causes mortality when decay advances from the heartwood into the cambium, girdling infected trees.

Similar Insects and Diseases: Old fruiting bodies of *I. andersonii* are black and are often mistaken for fire scars.

References: 30, 93

Cankers

Canker-causing fungi are common on hardwoods, especially aspen. Canker fungi are often the primary cause of aspen mortality because aspen bark is soft living tissue, extremely susceptible to wounding and subsequent infection by canker fungi. Disturbances such as selective logging, campsite construction, and recreation abuse can increase the incidence of canker diseases. Although the majority of canker-causing fungi described below occur on hardwoods, the last fungus discussed occurs on conifers. Canker-causing stem rust fungi are discussed in another section, "Stem and Cone Rusts of Pine."

Figure 209. Canker development in aspen begins with discoloration of the bark.

Cankers

Black Canker
Ceratocystis fimbriata Ellis & Halst.

Host: Aspen

Symptoms/signs: Cankers are target shaped with concentric ridges of dead callus. Older cankers typically have a central area of dead wood surrounded by a series of bark calluses. These callused areas may be concentric in outline, but usually are irregularly shaped and ragged in appearance because of the massive callus folds and flaring dead bark. Bark and exposed wood darken, resulting in a black canker.

Figure 210. Callus folds and flaring dead bark caused by Ceratocystis fimbriata.

Biology: *Ceratocystis fimbriata* can infect through the epidermis of leaf blades, petioles, and young stems; but trunk wounds are considered to be the primary places of infection. Several species of beetles have been found to carry the fungus and are believed to vector it. Infection first appears as a circular necrotic area on the trunk around a fresh wound or branch junction. During cambial growth in the spring, the tree forms a callus at the margins of the canker, which temporarily walls off infection. The fungus invades the new cambium and inner bark during the tree's next dormant season and kills a new zone of tissue. This process is repeated each year until the canker, consisting of successive rings of dead bark and wood, is formed. The fruiting structures, perithecia, are formed in the spring along the border of the canker on tissues dead at least a year. Spores ooze from the perithecia in sticky masses and are often vectored to other wounded trees by insects. Boring insects are often found in cankered areas. There appears to be a genetic predisposition to infection, as some aspen clones are more susceptible to infection than others.

Figure 211. Bark and callus removed to expose target canker.

Effects: *C. fimbriata* seldom kills large trees since trees generally grow faster in circumference than black cankers enlarge. However, it is possible for several cankers to coalesce and girdle a tree. The greatest damage from this disease is stem deformation and subsequent decay that can result in bole breakage.

Similar Insects and Diseases: Sooty bark (*Encoelia pruinosa*) is also black in color but does not form a target canker like *C. fimbriata*.

References: 39, 40, 45, 93

Cankers

Sooty Bark Canker

Encoelia pruinosa (Ellis & Everh.) Torkelson & Eckblad (*Cenagium singulare* (Rehm) R.W. Davidson & Cash)

Host: Aspen

Symptoms/signs: Young cankers appear as slightly sunken areas with near normal bark color. Dead bark eventually falls off and reveals the black, sooty and crumbly inner bark diagnostic for this canker. Beneath the inner bark is a distinctive, black, feather-like pattern on the wood surface. The perennial cankers form a band of light gray bark that remains attached at the margin of each annual zone of expansion giving the tree a barber pole appearance. Gray to black leathery cup-shaped fruiting bodies develop on the inner bark along the canker margin. The wood beneath cankers is light gray.

Figure 212. Black stripes on aspen bole indicate infection by Encoelia pruinosa.

Biology: The fungus infects trees through wounds and invades the inner bark and cambium. Cankers develop rapidly, extending as much as 1 m in length and 0.3 m in width in a year, however, the mean annual extension is about 45 cm vertically and 16 cm horizontally. The cup-shaped fruiting bodies—apothecia—develop on the surface of old dead inner bark and open when wet. Spores are forcibly ejected and wind disseminated when moisture and temperature conditions are favorable. These spores can cause new infections.

Effects: *Encoelia pruinosa* is considered the most lethal and aggressive pathogen of aspen in the West because it can kill trees of all sizes in 3 to 10 years; some mature trees have been observed to die in 4 to 5 years. Sooty bark is found mainly on the larger dominant and codominant trees older than 60 years, in the middle elevational limits of aspen. Cankers are more common in stands disturbed by partial cutting, construction, camper damage, or animal damage.

Figure 213. Cup-shaped fruiting bodies of sooty bark canker.

Similar Insects and Diseases: Cryptosphaeria canker can also produce dead inner bark with a soot-like appearance. However, Cryptosphaeria produces a long lens-shaped, light-colored area, which lacks the barber pole design.

References: 39, 40, 45, 93

Cankers

Cytospora Canker

Cytospora chrysosperma (Pers.:Fr.) Fr.

Hosts: Aspen, cottonwood, alder and other riparian species

Symptoms/signs: Young cankers on smooth bark appear as brownish-yellow sunken areas. They are often irregular in outline and range from diffuse to slightly target-shaped. Later, the bark often splits at canker margins, the inner bark turns black, and wood beneath the canker is stained brown and water soaked. Black, pimple-like, asexual fruiting bodies (pycnidia) develop within a few weeks after death of the bark. They extrude spores in orange-red tendrils in wet weather. Later, black, pimple-like sexual fruiting bodies (perithecia) originate beneath the bark, which expel white masses of spores during wet weather that collect on the surface of the bark.

Figure 214. An expanding cytospora canker.

Biology: The fungus causing cytospora canker exists in two stages, a sexual stage known as *Valsa sordida*, and an imperfect, or asexual, stage called *Cytospora chrysosperma*. The latter is more commonly encountered. The fungus is considered a normal inhabitant of aspen bark microflora, which readily enters and parasitizes bark that has been injured or weakened by any cause.

Cankers

Trunk cankers are formed by a gradual killing of the bark in a more or less circular area over a period of several years. Annual canker growth can be seen by the slight annual callus formation around the perimeter of infection. The fungus fruits readily in the dead outer bark; even when typical canker symptoms fail to develop. The *Cytospora* stage forms small black fruiting bodies from which sticky spores ooze out in long, coiled, orange-to-dark-red masses called spore tendrils. The "Valsa" stage appears as flask-shaped perithecia formed beneath and in a circle around the old pycnidia. Some ascospores are forcibly discharged from the perithecia; others collect around the openings of the perithecia in sticky white masses on the dead bark. The diseased inner bark remains attached to the tree for 2 or 3 years before turning lighter brown in color and falling off in large pieces.

Effects: *Cytospora chrysosperma* is the most common fungus found on aspen throughout its range. It is weakly parasitic and normally attacks stressed trees. *Cytospora* infection is associated with frost cracks and sunscald, elk feeding wounds, tree vigor and damage by fire.

Figure 215. Cytospora spore tendrils exuding from bark of a dead tree.

Similar Insects and Diseases: The orange tendrils or spore horns distinguish this fungus from all of the other aspen canker causing fungi.

References: 39, 45, 93

Cankers

Cryptosphaeria Canker
Cryptosphaeria lignyota (Fr.:Fr.) Auersw.

Host: Aspen

Symptoms/signs: Young infections and canker margins are orange to light brown. The cankers are long (3 meters or more) and narrow (2-10 centimeters wide), appearing as grayish depressions in the bark, with callus ridges forming at the edge. Dead bark adheres to the canker face. Inner bark is black and sooty with obvious fibers and small, light-colored flecks (<2 mm). Light orange, tiny asexual fruiting bodies may form near the edge of the canker. Clusters of black, flask-shaped sexual fruiting bodies (perithecia) develop beneath bark dead for more than 1 year. *Cryptosphaeria populina* also causes stain in the sapwood and heartwood and causes a yellow-brown, mottled decay.

Biology: Spores of *C. populina* are released during wet weather and infect fresh wounds in the inner bark and wood. The fungus eventually colonizes sapwood and heartwood,

Figure 216. Cryptosphaeria colonizes sapwood and cambium.

causing discoloration and decay, before penetrating the bark and causing a canker. Brown, mottled decay develops in the central part of the column of discolored wood. Mortality occurs not from bark necrosis as it may seem, but because the pathogen kills a large volume of sapwood.

Effects: Trees up to 15 centimeters d.b.h. may be killed within 3 years, with older trees taking longer to girdle. Branch cankers are often found on large trees, where they girdle the branch and enlarge onto the trunk. The decay associated with the canker predisposes infected trees to wind breakage.

Similar Insects and Diseases: Bark that has been dead for more than 1 year from *C. lignyota* is black, stringy, and sooty-like, similar to sooty-bark canker (*E. pruinosa*). However, they are easy to distinguish, because of the lenticular-shaped fruiting structures and barber pole design of *E. pruinosa*, both lacking in a Cryptosphaeria canker.

References: 39, 45, 93

Cankers

Hypoxylon Canker

Hypoxylon mamatum **(Wahlenberg) J.H. Miller**

Host: Aspen

Symptoms/signs: Young infections occur as slightly sunken, irregular, yellowish-orange areas around wounds or branch stubs. The underside of diseased bark appears laminated or mottled black and yellowish white. White mycelial fans form under the bark and are most evident at the top and bottom edges of the canker. Gray fungal pillars (asexual fruiting bodies) form beneath loose, blistered bark. Later, patches of gray-black, crust-like mounds form on the wood. These mounds contain perithecia, sexual fruiting bodies. The papery outer bark sloughs from older infections, exposing a blackened, crumbly inner bark. The cortex in the central portion of older cankers cracks in a checkerboard fashion, sloughing off in small patches.

Figure 217. A section of a Hypoxylon canker with cracked and blistering bark.

Biology: In the humid Lake States area, the fungus invades the sapwood and trees often die before they are completely girdled because sapwood decay beneath a trunk canker predisposes the tree to wind breakage. In the arid Southwest, however, breakage is not common. Cankers on large trees in the Southwest may attain ages of 20 to 50 years before tree death. A live 1 m d.b.h. aspen tree in Arizona was observed with a Hypoxylon canker extending from the ground to a height of about 12 m, only half-girdling the tree. There appears to be a genetic predisposition to infection, because some clones are more susceptible to infection than others within the same geographic area.

Effects: Hypoxylon canker disease is the most important canker disease of aspen in the Lake States region, but of minor importance in the Southwest. Hypoxylon canker annually kills an estimated 1 to 2 percent of the standing aspen volume in the Lake States area. While the disease causes serious mortality in localized areas in the Southwest, mortality rates have not been determined.

Similar Insects and Diseases: It is the checkerboard pattern of older infections that distinguishes this canker disease from others that occur on aspen.

References: 39, 45, 93

Cankers

Atropellis Canker
Atropellis piniphila (Weir) Lohman and Cash

Hosts: Southwestern white pine, limber pine and ponderosa pine

Symptoms/signs: Cankers appear as elongated depressions covered with bark. Atropellis species produce two kinds of fruit bodies, one flask-shaped and one cup-shaped, on killed bark. The flask-shaped structure develops first. These are black, about 1 mm across, and contain multiple chambers where spores form. The cup-shaped structures are black with a brown interior, measuring 2-4 mm across when moist. They form on cankers 2 or more years old and are present year round. Dark brown mycelium permeates the bark and wood, creating a zone of bluish black stain that in cross-section is initially wedge shaped, pointing toward

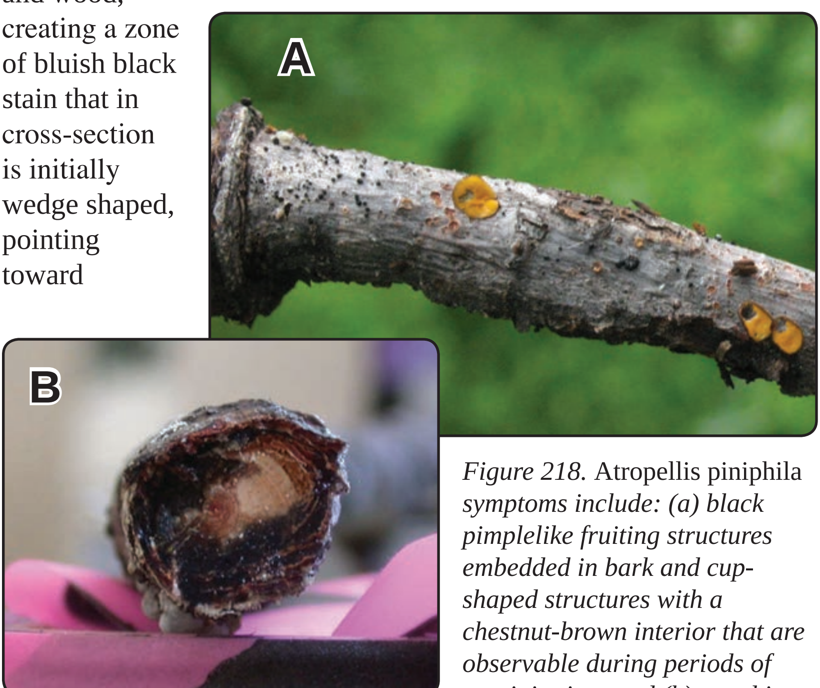


Figure 218. Atropellis piniphila *symptoms include: (a) black pimplelike fruiting structures embedded in bark and cup-shaped structures with a chestnut-brown interior that are observable during periods of precipitation; and (b) wood is stained black.*

the center of the stem, becoming irregular with age. Species are separated based on spore morphology.

Biology: Infection begins in a branch axil on stems 5-30 years old and so there is typically a branch stub in the center of the canker. Some cankers start on internodes, reflecting the ability of the fungus to infect wounds or bruised bark as well as apparently undamaged bark of young stems.

Effects: Atropellis canker can be found throughout the region but its occurrence is infrequent in natural forest settings. Although Atropellis rarely kills trees, there are areas where outbreak levels are reached and mortality occurs in young trees. It can be damaging in Christmas tree plantations where it causes trunk deformities and economic loss.

Similar Insects and Diseases: Atropellis canker may be confused with other canker-causing fungi; however, atropellis is the only one that stains the wood.

Reference: 101

Stem and Cone Rusts of Pine

There are several species of stem rust fungi on conifers in the Southwest. The rust fungi are unique in many respects. Some species of rust fungi are autoecious, which means they complete their life cycle on one host. Other species are heteroecious, which means they complete their life cycles on two entirely unrelated hosts. The most important rust species of trees are those that invade the main stem and cause mortality. The most destructive stem rust listed below is white pine blister rust, a nonnative pathogen found in New Mexico.

There is one species of cone rust in the Southwest and it infects Chihuahua pines in the southeast corner of Arizona.

Figure 219. Branch flagging and top-kill are common signs of stem rust infection.

Stem and Cone Rusts of Pine

White Pine Blister Rust
Cronartium ribicola J.C. Fisch.

Hosts: Southwestern white pine is the only species currently affected in the Southwest; limber pine and bristlecone pine are also susceptible. Currants and gooseberries (*Ribes* spp.) are alternate hosts.

Symptoms/Signs: Tapered branch swellings or stem swellings (on young trees) are an early symptom on pine. The characteristic white blisters (aecia) appear on mature cankers in late spring. After the blisters disintegrate, cankers have a dark, roughened appearance. Flagging (i.e. recently killed branches with red needles) occurs several years after initial infection.

Figure 220. Cronartium ribicola *spores are discharged from sacs or blisters in the spring.*

Figure 221. White pine blister rust sporulating on the bole of an infected tree.

Biology: Spores produced on *Ribes* leaves are wind dispersed and infect pine needles. The fungus grows into the inner bark, forming a canker that eventually girdles the branch or stem. Blisters erupt through the bark of the canker, releasing the spores that infect *Ribes*.

Stem and Cone Rusts of Pine

Effects: This nonnative disease is one of the most damaging tree diseases in North America. Trees of all sizes can be affected, although smaller trees are killed more rapidly than larger trees.

In the Southwest, white pine blister rust was first observed in 1990 near Cloudcroft, New Mexico. It was dispersed throughout the Sacramento and adjoining White Mountains, but was more common in moist, mixed conifer sites above 2,450 m. The disease was later found in the nearby Capitan Mountains and on Gallinas Peak (near Corona, NM). By 2005, it was discovered on the Gila National Forest in far western New Mexico. Although the forests of Arizona were scouted since the Cloudcroft discovery,

Figure 222. White pine blister rust cankers eventually girdle infected stems and branches.

Figure 223. Cronartium ribicola *on ribes.*

the first confirmed observation was in 2009, in the east-central White Mountains, including both White Mountain Apache tribal lands and the Apache-Sitgreaves National Forests.

Blister rust incidence does vary by habitat, with the higher incidence found on cooler, wetter sites. However, there is also a temporal effect. In newly infested areas, branch flagging and death of small trees is observed with little, if any, impact to mature trees. In older infestations, branch flagging and top kill of mature trees is common.

Figure 224. Top-kill and flagging on mature white pine.

Similar Diseases: The slight swelling and roughened bark formed by Atropellis canker can be mistaken for blister rust, and so can branch flagging due to rodent feeding of dwart mistletoe infected limbs. Ribes leaves are often infected by other rusts, such as Coleosporium ribicola, that can be mistaken for white pine blister rust.

References: 27, 70, 93

Stem and Cone Rusts of Pine

Limb Rust

Cronartium arizonicum Cummins

Host: Ponderosa pine, with Indian paintbrush as the alternate host

Symptoms/Signs: Dead and dying branches, often in the middle of the crown, are quite characteristic of this disease. Spore-producing sacs (aecia) are produced on live infected branches, and erupt through the bark in spring to midsummer. Trunks are not affected by this disease even though the fungus travels through it to get to the branches.

Biology: Initial infection occurs on a needle-bearing twig. The fungus grows into the sapwood and eventually reaches the main stem. It grows up and down the stem,

Figure 225. Live limbs bearing Cronartium arizonicum *spore sacs in the spring/summer die in the fall.*

Figure 226. Limb rust infection typically starts mid-crown and spreads in both directions.

entering and killing individual branches. Disease from this pathogen results in a progressive invasion and killing of branches by the fungal mycelium that is perennial in the trunk, but does not injure it. From an initially infected branch, the parasite grows into the wood of the trunk and advances upward and downward up to 18-21 cm per year in each direction and then out into branches where it sporulates. Infected branches typically die the following year.

There are at least three varieties of limb rust in the western U.S., collectively known as *Peridermium filamentosum*. *Cronartium arizonicum*, which uses Indian paintbrush (*Castilleja* spp.) as an alternate host, is the most common variety in Arizona and New Mexico. Another variety that spreads directly from pine to pine has been detected on the Kaibab Plateau in northern Arizona.

Effects: Although the disease can be very damaging to individual trees, its occurrence in an area is usually low. In Arizona, it has been observed throughout the ponderosa pine type, from the Coronado National Forest to the North Kaibab Ranger District.

Similar Diseases: Many agents can cause branch mortality, but limb rust is distinctive because of the progressive mortality in the center of the crown.

References: 80, 93, 117

Western Gall Rust
Peridermium harknessii J.P. Moore
Endocronartium harknessii (J.P. Moore) Y. Hiratsuka

Host: Ponderosa pine

Symptoms/Signs: This fungus forms round or pear-shaped galls on the main stem or branches, which emit orange spores. There is a white-spored race in Arizona and New Mexico that sometimes develops elongated galls.

Biology: This disease spreads directly from pine to pine. Infection occurs on a needle-bearing twig. The fungus stimulates the production of xylem, forming galls, which enlarge over the years. Spores appear on the galls in late spring.

Figure 227. White-spored gall rust displaying spore sacs and swollen branch.

Effects: This disease is probably widespread in the region, but at very low levels. Occasionally it has been destructive to seedlings and saplings, following infrequent "wave years" of new infection. Gall rust deforms but seldom kills older trees.

Similar Diseases: Dwarf mistletoe can cause trunk swellings (cankers) that are usually much longer than those produced by western gall rust.

References: 93, 117

Stem and Cone Rusts of Pine

Comandra Blister Rust
Cronartium comandrae Peck

Hosts: Ponderosa pine and Mondel pine (*Pinus eldarica*), and *Comandra pallida* is the alternate host.

Symptoms/Signs: Symptoms of disease on pine begin with slight, spindle-shaped swellings that give rise to pustules that soon exude a mass of rust colored spores. On the nonnative Mondel/Eldarica pine, comandra blister rust causes dieback of branches and eventual tree death. On ponderosa pine, its native host, this disease is rare but occasionally girdles seedlings and saplings. On *Comandra pallida*, the native alternate host, the rust causes pale yellow leaf and stem spots and leaf abscission.

Biology: The aecial stage develops on pine in late spring through early summer and spores disseminate by wind at that time. These spores are responsible for the primary infection of the alternate host, *C. pallida*. Rain and cool temperatures favor their germination. The next spore stage, the so-called repeating stage, occurs and builds up on Comandra, as long as there is wet weather. The final stages give rise to basidiospores in late summer, which are wind-dispersed to infect pine needles. The fungus grows into the inner bark, forming a canker that eventually girdles the branch or stem.

Effects: Although this disease causes major damage to lodgepole pine and sometimes ponderosa pine in northern Colorado and Wyoming, it is of minor consequence to ponderosa pine in Arizona and New Mexico.

Figure 228. Comandra pallida *with leaf infections.*

However, comandra blister rust has done considerable damage to plantings of Mondel pine in the Prescott, Sedona and Payson areas of Arizona. Beginning in the late 1970s, Mondel pines were planted widely as a landscape tree throughout these areas, until it was realized that comandra blister rust impacted their survival. Infected *C. pallida* are typically observed near infected Mondel pines.

References: 29, 93, 117

Figure 229. Comandra blister rust swollen canker.

Stem and Cone Rusts of Pine

Gymnosporangium Rusts
Gymnosporangium spp.

Hosts: Junipers and Arizona cypress

Symptoms/Signs: There are eight species of *Gymnosporangium* rusts of juniper in the Southwest and one on cypress. Most Southwestern Gymnosporangium rusts alternate on members of the Rosaceae family (especially serviceberry and hawthorn). The very showy *G. speciosum* alternates on littleleaf and false mock orange, members of the Hydrangeaceae. On the evergreen host tree, these rusts cause witches' brooms, galls, other branch distortions, and dieback of twigs and branches. Brown to orange hornlike or cushionlike projections (telia) are produced in the spring; these swell and gelatinize during wet periods and are quite

Figure 230. Telia stage of two juniper rusts: (a) G. speciosum *on unidentified juniper and (b)* G. clavariiforme *on common juniper.*

spectacular. On alternate hosts, the rust develops colorful spots and localized swellings on leaves, fruits, and green twigs, followed by casting or distortion and death.

Biology: Some *Gymnosporangium* species complete their life cycles in 1 year, but many require 2 years. Two spore stages form in spring through late summer on the alternate host. The second spore type is wind disseminated and infects juniper or cypress (depending on the rust species). *Gymnosporangium* species overwinter in their evergreen hosts, where they produce telia in the spring. The telia produce the final spore stage that infects the alternate host. Many of these rust species become perennial in juniper or cypress and produce telia annually on galls, swellings, or witches' brooms, until the infected area is killed by the infection.

Effects: In the Southwest, these fungi generally cause minimal damage to junipers, other than some deformities. Impact on the foliage and fruits of the alternate hosts may be more significant in years with adequate rainfall, causing early defoliation.

Similar Diseases: Witches' brooms caused by some of the juniper rusts could be confused with true or dwarf mistletoe infection.

References: 79, 93, 117

Fir Broom Rust
Melampsorella caryophyllacearum J. Schröt

Hosts: White and subalpine fir, with chickweeds as alternate hosts.

Spruce Broom Rust
Chrysomyxa arctostaphyli Dietel

Hosts: Engelmann and blue spruce, with bearberry and kinnikinnick as alternate hosts.

Symptoms/ Signs: Both of these diseases appear very similar on their respective hosts. The yellow to pale green brooms are dense and compact. Stem or branch swellings may also occur near the point of infection.

Figure 231. Yellow to pale-green witches' brooms are conspicuous even at the forest level.

Biology: Windblown spores produced on an alternate host are needed to start new infections on trees. Once a tree is infected, the fungus stimulates bud formation, leading to broom development.

Figure 232. Expanding foliage is pale green.

The brooms shed their needles in the winter and grow new ones in the spring.

Effects: Broom rusts can be found throughout much of the Southwest on their respective hosts. They typically occur at low levels, but are abundant in some locations. Infection typically results in deformity, which is most significant on young trees. Stem infections sometimes result in topkill and/or stem breakage.

Similar Diseases: Broom rusts are sometimes mistaken for dwarf mistletoe witches' brooms. However, the former are more

Figure 233. Foliage yellows in late summer.

Figure 234. Needles die and drop, leaving the broom devoid of foliage during winter.

dense and compact, and lack mistletoe shoots. Dwarf mistletoes of true firs and spruces have very limited distributions in the Southwest.

References: 93, 117

Figure 235. Chickweeds are alternate hosts for fir broom rust.

Figure 236. Topkill caused by spruce broom rust.

Figure 237. Infected needles release spores in mid to late summer.

Figure 238. Kinnikinnick is the alternate host to spruce broom rust.

Stem and Cone Rusts of Pine

Southwestern Cone Rust

Cronartium conigenum Hedgc. & N. Hunt

Host: Chihuahua pine, with live oaks as alternate hosts.

Symptoms/Signs: This disease produces swollen, deformed cones on Chihuahua pine that, when ripe, are loaded with orange spores beneath a thick papery outer surface. On oak, this disease produces several different spore stages. The type most often observed has the appearance of brown to black wool on the lower leaf surface.

Biology: This fungus produces spores on swollen deformed cones (galls) of Chihuahua pine in July and August, and other spores on the undersides of leaves of Mexican blue, Dunn, Emory, gray, canyon live, netleaf, silverleaf and Arizona white oaks throughout the summer. Cones become infected during their first year of development, swell into misshapen galls of various sizes, produce no seeds and do not open. Aecia develop 2 to 3 years after infection. Galls die after aecial production but remain on the trees. Large galls usually kill the branches that bear them.

Figure 239. Swollen Chihuahua pine cone infected with C. conigenum *and sporulating. An uninfected cone is on the right.*

Effects: During periods of outbreak brought on by favorable weather, cone rust may kill more than 50 percent of the cones on groups of trees. This disease also affects other pine species in Mexico.

Similar Diseases: None

References: 93, 117

Mistletoes

Mistletoes are parasitic plants that slowly weaken and eventually kill their host trees. There are two types of mistletoe in North America, true mistletoe (*Phoradendron*) and dwarf mistletoe (*Arceuthobium*). Both are parasitic on the stems of woody plants from which they derive water and mineral nutrients. True mistletoes produce most of their organic nutrients by their own photosynthesis and are believed to obtain little from the host. Although photosynthetic, dwarf mistletoes are dependent on the host for carbon nutrients for growth and reproduction. Dwarf mistletoes are generally considered to be more damaging than true mistletoes; however, host mortality associated with either type of mistletoe infection can occur during periods of drought when lack of stomatal closure of leaves of the parasite causes fatal water loss of the host.

Figure 240. Male (above) and female (below) A. vaginatum subsp. cryptopodum.

Mistletoes

Dwarf Mistletoes
Arceuthobium spp.

Dwarf mistletoes are the most common pathogens in Southwestern coniferous forests. They are parasitic, seed-bearing plants that depend on their hosts almost completely for water and nutrients. Dwarf mistletoes are natural components of many forest ecosystems in the West, having co-evolved with their hosts for hundreds of thousands of years. There are eight species in the region, each typically having one preferred host species.

Ponderosa pine dwarf mistletoe (generally referred to as **southwestern dwarf mistletoe** to distinguish it from a different species affecting ponderosa pine in California and the Northwest; it has recently been referred to as **pineland dwarf mistletoe** by some) has long been recognized as the most damaging disease of ponderosa pine in the Southwest. It occurs in over one-third of the ponderosa pine acreage in the region. Douglas-fir dwarf mistletoe occurs in roughly one-half of the mixed conifer acreage in the region. Other species of dwarf mistletoe have more limited distributions (see table).

Hosts: See table

Symptoms/signs: Aerial shoots of dwarf mistletoe plants vary by species in size, color, and pattern of branching. For example, southwestern dwarf mistletoe of ponderosa pine are often bright orange and conspicuous, and those of Douglas-fir dwarf mistletoe are often small and inconspicuous. Host branches and stems are often swollen at the site of dwarf mistletoe infections. Witches' brooms develop from either systemic infections or as a result of discrete, localized infections. The size and extent of brooms varies among dwarf mistletoes and their host.

Biology: Dwarf mistletoes have separate male and female plants. Seeds are produced annually on female plants. These are explosively released (typically 1 to 12 meters), and stick to host material. Upon germination, dwarf mistletoes produce an endophytic system, a specialized rootlike structure that is in contact with the phloem and xylem of host trees, from which the parasite obtains nutrients and water. Aerial shoots appear 3 to 5 or more years after infection; the period before shoots are visible is known as the latent period.

Figure 241. Male (above) and female (below) Douglas-fir dwarf mistletoe.

Spread of dwarf mistletoe occurs both from tree to tree and within the crowns of individual trees. Infections tend to build up initially in the lower half of a crown and gradually spread upward. Lateral spread of dwarf mistletoe through single-storied stands averages about 0.5 meter per year. Spread is relatively rapid from infected overstory trees to nearby regeneration.

Effects: As parasites, dwarf mistletoes cause significant changes in physiological processes and structural characteristics of infected trees, resulting in changes in the structure and function of forest communities. Tree growth and vigor usually decline when more than half the crown is parasitized. Most infected trees can survive for several decades; generally smaller trees decline and die more quickly than larger ones. Tree mortality in areas with extensive infection is often three to four times higher than in uninfested areas. Bark beetles frequently attack heavily infected trees, especially during drought.

Mistletoes

Extensive dwarf mistletoe infection greatly reduces forest productivity. On the other hand, infection has some benefits for wildlife. Large witches' brooms can serve as ideal nesting platforms for birds and small mammals, and snags create habitat for cavity nesting birds. A few species (most notably the blue grouse) are known to eat dwarf mistletoe shoots, although none depend on it as a primary food source.

Figure 242. Spruce dwarf mistletoe.

Figure 243. Apache dwarf mistletoe on southwestern white pine.

Similar Insects and Diseases: Some fungi cause the formation of witches' brooms: Broom rusts in white fir and spruce; Elytroderma needle cast in ponderosa, southwestern white pine, and piñon.

Where brooms are observed, branches should be checked for the presence of aerial dwarf mistletoe shoots to distinguish broom symptoms caused by other pathogens or physiological disorders.

References: 13, 34, 35, 77, 102

Figure 244. Female pinyon dwarf mistletoe with mature fruit.

Figure 245. Large witches' brooms and dying top on severely infected ponderosa pine.

Figure 246. Witches' brooms on Douglas-fir are often utilized by birds and mammals.

Mistletoes

Principal Hosts and Distribution of Dwarf Mistletoes in Arizona and New Mexico

Common Name	Species	Principal Host	Distribution
Southwestern dwarf mistletoe	*Arceuthobium vaginatum subsp. cryptopodum* (Engelmann) Hawksworth & Weins	Ponderosa pine	Throughout host type
Douglas-fir dwarf mistletoe	*Arceuthobium douglasii* Engelmann	Douglas-fir	Throughout host type
Western spruce mistletoe	*Arceuthobium microcarpum* (Engelmann) Hawksworth & Weins	Engelmann spruce, Blue spruce, and Bristlecone pine	Limited portions of host type, although common in eastern and central Arizona
Pinyon dwarf mistletoe	*Arceuthobium divaricatum* Engelmann	Piñon	Throughout the Southwest, except southeast Arizona
Apache dwarf mistletoe	*Arceuthobium apachecum* Hawksworth & Weins	Southwestern white pine	Eastern and southeastern Arizona, central and southern New Mexico
True fir dwarf mistletoe	*Arceuthobium abietinum* f. sp. *concoloris* Engelmann ex Munz	White fir	North rim of Grand Canyon National Park, Santa Catalina and Chiricahua Mts., AZ
Chihuahua pine dwarf mistletoe	*Arceuthobium gillii* Hawksworth & Weins	Chihuahua pine	Mostly southeast Arizona, but some in central
Blumer's dwarf mistletoe	*Arceuthobium blumeri* A. Nelson	Southwestern white pine	Huachuca Mts., Arizona

Figure 247. Dwarf mistletoe infected spruce.

Figure 248. Witches' broom caused by A. gillii.

Figure 249. Pinyon dwarf mistletoe witches' broom.

Mistletoes

Figure 250. Dwarf mistletoe infected piñon pine with declining crown.

Figure 251. Dead piñon with signs of severe mistletoe infection.

Figure 252. Southwestern dwarf mistletoe plants and witches' broom on ponderosa pine.

Mistletoes

True Mistletoes
Phoradendron spp.

True mistletoes are commonly known as the Christmas or leafy mistletoes. There are eight species in the Southwest, all within the genus *Phoradendron*. Three species occur on hardwoods, the other five infect conifers. *Phoradendron macrophyllum* has a very broad host range, occurring on most riparian tree species, while the other true mistletoes are genus specific.

Figure 253. Phoradendron coryae *in December.*

Hosts: See table

Symptoms/signs: True mistletoes are flowering plants with thick green stems. Plants are often round in form and up to 1 meter in diameter, depending on the species. Hardwood true mistletoes have thick green leaves that are nearly oval in shape, contrasting with conifer true mistletoes, which have small thin leaves or are nearly leafless. The small, sticky, berries are white, pink or red and are ripe from October to January, depending on the species. Evergreen clumps of mistletoe are readily observed on bare deciduous trees in winter.

Figure 254. Phoradendron juniperinum *with pink ripe berries.*

Biology: Fruit-eating birds distribute the seeds in their droppings or by wiping their beaks. Some bird species swallow the fruit whole and disperse the seeds to another tree, while other bird species pick out the seed, leaving it on the host plant, and swallow only the pulp.

Figure 255. True mistletoe on juniper.

When the seeds germinate a modified root penetrates the bark of the host and forms a connection through which water and nutrients pass from the host to the mistletoe. It takes approximately 2 to 3 years for shoots to develop, following initial infection, and another year before the plant is producing berries.

Figure 256. Phoradendron macrophyllum *on Arizona sycamore.*

Effects: Young or small trees are seldom infected by true mistletoe. In nearly all cases, initial infection occurs on larger or older trees because birds prefer to perch in the tops of taller trees. Severe buildup of mistletoe often occurs within an infected tree because birds are attracted to and may spend prolonged periods feeding on the mistletoe berries. True mistletoes are not aggressive pathogens. They use the host xylem as a water source and do not cause mortality until water availability to the host is limited. In some hosts, infected portions of the tree often exhibit galls on branches or burls in the trunk. On oaks, sycamores, and cottonwoods, branch dieback is associated with galls formed by the corresponding mistletoe.

Similar Insects and Diseases: Deformities caused by canker and rust fungi can resemble those caused by mistletoe.

References: 26, 36, 85, 93

Figure 257. Phoradendron californicum *has red berries that ripen in winter.*

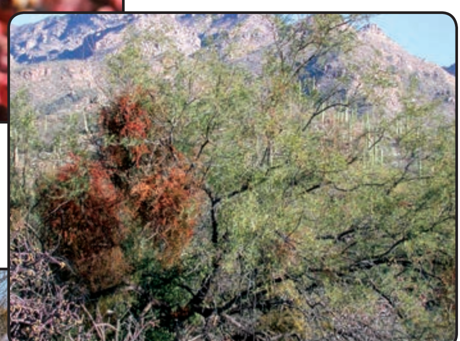


Figure 258. Desert mistletoe plants are red when full of fruit.

Figure 259. True mistletoes are easy to spot on deciduous trees like this mesquite tree.

Mistletoes

Principal Hosts and Distribution of True Mistletoes in Arizona and New Mexico

Common Name	Species Name	Principal Host	Distribution
Bigleaf mistletoe	*Phoradendron macrophyllum* (Engelm.) Cockerell	Most riparian hardwood species, except oaks	Throughout lower elevation riparian areas of both states
Southwestern oak mistletoe	*Phoradendron coryae* Trel.	Oak species	Throughout live oak woodlands and lower elevation gambel oak areas of both states
Desert mistletoe	*Phoradendron californicum* Nutt.	Leguminous trees and shrubs (e.g. Mesquite (*Prosopis* spp.), Acacia (*Acacia* spp.), Palo Verde (*Cercidium* spp.), and ironwood (*Olneya* spp.)	Throughout the ranges of host types in Arizona and extreme southwest corner of New Mexico

Figure 260. Phoradendron densum *on Arizona cypress.*

Juniper mistletoe	*Phoradendron juniperinum* Engelmann	All juniper species	Throughout juniper woodlands of Arizona and New Mexico
Hairy juniper mistletoe	*Phoradendron capitellatum* Torr. ex Tel.	Utah, alligator and red-berry juniper	Southern Arizona and southwest New Mexico
Texas juniper mistletoe	*Phoradendron hawksworthii* Wiens & CG Shaw	Alligator and one-seed juniper	Southeastern New Mexico
Dense mistletoe	*Phoradendron densum* Torr. ex Tel.	Arizona cypress	Central Arizona
White fir true mistletoe	*Phoradendron pauciflorum* Torr.	White fir	Santa Catalina Mountains of southeast Arizona

Figure 261. Phoradendron hawksworthii *on juniper in New Mexico.*

Figure 262. Phoradendron pauciflorum *often kills tops of infected white fir.*

Root Disease

Root disease fungi affect all tree species in the Southwestern Region, with Douglas-fir, true firs, spruce, and aspen being the most susceptible to damage. Susceptibility also varies by tree age, genetics, type of root disease pathogen present and site history.

Root disease or decay fungi spread from roots of diseased trees to those of healthy ones. They start in a tree or stump and spread slowly outward in all directions, resulting in a slowly enlarging group of dying and dead trees. The oldest mortality is located at the center of infection with a fringe of recently killed and dying trees around the outer edge. In the Southwest, these "centers" of disease are small in size, typically less than 1 acre.

Figure 263. Fruiting bodies of root disease fungi are located at the base or roots of infected trees.

Root disease is referred to as "a disease of the site" because the fungi colonize dead and dying trees and remain in dead roots and soils for many years. Many of these fungi have the ability to act as both pathogens in live trees and saprophytes in dead wood material. Not only are the current trees affected, but also trees that become established in the future. Some root disease fungi have been shown to remain alive and active in infested sites for more than 50 years.

The aboveground symptoms of trees affected by root disease include chlorosis, reduced needle length, progressive thinning of foliage, fading crown, reduced tree growth, and death. These symptoms are similar to those caused by drought, high water table, and bark beetle attack. However, the decline of trees affected by root disease usually extends over a period of a few to several years and not all trees succumb at the same time. The other causes of decline kill trees more rapidly, generally in 1 to 2 years, and a group of trees all die at the same time. Bark beetles commonly attack trees weakened by root disease infection.

The incidence of root disease often relates to the amount of human activity in forest sites. Harvesting timber from infected stands often increases root disease activity. In addition, changes in forest structure brought about by fire suppression and selective logging have led to increases in tree species more prone to root disease.

Figure 264. Root disease killed saplings associated with stumps.

Figure 265. Root disease infected trees are susceptible to bark beetle infestations.

Root Disease

Armillaria or Shoestring Root Rot
Armillaria spp.

Hosts: Douglas-fir, spruce, subalpine fir, oaks, and ponderosa pine.

Figure 266. White mycelial fans are found under the bark of infested trees.

Symptoms/ signs: The most diagnostic trait of *Armillaria* is the thick, fan-shaped mat of white mycelium in the cambium of roots and root crown. This may be accompanied by copious resin flow on bark surfaces, although this trait is not common in the Southwest. Other signs of the fungus include rhizomorphs, or black shoestring-like structures, on the outside of infected roots. The fruiting bodies of this fungus are commonly produced in clusters but can be found singly. The caps are yellow brown to dark tan, with small scales on upper surface. The stem is stout, tapering upward to a ring of tissue just below the cap. The decay is light yellow, soft and spongy to stringy often containing numerous black zone lines.

Figure 267. Armillaria produces shoestring-like rhizomorphs.

Biology: Armillaria root decay spreads primarily by rhizomorphs and root contacts. Armillaria invades the bark and cambial region of roots and the root collar, killing roots and trees of all sizes. Wood decay follows cambial attack, and the wood serves as a source

Figure 268. Fruiting bodies of Armillaria *spp.*

of energy necessary for infection of new hosts. New infections are less common, occurring when mushrooms release windborne spores that germinate and colonize recently killed material. As with other root disease fungi, Armillaria can persist for decades in decaying wood in soil.

Armillaria often acts in conjunction with other secondary pests and pathogens. For example, *Dendroctonus* and fir engraver beetles may attack trees with this root disease.

Effects: Armillaria is the most common root disease in the Southwest and may account for up to 80 percent of the root disease conifer mortality in the region. There are over 10 species of Armillaria, some are virulent parasites while others are opportunists that act selectively on small or weak individuals such as those shaded by taller plants, defoliated by insects, attacked by other fungi, or weakened by drought.

Figure 269. Decay of Armillaria is soft and spongy.

Similar Insects and Diseases: Other fungi such as *Fomitopsis pinicola* produce white mycelium beneath the bark of infected stumps, but the mycelium is not thick and fan-shaped like that produced by *Armillaria* spp, and *F. pinicola* produces a brown cubicle rot.

References: 32, 72, 91, 93, 113, 115

Root Disease

Annosus Root Rot

***Heterobasidion irregulare* (Underw.)**

Host: Ponderosa pine

***Heterobasidion occidentale* (Otrosina & Garbel)**

Hosts: White fir, subalpine fir, Engelmann spruce

Symptoms/signs: Fruiting bodies of annosus are grey-brown on the upper surface with an undersurface that is chalky white with pores. They are found on the underside of decayed roots and slash, inside stumps (common in the Southwest), or under the duff at the base of infected stumps and trees (rare in the Southwest). Annosus root disease leads to crown thinning and mortality or windthrow, the latter of which can occur before aboveground symptoms are evident.

Figure 270. Fruiting bodies of annosus root disease are often flat with the pores facing down.

Figure 271. Annosus fruiting bodies are commonly found on underside of roots and inside stumps.

Figure 272. Characteristic white pocket rot caused by annosus root disease.

Biology: Spores are produced on conks in decayed stumps or on roots of windthrown trees. The most common means of initial entry of annosus root disease into a site is via airborne spores that germinate on freshly cut stumps and basal wounds. Mycelium of the fungus quickly colonizes the stump and grows into its roots. Transmission to adjacent trees occurs via root contacts. In live trees, the fungus decays woody root systems and then advances to the root collar where it may surface to the cambium and kill by girdling, as in ponderosa pine, or progress more slowly through roots to the stem and cause butt decay, as in true fir.

There are two species of Heterobasion that cause root disease in North America, each with specific host preferences. In Arizona and New Mexico, *H. occidentale* infects white fir and sometimes spruce and subalpine fir, and *H. irregulare* infects ponderosa pine. Like *Armillaria*, the *Heterobasidion* fungi are common decays of dead woody material as well as pathogens.

Effects: This is one of the most important forest tree diseases in temperate zones worldwide. Damage to forests in North America has been most severe in the Southeast, where intensive forestry has exacerbated the disease due to providing stumps for colonization. In the Southwest, *H. occidentale* is a common root disease of white fir, but *H. irregulare* is fairly rare in ponderosa pine by comparison. For both species, infected trees are predisposed to attack by bark beetles.

Similar Insects and Diseases: The aboveground symptoms are similar to those caused by other root disease fungi.

References: 30, 54, 60, 74, 89, 93, 115

Figure 273. Wood discoloration is an early sign of annosus decay.

Tomentosus Root Disease
Onnia tomentosa (Fr.) P. Karst

Hosts: Spruce and Douglas-fir

Symptoms/signs: Fruiting bodies of *onnia tomentosa* most commonly develop in August and September. They are small (usually less than 10 cm in diameter), mushroom shaped, and have a lower pore surface from which the spores are released. Although leathery, they are annual. The upper surface is yellow-brown to rust-brown and velvety, and becomes dark brown with age. The early stage of decay is characterized by a red-brown discoloration in the heartwood of roots. The late stage is also reddish brown but appears lighter because of numerous small elongate pockets with pointed ends, filled with white mycelium. This type of decay is known as a white pocket rot. The most distinctive characteristic of tomentosus rot is that a cross section of an infected stem in advanced stages of decay has a honeycomb appearance.

Figure 274. Leathery O. tomentosa *fruiting body.*

Biology: Tomentosus root disease spreads primarily by root-to-root contact, however, infection by spores can occur through deep wounds in roots. There is no evidence that spores colonize stump surfaces as with annosus root disease. Diseased trees occur singly or in groups. The fungus spreads both outward in roots and up into the butt. Diseased roots have dead, decayed distal portions and red-brown, resin-soaked wood extending into the living portion and the butt. Advanced decay develops slowly and expands to involve both deep-lying wood and sapwood near the cambium. Infected trees often die standing, but sometimes blow over while alive because of advanced decay in major roots or butt. *O. tomentosa* has been found to persist for more than 50 years in decaying wood in soil.

Effects: Although tomentosus root disease has been observed in spruce/fir and transition forests throughout the Southwest, there is little information available on the extent and damage from this disease. In other parts of the country, blowdown caused by tomentosus root disease has initiated spruce beetle (*Dendroctonus rufipennis*) outbreaks but that has not been reported here.

Similar Insects and Diseases: *O. tomentosa* and *O. circinata* are nearly identical and difficult to differentiate macroscopically. Microscopically, *O. circinata* can be differentiated from *O. tomentosa* based on hooked structures the latter does not produce. *O. tomentosa* and *O. circinata* are sometimes called false velvet-top fungi, because of the similarity of the conks of these fungi with that produced by *Phaeolus schweinitzii,* which is the real velvet-top fungus.

Figure 275. Red-brown discoloration of roots decayed by O. tomentosa.

References: 30, 93, 103, 111

Schweinitzii Root and Butt Rot
Cow Patty, or Velvet Top Fungus
Phaeolus schweinitzii **(Fr.:Fr.) Pat.**
(*Polyporus schweinitzii* Fr.:Fr.).

Hosts: Douglas-fir, ponderosa pine, southwestern white pine, spruce

Symptoms/signs: Trees infected with *Phaeolus schweinitzii* do not typically show outward symptoms, so the presence of disease is usually not realized until a tree breaks or is windthrown due to loss in structural support. The fruiting bodies of *P. schweinitzii* often emerge through soil from decayed roots. They have a velvety surface which is yellow to orange at first, then turning brown with a yellow margin. It turns a dark red brown upon aging, is crumbly and can be mistaken for a cow pie at this point, hence the nickname "the cow patty fungus." Incipient decay appears as a light yellow to pale reddish-brown color. As the decay advances, the color intensifies and the wood rapidly loses strength. In advanced stages of decay, the wood breaks up into large cubes that are crushed easily,

Figure 276. Fruiting structures of P. schweinitzii *popping up from decayed roots.*

and the butt portions of infected trees can be swollen.

Biology: Spores likely initiate most *P. schweinitzii* infections. *P. schweinitzii* is unusual in that the fungus establishes itself in forest soil and enters trees through root tips. There is no root-to-root spread as used by other root disease causing fungi. Decay is confined to the roots and lower 1-2 m of the butt log, rarely extending much higher.

Figure 277. A young and colorful specimen of P. schweinitzii.

Effects: Schweinitzii root and butt rot is a major disease of older trees. It causes decay of the roots and lower stem and the resulting strength loss predisposes trees to windthrow and breakage.

Similar Insects and Diseases: The fruiting bodies of *O. tomentosa* and *O. circinata* are similar to *P. schweinitzii* since they are all velvety on top when fresh and have a pore surface beneath. However, *P. schweinitzii* fruiting bodies are larger, greater than 15 cm in circumference, while the other two are about 5 cm maximum.

References: 31, 93

Black Stain Root Disease
Leptographium wageneri (Kendrick) MJ Wingfield

Hosts: Piñon and Douglas-fir

Symptoms/signs: Like other root diseases, black stain usually exhibits symptoms of gradual crown decline before tree death. In the early stages of decline, terminal growth is reduced and older needles become chlorotic. As the disease progresses, older needles are shed prematurely, new needles are somewhat stunted and yellow, and reduced internodal growth is evident on lateral branches. Very small trees may succumb quickly without exhibiting gradual decline symptoms.

Black stain root disease is distinguished from other root diseases by the dark-brown to purple-black discoloration in the sapwood of the lower bole and root collar. When observed in cross section, the black stain appears in arcs roughly concentric with the growth rings.

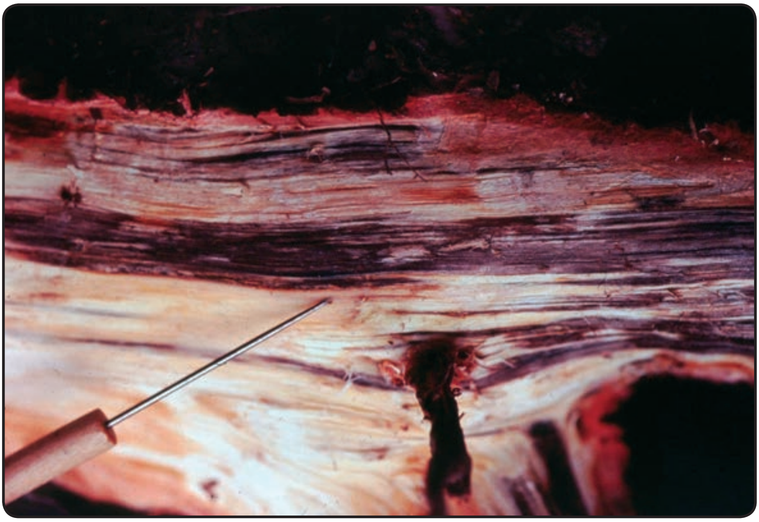


Figure 278. Black stain of piñon caused by Leptographium wageneri.

Root Disease

Biology: The Southwestern Region has two physiologically and morphologically distinct variants of black stain root disease. *Leptographium wageneri var. wageneri* is pathogenic to piñons and *L. wageneri var. pseudotsugae* (Harrington et Cobb) causes black stain in Douglas-fir. Both of these have been found in New Mexico but not in Arizona. A third variety *L. wageneri var. ponderosum* infects hard pines in California but has not been found in the Southwest.

Effects: Black stain root disease fungi grow in sapwood and plug tracheids, which prevents water transport and causes a wilting and rapid tree decline and death. Unlike species of *Armillaria heterobasidion, L. wageneri* does not cause wood decay and dies with its host.

Black stain root disease affects groups of trees in distinct infection centers. Typical infection centers have trees in various stages of decline near the perimeter and dead trees in the interior where infection originated.

Similar Insects and Diseases: Blue stain fungi, which are often confused with black stain fungi, are usually a lighter color and typically are wedge-shaped in cross-section and they can discolor the entire sapwood radius.

References: 38, 93

Ganoderma Root Rot
Artist's Conk
Ganoderma applanatum (Pers.) Pat.

Hosts: Aspen

Symptoms/signs: Infected trees often break or fall before death, however, a fruiting body or conk can be found at the base of most infected trees. The tough semicircular conk is usually found near ground level. It has a brown upper surface with a white rim and an undersurface that is white and stains when touched or scratched. The latter trait allows for artistic expression that is permanent if the conk is allowed to dry. *Ganoderma applanatum* produces advanced white-mottled decay in the large roots and lower parts of the stem.

Biology: *G. applanatum* infection occurs at wounds and the fungus attacks sapwood, heartwood, and cambium. The white-mottled rot is usually concentrated in large roots (larger than 5 cm in

Figure 279. Ganoderma applanatum *conks are often found at the base of infected trees.*

Figure 280. Trees often topple over due to severe decay of major roots.

diameter) and base of the stem, but can extend up into the trunk for a meter or more. The larger roots are believed to act as avenues of spread to new hosts.

Effects: *G. applanatum* is found in almost all aspen stands but is more abundant on moist sites with deep soils. Windthrow is common.

Similar Insects and Diseases: Although there are other root decay fungi of aspen, *G. applanatum* is the most prominent and the only one that produces a tough woody-conk at ground line in live trees in the Southwest.

References: 39, 93

Noninfectious Disorders

The symptoms of noninfectious, or abiotic, disorders closely resemble those of some parasitic diseases making it difficult to determine the cause. Some of these disorders serve as an entry for pathogens, such as canker and wood decay fungi.

Figure 281. Aspen stand with mortality caused by frost and drought.

Noninfectious Disorders

Drought

Water deficit develops as a normal phenomenon in plants when water loss by transpiration exceeds the rate of absorption from soil. Chronic injury results from long-term exposure to low water supplies (e.g. in areas with poor soils) and is expressed by growth loss and increased susceptibility to parasitic fungi and insects. Acute injury occurs under extreme water deficiency and is expressed by significant growth loss or death. Symptoms of drought damage include wilting, discoloration of foliage and premature leaf fall. Progression within the crown is from the top down and outside in, and the roots are usually the last portions to die. Symptoms can be similar to those of trees suffering from root disease, except that with root diseases, the roots die before the foliage. In the Southwest, drought symptoms have been observed in many trees including aspen, ponderosa pine, piñon, and soapberry.

Figure 282. Western soapberry with branch dieback following dry spring.

Figure 283. Aspen branch dieback during summer drought.

Winter drought is particularly harmful in Southwestern upland forests and can render large areas vulnerable to bark beetles and wildfire.

References: 83, 93

Frost

Figure 284. Aspen leaves succumb to June frost.

Frost damage of many tree species including aspen, locust, spruce, and oak has been observed throughout the Southwest. The tolerance of foliage and small branches to cold temperature depends on their "hardiness," which is closely correlated with the time of year and species. Temperatures just above freezing and short photoperiods induce frost hardiness. The sudden onset of below-freezing temperatures (frosts) in spring or early autumn can severely damage unhardened tissues, killing young shoots and leaves or needles.

As temperatures rise in late winter and early spring, plants deacclimate until, by the time growth begins, they can no longer tolerate more than a few degrees of frost. Leaves and stems killed by spring frost are usually small and succulent at the time of injury. More mature leaves and stems can tolerate lower temperatures. After thawing, damaged tissues at first appear water soaked and soon become shriveled and reddish brown, dark brown, or black, depending on the species. Dead leaves and shoots break off or abscise during the next several weeks. New shoots and leaves begin to grow almost immediately and soon mask the early season damage.

Figure 285. Newest and most sensitive growth of fir killed by frost.

References: 83, 93

Noninfectious Disorders

Winter Injury

Figure 286. Needle bases of 1-year needles are green but tips are brown.

There are several different types of winter damage of conifers in the Southwest. Water deficit can develop in dormant evergreens during warm weather in late winter or early spring when needles transpire water from leaves and stems while the soil is cold or frozen. Roots extract insufficient water from cold soil and none from frozen soil. Freeze damage occurs when needles no longer have enough moisture to survive normal nighttime temperatures. Freeze damage can also follow untimely deacclimation from temporary warm weather. Ponderosa pine and alligator juniper are the species most often observed with damage by these phenomena. Sometimes the result is trees that have needles with brown tips and green bases, and other times trees may have winter-killed needles that are completely brown regardless of age, but the branch and bud tissues are still green and viable. In either case, trees recover during the growing season. Occasionally, severe freeze damage near the upper elevational limits of a particular tree species causes mortality or topkill.

Figure 287. Winter injury can be mistaken for mortality at a distance.

References: 83, 93

Red Belt

Red belt, another type of winter damage, is named because of the appearance of red needled trees distributed in well-defined bands varying from less than 20 to as much as 1,000 yards wide on slopes and benches. These events are associated with the sudden occurrence of warm, dry winds (e.g. Chinook winds) that produce a temperature inversion. A relatively thin layer of warm air arrives that cannot mix downward and continues to contact side slopes. Trees exposed to unseasonably warm air by day receive seasonably cold air at night. This alteration of warm and cold air exposure, along with the frozen condition of the soil, results in desiccation injury because daytime transpiration removes moisture from the needles more rapidly than roots in frozen soil can replace it. Later, older needles fall off, leaving only current year needles on living branches after bud-break.

References: 83, 93

Figure 288. A band of cold air gets trapped at a specific elevation around mountains.

Windthrow

Windthrow is most common when soils are shallow and/or water saturated. Spring is very windy throughout much of the Southwest, and is the time when blowdown occurs in many root diseased infected areas. Blowdown is also prevalent in winter months when trees are loaded with snow.

More severe windthrow damage takes place with tornadoes and microbursts, which are occasional events in the Southwest. Tornadoes and microbursts both result in windthrown trees lying parallel to one another in the same direction as the wind. Tree species with shallow root systems (e.g. spruce) are more prone to windthrow.

Reference: 108

Figure 289. There are typically decay or soil defects associated with windthrown trees.

Figure 290. Tornadoes and microbursts have been known to knock down a swath of trees.

Noninfectious Disorders

Lightning

Most lightning struck trees are only superficially damaged, but approximately 2 percent of the annual tree mortality in the region has been attributed to lightning. Killed trees are either blown apart at impact or soon colonized by bark beetles, or both. Damage is in the form of a long narrow furrow in which the bark is removed and a narrow band of wood exposed. Sometimes lightning damage results in internal decay that may provide cavity-nesting habitat for wildlife.

References: 115

Figure 291. Lightning struck trees are often attacked by bark beetles.

Figure 292. Many lightning struck trees survive for decades and are slowly decayed.

Salt Damage

The uptake of salts by the roots of roadside trees is a common problem wherever sodium chloride, calcium chloride, and/or magnesium chloride are applied to de-ice highways in the winter or for dust abatement in the summer. Symptoms start as tip burn with the bases of the needles still green. Damage progresses with the continuation of salt application; first terminal growth of branches ceases, eventually followed by mortality.

References: 6, 83, 93

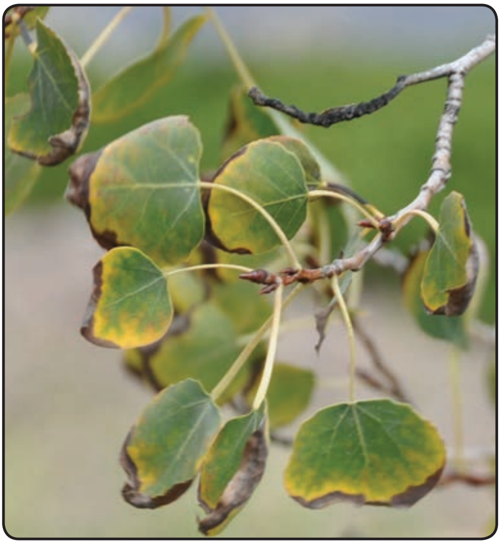


Figure 293. Damage from the application of de-icing salts along roadways appears on hardwood trees in the summer.

Figure 294. Most tree species experience tip burn from salt damage.

Noninfectious Disorders

Burls

Burls are large woody, more or less hemispheric, swellings on the main stems of trees. Although some stem swellings are the result of pathogens, often the cause of burls is unknown. Burls may often bear many buds or sprouts.

References: 93

Figure 295. The cause of burls is often unknown.

Animal Damage

Ungulates

Domestic livestock and wild ungulate browsing can cause severe damage to forest regeneration. Aspen forests in particular have suffered extreme damage. Rocky mountain elk are considered the primary threat to the long-term survivability of aspen, because they impact aspen in so many ways. Elk have a height advantage over other ungulates and are able to reach higher in the crowns of saplings, often snapping the main bole and killing it. Elk rub antlers on small diameter trees (7 to 15 cm), creating wounds that allow entry for canker and wood decay fungi. Elk also gnaw or strip the bark (a.k.a. barking) of larger trees, allowing the entry of insects such as the bronze poplar borer.

References: 39, 92

Figure 296. Aspen suckers are heavily browsed by ungulates, especially elk.

Figure 297. Elk "bark" mature trees with their teeth.

Figure 298. Elk snapped these saplings while feeding on foliage after a protective fence was removed.

Figure 299. Ponderosa pine browsed by ungulates.

Animal Damage

Black Bear

Ursus americanus

Figure 300. Black bears rip strips of bark from trees and feed on the cambium.

Black bears rip wide strips of bark from trees, often starting at about 1 m from ground line. They forage on the cambial zone in the lower bole by removing or peeling the bark with their claws and scraping the vascular tissue with their incisors. Trees are often girdled and die from one stripping, but sometimes survive. The wound left in partially girdled trees can lead to extensive decay. Bears also break branches on oak trees to access acorns.

In the White Mountains and Pinaleño Mountains of eastern Arizona, black bear strip the bark of southwestern white pine and subalpine fir greater than 25 cm in diameter. This activity is so widespread in some areas that it is difficult to find a large undamaged southwestern white pine or subalpine fir.

References: 47, 50, 94

Animal Damage

Porcupines and Squirrels

Although squirrels and porcupines have a variable diet during the growing season, in the winter they chew through the outer bark of branches or boles and feed on cambium. Coniferous trees are preferred. Squirrels target smaller branches and often target dwarf mistletoe infested limbs. Porcupine injury can be locally damaging because the animal tends to stay in a small area, girdling and killing the tops of many trees. Since porcupine populations tend to fluctuate, trees often form new leaders and grow to maturity.

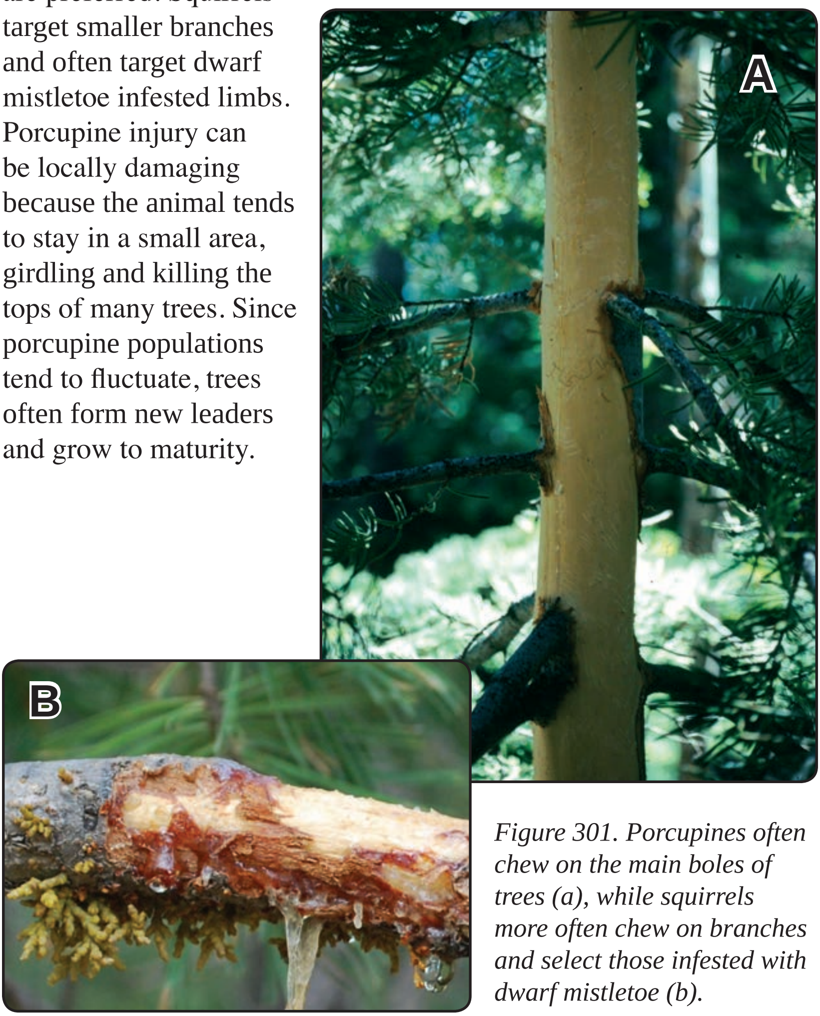


Figure 301. Porcupines often chew on the main boles of trees (a), while squirrels more often chew on branches and select those infested with dwarf mistletoe (b).

Animal Damage

Sapsucker

Sapsuckers feed primarily on the sap of trees, moving among different trees and tree species on a seasonal basis. Insects are attracted to the sweet sap exuding from sap holes, and are often captured and fed to young sapsuckers during the breeding season. When feeding, sapsuckers puncture the bark in horizontal lines around tree limbs or main stems. These punctures sometimes serve as entry points for stain or decay fungi. Intensive feeding by sapsuckers sometimes results in severe tree damage and mortality, even to large ponderosa pines.

Figure 302. Sapsuckers drill parallel rows of holes and feed on sap and insects caught in the sap.

Glossary

A

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 a biotic disease.

Aecia: A cuplike structure bearing aeciospores in the rust fungi.

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., rust fungi that use two hosts to complete a life cycle.

Arthropod: A member of the largest phylum in the animal kingdom including insects, crabs, spiders, etc.

B

Basidiospore: Spore formed after sexual recombination has occurred.

Biotic: A living organism.

Blue stain: A bluish to grayish discoloration of sapwood of a killed tree caused by fungi that utilize the material without causing decay, has no effect on the strength of the wood.

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: Fragments of phloem or wood excavated by adult bark beetles as it bores through the outer bark; brown to tan, often found in small piles in bark crevices and around the base of a tree.

Brood: The offspring or next generation of young hatched from eggs laid by one series of parents, and that mature about the same time.

C

Callus: Healing tissue of trees on branches, boles, or roots that attempts 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.

Cocoon: A thin covering often largely of silk which an insect larva forms about itself and in which it passes the pupal stage.

Conk: Fruiting body of a wood-decay 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.

Crawler: The dispersal life stage of aphids and scale insects.

Crop tree: Tree left after thinning, often because of superior quality or species and lacking defect or disease.

D

Decay: Rot or destruction and decomposition of plant material by fungi; wood decay is typically separated into brown or white rot depending on the wood compounds consumed.

Declivity: A term used to describe the descending distal slope of beetle forewings. For example, Ips beetles have spines on their elytral declivity, while Dendroctonus species have a rounded elytral declivity.

Defoliator: An organism that causes damage to plant foliage.

Diapause: The dormant phase of some insects. Can be either facultative or obligatory.

Dioecious: Male flowers and female flowers on different individual plants, as in mistletoe.

Disease: A disturbance of a plant caused by a pathogen (not an insect) or environmental condition that interferes with the plant's normal growth, structure, or reproduction. See also abiotic disorder.

E

Egg niche: A small impression or incision created by female bark beetle in which an egg is deposited.

Elytra: Hardened forewings of beetles that serve to protect the functional posterior wings.

Endemic: Typical, nonepidemic population.

Endophytic: An organism living within tissues of a live plant, as in mistletoe.

Epidemic: Large-scale, temporary increase in an insect or disease population.

F

Fecundity: Ability to produce young.

Flagging: Dying or recently dead branches; 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. Fungi cause decay of plant material.

G

Gall: An abnormal growth of plant tissue, stimulated by insect or fungal activity.

Gallery: Engraving of cambium or bark caused by bark beetles. Beetles create both egg galleries and feeding galleries. Design of egg galleries are used to identify beetle species.

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, one stage of an insect, typically a beetle, wasp, or bee, usually sluggish.

H

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.

Hibernacula: Shelters occupied during the winter by dormant insects, i.e., spruce budworm larvae overwinter in hibernacula.

Honeydew: Sugary liquid excretion of aphids or scale insects.

Host: A plant that is invaded by a parasite and from which the parasite obtains its nutrients.

Hypha: (plural=hyphae) a single branch of a mycelium.

I

Incipient decay: The early stage of decay in which degradation has not proceeded far enough to soften the wood or to cause a perceptible reduction in hardness. Such strength properties as toughness or impact strength are appreciably reduced in wood with incipient decay, but the damage is not normally visible to the naked eye.

Infection: The establishment of a parasite within a host plant.

Instar: The stage of an insect between successive molts.

L

Lanceolate: Spear-shaped, tapering at each end.

Larva: Immature form of an insect such as a caterpillar, grub, or maggot.

Lesion: A localized area of discolored, diseased tissue.

Latent infection: The state in which a host is infected with a pathogen but does not show any symptoms.

Life cycle: The stage or successive stages in the growth and development of an organism that occur between the appearance and reappearance of the same stage (e.g., spore) of the organism.

M

Metamorphosis: Change in form and structure between different life stages of insects. Some insects have incomplete metamorphosis (egg, nymph, adult), while others have complete metamorphosis (egg, larva, pupa, adult).

Midge: Tiny two-winged fly.

Molt: Process of shedding the exoskeleton, the insect "skin."

Monogamous: Mating with only one individual.

Mushroom: Fleshy fruiting body of a fungus that has either 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; associated with *Armillaria* spp.

Mychorrhizae: Association between plant rootlets and specialized fungi that is beneficial to their tree associate by assisting in nutrient and water uptake.

N

Necrotic: Dead plant cells or tissues.

Nuptial chamber: Mating site.

Nymph: Immature form of an insect resembling the adult, except for incomplete wing development.

O

Obligate parasite: An organism capable of existing only as a parasite on a live host.

Overwinter: Term used to describe what life stage an insect passes the winter in.

Oviposit: Lay or deposit eggs.

Ovipositor: Egg-laying apparatus.

P

Parasite: An organism living in or on another living organism (host) and obtaining its food from the latter. 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. Many pathogens of forest trees are fungi.

Perennial: Lasting for several years or more.

Pheromone: Chemicals produced by one individual to affect or alter the behavior of another individual of the same species. Many bark beetle species produce both aggregation and anti-aggregation pheromones, which mediate the colonizing behavior of other beetles.

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 resin mixed with bark, wood borings, and insect excrement that form 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.

Proleg: A fleshy leg that occurs on the abdominal segment of some insect larvae but not in the adult.

Prothorax: The anterior of the three thoracic segments.

Punk knot: An overgrown knot filled with old conk material or the beginning of a new conk, also called blind conk, reliable indicator of the presence of some wood decay fungi, i.e., *Phellinus pini*.

Pupa: Inactive stage of an insect, a transitional stage from larva to adult.

R

Radial growth: One-half the diameter growth of a tree.

Resinosis: Pitch or resin flow of a host tree in response to disease.

Rhizomorph: A specialized form of mycelium produced by certain fungi (e.g. *Armillaria* spp.) consisting of several strands of hyphae twisted together so as to be rootlike, and covered with a protective sheath.

Rot: Decay or deterioration of organic material through the enzymatic activity of microorganisms.

Rust: A disease caused by one of the rust fungi; highly specialized pathogens that are obligate parasites, which frequently require two different types of hosts to complete their life cycles (heterocyclic), and produce orange, yellow, or brown spores.

S

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.

Scales: A small thin, plate-like structure found on the wings of Lepidoptera.

Serrate: Saw-toothed edge.

Shootborer: Insects that feed in the pith of shoots.

Sign: The pathogen or its parts or products seen on a host plant.

Slash: Debris such as logs, bark, and branches left after cutting timber.

Spore: The reproductive unit of fungi consisting of one or more cells, analogous to the seed of green plants.

Sporophore: Fruiting body of a fungus that produces spores (i.e., mushroom or conk).

Stage: A distinguishable period of growth and development of an insect, i.e., the larval stage of an insect.

Stomata: Breathing pore in the epidermis (outer layer) of a plant.

Subcortical: Below the bark.

Sunscald: Death of bark due to sudden exposure to sun. This is common in mature aspen where neighboring trees have been removed.

Symbiotic: An intimate association between two species, which benefits both.

Symptom: The external and internal reactions or alterations of a plant as a result of a disease or insect.

Systemic: Throughout the plant host tissues, usually surviving from year to year.

T

Target canker: Perennial canker produced by a fungus which invades live tissue during the host dormant season, and survives in dead material during the host growing season.

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.

V

Vector: An organism such as an insect that transmits a pathogen.

W

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 is also sometimes 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).

Woodborer: Diverse group of insects that feed at least in part in the wood. Many of these insects begin their larval stage in the cambium before constructing galleries in the xylem (wood).

X

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.

Z

Zone line: Narrow black to brown lines in decaying wood formed by fungi.

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Instructions for Submitting Insect and Disease Specimens for Identification

Both zone offices are equipped to receive forest insect or disease specimens submitted from the field for identification. Specimens may be shipped to the appropriate zone office (addresses shown on next page). The following procedures for collecting and shipping specimens should be used:

Collecting

1. Adequate material should be collected
2. Adequate information should be recorded, including:
   a. location of collection
   b. when collected
   c. who collected the specimen
   d. host description (species, age, condition, etc.)
   e. area description (forest type, site conditions, etc.)
   f. unusual conditions (frost, poor drainage, etc.)
3. Personal opinion of the cause of the problem may be helpful.

Packing

1. *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 sure bottles are well sealed.
2. *Pupae and hard-bodied insects* may be shipped either in alcohol or in small boxes. Specimens should be placed between layers of tissue paper in the boxes. Pack carefully and make sure there is little movement of material within the box. Do not pack insects in cotton.

3. *Needle or foliage diseases:* Do not ship in plastic bags as condensation can become a problem. Use a paper bag or wrap in newspaper. Pack carefully and make sure there is little movement within the box.
   Mushrooms and conks: Do not ship in plastic bags. Either pack and ship immediately or air-dry and pack. To pack, wrap specimens in newspaper and pack into a shipping box with more newspaper. If on wood, include some of the decayed wood.

Federal Forest Health Zone Offices

Arizona Zone Forest Health
2500 South Pine Knoll Drive
Flagstaff, AZ 86001

New Mexico Zone Forest Health
333 Broadway Blvd., SE
Albuquerque, NM 87102

State Insect and Disease Specialists

Arizona
Forest Health Program
P.O. Box 15018
Northern Arizona University
Flagstaff, AZ 86011

New Mexico
New Mexico EMNRD, Forestry Division
1220 S. St. Francis Drive
Santa Fe, NM 87505

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