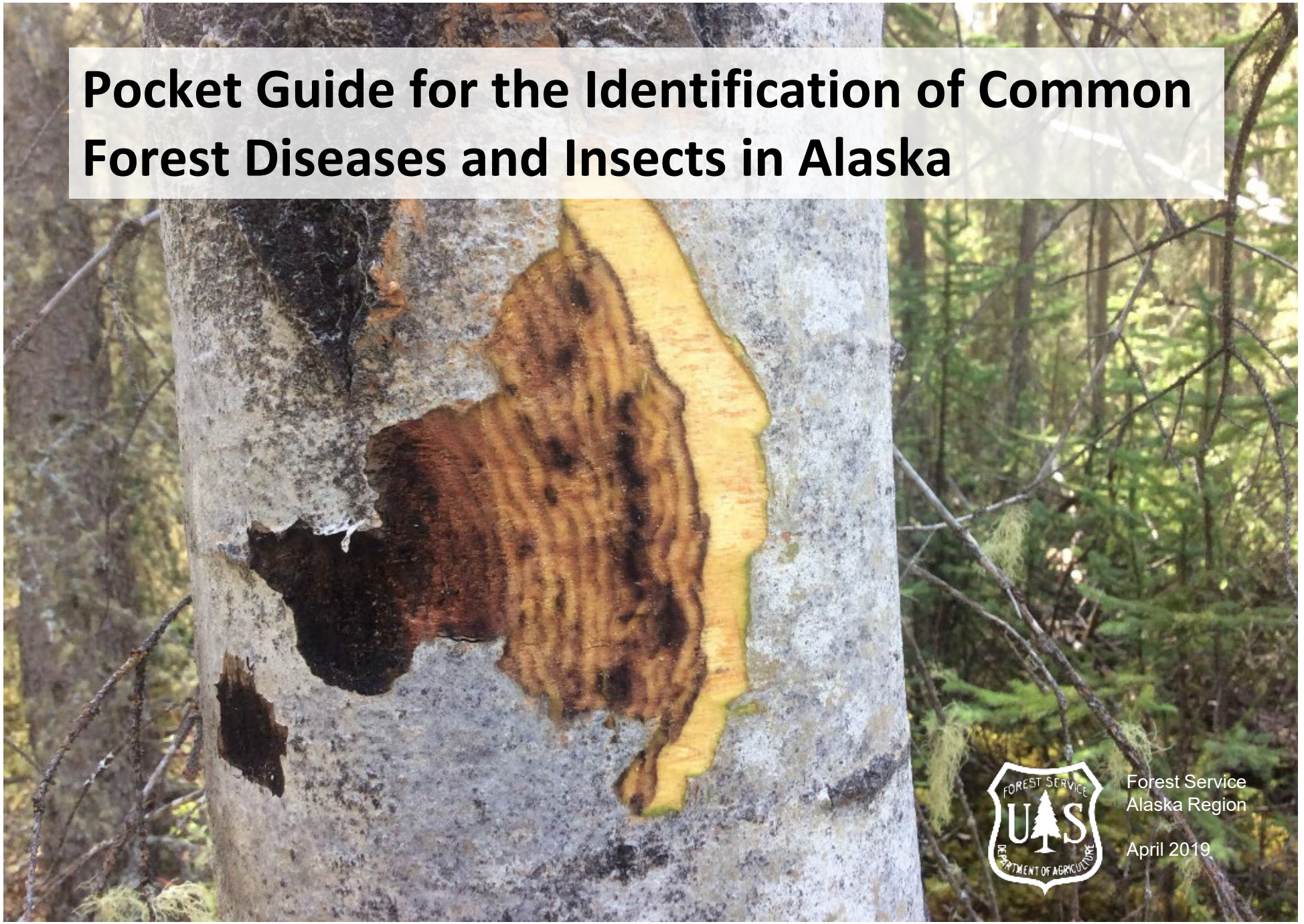
Pocket Guide for the Identification of Common Forest Diseases and Insects in Alaska



Forest Service
Alaska Region

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Diseases and insects cause enormous volume loss and tree mortality to the forests of Alaska. They also play vital ecological roles by cycling nutrients, providing wildlife habitat, and enhancing forest diversity. This guide is designed to assist with the identification of the most common diseases and insects of trees in Alaska. It was produced as an aid for field-going crews.

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Printed on waterproof materials

On the cover: A debarked lesion of Aspen Running Canker; the brown tissue is necrotic, the greenish-yellow tissue is still healthy.
On the back cover: Willow leafblotch miner damage. Mining produces necrotic tissues reducing photosynthesis

Root and Butt Rots

Root and Butt Rots

Hosts: All tree species in Alaska.

ID: Decayed roots and butts. Mushrooms, conks, or other fungal structures on the root collar or roots (nonpathogenic mushrooms and conks can also be found near tree bases). Uprooted trees have few remaining roots (root ball, root wad). In a root disease center, the direction the trees fall may be inconsistent with the direction of prevailing wind.

Remarks: Root diseases are the most damaging group of forest diseases in the U.S. The known root and butt diseases in Alaska are caused by internal wood decay (rot) fungi that may overlap with stem decay fungi. Butt rot fungi decay the heartwood at the base of the stem. Trees can live with butt rot for years or decades. Tree mortality usually occurs due to uprooting or snapping associated with the loss of structural integrity.

Armillaria species

Armillaria Root Rot

Armillaria species

Armillaria Root Rot

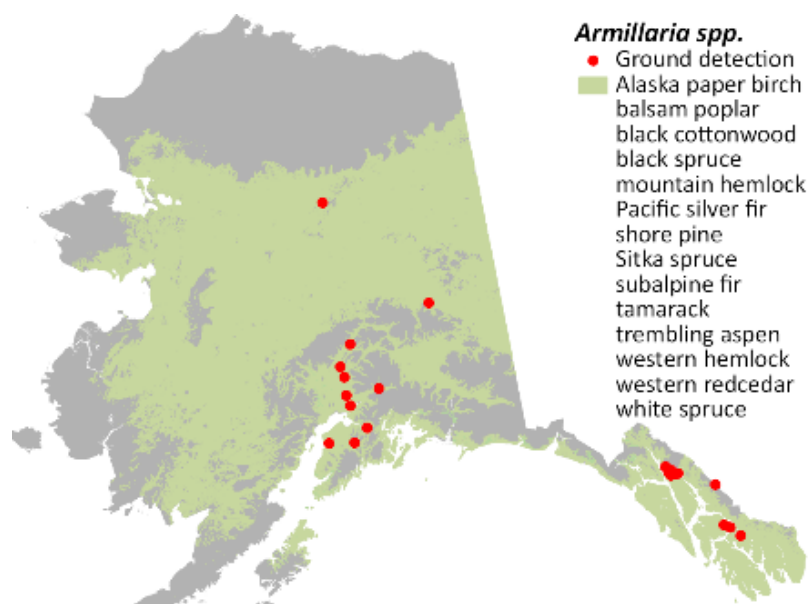
Hosts: All tree species in Alaska.

ID: Thick, latex-like mycelial fans under bark and black shoestring-like structures (rhizomorphs) under bark and on surface of roots and/or lower bole are the best indicator. The mushroom sometimes occurs in clusters at tree base but is uncommon and difficult to identify.

- Top: honey colored, sometimes with dark brown scales.
- Bottom: white gills attached to both stalk and cap.
- Stalk: ring around stalk below gills.

Damage: Growth loss**,** snapped trees, mortality. Advanced decay is white stringy rot, often spongy and wet. On hardwoods, often with gelatinous pockets.

Remarks: Also called shoe-string rot and honey mushroom. Some species are bioluminescent! *Armillaria* species can form humongous clones and vary in their aggressiveness and ecological role; some are highly pathogenic, while others attack trees already stressed or killed by other factors.



Onnia tomentosa Tomentosus Root Rot

Onnia tomentosa Tomentosus Root Rot

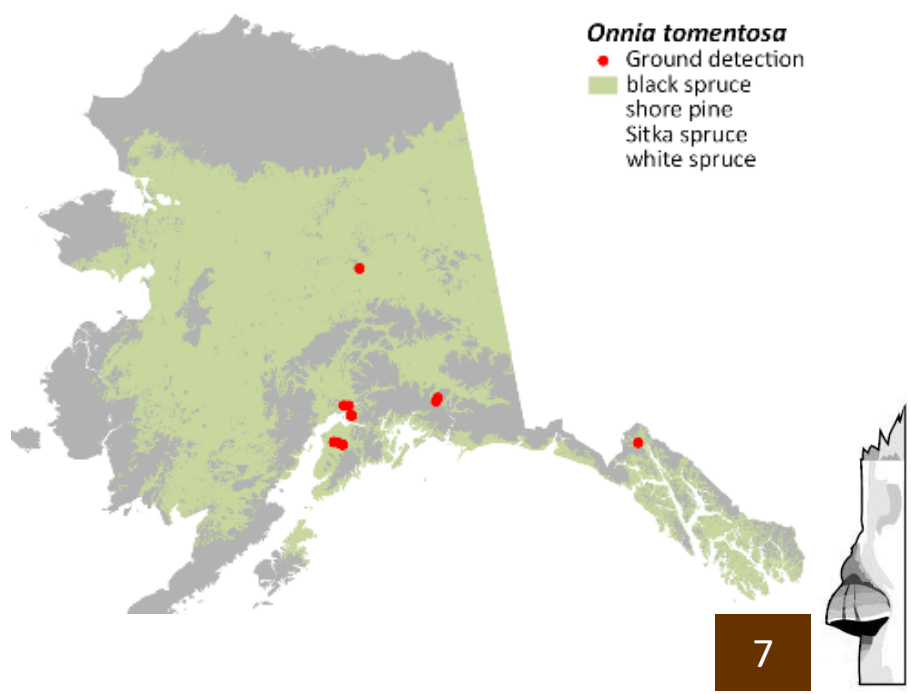
Hosts: Primarily white and black spruce; but also Sitka spruce and lodgepole pine.

ID: Leathery mushroom < 4“ diameter, often has embedded litter; on ground attached to roots or tree base; found late summer and autumn.

- Top: distinctly felty, yellow-brown to rusty-brown with a blunt, rounded, yellowish-white margin.
- Bottom: creamy-white with small round pores (no gills).
- Stalk: thick central stalk has pores that run partway down and there is often brown felt along the portion closest to the ground.

Damage: Mortality, uprooted trees with few intact roots, ; White pocket rot results in pitted to honeycombed decay of roots; look carefully for honeycombed roots on uprooted spruce. Stump incipient decay is pinkish to red-brown.

Remarks: Canada’s neighboring Yukon Territory has conducted limited surveys that suggest more than 40% of trees were infected. Can be very difficult to diagnose. Conks often not present. Formerly known as *Inonotus tomentosus*.



Phaeolus schweinitzii Schweinitzii Butt Rot

Phaeolus schweinitzii Schweinitzii Butt Rot

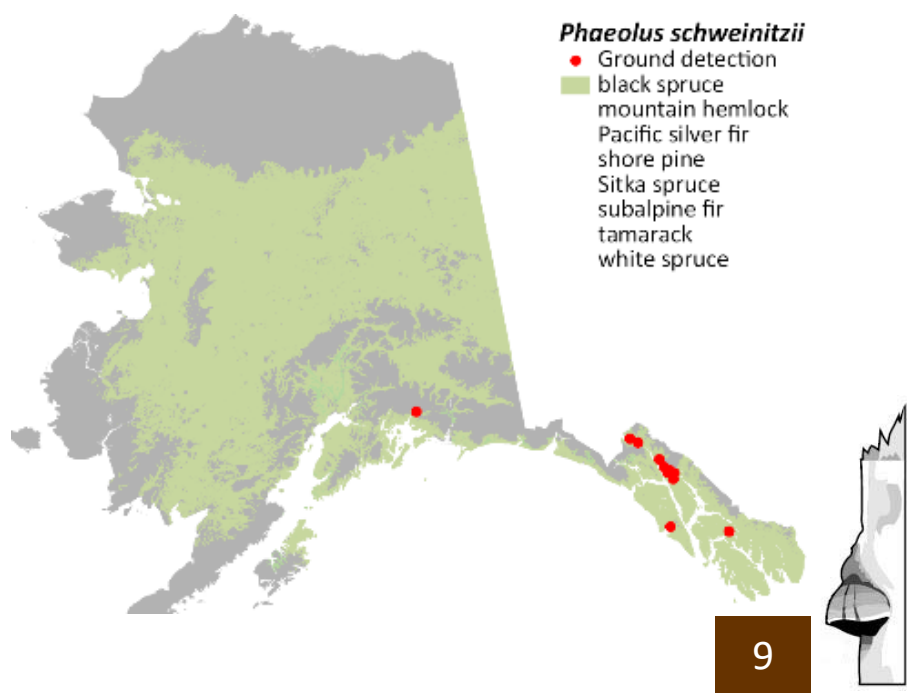
Hosts: Sitka spruce, white spruce, and hemlock; rare on shore pine in Alaska.

ID: Large, annual, layered fruiting body; shelf-like on lower bole; circular and stalked with sunken center on ground. Develops on both live and dead trees/logs. Turns dark red brown and brittle when dead (resembles cow pie)

- Top: velvety, yellow to orange when young, turning brown with a olive brown to yellowish margin.
- Bottom: large, irregularly shaped pores, bright yellow to orange when young becoming greenish yellow, olive or brown; quickly bruises dark brown.

Damage: Brown cubical butt rot, often extensive. Rapid loss of tensile strength, even at fairly early stages of decay, may lead to breakage on lower bole.

Remarks: Also known as the cow pie fungus, velvet top fungus or dyer's polypore. Can be used to create yellow, brown, and green dyes. Sometimes confused with *Onnia tomentosa*.



Pholiota species

Yellow Cap Fungus

Pholiota species — Yellow Cap Fungus

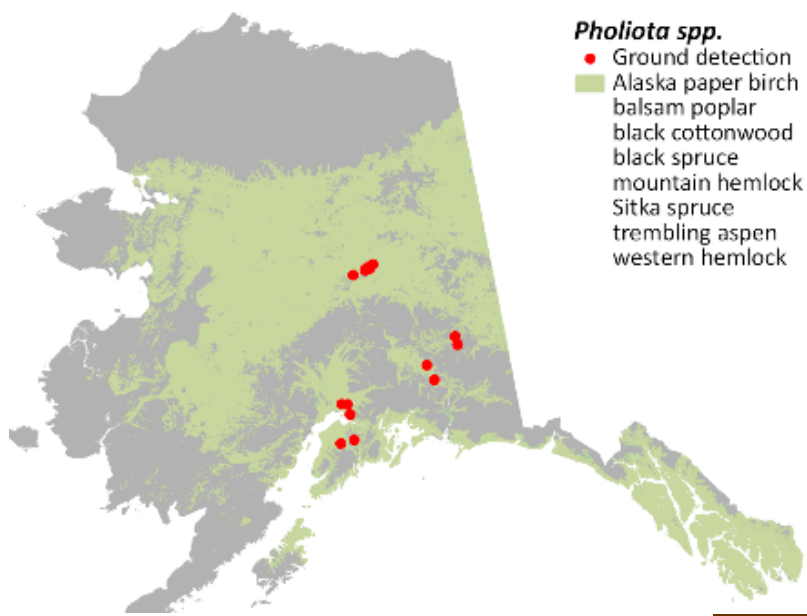
Hosts: Aspen; sometimes birch, cottonwood, balsam poplar, spruce and hemlock.

ID: Yellowish tender mushrooms on lower bole or base of living trees, or on the ground near base, usually in clusters.

- Top: yellow-brown and scaly when young, becomes sticky with age and loses scales.
- Bottom: gills yellow at first, later turning brown.
- Stalk: usually scaly when young, may or may not have a ring.

Damage: Incipient decay is a yellow stain in the heartwood. Advanced decay is yellow-white with yellow or yellow-brown streaks; thin strands of yellow-brown mycelium occur along the grain.

Remarks: Several *Pholiota* species have been reported to cause butt and trunk rot of trembling aspen throughout its range in North America. *Pholiota* require microscopic examination to determine species.



Cankers

Cankers

Hosts: Common on hardwoods, but occur on all tree species in Alaska.

ID: Localized death of bark and cambium on stems, branches, and twigs; often sunken; may appear swollen around canker when callus tissue forms; may be resinous in conifers; canker margin variable and may be subtle, diffuse, elongated, or distinctly target-shaped with flaring bark.

- Diffuse – Indistinct canker margin unless discoloration is severe. Scraping away bark reveals sharp margin between live and dead/dying cambium. Necrosis spreads rapidly so the host does not build callus to retard the fungus. Fungus can expand during growing season.
- Target – To contain the fungus, the tree forms callus at canker margin each year thereby forming a target pattern. Fungus expands when tree is dormant.

Damage: Death of cambium; may girdle and kill main stem or branches; may predispose tree to snapping.

Remarks: The only way to positively distinguish many cankers from abiotic wounds/injury is to collect and identify the microscopic fungal fruiting bodies. However, target-shaped cankers with flaring bark can be more reliably identified in the field.

Unknown fungus

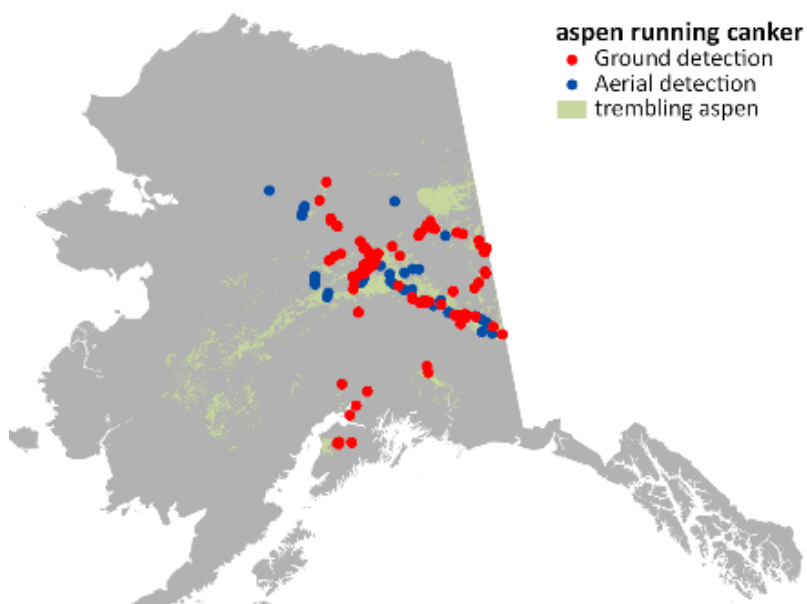
Aspen Running Canker

Hosts: Aspen.

ID: Bark looks dead or discolored orange to brown. Distinct margin between live and dead/dying tissue, may need to scrape away the bark to see. Often has a slight ridge where new wood is forming at margin between live and dead tissue. With older cankered areas, the bark over the dead cambium dries and may crack at margin.

Damage: Death of cambium, branches, and eventually entire tree. Tree mortality can occur within a year or two when the aggressive cankers girdle the main stem. Trees killed by aspen running canker often occur as singletons scattered throughout a stand. However, it is not uncommon to see groups of trees killed by this disease.

Remarks: Disease incidence is higher (up to 64%) on smaller diameter trees in older stands. In contrast, young stands (less than about 20 years old) have little to no disease. The causal agent of this disease has not yet been identified.



Unknown fungus

Aspen Target Canker

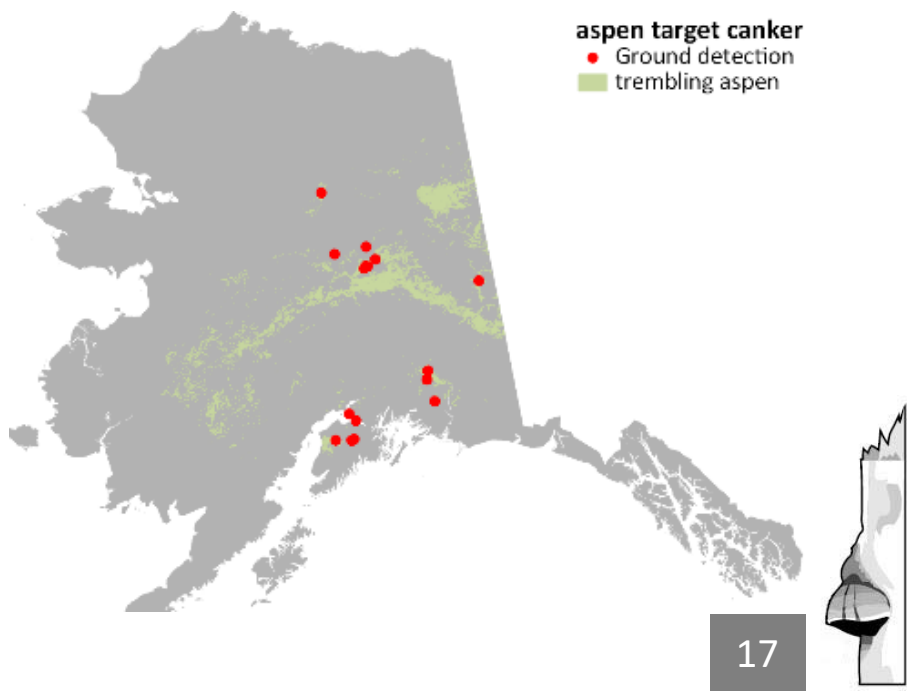
Unknown fungus — Aspen Target Canker

Hosts: Aspen.

ID: Distinctive target-shaped cankers with flaring bark. The concentric rings of the target are formed as the fungal infection inhibits wood production each year. One might estimate the age the canker by counting the rings.

Damage: Death of cambium. As fungus goes dormant the tree puts on wood and callus tissue to try and contain fungus.

Remarks: These cankers are very slow. On aspen it does kill trees, however it usually requires several cankers to eventually girdle and kill. Macroscopically similar in appearance to cankers caused by *Ceratocystis fimbriata*, however, signs of a causal fungus have not yet been found.



Unknown fungus

Hemlock Canker

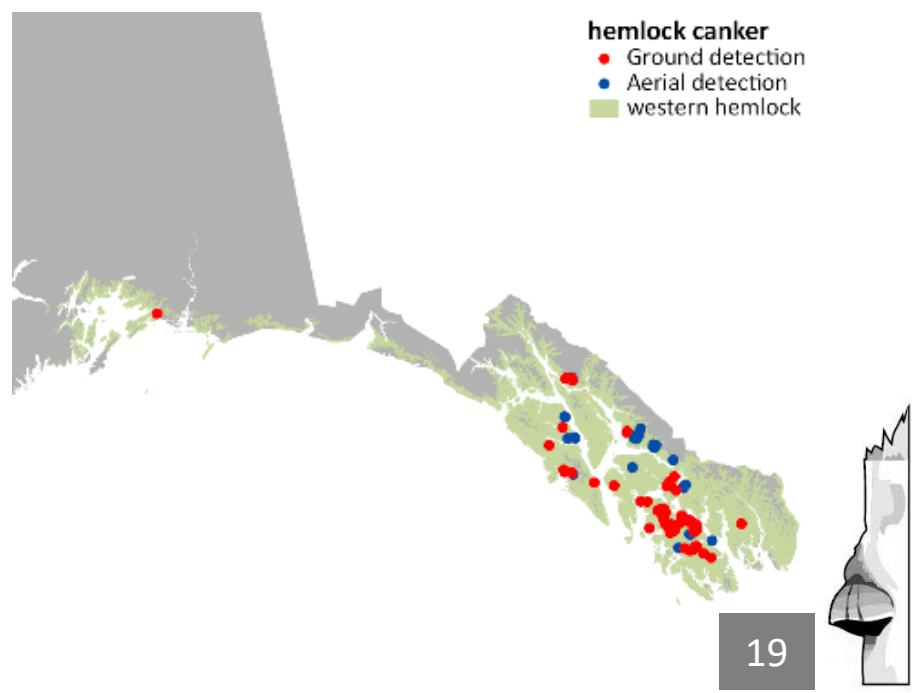
Unknown fungus — Hemlock Canker

Hosts: Western hemlock.

ID: Synchronized mortality of small and medium western hemlock trees and lower branches of large trees. The disease usually does not kill trees greater than 14 inches in diameter. Recently-killed branches and trees will hold red-brown needles for one to two years. Other symptoms include bark lesions and bleeding or resinous cankers.

Damage: Death of cambium, girdling branches and boles.

Remarks: This disease flares-up a few times per decade in Southeast Alaska, most recently since about 2012-2014. Prevalent on Prince of Wales Island, also found on Etolin, Revillagigedo, Kuiu, Chichagof, and Baranof Islands, and also the coastal mainland to Cordova. This disease tends to be most severe along roads in unthinned young-growth stands, but can also kill hemlock crop trees in thinned young-growth stands and old-growth forests.



Stem Decays

Stem Decays

Hosts: All tree species in Alaska.

ID: Rotting or deteriorating wood that initially develops in the trunk, rather than roots and butt. Presence of conk, mushroom, or other fungal structure on bole. Heart rot develops in the heartwood (inner wood) of living trees. Sap rot develops in the sapwood (outer wood beneath bark) and is usually extensive only in dead trees. Bole wounds and cracks provide entry points for many stem decay fungi. Wildlife holes, cavities, and hollows also indicate the presence of stem decay on live trees.

Damage: Stem decays predispose trees to bole breakage.

- Brown rots are particularly detrimental to tree strength. They degrade cellulose fibers leaving behind brownish lignin, which dries in brittle cubes.
- White rots decompose all wood components (cellulose and lignin); wood remains fibrous until very late stages of decay. The color and texture of white rots is dependent upon the causal fungi.

Remarks: Tree defense mechanisms in living trees include bark, sapwood, and cambium. Heartwood defense compounds degrade over time.

Echinodontium tinctorium Paint Fungus

Echinodontium tinctorium Paint Fungus

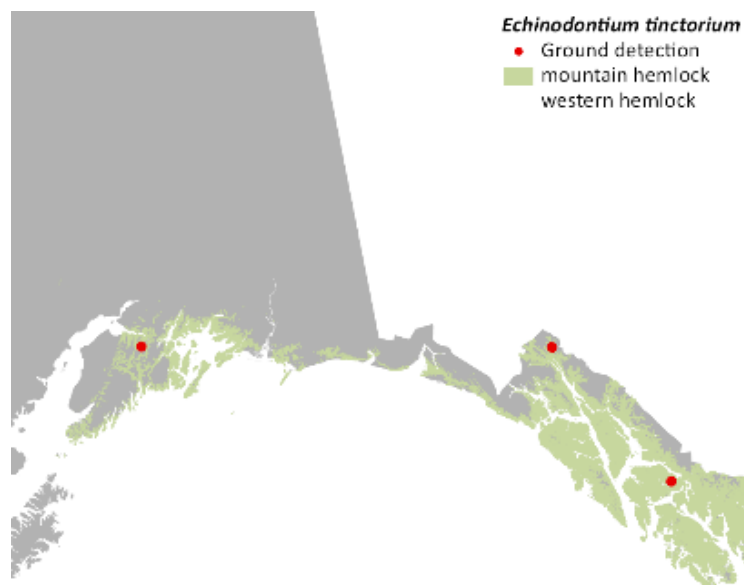
Hosts: Western and mountain hemlock; occasionally spruce.

ID: Perennial, woody, hoof-shaped conk anywhere on bole. Forms as a parasite on living trees, usually on or under branch stubs or dead branches.

- Top: rough and cracked, dull black to dark grey.
- Bottom: grey-brown to black; thick, blunt spines or teeth.
- Inside: brick red to rust red or orange. The pigment extends into the adjacent wood.

Damage: Laminated stringy white rot, usually mid-trunk. Trunk may become completely hollow.

Remarks: Presence of conk indicates substantial heart rot. In Alaska, occurs in the northern Panhandle near Haines and Skagway and in south-central Alaska within the distribution of mountain hemlock. Identified at one location on Mitkof Island, so may be present elsewhere on the Panhandle. Traditionally used to prepare red paint pigments.



Fomes fomentarius Tinder Conk

Fomes fomentarius Tinder Conk

Hosts: Birch; occasionally alder, aspen, balsam poplar and cottonwood.

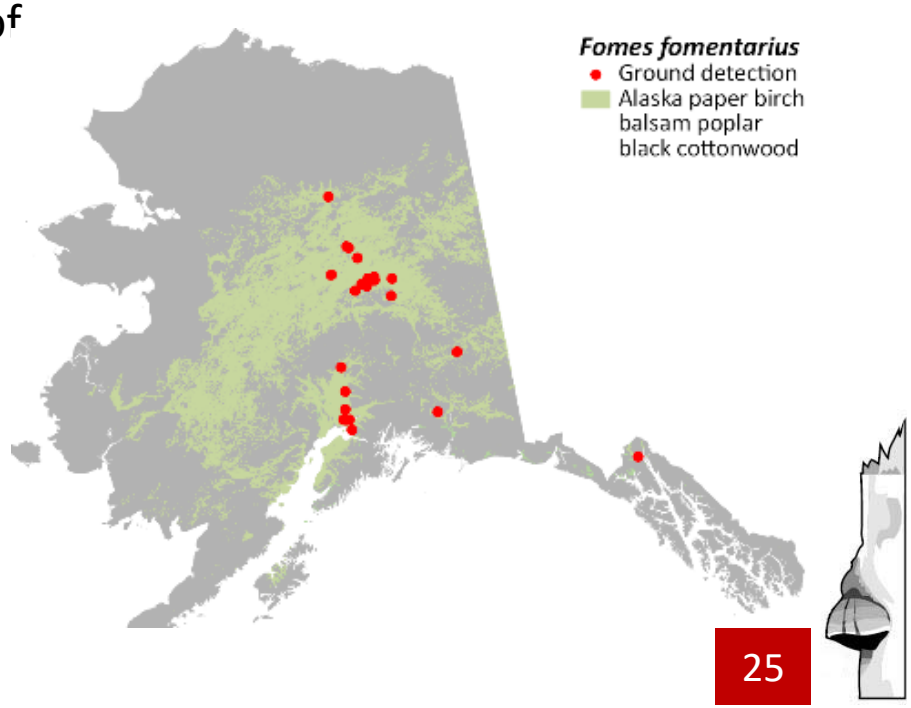
ID: Perennial, woody, matte, and usually distinctly hoof-shaped conk. Extremely common saprobe of dead trees and dead parts of live trees.

Top: zones of light grey to brown, dark grey, or black; smooth.

- Bottom: concave, tan to brown with small regular pores.
- Interior: thin brown layer between thick surface crust and several distinct layers of tubes; the dark brown tubes partially filled with white mycelium.

Damage: Early decay light brown. The presence of fruiting bodies indicates extensive advanced decay. Advanced decay soft, spongy, yellowish white rot, with blackish zone lines.

Remarks: Traditionally used to make fire tinder. Found on the 5000 year old Oetzi Iceman in a pouch with flint. Also used to make felt-like Amadou. Sometimes confused with *P. igniarius*.



Fomitopsis officinalis Quinine Conk

Fomitopsis officinalis Quinine Conk

Hosts: Spruce (especially Sitka spruce), hemlock, larch and shore pine.

ID: Perennial, woody, vaguely hoof-shaped to elongated-columnar conk. Usually occurs high on bole of living old-growth trees, but also persists for many years as a saprobe on dead trees. Rare.

- Top: zoned, white or yellow-white turning to grey or light brown with age, chalky coating, sometimes greenish with algae.
- Bottom: convex, white when fresh with tiny round uniform pores, drying to light brown.
- Inside: white to grey, cheesy to chalky with age, distinctly bitter taste.

Damage: Early decay light yellow to red-brown. Advanced decay is a crumbly brown cubical rot. Thick, white, bitter-tasting mycelial felts may form in shrinkage cracks.

Remarks: A single fruiting body indicates extensive heart rot and hazard of tree failure. Conks have long been used in traditional medicine & show promise in modern research. Many cultures, including the Tlingit, have carved conks into shaman grave guardians.

Fomitopsis pinicola Red Belt Conk

Fomitopsis pinicola Red Belt Conk

Hosts: Spruce, hemlock and pine; occasionally western redcedar, birch and aspen.

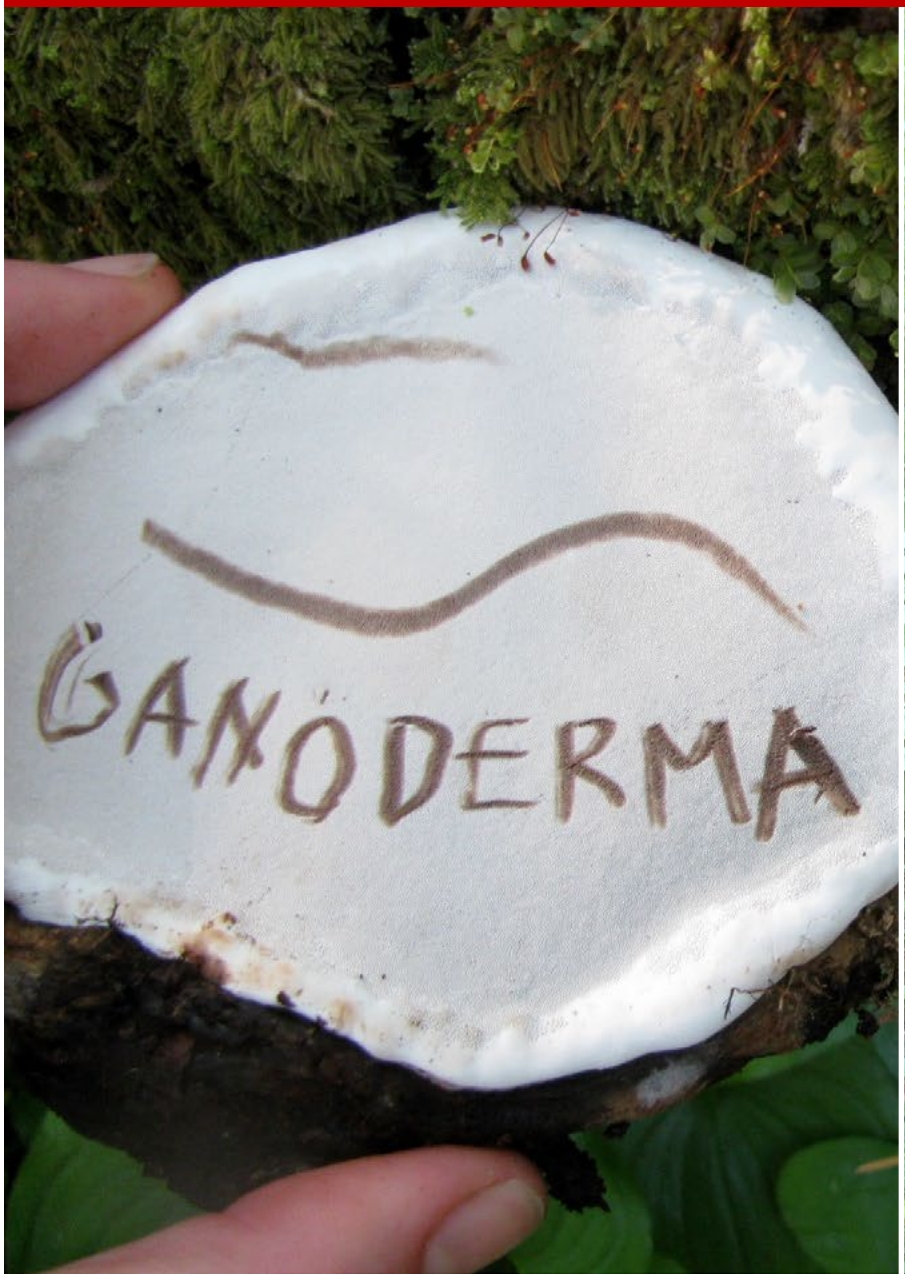
ID: Perennial, leathery to woody, flat to vaguely hoof-shaped conk. Found as a firm, rounded white mass on wood surface when young. Primarily saprobic and extremely common on dead wood. Also commonly associated with wounds of live trees, especially Sitka spruce.

- Top: dark brown to grey to black, zoned, often with reddish brown band near rounded margin.
- Bottom: creamy white with minute round pores.
- Inside: creamy white with corky texture.

Damage: Incipient (early) decay has a yellow-brown to brown stain. Wood with advanced decay is a crumbly brown cubical rot. Thick white mycelial felts may form in shrinkage cracks. The mycelial felts are similar to that of the quinine conk but do not taste bitter.

Remarks: Sometimes confused with artist's conk but bottom pore layer does not immediately bruise when touched. In Southeast Alaska, considered an important stem decay of live spruce, but its brown cubical decay may be confused with that of *Phaeolus schweinitzii*.

Ganoderma applanatum — Artist's Conk



Ganoderma applanatum — Artist's Conk

Hosts: Mainly hardwoods; but sometimes western and mountain hemlock, and white and Sitka spruce.

ID: Perennial, woody, fan- or shelf-shaped conk. Usually occurs as a saprobe on decaying logs and stumps. Occasionally found as a heart rot on wounds of living trees.

- Top: dull, dusty brown to grey-brown with concentric ridges.
- Bottom: white pore surface that immediately browns when touched.
- Interior: dark brown to cinnamon.

Damage: Spongy mottled white rot of sapwood and heartwood.

Remarks: Known as the artist's conk because the fresh pore surface bruises dark brown when touched or scratched. Intricate etchings can be preserved for years if properly dried.

Ganoderma tsugae Varnish Conk

Ganoderma tsugae Varnish Conk

Hosts: Western hemlock; occasionally other conifers.

ID: Annual, shelf or fan-shaped conk. Usually saprobic on large, old stumps or logs.

- Top: surface distinctly varnish-like and shiny reddish brown, at first knobby or elongated becoming somewhat fan-shaped.
- Bottom: white pore surface, becoming brownish with age. Usually bruises brown. Pores minute.
- Stalk: lateral (from side), varnished reddish brown, sometimes absent.

Damage: White rot decay appears wet, spongy, soft, straw-colored or white in the butt or stem. May have large black spots scattered throughout.

Remarks: Also called lacquer conk, this fungus has long been used in traditional medicine; modern research has shown potential medicinal benefits, including wound healing and anti-tumor activity in mice.

Inonotus obliquus Cinder Conk

Inonotus obliquus Cinder Conk

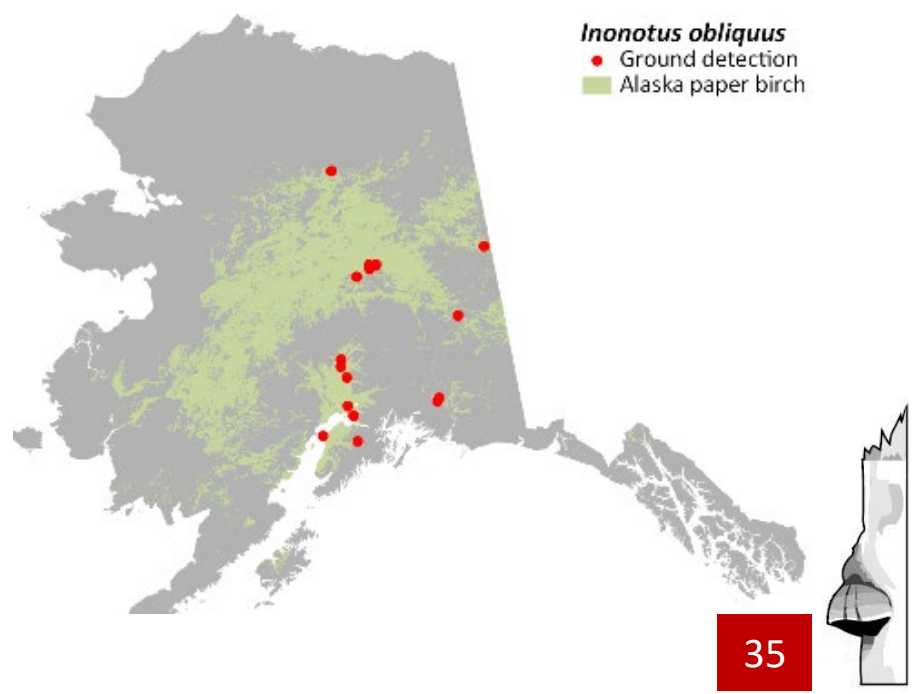
Hosts: Birch, rarely *Populus* spp.

ID: Perennial, woody, cinder-like mass on trunk, often large. Occurs on living and recently dead trees.

- Outside: very hard, rough and deeply cracked, black to dark brown, exterior looks like something that has been burned.
- Interior: yellow to rusty-brown, often with flecks of white.

Damage: White rot; incipient decay has yellowish white streaks and spots. Advanced decay is white, soft, with fine black zone lines throughout.

Remarks: Superficially resembles Diplodia gall (*Diplodia tumefaciens*) which occurs on trembling aspen. Cinder conks, also called clinker conks or Chaga, are sterile (not true conks, which produce spores). Short-lived fertile conks may appear after the tree dies. Has been traditionally used as a tonic or tea in northern folk medicine. Recent research has shown it to produce anti-tumor compounds. It has also long been used as a yellow or sepia dye for wool.



Laetiporus sulphureus Chicken of the Woods

Laetiporus sulphureus Chicken of the Woods

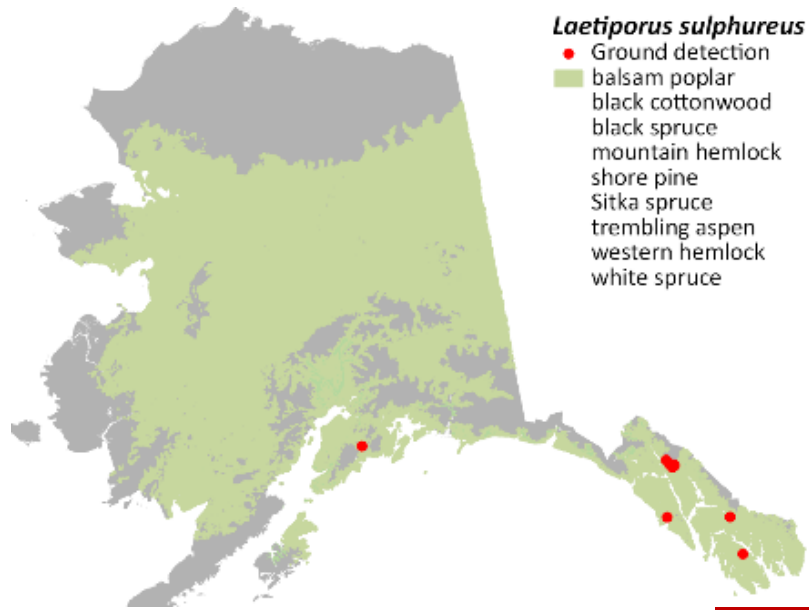
Hosts: Spruce and hemlock; occasionally shore pine, cottonwood, balsam poplar and aspen.

ID: Annual, shelving, in clusters, fleshy; usually on lower bole. Primarily saprobic on dead trees and stumps, but occasionally causes heart rot on living trees.

- Top: bright orange to yellow when fresh; crumbly white after it dies.
- Bottom: sulfur-yellow with small pores often in clusters.
- Inside: yellow, watery, and soft when fresh; white and chalky or soggy after it dies.

Damage: Brown cubical rot, may have white mycelial felts.

Remarks: Edible when young, some think the conk tastes like chicken. The fungus is also called Sulfur Shelf fungus. The mycelial felts in decayed wood is somewhat similar to that of the quinine conk but do not taste bitter. Use caution when harvesting fungi for consumption.



Phellinus hartigii Hartig's conk

Phellinus hartigii — Hartig's conk

Hosts: Western and mountain hemlock.

ID: Light brown perennial conk, often occurs on undersides of limbs or branch stubs, also on tree bole; may be velvety and flattened against tree bole.

- Top: dark brown to black, cracked.
- Bottom: tan to rusty-brown with very small, uniform pores. The pore layer of the conk may cover a much greater area than the upper surface. Appears velvety when fresh.
- Inside: yellow- to rusty-brown with streaks of white mycelium.

Damage: White rot of the sapwood and heartwood of living trees. Incipient (early) decay appears as irregular patches of brown to purple discoloration. Advanced decay appears bleached and laminated on radial sections with brown zone lines. Decay is usually limited to the area just above and below the conk. Bark may appear sunken around conks when the sapwood is killed.

Remarks: Conks are difficult to remove from trees. Hartig's conk is named after Robert Hartig, a 19th century German forest scientist regarded by many as the father of forest pathology.

Phellinus igniarius, P. tremulae False Tinder Conk

Phellinus igniarius, P. tremulae — False Tinder Conk

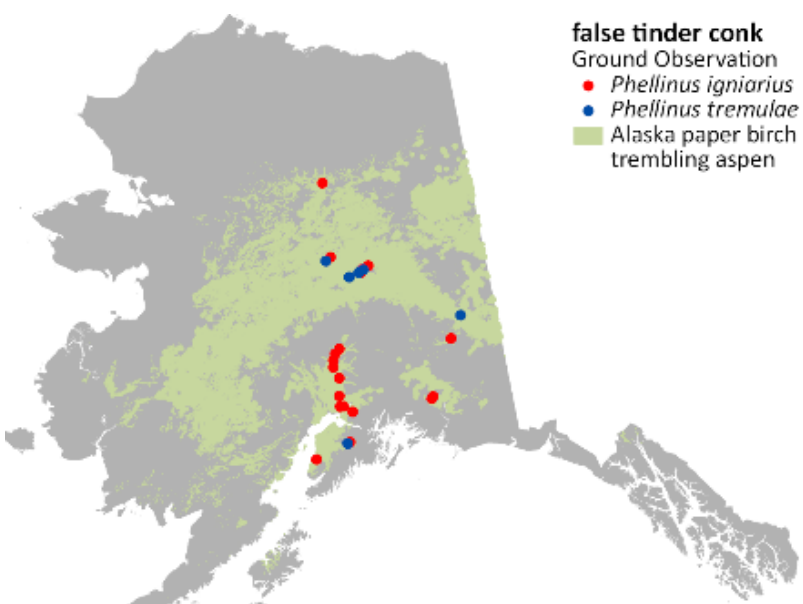
Hosts: Birch (*P. igniarius*), trembling aspen (*P. tremulae*) and possibly balsam poplar.

ID: Perennial, woody, vaguely hoof-shaped conk. Occurs on live trees but can persist as a saprobe years after trees die.

- Top: dark brown to greyish-black to black, many small cracks.
- Bottom: convex, light brown with tiny circular pores.
- Interior: rusty-brown with numerous white flecks.

Damage: Initial decay is yellowish to yellowish-white surrounded by a distinct dark zone line. Advanced decay is spongy or punky with numerous irregular, black zone lines. The presence of conks indicates considerable heart rot.

Remarks: Used to make punk ash. *P. igniarius* is very common on live birch and looks identical to *P. tremulae* on aspen. *P. tremulae* is the most important heart rot organism of aspen; in its commercial range in the Lower 48, it is reported to cause more volume loss than any other disease of aspen.



Piptoporus betulinus Birch Conk

Piptoporus betulinus Birch Conk

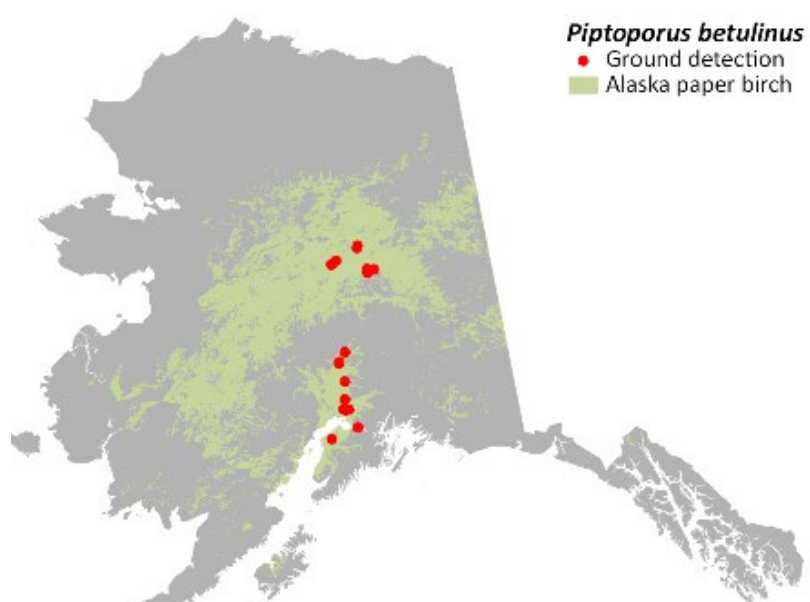
Hosts: Birch.

ID: Annual, leathery, shelving, light and corky conk. Extremely common saprobe of dead trees, also occurs on dead portions of live trees.

- Top: whitish to tan to mousy-brown, smooth or somewhat scaly. Lower margin of the cap incurving and projecting below the pore surface.
- Bottom: white pore layer when fresh, becoming yellowish to tan and slightly tooth-like when older.
- Interior: thick, white, firm, spongy when fresh and separates easily from the pore layer. Becomes corky with age.

Damage: Yellowish brown cubical rot of sapwood and heartwood. Advanced decay is very light weight and crumbles easily.

Remarks: Used as a bandage to prevent bleeding and infection in traditional medicine and has anti-inflammatory properties. Also called the Razor Strop fungus as barbers used the flesh to sharpen their razors.



Porodaedalea pini Red Ring Rot

Porodaedalea pini — Red Ring Rot

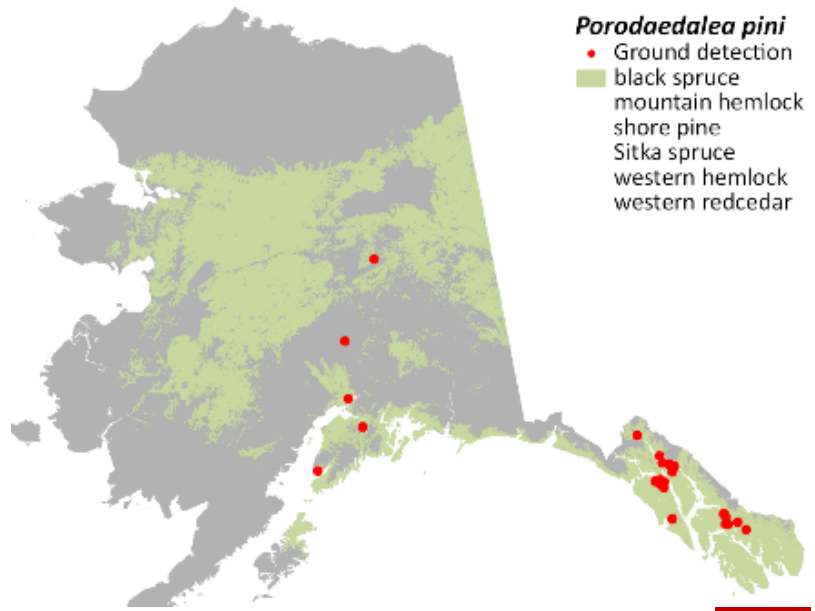
Hosts: Hemlock, spruce and shore pine; occasionally western redcedar.

ID: Perennial, woody, fan-, shelf-, to hoof-shaped conk. Occurs anywhere on bole of live or recently dead trees. Often associated with branch stubs.

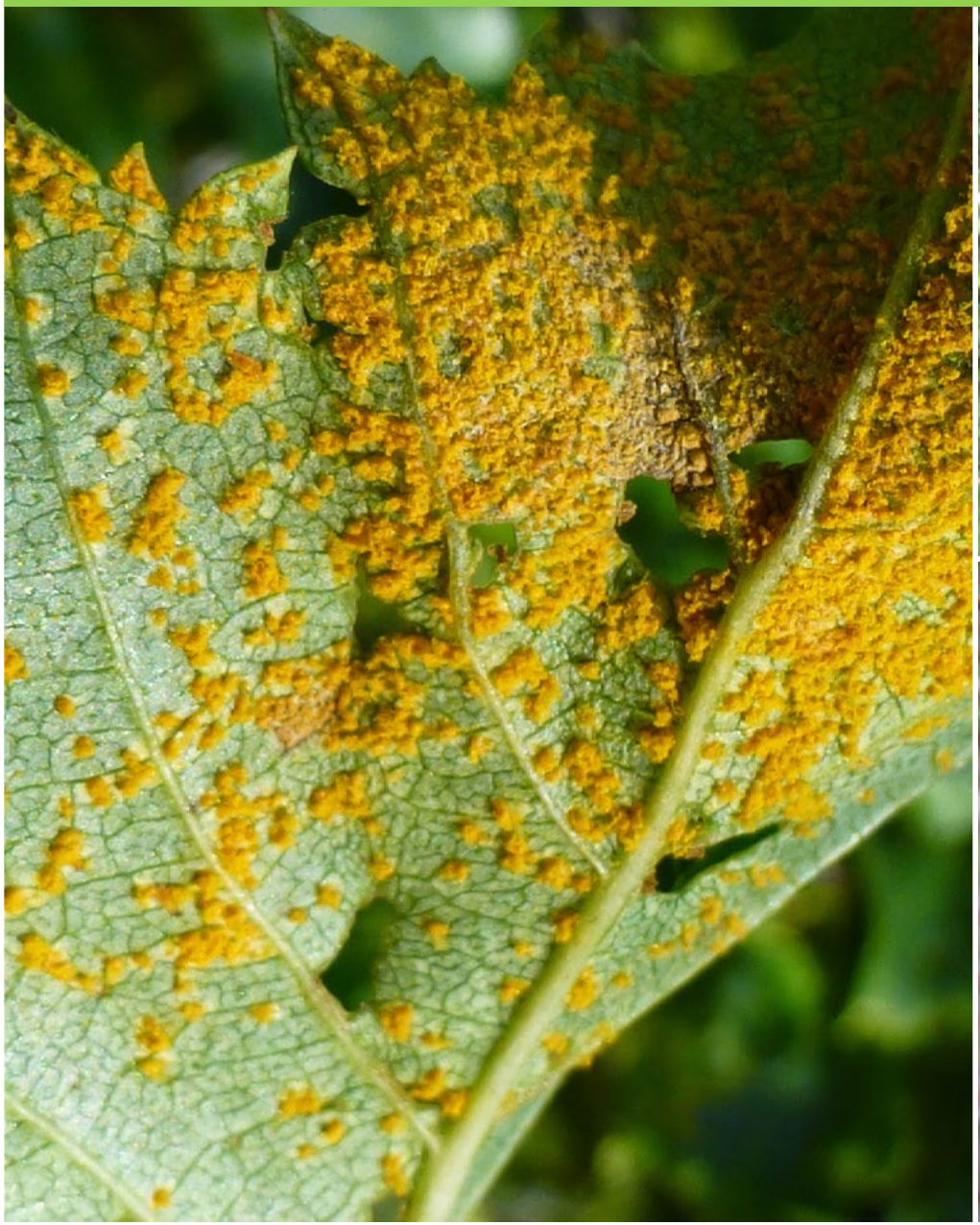
- Top: reddish brown to dark brown with a narrow, velvety golden margin; usually zoned in concentric rings; becoming furrowed and rough.
- Bottom: yellowish brown to rusty brown, pores angular to nearly slot-like.
- Interior: bright rusty brown; corky to woody.

Damage: White pocket rot. Incipient (early) decay is a red stain in the heartwood that appears as a well-defined ring in cross-section. In advanced decay, small flecks of fungal mycelium are evident and once-separate areas of decay merge.

Remarks: Formerly known as *Phellinus pini*. Decay can progress from the heartwood to the sapwood and cause tree death.



Foliage, Bud & Shoot Diseases



Foliage, Bud & Shoot Diseases

Hosts: All tree species in Alaska.

ID: Foliage usually discolored and evidence of fungal fruiting bodies (black, brown, orange or other distinctive color) are often microscopic. Some diseases target bud tissue. Shoot diseases cause leader and lateral shoot death, sometimes causing a 'shepherd's crook' appearance of affected shoots.

Damage: Usually don't cause serious damage unless over several consecutive years. Premature leaf and needle loss over consecutive years can cause growth and vigor reduction. Often more damaging on conifers than on hardwoods. Bud and shoot diseases are generally more damaging than foliage diseases because they may kill leaders and significantly deform growth.

Remarks: Many agents besides diseases may cause foliar discoloration.

Chrysomyxa ledicola Spruce Needle Rust

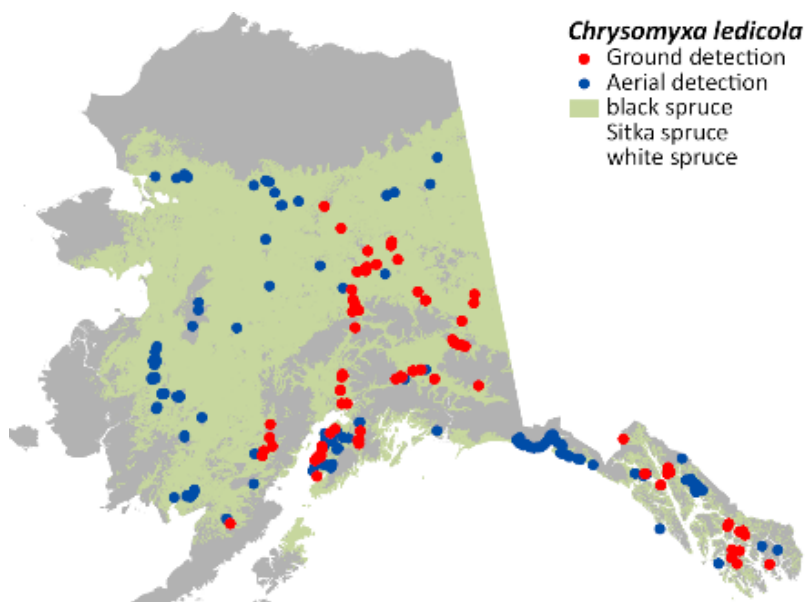
Chrysomyxa ledicola Spruce Needle Rust

Hosts: White, black, and Sitka spruce.

ID: Numerous orange pustules & spores produced on current-year needles give tree distinct orange tinge when fungus is fruiting in late summer and early fall.

Damage: Premature defoliation could reduce tree growth. Little damage usually occurs unless the tree is infected for several consecutive years.

Remarks: A floating mass of spores may be seen in eddies and shore edges of nearby water bodies during severe outbreaks. Spore stages occur on both spruce and Labrador tea (*Ledum* spp.), and both hosts must be present for the fungus to complete its full lifecycle. *C. weirii* is a closely related rust that appears similar, but it fruits on one-year-old needles in spring.



Didymascella thujina Cedar Leaf Blight

Didymascella thujina Cedar Leaf Blight

Hosts: Western redcedar.

ID: In spring, tiny, bleached, tan-brown spots appear on upper side of one-year-old foliage of seedlings and the lower branches of older trees. These spots darken to one to three olive-brown to black fruiting structures just under the epidermis. After spore discharge, the fruiting structure falls out and leaves a pit or hole in the dead brown foliage scales.

Damage: Foliage on severely infected cedars turns reddish and then grey. Seedlings and saplings sustain the most damage and may result in stem or branch death. The lower crowns of older trees may be heavily infected.

Remarks: This disease is very common on western redcedar, but does not generally cause mortality.

Dothistroma septosporum Dothistroma Needle Blight

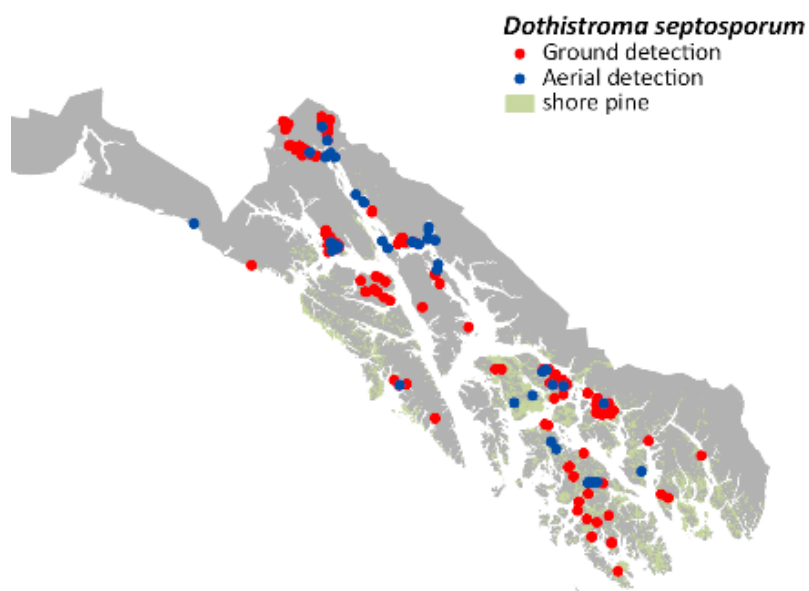
Dothistroma septosporum Dothistroma Needle Blight

Hosts: Shore pine and lodgepole pine.

ID: Black, pimple-like fruiting bodies and orange-red banding symptoms on needles in spring and early summer. Diseased trees may have sparse crowns and reduced growth from premature needle shed.

Damage: Premature needle shed does not usually kill trees but contributes to growth loss; however, multiple years of severe disease can cause substantial tree mortality.

Remarks: This disease is common throughout the range of shore pine in Southeast Alaska, usually causing minimal damage. Severe outbreaks of this disease have been noted in the northern Panhandle near Gustavus, Northern Lynn Canal, and localized areas from Juneau down to Prince of Wales Island. Pine diseases can be difficult to differentiate, but distinctive banding and fruiting structures of *Dothistroma* facilitate identification.



Kabatina thujae Yellow-cedar Shoot Blight

Kabatina thujae Yellow-cedar Shoot Blight

Hosts: Yellow-cedar.

ID: Terminal and lateral shoots on seedlings and saplings become infected and die during late winter or early spring. Symptoms of this disease are sometimes confused with spring frost damage. Dieback may extend 4 to 10 inches from the tip of the shoot.

Damage Shoots or entire seedlings up to 2 feet tall are killed. The long-term tree structure of taller saplings or trees is not thought to be compromised by leader infections.

Remarks: Yellow-cedar shoot blight is frequently noted in young-growth stands of Southeast Alaska that contain yellow-cedar. The disease is also observed in British Columbia. Prior to 2013, the identity of the causal pathogen in Alaska was not known (it was tentatively called *Apostrasseria* sp.). Elevated disease activity in Southeast Alaska was noted in 2008, 2014 and 2015.

Naohidemyces vaccinii Hemlock Needle Rust

Naohidemyces vaccinii — Hemlock Needle Rust

Hosts: Western hemlock and blueberry species.

ID: Yellow-orange pustules on the underside of current-year needles; pustules have a dome-shaped covering with a centrally located hole; infected needles turn yellow, but are usually scattered amongst green, uninfected needles.

Damage: Scattered infected needles turn yellow, die, and are shed prematurely. Injury to trees is negligible, thinning foliage and perhaps slightly reducing growth. Damage to blueberry plants is also negligible.

Remarks: May be confused with *Melampsora epitea*, another hemlock rust. However, *M. epitea* pustules lack the dome-shaped covering and have alternate hosts of willow, aspen, cottonwood, and birch.

Sirococcus tsugae Sirococcus Shoot Blight

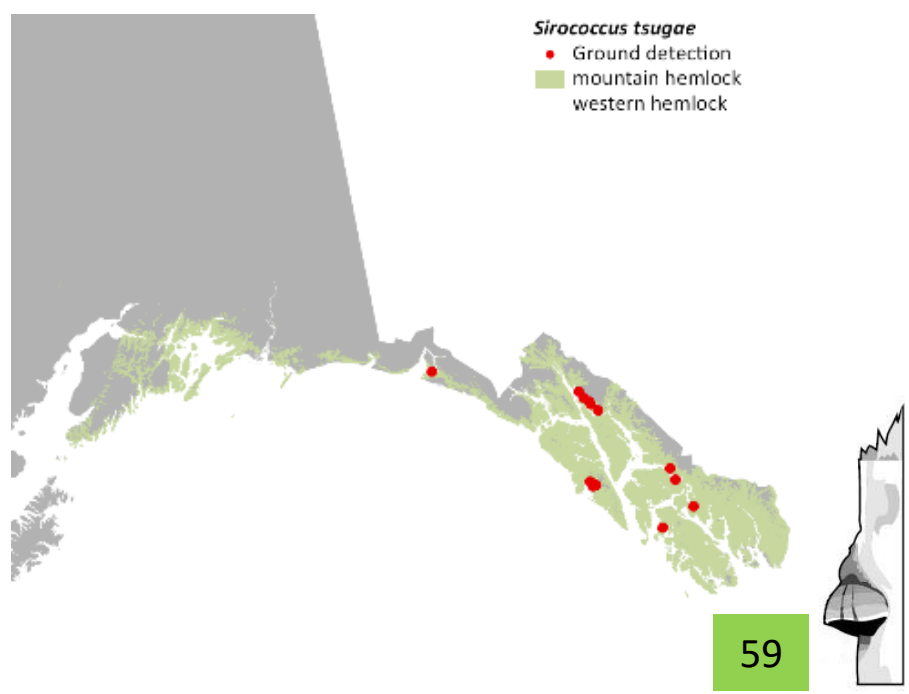
Sirococcus tsugae Sirococcus Shoot Blight

Hosts: Mountain hemlock and western hemlock (rarely spruce).

ID: Dead shoots with clumped reddish-brown foliage attached and curled over ("shephard's crook"). In cases of severe recurring infection, tree form will be compromised by repeated new leader development; some shoots will be recently killed and some older killed shoots will lack foliage.

Damage: This disease of young lateral or terminal shoots occurs in Southeast Alaska on both western and mountain hemlock (rarely spruce). Mountain hemlock is considered more susceptible, but shoot symptoms are sometimes widespread on both hemlock species.

Remarks: There appears to be a correlation between cold air drainage and higher disease incidence; disease has been pronounced on forest edges, riparian areas, and bowls or depressions in mountain valleys. Hemlocks growing in conducive infection environments often show evidence of repeated years of shoot dieback resulting in compromised tree form.



Gemmamyces, Dichomera, and Camarosporium Spruce Bud Blight

Gemmamyces, Dichomera, and Camarosporium Spruce Bud Blight

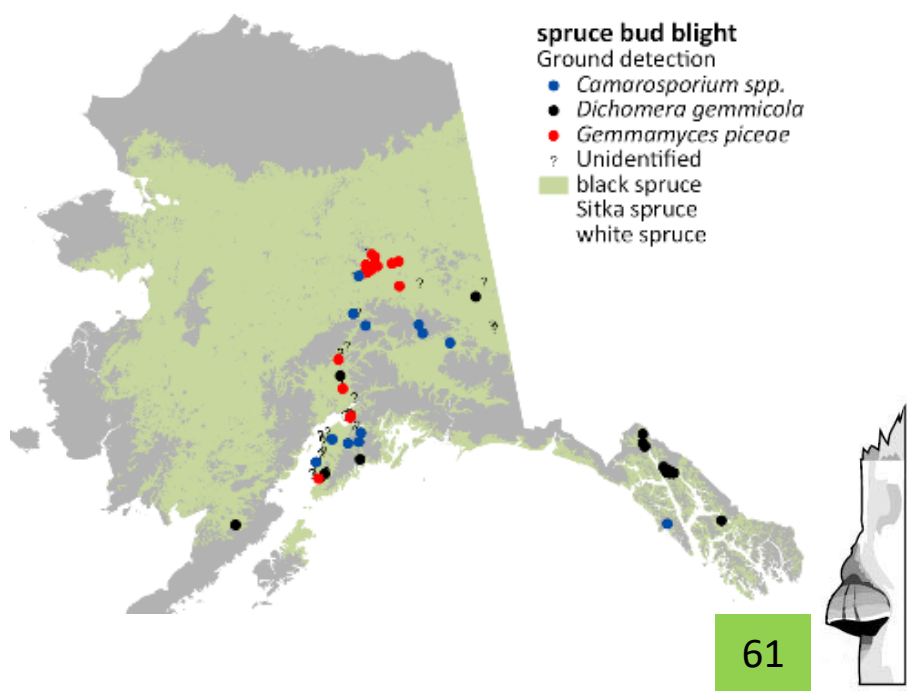
Hosts: White, black, and Sitka spruce.

ID: Tiny, black, spherical fruiting bodies on buds (may need hand lens). May cover entire bud or occur in patches. Specific identification requires a microscope.

- *Gemmamyces piceae* – Found on white spruce and ornamental spruces.
- *Dichomera gemmicola* – Found on white, black, and Sitka spruce.
- *Camarosporium sp.* – Found on white, black, and Sitka spruce.

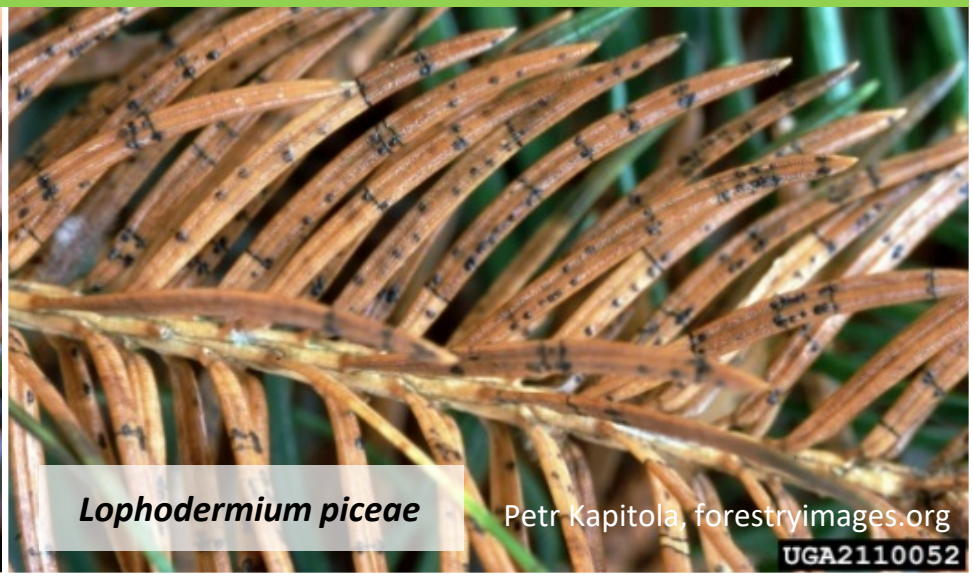
Damage: Damaged buds become noticeable soon after elongation starts and may become curved/twisted or swollen. Affected parts of the crown may become sparsely branched with twisted shoots, and irregularly shaped with characteristically deranged branching patterns. Tree mortality in Alaska has not been observed.

Remarks: *G. piceae* is also known as *Cucurbitaria piceae* and kills Sitka, white, and Colorado blue spruce in Central European plantations.



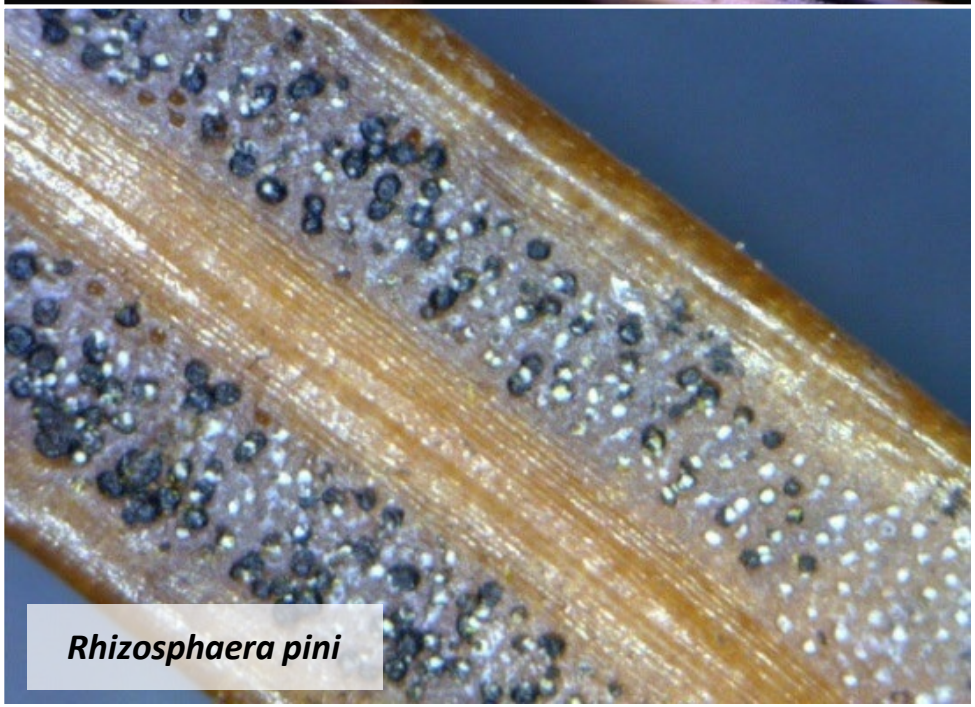
Lirula, Lophodermium, Rhizosphaera Spruce Needle Cast/Blight


Lirula macrospora


Lophodermium piceae

Petr Kapitola, forestryimages.org

UGA2110052


Rhizosphaera pini

Lirula, Lophodermium, Rhizosphaera Spruce Needle Cast/Blight

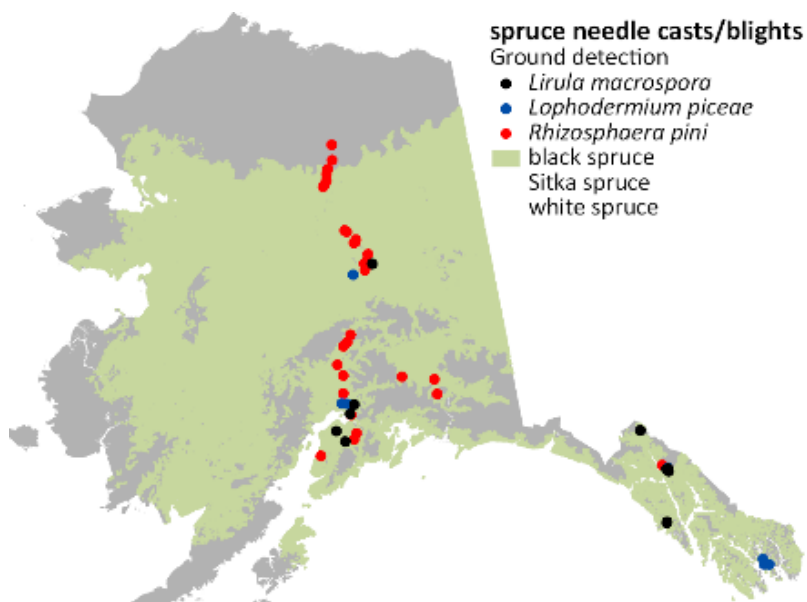
Hosts: Spruce.

ID: Small black fruiting bodies on needles older than the current year; needles turn yellow to reddish-brown to tan.

- *Lirula macrospora* – long black line-like fruiting bodies on two year old needles. One-year-old needles reddish-brown becoming tan on older needles.
- *Lophodermium piceae* – small, black, oval fruiting bodies scattered over dead needles, separated by black zone lines perpendicular to needles.
- *Rhizosphaera pini* – microscopic spherical fruiting bodies emerging from stomata.

Damage: Premature needle loss or death is not damaging unless there are several successive years of severe attack, which may result in growth reduction.

Remarks: *Lirula* is the most easily identified of these needle fungi due to the long black fruiting structures.



Diplodia tumefaciens Diplodia Gall

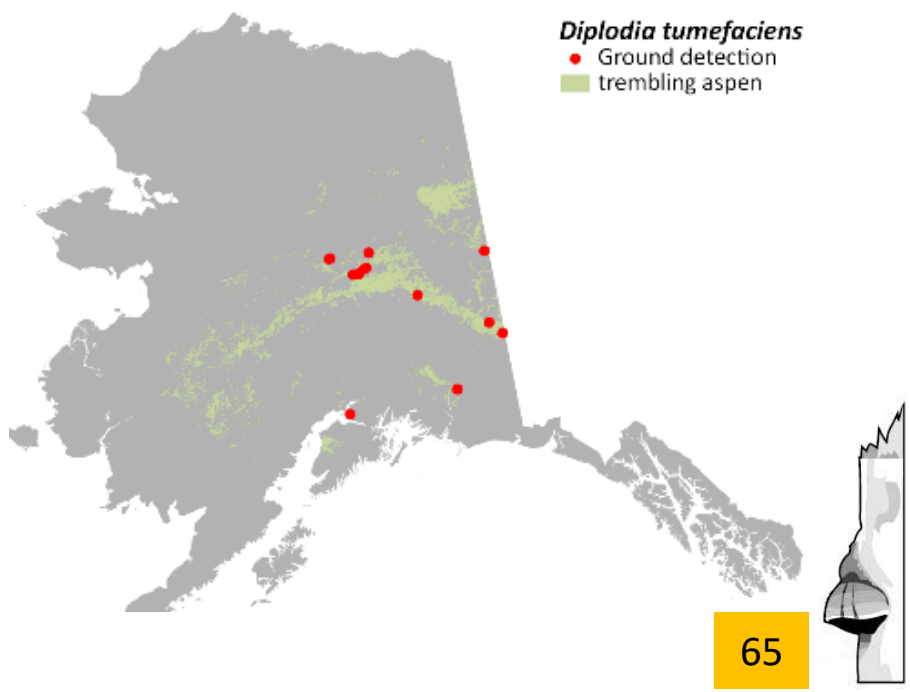
Diplodia tumefaciens Diplodia Gall

Host: Aspen, occasionally balsam poplar and black cottonwood.

ID: Black, rough, swollen galls on branches or main stems of aspen. Fruiting bodies may be produced in cracks of galls.

Damage: Globose branch and stem galls of various sizes. Bands of rough, corky bark have also been attributed to this disease.

Remarks: Galls may superficially resemble Chaga (*Inonotus obliquus*), however Chaga occurs on birch while Diplodia gall is on trembling aspen and balsam poplar. This disease is widely distributed throughout North American regions where hosts are present.



Endocronartium harknessii Western Gall Rust

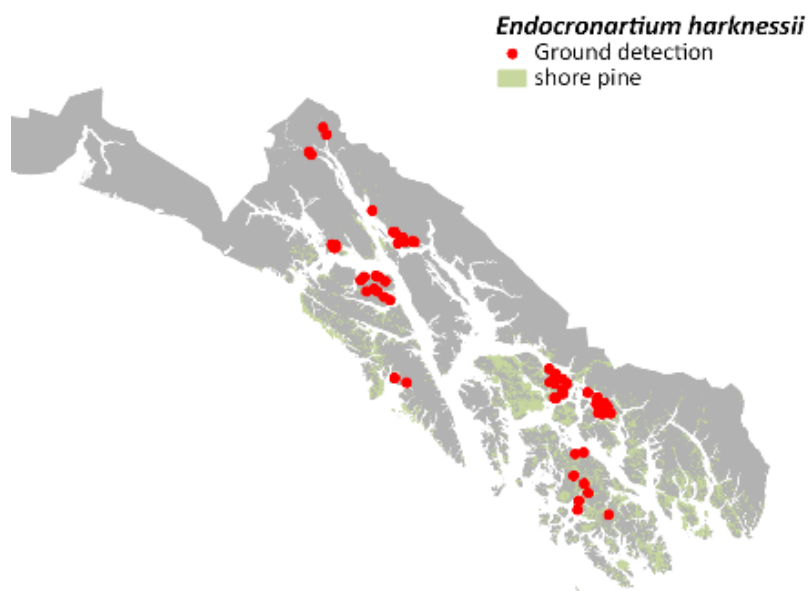
Endocronartium harknessii Western Gall Rust

Host: Shore pine and lodgepole pine.

ID: Spherical swellings on branches and main stem. Bright orange spores erupt from gall tissue in spring.

Damage: Top kill, growth loss, and stem deformation. Western gall rust is one of the most common and important damage agents of shore pine in Alaska. Nearly all shore pine are affected, but infection severity is variable. Pines in some areas experience significant topkill and branch dieback associated with western gall rust. Bole galls are more damaging than branch galls.

Remarks: Gall tissue attracts secondary insects and fungi, which frequently girdle affected boles and branches. The fungus usually does not girdle stems and branches directly, but infection facilitates topkill and dieback from other agents.



Arceuthobium tsugense Hemlock Dwarf Mistletoe

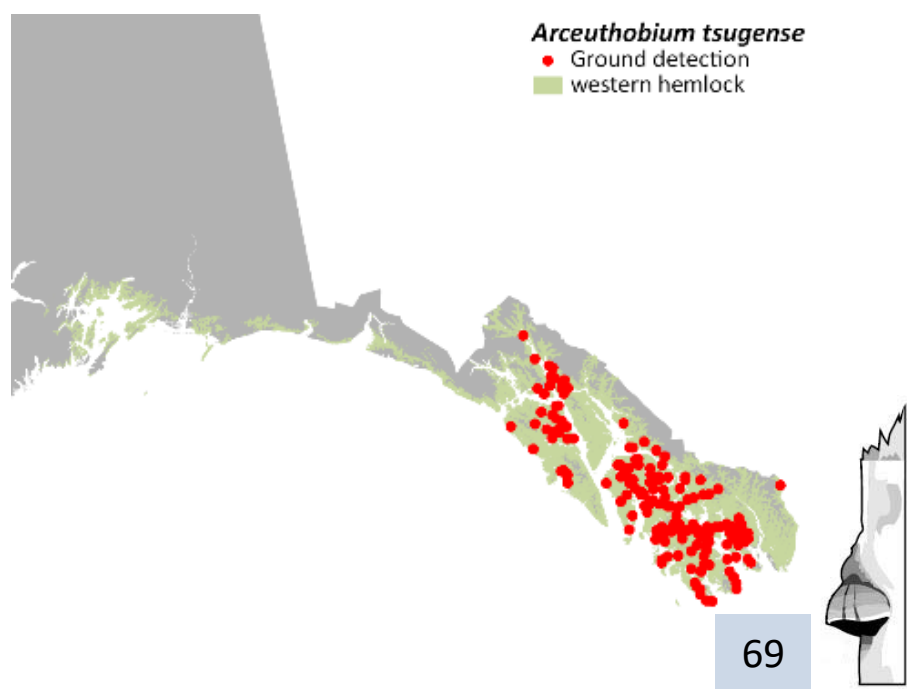
Arceuthobium tsugense Hemlock Dwarf Mistletoe

Hosts: Western hemlock.

ID: Conspicuous clusters of prolific branching (brooms) on western hemlock. Branches, stems, and boles are often swollen at the site of infection. *A. tsugense* is a small parasitic flowering plant of living trees. When present, the small aerial shoots are small, leafless, and yellow-green.

Damage: Infections on the main stem may result in large disfiguring burls. Branch infections divert photosynthate away from other parts of the tree. Infection reduces growth and vigor in correlation with the intensity of infection.

Remarks: May be confused with spruce broom rust, but the hosts differ. Hemlock dwarf mistletoe is one of the most important diseases of western hemlock in Alaska. It is more common at low elevations and is favored by small-scale disturbance in old growth forests. Brooms may be used as wildlife habitat.



Chrysomyxa arctostaphyli Spruce Broom Rust

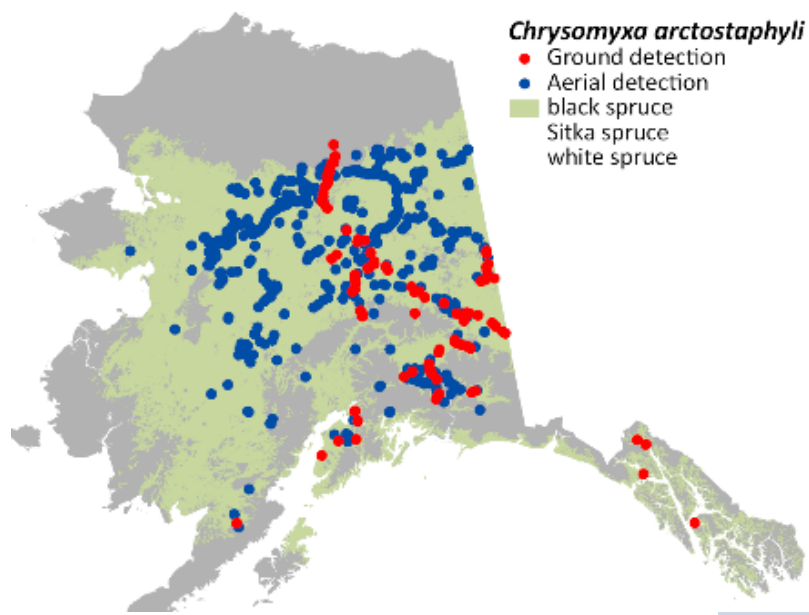
Chrysomyxa arctostaphyli Spruce Broom Rust

Hosts: Spruce.

ID: Conspicuous, dense, perennial brooms on spruce anywhere in the tree. In the spring, brooms are pale green then turn yellowish and then orange in mid-summer. Needles shed in fall and brooms appear dead.

Damage: Rust brooms result in broken tops, bole deformation, reduced growth, and occasional tree mortality. Brooms also serve as infection courts for decay fungi.

Remarks: May be confused with hemlock dwarf mistletoe. Check tree species! Hemlock dwarf mistletoe is very rare on spruce (only when close to heavily infected hemlocks) and does not occur north of Haines, AK. May observe sporulation on the alternate host (bearberry/kinnikinnick) in early summer.



Yellow-cedar Decline

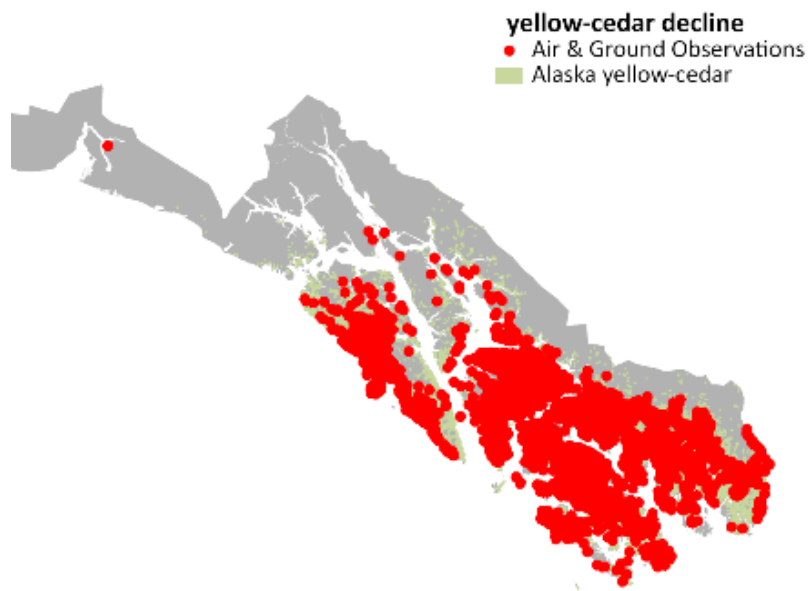
Yellow-cedar Decline

Hosts: Yellow-cedar.

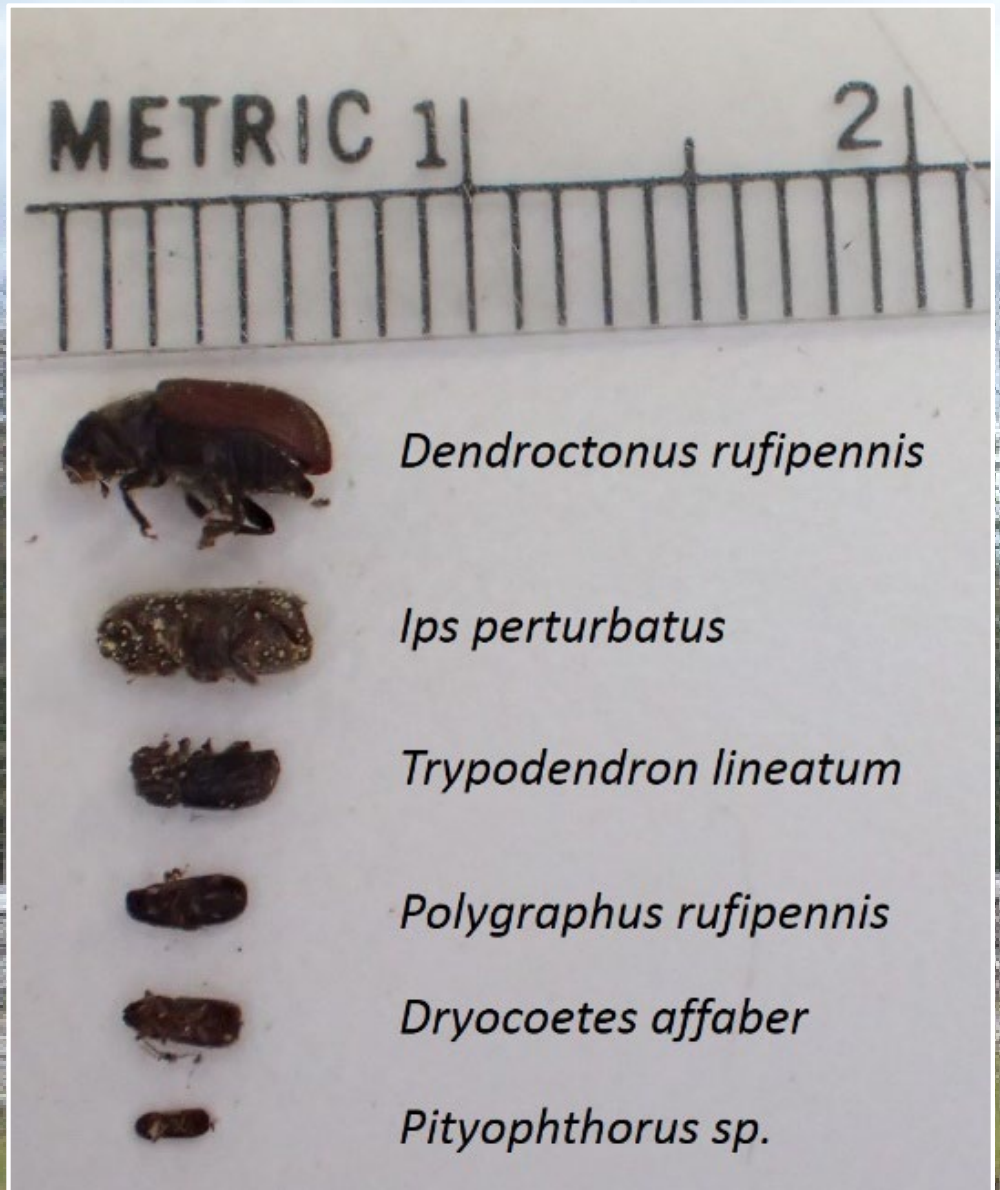
ID: Red-brown to yellow discolored foliage affecting 15-100% of the tree crown. Often occurs on sites with saturated, shallow soils and with low late-winter snowpack . Affected stands have a mixture of trees dying, dead, and healthy in small patches to expansive areas.

Damage: Yellow-cedar decline is caused by fine-root freezing injury, which can take 15 years or more to kill an individual tree. Beetle pitch tubes, frass or galleries and signs of *Armillaria* spp. may be observed on affected trees, but are secondary to environmental causes of yellow-cedar decline .

Remarks: Forest decline is widespread tree death resulting from a complex of interacting abiotic and biotic factors. Mortality generally affects a particular tree species or genus. Information from a range of studies indicates that yellow-cedar decline is linked to climate change, because yellow-cedar trees are killed by early spring freezing injury to fine roots where there is insufficient snowpack to insulate them from lethal cold temperatures.



Bark Beetles



Bark Beetles

Hosts: Spruce, larch, hemlock, cedar, willow, birch and other tree species.

ID: Adults are typically brown to black, small (generally 2.0 - 7.0 mm long) beetles, with clubbed and elbowed antennae. Their larvae are white, legless, and grub-like. Bark beetles live in characteristic galleries which they create in a tree's phloem.

Damage: Bark beetles infest injured, stressed or recently killed trees. During outbreaks some species can attack, colonize, and kill healthy trees. Key indicators of beetle attack include boring dust on the bark and at the tree base, pitch tubes on the tree bole, branch dieback, top kill, and mortality. Following successful beetle colonization, conifer foliage will fade from green to yellow to red, but this process may take over a year.

Remarks: Bark beetles are separated in to two broad categories, "Primary" and "Secondary" bark beetles. Secondary bark beetles are not classified as tree-killers, and attack dead or dying trees. Some secondary beetles act as parasites, and are capable of surviving in living hosts. Primary bark beetles, are tree killing species. They require tree death, or a portion of the tree to die in order to complete development. Primary bark beetle populations can grow to outbreak levels, potentially killing millions of acres of trees over a relatively short period.

Dendroctonus rufipennis Spruce Beetle

Pitch tube on the bole

Beetle caught in pitch

Exit holes

Dendroctonus rufipennis Spruce Beetle

Hosts: Spruce.

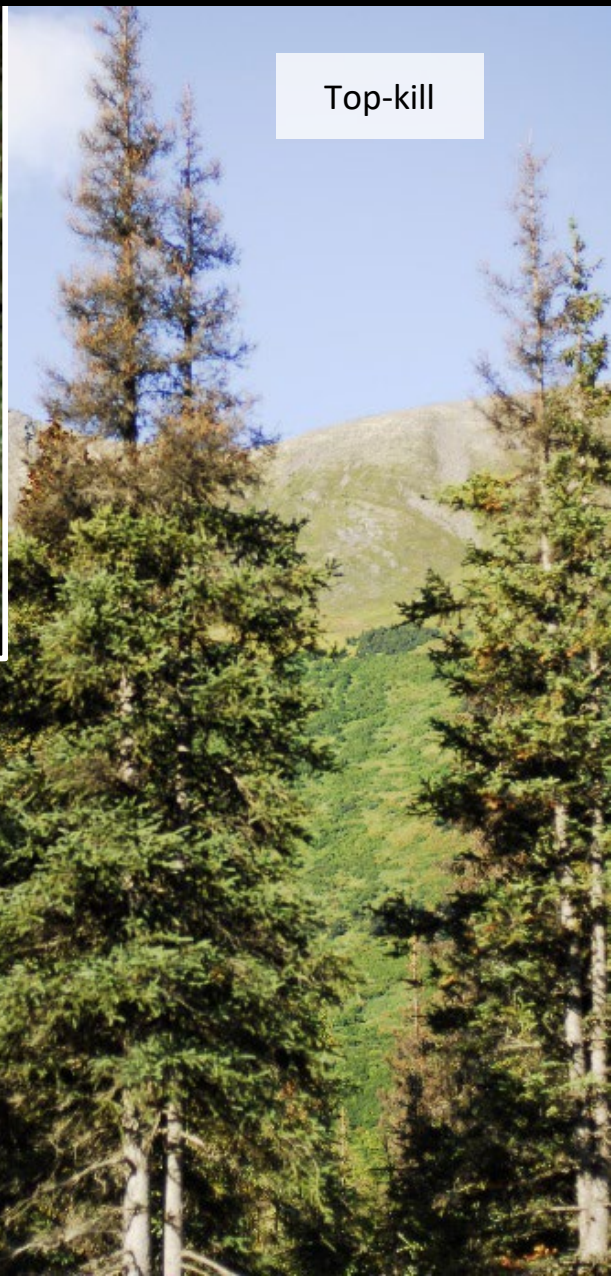
ID: Spruce beetles are a major tree killing species in Alaska. They are dark brown to almost black in color, cylindrical in shape, 4.4 to 7.0 mm in length. Larvae are cylindrical, legless and grub-like.

Damage: Spruce beetles generally attack a tree's mid to lower bole and are evident due to the presence of boring dust and "pitch tubes." Pitch tubes are globules formed on tree bark by beetles burrowing into host trees and severing tree resin ducts. When mass attacks occur, pitch tubes can be numerous and clearly visible; mass attack trees are commonly referred to as "popcorn bark" trees.

Remarks: To date, the majority of spruce beetle mortality and spruce beetle outbreaks have occurred south of the Alaska Range. Spruce beetles are present in the Alaskan Interior, but historically spruce mortality due to this insect has been infrequent and light.

Ips species

Engraver Beetles



Ips species — Engraver Beetles

Hosts: Spruce and pine.

ID: Engraver beetles are approximately 2.7-6.0 mm long with adults cylindrical and reddish brown to black. The posterior of engraver beetles are concave and armed on the margins with 4 pairs of tooth like spines. Larvae are cylindrical, legless and grub-like.

Damage: Engraver beetles generally attack the upper bole of host trees, but have been found in the mid to lower boles. The first evidence of attack is the presence of fine yellow-red boring dust in crevices of the tree bark or on the ground at the tree base. Resinous "pitch tubes" are rarely formed. Trees attacked by engraver beetles can exhibit "top-kill" where the top half or top third of a host tree turns red.

Remarks: There are many species of engraver beetles present in Alaska, most are similar in size, coloration and habits. To date, engraver beetles are more prevalent in the Alaskan Interior than Spruce beetle (*D. rufipennis*), possibly due to superior adaptation to the colder temperatures. The majority of recorded beetle kill in the Interior has been due to engraver beetles.

Beetle image: Pest and Diseases Image Library, Bugwood.org
Damage images: Edward H. Holsten, USDA Forest Service, Bugwood.org
Declevital image: Ken Walker, Museum Victoria, Bugwood.org

Polygraphus rufipennis Four Eyed Bark Beetle

Polygraphus rufipennis Four Eyed Bark Beetle

Hosts: Lutz, Sitka and white spruce.

ID: Four eyed bark beetles are reddish brown to black in color, with a stout cylindrical shape, approximately 2.0 mm to 3.0 mm long. The eye is split horizontally, giving it the appearance of having four eyes. Larvae are cylindrical, legless and grub-like.

Damage: Galleries occur under the bark of dead and dying trees and when heavily infested, appear to have haphazard sculpturing full of frass. These galleries are evident in stressed and dead trees as bark sloughs off.

Remarks: Four Eyed Bark Beetles are considered a secondary species (non-tree killing). They attack stumps, boles, and branches of weakened trees. Often capitalizing of the activities of other forest pests such as spruce beetle and spruce budworm. Because they affect dead and dying trees, this beetle is not considered a major forest pest.

Beetle image: Javier Mercado, Bark Beetle Genera of the U.S., USDA APHIS ITP, Bugwood.org

Wood Boring Insects

Wood Boring Insects

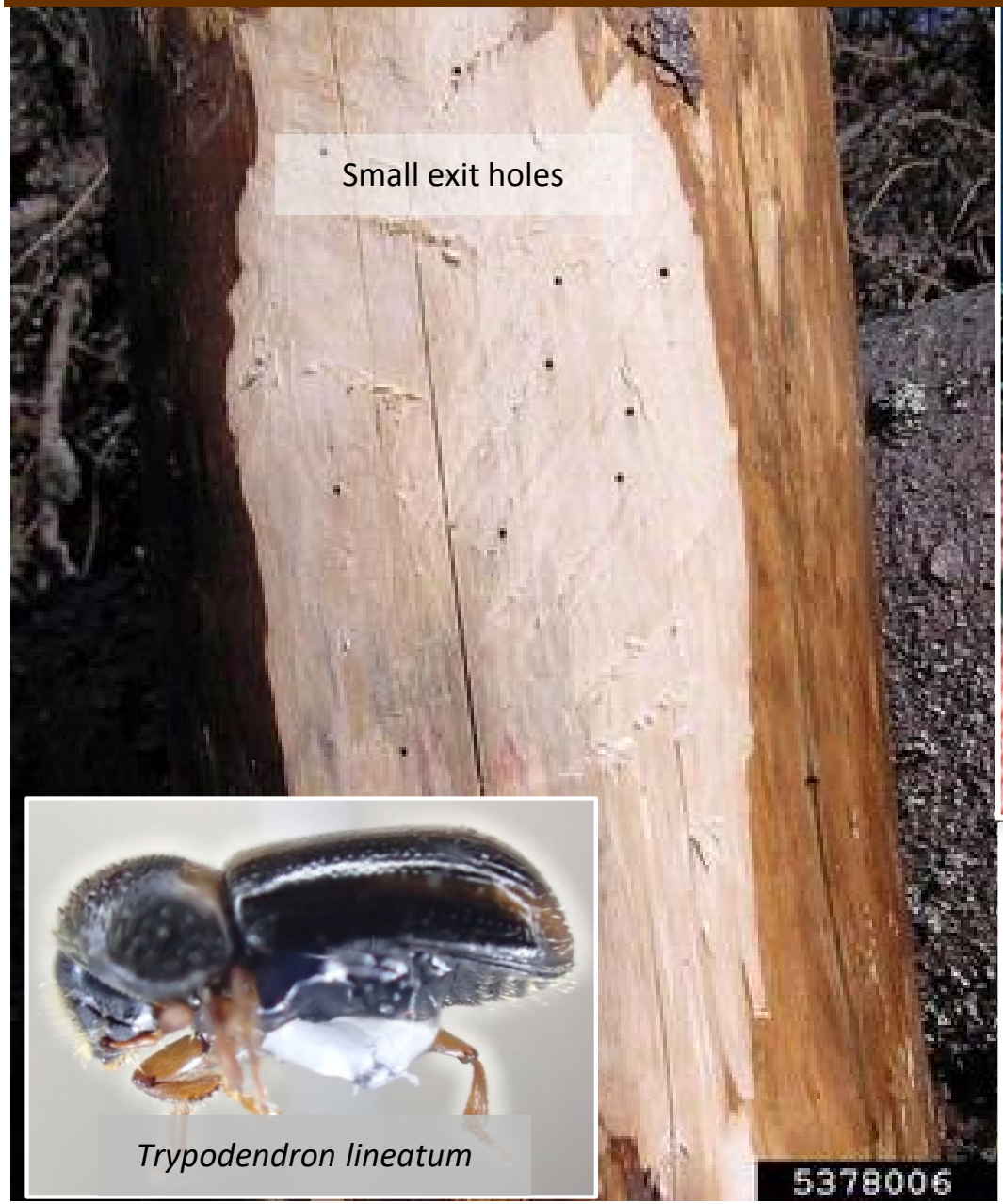
Hosts: All tree species in Alaska.

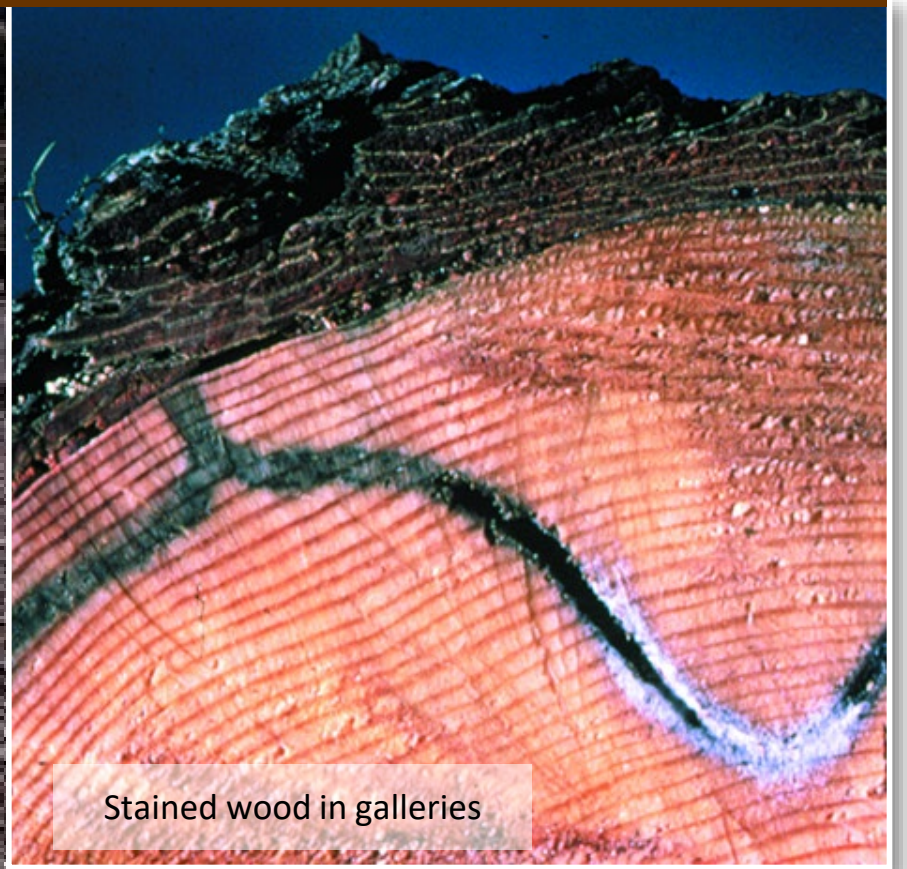
ID: A diverse group of beetles, wood wasps, and a few moths that can most easily be identified as part of this category by their galleries which are present in the sapwood and, at times, the heartwood of their hosts. The exit holes (with the exception of ambrosia beetles) are often larger than those of bark beetles, and are typically round or "D" shaped.

Damage: Wood borers can cause significant wood degradation and volume loss. Some species are known to vector pathogens. Although uncommon in Alaska, some species are capable of killing trees.

Remarks: Wood borers differ in their utilization of wood. Some use wood for food and shelter, other just of shelter. Others attack only dead, dying, or recently cut trees, while others are capable of attacking and killing healthy trees (not currently present in Alaska). Early life stages of some wood boring insects feed in phloem (conductive tissue) prior to moving deeper into trees, while others bore straight into the sapwood.

Ambrosia Beetles





Trypodendron lineatum

Ambrosia Beetles

Hosts: All tree species in Alaska.

ID: Ambrosia beetles are very small, at times only a 1 or 2 mm in length, ranging from brown, reddish brown to black. Although there are many species of ambrosia beetles in Alaska, the most common genus is *Trypodendron* spp.

Damage: In Alaska, ambrosia beetles bore into the sapwood and heartwood of dead or dying trees leaving very small entrance and exit holes. Beetles build galleries for reproduction, and as they do so, they inoculate the tree with a symbiotic fungi which they feed on (they do not feed on the tree). This fungi stains the sapwood and heartwood of the tree brown to black.

Remarks: Because of the staining caused by vectored fungi, ambrosia beetles can be an important pest of wood products.

Damage images 5378006 and 1258204: Stanislaw Kinelski, Bugwood.org

Longhorn Beetles

Roundheaded Borers

Typical longhorn exit holes

Tetropium cinnamopterum

Xylotrechus undulatus

White spotted sawyer,
Monochamus scutallatus

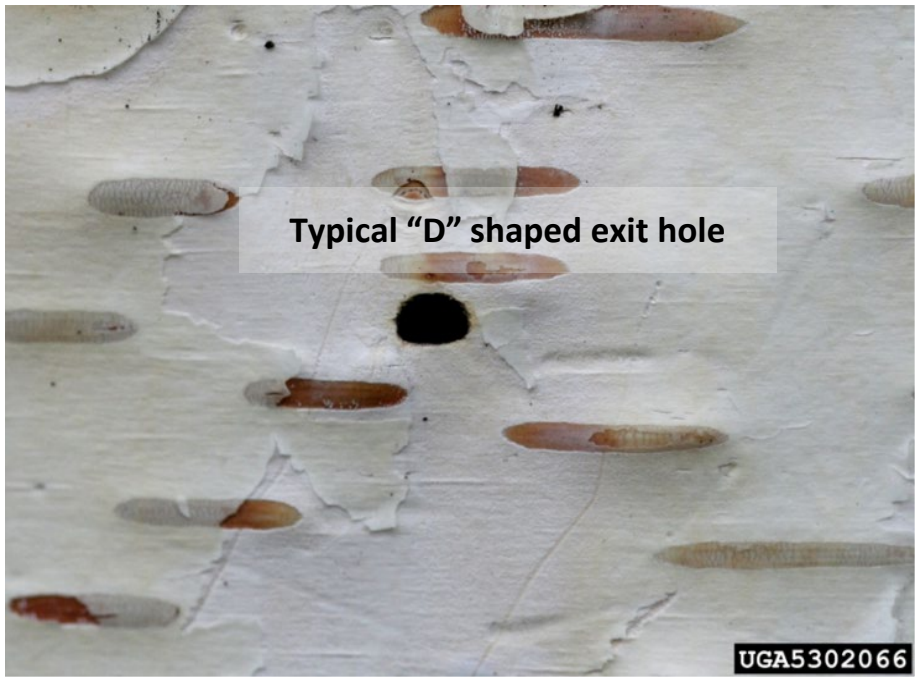
Hosts: All tree species in Alaska.

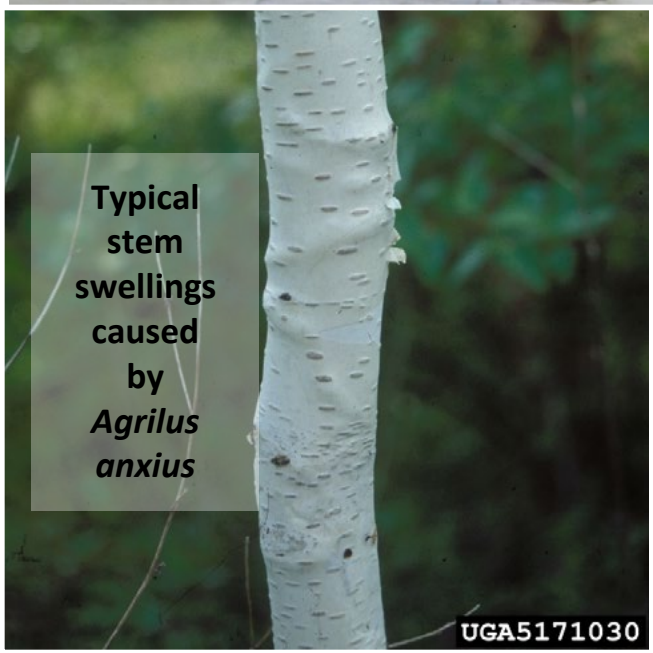
ID: Longhorn beetles, also known as roundheaded wood borers, can be serious pests but are often found in stressed, dying or dead trees. Various species are found in Alaska. Some typical characteristics of the adult beetles are long antennae, somewhat round bodies, and round and sometimes large exit holes in host trees. Larvae are robust, and somewhat cylindrical.

Damage: Stressed, dead or decaying trees can be affected. Occasionally, feeding under the bark can girdle small trees, but damage commonly associated with longhorn beetles consists of galleries in the tree sapwood and round exit holes. Circular exit holes distinguish longhorned beetles from flathead borers which produce D-shaped exit holes

Remarks: Some longhorn beetles can vector diseases and can have economic impacts by affecting the grade, quality and volume of pulp and saw logs. Theses species are not currently present in Alaska. No species of “tree-killing” longhorn beetles have currently been detected in Alaska.

Metallic Wood Boring Beetles — Flatheaded Borers





Hosts: All tree species in Alaska.

ID: Metallic wood boring beetles are also known as flatheaded wood borers. These beetles can be brightly colored or iridescent with short antennae. Adult beetles vary in size, are somewhat flattened and create D-shaped exit holes in host trees. Larvae have greatly expanded heads with long slender bodies.

Damage: Stressed and recently dead trees may be affected. A key external indication of infestation are D-shaped exit holes, distinguished from circular exit holes formed by the emergence of longhorned beetles. Heavy woodpecker activity can also indicate the presence of flathead borers. In some hardwood trees, stem swellings are evident.

Remarks: No species of “tree-killing” metallic wood boring beetles have currently been detected in Alaska.

Exit hole and galleries image: Whitney Cranshaw, Colorado State University, Bugwood.org
Stem swelling image: Daniel Herms, The Ohio State University, Bugwood.org

Wood Wasps

Wood wasp damage

Larvae of *Urocerus gigas flavicornis*

Alaska's most common wood wasp, *Urocerus gigas flavicornis*

Xeris spectrum and exit hole

UGA1258243

Wood Wasps

Hosts: Spruce and yellow-cedar.

ID: Various species of wood wasps occur in Alaska and coloration varies slightly. These insects are also known as horntails. Adult wood wasps are large and wasp-like without a constricted waist. The larvae are legless, stout and cylindrical. Both the adults and the larvae have a spine located at the end of the abdomen. In addition, the adult female also has a distinctive ovipositor.

Damage: Stressed or damaged trees can be affected. Damage consists of galleries in the sapwood and heartwood of the tree, but not the phloem or cambium layer. Large round exit holes are also present. Distinguishing circular exit holes of wood wasps from longhorned beetles can be difficult. The bark should be removed to determine if serpentine galleries have been formed in the phloem. Galleries near relatively large circular exit holes indicates longhorned beetles, their absence indicates wood wasps.

Remarks: Although these insects have a "stinger" like spine, they do not sting.

Damage image: USDA Forest Service - Region 10 - Alaska Archive, USDA Forest Service, Bugwood.org
X. Spectrum image: Stanislaw Kinelski, Bugwood.org
Larvae image: Edward H. Holsten, USDA Forest Service, Bugwood.org

Defoliators

Large Aspen Tortrix defoliation

Large Aspen Tortrix webbing

Leaf beetles

Alder woolly sawfly, *Eriocampa ovata*

Striped alder sawfly, *Hemichroa crocea*

Defoliators

Hosts: All tree species in Alaska.

ID: Moths, butterflies, leaf beetles and sawflies.

Damage: Severe defoliation can kill trees outright, but usually predispose them to other stressors. Deciduous trees are more resilient to attacks if they are able to re-foliate in the same year. Some defoliators feed on current foliage, others feed on previous year's foliage. Larvae of leaf beetles tend to skeletonize material between leaf veins, while larvae of butterflies, geometrids (inchworms) and sawflies can consume all leaf and needle material.

Remarks: Insect defoliation negatively effects trees by reducing photosynthesis, gas exchange, and processes translocation nutrients within trees. Defoliation for several consecutive years may not kill trees, but may weaken them, increasing their susceptibility to secondary insects and diseases. Mortality generally begins following 2 to 3 years of moderate to heavy defoliation.

H. crocea image: USDA Forest Service - Region 10 - Alaska Archive, USDA Forest Service, Bugwood.org

Budworms

Budworms

Hosts: Western hemlock, mountain hemlock, Sitka spruce, Lutz spruce and white spruce. Attacks on black spruce have been reported in other regions, but not in Alaska.

ID: The head of budworm larvae are typically black or brown depending on the species, during most larval stages.

Damage: Young larvae feed within unopened buds, moving to new needles as the shoots elongate. New damage typically becomes noticeable in mid-summer. During outbreaks larvae will feed on older needles after new needles have been consumed. Multi-year outbreaks can occur, top-kill is common during severe infestations, and tree mortality is possible following multiple years of defoliation.

Remarks: In the absence of management, budworm outbreaks typically collapse after 7-10 years of heavy defoliation. Unfavorable weather conditions in early summer, host and resource availability, and increases in predators, parasites, and diseases are generally the causes of outbreak collapse.

Leaf Miners

Serpentine mines of the aspen leaf miner, *Phyllocnistis populiella* on cottonwood

Serpentine mines of the aspen leaf miner, *Phyllocnistis populiella* on aspen

Mine of the amber-marked birch leaf miner, *Profenusa thomsoni*

Cottonwood leaf blotch miner, *Phyllonorycter nipigon*

Mine of the birch leaf-edge miner, *Heterarthrus nemoratus*

Leaf Miners

Hosts: All tree species in Alaska.

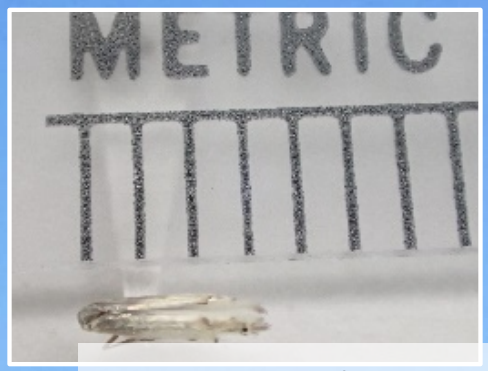
ID: Moths, butterflies and sawflies.

Damage: Larvae mine between the epidermal layers of the leaves of the various host species, reducing the photosynthetic capabilities of the leaf. Each species has a slightly different manner in which they mine the leaves, but all have similar characteristics, such as “hollowing” out areas of the leaf. These areas tend to be slightly transparent and as a result, frass and larvae can be observed inside the leaf.

Remarks: Different species are active at different times of the year. Serpentine mines of aspen leafminer can be found as early as May, while blotch mines of amber-marked birch leaf miner are not evident until late July early August. Mining can reduce photosynthesis, disrupt leaf gas exchange, disrupt translocation of nutrients, and lead to grow loss.

Aspen Leaf Miner

Serpentine mines of the aspen leaf miner on aspen



Adult Aspen leaf miner (*Phyllocnistis populiella*)

Serpentine mines of the aspen leaf miner on cottonwood

Aspen leaf miner mines give aspen leaves a silvery appearance

Aspen Leaf Miner

Hosts: Trembling or quaking aspen, balsam poplar, an black cottonwood. Willow and ornamental cherry are occasional hosts

ID: Small, white moths, with subtle brown or blackish marking on wings.

Damage: Larvae mine epidermal tissues of the leaves, reducing a tree's ability to conduct photosynthesis and regulate water loss. Mines on the underside of leaves negatively impact photosynthetic rates due to the destruction of guard cells surrounding leaf stomates (leaf pores). When guard cells are damaged stomates remain closed reducing the uptake of carbon dioxide (CO_2), a necessary component of photosynthesis.

Remarks: Adults emerge in early spring, generally prior to aspen bud break (early May). Individual eggs are deposited on edges of newly emerging aspen leaves. A majority of mining damage occurs later in larval development (early to mid-June).

Birch Mining Sawflies

Birch Leaf Miners

Hosts: All native species of birch in Alaska and alder.

ID: Sawflies (small, stingless wasp) Appears as a small fly-like insect roughly 3/8 of an inch in length.

Damage: Birch leaf miner larvae feeding becomes obvious in late July early August after a substantial portion of the leaf has been mined. Browning foliage can be mistaken for early transition to fall colors, but close examination of the leaf will prove otherwise.

Remarks: Both birch leaf miners can be found in the same tree and in the same leaf, but late birch leaf edge miner appears as a reddish ring on the edge of a leaf expanding inward, compared to amber-marked (AMBLM) which begin in the center of the leaf, often near a major lateral vein, and expands outward. Late birch leaf edge miner clean their mines, so mines will contain less frass and molts compared to AMBLM.

Willow Leafblotch Miner

Mines of willow leafblotch miner

Willow leafblotch miner (*Micrurapteryx salicifoliella*)

Birch Leaf Miners

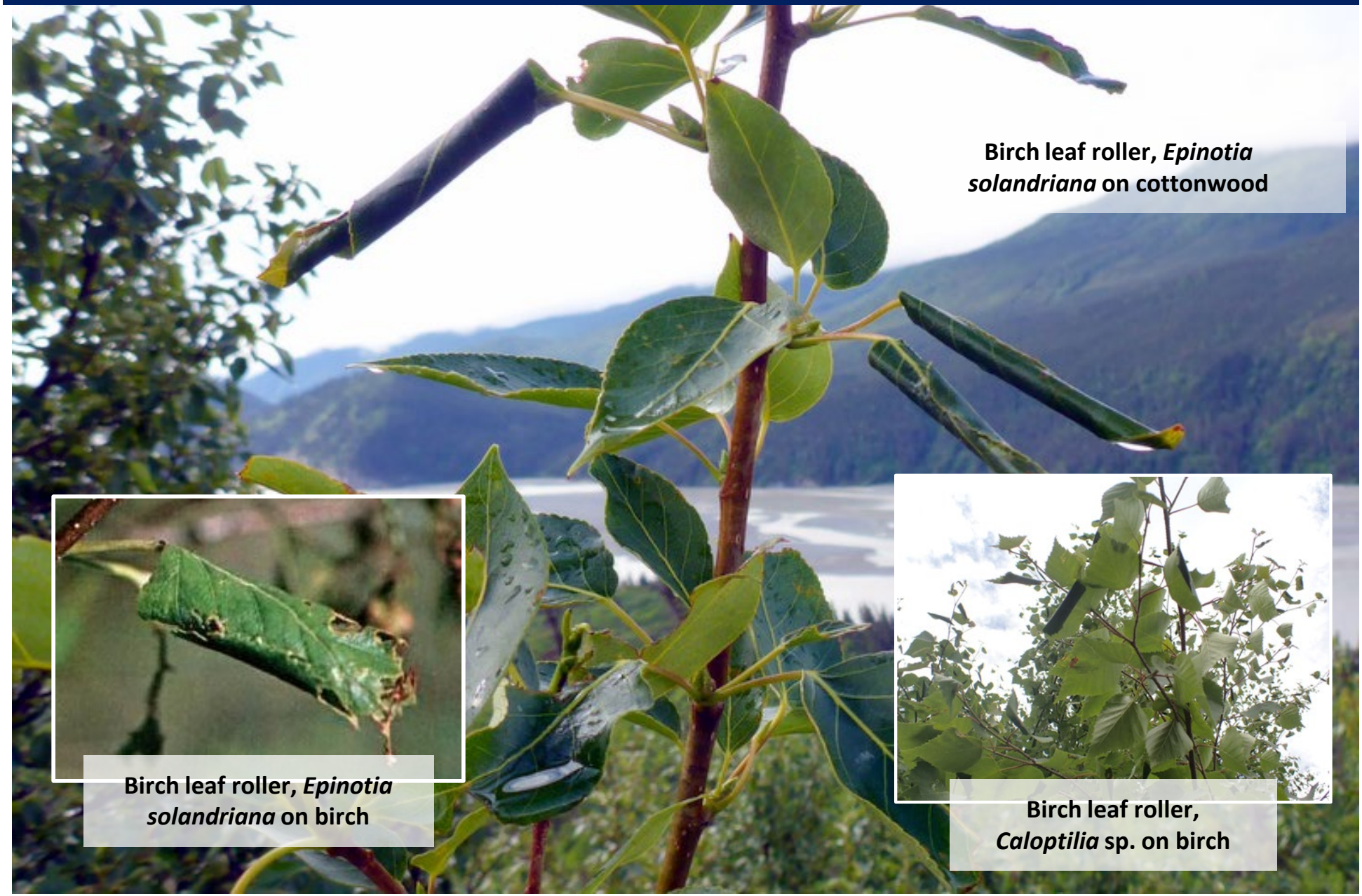
Hosts: Willow

ID: Small moth with mottled areas of light and dark gray to brown wings. Wingspan roughly 1 inch in length, with antennae approximately as long as wings.

Damage: Larvae feed within leaves, creating areas of dead and discolored tissue on upper surfaces of willow leaves. Severe damage can defoliate entire plants, kill leaves and branches, and can result in willow mortality. Willows are well-adapted to disturbances, and can often recover unless defoliation persists for several consecutive years.

Remarks: In Alaska, willow is a critical food source for several wildlife species, including moose. During winter, moose feed on woody stems of multiple species, including willow. High willow leafblotch miner population levels can reduce resource availability for overwintering moose.

Leaf Rollers



Birch leaf roller, *Epinotia solandriana* on cottonwood

Birch leaf roller, *Epinotia solandriana* on birch

Birch leaf roller, *Caloptilia* sp. on birch

Leaf Rollers

Hosts: Birch, alder, aspen, cottonwood and willow.

ID: Gray-brown moths with varied patterns in coloration. Wingspan is 1.5 to 2.0 cm. Larvae have a black head capsule, with a pale green, blue-green or pale yellow body, depending on developmental stage.

Damage: Leaf roller damage is caused by the larvae. Early stages of the larvae feed on buds. Later stages roll leaves into loose to tight tubes and skeletonize the leaves and feed within the shelter of the leaf. Webbing is often visible if the leaf is unrolled. Later larval stages drop to the duff and the rolled or curled leaves may turn brown and drop prematurely. Repeated heavy infestation can cause branch dieback and mortality.

Remarks: Leaf rollers roll, fold, or tie leaves, and feed within the shelter. This activity helps protect them from predators and parasitoids.

Sucking Insects — Aphids, Adelgids, Spider Mites, Eriophyid Mites

Erineum, Eriophyid mite damage on alder

Spruce aphid (*Elatobium abietinum*) on Sitka spruce

Birch aphid (*Euceraphis betulae*) on birch

Hosts: All tree species in Alaska.

ID: Hosts are injured either by feeding damage or by introducing plant diseases. Feeding damage results in discolored foliage, curled leaves, and enlarged growths or galls. Silk webbing is a symptom of mites and woolly adelgids.

Damage: Some sap-sucking insects are able to kill their hosts outright, but damage usually results in reduced growth rates and a generally weakened condition. Some vector pathogens.

Remarks: In Alaska, several sucking insects cause noticeable damage in trees and shrubs, and prolonged feeding can kill trees, or weaken them to a point where they become susceptible to other insects and pathogens. These insects are often visible while feeding, are extremely small, so use of a hand-lens for detection and identification is recommended.

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*Damage Causing Agent code from https://www.fs.fed.us/foresthealth/technology/detection_surveys.shtml