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IMPORTANT INSECTS AND DISEASES OF WETLAND HARDWOODS IN THE BLUE AND WALLOWA MOUNTAINS-with an Emphasis on Aspen

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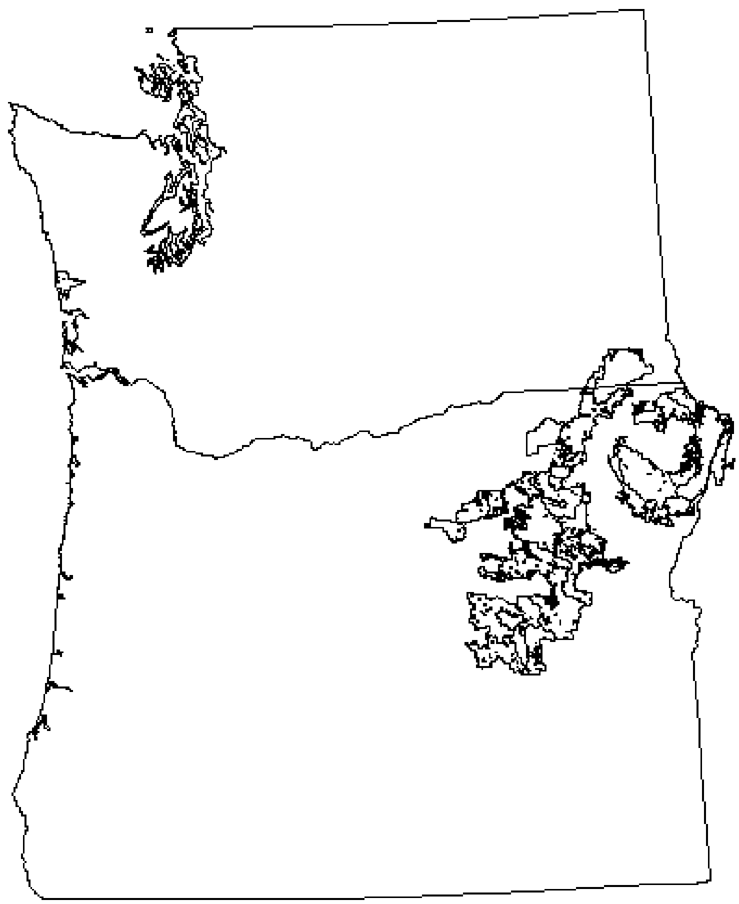

Caring for the Land and Serving People

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INSECTS AND DISEASES OF WETLAND HARDWOODS IN THE BLUE AND WALLOWA MOUNTAINS
--with an Emphasis on Aspen

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Introduction

Deciduous hardwood trees and woody shrubs comprise dominant vegetation in many wetland communities and are substantial components of most others in the Blue and Wallowa Mountains. Most common are species of alder (*Alnus* spp.), poplar (*Populus* spp.), willow (*Salix* spp.), dogwood (*Cornus* spp.), hawthorn (*Crataegus* spp.), maple (*Acer* spp.) and birch (*Betula* spp.). Although most prevalent along streams and rivers, these genera are also found in other wet sites including seeps, around springs, and adjacent to meadows. In the Blue and Wallowa Mountains, distribution of these wetland species is usually limited and seldom extends beyond the immediate wet microsites except in some mesic high elevation communities. In this discussion, riparian communities will specifically refer to those sites influenced by streams or rivers.

There is an increasing interest in active management of hardwood communities in the Blue and Wallowa Mountains on both private and public lands. This new interest stems from primarily ecological values offered by this vegetation to streamside stability, shading, water temperature and wildlife habitat. Although hardwood tree species in the Blue and Wallowa Mountains have not historically been used for wood fiber, minor markets have developed. These markets are mainly for aspen and cottonwood, where chips are used for paper products, and sawlogs used for veneer. To date, trees for the markets are harvested almost exclusively from private land.

It is believed that many of our riparian communities and their hardwood components are in poorer condition than existed historically; that is prior to European influences. Some of the most severe riparian degradation appears associated with lower elevation private holdings that have had many decades of heavy grazing pressure and associated streamside disturbances. Fire suppression is thought to have contributed to stand deterioration, as well. Sprouting of some hardwoods such as aspen and cottonwood are stimulated by fire. Lack of fire may also allow encroachment of conifer into the hardwood community.

Future management practices in riparian communities aimed at restoration and regeneration will undoubtedly need to consider insect and disease activity in the hardwood species. Many insect and disease agents affect the establishment, growth, and productivity of hardwood tree species (Shaw 1973; Furniss and Carolin 1977).

Most of the research and documentation concerning the biology and epidemiology of insects and diseases of hardwoods has been done in other parts of the United States, where hardwoods have been an important timber commodity. It is known that throughout the Blue and Wallowa Mountains, hardwoods are host to a variety of leaf spots, rusts, shoot blights, stem cankers, stem decayers, and defoliating and wood-boring insects. However, information regarding insect and disease outbreaks, distribution, severity, specific to the Blue Mountains is almost non-existent. Historical records of insect and disease activity on hardwoods in the Blue and Wallowa Mountains, including probable epidemics, are almost non-existent.

Given the information available, the following discussion will center on the insects and diseases believed important to these communities of the Blue and Wallowa Mountains.

INSECTS

Insect defoliators

Defoliating insects usually have population cycles that periodically become epidemic. Thus, periodic occurrences of often dramatic insect-caused damage can also be expected in these communities.

Fall Webworm

The fall webworm (*Hyphantria cunea*) is a very common defoliator of hardwoods in the western United States and is known to affect species of *Alnus, Populus,* and *Salix* in the Blue and Wallowa Mountains. Schmitt (1993) reported it on black cottonwood along the Umatilla River on the Umatilla Indian Reservation just east of Mission, OR.

Adults appear in late June to early July. Eggs are laid on the undersides of leaves and there is one brood per year.   Larvae of the webworm feed in the summer through mid-September, feeding on the whole leaf of the host, leaving only the petiole untouched. Mature larvae have a black head, a pale yellowish or greenish body with a dark stripe on the back, and long whitish hairs on the sides arising from black and orange tubercles. They feed gregariously, forming large thin flimsy webs around the foliage. The insects overwinter as pupae in the litter or attached to tree trunks. Larvae feed on both sides of leaves, and avoid veins and petioles leaving a "skeletonized" appearance to leaves. The fall webworm has a cyclic population, occasionally becoming epidemic for a year or two, often over fairly large areas and then returning to endemic levels. Defoliation usually doesn't result in tree mortality.

Tent Caterpillars

Several species of tent caterpillars (*Malacosoma* spp.) cause periodic defoliation of broadleaf vegetation throughout the western United States. Two of these are known to be common in eastern Oregon. Principal Blue and Wallowa Mountain riparian hosts for the western tent caterpillar (*M. californicum*) and the forest tent caterpillar (*M. disstria*) include: *Salix, Prunus, Populus, Betula,* and *Alnus.*

The typical *Malacosoma* lifecycle includes an egg-laying flight in mid-summer with eggs deposited on twigs, limbs, and boles of hosts. Within several weeks, larvae fully develop but do not emerge from eggs until next spring, just as new foliage is emerging. Young larvae are gregarious and form conspicuous large silken tents where they rest between periods of feeding. In addition to the preferred hosts, a wide variety of woody plants may be used. Pupation lasts just two weeks before adults emerge in mid-summer. Outbreaks of *Malacosoma* spp. are eventually controlled by a variety of insect parasites; larvae are eaten by predaceous beetles or bugs; and eggs, larvae, and moths are consumed by birds. A highly contagious nucleopolyhedrosis virus (specific to *Malacosoma* spp.) is also common and can quickly cause epidemic populations to collapse. Outbreaks of the forest tent caterpillar typically last 2 to 3 years and cover relatively large areas. Western tent caterpillars are reported to cycle with 9 to 10 year periodicity in British Columbia (Myers 1992). Weather has been shown to be a minor factor in population dynamics (Myers 1990).

Severe defoliation causes host mortality, probably at relatively low levels, and growth impacts. More importantly, loss of host foliage will likely result in reduction in streamside shading and wildlife hiding value.

Large Aspen Tortrix

The large aspen tortrix (*Choristoneura conflictana*) is widespread throughout the western range of trembling aspen. Two- to three-year outbreaks occasionally occur. During outbreaks, foliage of associated hosts will also be consumed.

A native insect, the tortrix has many insect parasites that keep the population in check. When outbreaks do develop, trees may be completely defoliated for one or two years with growth loss as the primary tree impact. Eventually, food sources are depleted and starvation of larvae results in the collapse of the population. Streamside shading and wildlife cover may be impacted for the duration of an epidemic. This insect overwinters as a second instar larvae and then mines buds in the spring. Later instar larvae are gray green to nearly black with a dark head. Severe bud damage alone may result in complete defoliation. Later instars roll leaves in which they feed, then pupate.

Aspen Leaftier

The aspen leaftier (*Sciaphila duplex*) reached epidemic levels in the Intermountain region in the early- to mid-1960's, and peaked at 250,000 acres throughout western Wyoming, Utah, and southeastern Idaho. (McGregor 1967). No reports of activity in the Blue and Wallowa Mountains are known, but infestations are periodically likely in this area.

Larval feeding lasts 45 to 60 days, starting with warm weather in the early part of May. In feeding, larvae skeletonize, roll and tie leaves. A single larvae may consume all the leaves produced on a single twiglet. Pupation occurs by the end of June. After 8 to 14 days, moths emerge, mate, deposit eggs, and die. Eggs hatch in August and the first instar larvae begin feeding on remnant leaves. They overwinter as second instar larvae.

Satin Moth

The satin moth (*Leucoma salicis*) was introduced into North America from Europe or Asia and discovered in British Columbia in 1920. It has spread through the Northwest on species of poplar and willow (*Populus and Salix* spp.).

These insects overwinter as larvae. Feeding resumes in the spring (May). Leaves are consumed through early June (Fig. 1). Pupation in June is followed by adult emergence in late June and early July. Adults are strong fliers. Mating, egg deposition, and early feeding by first and second instar larvae (Fig. 2) continue until the first frost. Hibernation in protected bark crevices as second instars is typical. Mature larvae are about 50mm long, blackish with a row of nearly square white marks along the back and white markings on the sides.

Figure 1. Satin moth defoliation of aspen. Note the difference in defoliation between clones.

Figure 2. Early instar satin moth larvae feeding on aspen in the fall.

This insect has become quite severe on the east coast and is most widely known in the west on ornamental plantings. In recent years, satin moth defoliation has been observed in a number of aspen stands throughout the Blue Mountains. Defoliation is often extensive.

Control options for most defoliators are limited. Non-native pests may sometimes be controlled by importing native predators and parasites. Use of direct control, through application of insecticides, such as formulations of *Bacillus thuringiensis*, or less likely--chemicals, are other alternatives that may be considered.

Wood Borers

<u>Bronze Poplar Borer</u>

The bronze poplar borer (*Agrilus granulatus liragus*) is a widely-occurring insect that is reported on aspen and black cottonwood in Oregon. We have seen this insect and its feeding damage in several areas of the Blue and Wallowa Mountains.

Adults of these insects emerge in the summer, feed for a week or so on foliage, and females lay their eggs in several groups of 5 to 8 eggs in crevices of the bark of host trees. Hatching larvae immediately bore through the bark and begin feeding in the cambium. Larvae bore into the xylem to molt. Life cycles may require one or two years with two year cycles being more common in more vigorous hosts, and weak trees more likely to allow completion of a one year cycle.

Trees that have a high incidence of injuries from other insects, animals, wind, animals, etc., are most likely to become infested with borers. Attacked trees display fading portions of the crown as individual branches decline or die. In severe cases, the entire tree will be killed. Aspen that are attacked are likely to become infected with hypoxylon canker (Barter 1965).

Control strategies include reducing avoidable injury-causing disturbances. Maintenance of high tree vigor will also reduce the incidence of attack. There are several known egg and larvae parasites that help keep populations levels in check. Woodpeckers readily feed on developing larvae, pupae, and newly transformed adults.

Blue Alder Agrilus


Figure 3. Feeding damage by blue alder agrilus larvae on alder stem.

The blue alder agrilus (*Agrilus burkei*) attacks mountain alder (*Alnus incana*) and other alders (*Alnus*) are reported as likely hosts. Range is throughout the west including Oregon and east through the Rocky Mountains. This wood borer is apparently very common in the Blue Mountains.

Adults emerge in the spring through mid-summer, feed on the foliage of host trees for a week or so and mate. Females then lay eggs on the bark of trunks and branches of alder. Apparently, females search out trees that are stressed and in poor condition (Solomon 1995). Few eggs are laid on healthy trees or trees that are in very poor condition. Hatching larvae will feed in the cambium, overwinter, and pupate in the early spring (Fig. 3). There is one generation per year.


Figure 4. Canker-like lesion indicates blue alder agrilus larvae feeding.

Infested portions of branches can be identified by sunken misshapen and discolored areas on the surface of stems and branches (Fig. 4).

Infested trees will display wilting foliage and branch dieback (Fig. 5). Heavily infested trees may be girdled. Smaller trees are most likely killed. Trees on disturbed sites, such as areas having heavy grazing or human-caused damage and trees that are stressed due to disturbance are predisposed to attack. Control strategy should include minimization of stress-resulting disturbance where possible.

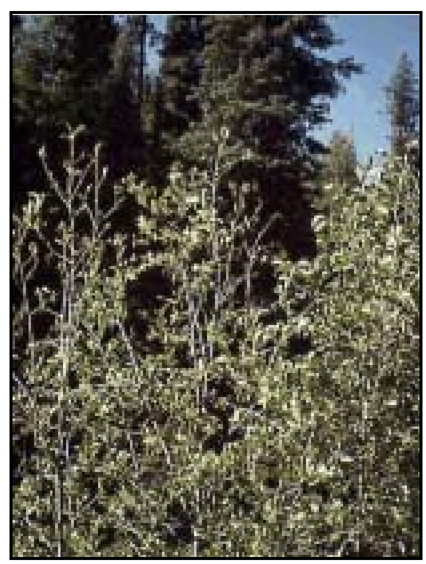
Figure 5. Branch dieback of alder caused by the blue alder agrilus.

Many streamside alder stands in the Blue Mountains have substantial amounts of infestations of this insect resulting in stem mortality and topkill.

<u>The Poplar Borer</u>

The poplar borer (*Saperda calcarata*) is a common pest of aspen in the northern portion of its range, although it is not as common in the West as in the East.


Figure 6. Oozing sap on the bark surface of aspen is characteristic of poplar borer activity.

The adults emerge in mid- to late-summer and begin feeding on foliage or bark on tender shoots of host trees. Following mating, females deposit single eggs in niches cut into the bark of the truck. After two weeks the eggs hatch and the larvae begin feeding on bark tissue and later move to the sapwood. Larvae overwinter in the sapwood and resume feeding in the spring. It may take 3 to 5 years to complete the life cycle, with the larvae boring through the wood of the roots, stem, and larger branches (Salomon 1995).

Wet spots and oozing sap mixed with boring frass on the bark are early signs of poplar borer infestation (Fig. 6). Woodpeckers searching and feeding on larvae contribute to tree weakening. In some cases, trees will be killed outright or break due to weakening of the bole from boring insects and the birds that feed on them. Decay and canker fungi entering through galleries and woodpecker holes contribute to tree weakening and occasional death. Attacks are reported to be heavier in poorly-stocked stands and to open-grown trees (Solomon 1995).

Miscellaneous Insects that damage alder


Figure 7. Alder flea beetle and feeding damage on alder.

Several insects have been reported on *Alnus rubra* in the Northwest. These include the alder woolly sawfly (*Eriocampa ovata*), striped alder sawfly

(Hemichroa crocea), alder flea beetle (*Altica ambiens*) (Fig. 7), a leaf beetle (*Pyrrhalta punctipennis*), and the alder aphid (*Pterocaulis alni*). The alder flea beetle was observed causing partial defoliation of sitka alder in several small patches on the Baker RD (WAW) in 1994. Defoliation did not result in tree mortality.

The host preferences of the most important hardwood insects are summarized in Table 1. Effects on the hosts are summarized in Table 2.

Table 1. Principle insects feeding on Blue and Wallowa Mountains wetland hardwoods

	fall webworm	tent caterpillars	large aspen tortrix	aspen leaf-tier	satin moth	bronze poplar borer	blue alder agrilus	poplar borer
Alder	**H**	**H**	**L**	**L**	**L**	**L**	**L**	**L**
Aspen	**H**	**H**	**H**	**H**	**H**	**H**	**H**	**H**
Cottonwood	**H**	**H**	**L**	**L**	**H**	**H**	**L**	**H**
Willow	**H**	**H**	**L**	**L**	**H**	**L**	**L**	**M**
Cherry	**M**	**H**	**L**	**L**	**L**	**L**	**L**	**L**
Birch	**M**	**H**	**L**	**L**	**L**	**L**	**L**	**L**
Hawthorn	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**

H -- Highly susceptible
M -- Moderately susceptible
L -- Low susceptibility (may be severely affected during insect epidemics)

Table 2. Effects of insect feeding on Blue and Wallowa Mountains wetland hardwoods

	fall webworm	tent caterpillars	large aspen tortrix	aspen leaf-tier	satin moth	bronze poplar borer	blue alder agrilus	poplar borer
Mortality	seldom	seldom	no	no	seldom	sometimes	sometimes	sometimes
Stem girdling	no	no	no	no	no	yes	yes	yes
Stem breakage	no	no	no	no	no	yes	yes	yes
Defoliation	yes	yes	yes	yes	yes	no	no	no
Crown dieback	no	no	no	no	no	yes	yes	yes
Predisposes to diseases	no	no	no	no	no	yes	probably	probably

DISEASES

Wounding often results in increased levels of hardwood canker and decay activity. Cool, moist conditions characteristic of wetland sites also favor a wide environmental window for production and spread of disease-inducing fungal spores, especially in years having long cool wet springs where conditions for spread are highly favorable.

Canker and gall diseases

There are several canker diseases of hardwoods caused by various pathogenetic fungi. Cankers both weaken branches and stems and cause branches and occasionally entire trees to succumb when the canker and killed tissue completely encircles the branch or stem. Breakage and mortality are likely on trees having large well-developed or multiple cankers (Fig. 8). Other secondary disease organisms sometimes enter canker wounds. Damage often occurs to portions of a tree's crown, without killing the entire tree. Some insects, especially woodborers, weevils, and bark beetles, probably play a role in transmitting some of these canker diseases tree to tree in their feeding.

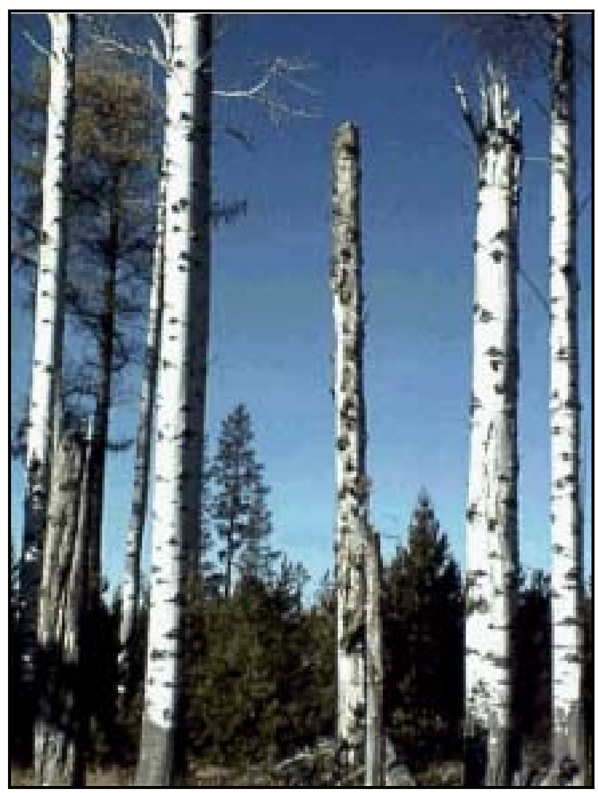

Figure 8. Stem breakage in aspen resulting from stem cankers.

Since these insects are often attracted to damaged and weakened trees, trees may be predisposed to infection by stress-causing disturbances. The incidence of most canker diseases increases proportionally with wounding in stands. Wounds are often created by wildlife use such as elk or deer feeding and antler rubs.

Cytospora cankers (caused by *Cytospora* sp.) have been identified on aspen and mountain alder (*Alnus incana*) in eastern Oregon and Washington. Black hawthorn (*Crataegus douglasii*) and red-osier dogwood (*Cornus stolonifera*) are not susceptible to infection. Wounded alder were found to be much more susceptible to infection than unwounded trees (Filip *et al* 1992).

A canker-causing fungus, *Didymorosphaeria oregonensis,* causes a disease known as rough bark of alder. All species of alder may be infected, and the disease results in swollen bands of roughened bark on branches and the main stem, primarily on thin-barked younger trees (Fig. 9). Little or no impact appears associated with this disease.

Figure 9. Rough bark disease of alder.

Other alder canker-causing fungi include *Hymenochaete agglutinans,* and several species of *Nectria*. These diseases are likely to be responsible for most of the dead branches observed on living trees in many alder thickets. There is some incidence of hypoxylon canker of aspen, caused by *Hypoxylon mammatum* in the Blue and Wallowa Mountains. This disease is reported to be much more common in the eastern United States than in the West. Johnson *et al.* (1995) reports that this disease is likely under-reported in the West. This canker readily girdles main stems and branches. Small trees are likely to be killed, whereas larger trees may only lose branches. Wounds, insect attacks, etc., predispose trees to infection by creating an infection court for the causal fungi.

Sooty-bark canker, caused by *Encoella pruinosa*, seems fairly common in some aspen clones in the Blue and Wallowa Mountains. This disease is recognized by the aggressive dying of portions of the bole, where portions of the bark sloughs off 2 or 3 years after infection. Trees are predisposed to infection by wounds. In turn, the cankers predispose the tree to trunk decay organisms. Some aspen stands are likely damaged by other canker diseases, caused by several species of *Certocystis* and closely-related fungi (Fig. 10).

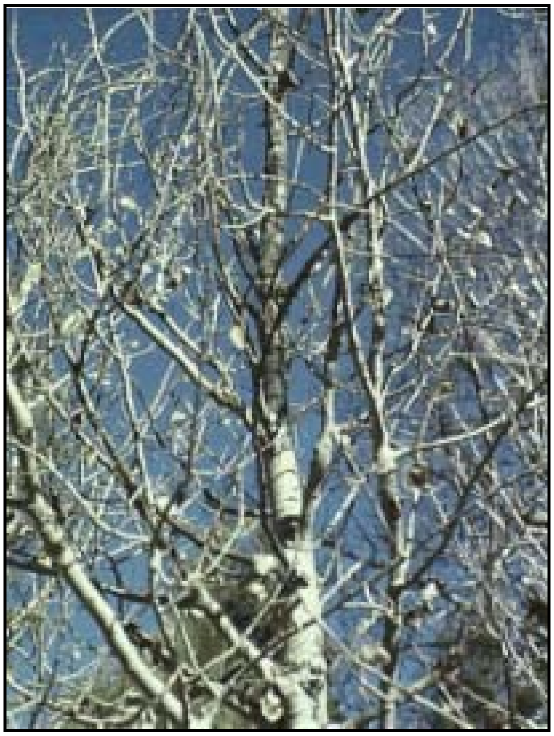

Figure 10. Ceratocystis canker girdling small diameter tops of aspen.

Included are Target canker (caused by *Valsa soridi*), Cytospora canker (caused by *Cytospora chrysosperma*), Ceratocystis canker (caused by *Ceratocystis fimbriata*) and Cryptosphaeria canker(caused by *Cryptosphaeria populina*). Some incidences of these diseases are known to occur based on observations made by the author. Since systematic surveys have not been done, levels of infection and damage are not known for aspen and other *Populus* sp. in the Blue and Wallowa Mountains. In the Rocky Mountains region, *Ceratocystis* canker is increased by selective logging associated disturbance (Sinclair *et al.* 1987).

Hypoxylon fuscum, is reported as a widely-distributed decay-causing fungus of alders and other Betulaceae (Fig. 11). Reports of this causal fungus infecting alder in southeastern Washington and north-central Idaho indicate that the Blue and Wallowa Mountains likely also host this disease (Crowe and Clausnitzer 1996). This fungus was reported as primarily a saprophyte, although its speed in fruiting following tree/branch death suggests it is able to infect trees while they're still alive.

Figure 11. Hypoxylon canker on aspen.

Apiosporina morbosa, which causes black knot of members of the genus *Prunus***,** occurs on chokecherry in some localities. This disease causes large rough elongated galls to form on various size twigs and branches. Deformed branches and dieback will result on often severely-affected trees. While some infections result through wounds, most occurs through new green shoots. There are a number of natural controls including insects, mites and hyperparasitic fungi. Sanitation and fungicidal controls are available for commercial orchards but are probably not effective options in natural stands.

Leaf and shoot blights

Incidence and severity of leaf diseases differ by genetic variabilty of clones and by weather conditions in the spring when buds swell and new leaves are emerging. Conditions that favor development and dispersal of specific disease-causing spores and simultaneous infection of host tissues are periodic events. Impact is typically restricted to premature leaf drop, although some diseases grow from the leaf tissue into branches and cause dieback. Ink spots of aspen leaves (caused by *Marssonina populi* and *Ciborinia whetzelii*), are believed to occasionally be severe, especially during years with moist and warm spring and early summer weather. The most prominent result of these diseases is premature leaf drop. Shepherd's crook, a leaf and twig die-back (caused by *Ventuia tremulae*) are also seen in some clones of aspen (Fig. 12). Damage and impact is most severe in seedlings and saplings.

Figure 12. Shepherd's crook on an aspen shoot.

In 1993, the author inspected black cottonwood on the Umatilla Indian Reservation having leaf blight and diagnosed infection by *Septoria musiva*, which causes Septoria leaf spot results in premature leaf drop. Historical incidence of this disease is not known for the area, but 1993 infection was attributed to the moist spring weather that year.

Leaf Rusts

Figure 13. Dormant telia of *Melampsora medusae* on recently fallen aspen leaves.

Melampsora rusts affect a diverse range of plants. In eastern Oregon, cottonwood, aspen, and willow are commonly infected, resulting in leaf spot and premature leaf drop if infestation is severe. As with most rusts, alternate hosts are required for the rust fungus to complete all spore stages and complete their life cycle. Douglas-fir, true firs, pines, and western larch may all serve as alternate hosts for one or more species of *Melampsora*. Generally, gymnosperm hosts are not affected to the degree of broadleafs. *M. occidentalis* is common on black cottonwood, *M. medusae* is most common on aspen (Fig. 13), and the *M. epitea* complex is common on willows.

There are often dramatic levels of resistance/susceptibility to rusts and their effects by different genotypes of the hosts. Selection and breeding for rust resistance might be considered as part of the broadleaf tree improvement program.

Black hawthorn (*Crataegus douglasii*) is a streamside disturbance-induced seral hardwood found mainly at low to mid elevations throughout the Blue and Wallowa Mountains. Along Catherine Creek in the Grand Ronde Valley it is the dominant hardwood. Bethel's juniper rust (*Gymnosporangium bethelii*) has been found where hawthorn is located within several hundred yards of Rocky Mountain juniper (*Juniperus occedentalis*). This rust infects both juniper and hawthorn, and cycles between them, resulting in production of telia on juniper and aecia on hawthorn. Infected leaves of hawthorn become yellow in early summer and may result in premature leaf drop, resulting in reduced streamside shading late in the season. The severity of this disease varies with spring weather patterns. Cool moist conditions when the telia are maturing will likely result in severe infection of nearby hawthorn. In addition to the Grand Ronde Valley, this disease was identified in 1994 in the Five Points drainage on the LaGrande RD, and on the Powder River 5 miles southwest of Baker City. It is believed to occur throughout communities where juniper and hawthorn grow in close proximity.

Trunk Rots and Stem decays

White Trunk Rot

White trunk rot (caused by *Phellinus tremulae*) is quite common in aspen stands in the Blue and Wallowa Mountains. Incidence is very severe in some cases. Distinctive conks are readily produced on infected trees indicating extensive decay (Fig. 14). Wood decay is typified by white-yellow spongy rot in the heart. Older trees are more likely to have decay, as are trees having wounds and scars. Environmental damage, such as ice or windstorms, and other wounding can predispose trees to decay, which can quickly become excessive.


Figure 14. *Phellinus tremulae* conks on aspen indicate extensive decay.

Cottonwood are very susceptible to stem decay and truck rot, older trees especially. Decay caused by *Pholiota destruens* and *Spongepellis delectans* are common in the Blue and Wallowa Mountains (per. com. C. Parks 1996).

These trees and snags having white trunk rot or other stem decays are frequently used by cavity-nesting birds that excavate a chamber or use existing chambers in the decayed stem. Since living trees with truck rot can provide long-term habitat for cavity nesters, an endemic level of disease-caused decay is desirable. Incidence of decay can be minimized by reducing disturbances that result in tree wounding. Developing young vigorous stands that are well stocked and self-prune early in life, thus minimizing branch size, will limit infection and decay in the future.

Peniophora Stem Rot

Peniophora stem rot, caused by *Peniophora polygonia*, causes a stem decay similar to that caused by *Phellinus tremulae.* Because fruiting bodies are not produced, it is both difficult to determine the presence of hidden decay, and to confirm diagnosis of the causal fungus. Tissue culturing is required for confirming diagnosis. In Colorado, Powell (1988) lists this as the second most common cause of decay in aspen. Shaw (1973) lists this in several western states and British Columbia, although not Oregon.

Root diseases

Two root diseases are likely to cause the bulk of root rot, root mortality, and tree toppling. Armillaria root and butt rot (caused by *Armillaria bulbosa*), similar to related *Armillaria spp.* in conifers, is seen in broadleaf trees and shrubs. Trees are predisposed to mortality or windthrow when decay is advanced. The fungus will persist on the site and likely infect other hosts nearby or cause mortality in the future as the site regenerates.. Armillaria-infected trees are easily identified by characteristic decay, mycelial fans, and rhizomorphs.

White mottled rot, caused by *Ganoderma applanatum*, is known to occur in the Blue and Wallowa Mountains. An infected site with windthrown trees and characteristic conks was identified on the North Fork John Day RD (UMA) in 1995 (Schmitt and Scott 1995). The level of incidence throughout the area is not known, however *G. applanatum* conks do not seem very common.

Miscellaneous Diseases

Catkins are sometimes infected by fungi that deform these reproductive structures affecting regeneration potential. The female catkins of alder are known to be host to *Taphrina occidentalis, T. amentorum* (Hepting 1971) and *T. alni* (Mix 1949). Affected female catkins have enlarged bracts that prevent or hinder normal fertilization and seed development (Fig. 15).

Figure 15. Damage to female catkins of alder by *Taphrina* sp.

The host susceptibility of the principle hardwoods in the Blue Mountains is summarized in Table 3. The effects on the hosts are summarized in Table 4.

Table 3. Blue and Wallowa Mountains wetland hardwood susceptibility to principle diseases

	cytospora canker	hypoxylon canker	sooty-bark canker	Bethel's shepherds crook	white juniper rust	white trunk rot	melampsora rusts	mottled rot
Alder	**H**	**H**(1)	N	N	N	N	N	**M**
Aspen	**H**	**H**(2)	**H**	**H**	N	**H**(3)	**H**	**H**
Cottonwood	**H**	**L**	**M**	**M**?	N	N	**H**	**M**
Willow	**H**	**L**	N	N	N	N	**H**	**M**
Cherry	**L**	**L**	N	N	N	**M**(4)	N	**M**
Birch	**L**	**H**	N	N	N	N	N	**M**
Hawthorn	N	N	N	N	**H**	N	N	**L**

H -- Highly susceptible
M -- Moderately susceptible
L -- Low susceptibility
N-- Not susceptible

1--*Hypoxylon fuscum*
2--*Hypoxylon mammatum*
3--*Phellinus tremulae*
4--*Phellinus ignarius*

Table 4. Effects of diseases on Blue and Wallowa Mountains wetland hardwoods

	cytospora canker	hypoxylon canker	sooty-bark canker	shepherds crook	Bethel's juniper rust	white trunk rot	melampsora rusts	white mottled rot
Mortality	yes	yes	yes	no	no	yes	no	yes
Stem breakage	yes	yes	yes	no	no	yes	no	no
Windthrow	no	no	no	no	no	no	no	yes
Shoot dieback	no	no	no	yes	no	no	no	no
Defoliation	no	no	no	yes	yes	no	yes	no
Predisposes to decay	yes	yes	yes	no	no	N/A	no	N/A

DISCUSSION

Stem breakage contributes to down material in stream channels and creation of snags. Cavity nesting bird use is often very high in such aspen, especially when stem decay is also present. Since aspen is very susceptible to wounding, and wounded trees are very susceptible to a variety of canker- and decay-causing fungi, management of clones should avoid wounding of residuals. Where unacceptably high cankering already exists, Johnson *et al.* (1995) recommends clearcutting to promote sucker production and a new stand.

Figure 16. A recently burned aspen community. All of the burned stems were killed.

Riparian hardwoods are apt to be influenced by disturbances associated with fluctuating water tables, flooding, ice flows, mining, livestock grazing and big game use. Fire frequency varies substantially depending upon the plant community type and inherent moisture regimes. Some communities with aspen or cottonwood/ Kentucky bluegrass likely burn fairly frequently under natural conditions, dependent upon surrounding forest conditions, while mountain alder communities rarely burn (Crowe and Clausnitzer 1996). Because most of the exceptionally wet communities are infrequently visited by fire, fuel loads accumulate and infrequent historical fire events are often stand replacement in nature (Fig. 16). Because hardwoods are usually relatively short-lived species, down and dead standing material are usually well represented, especially if there has not been a recent fire. Sprouting of some hardwoods, such as aspen and cottonwood, is stimulated by fire. Lack of fire in stands of older, deteriorating hardwood stands will both hinder stand perpetuation and allow encroachment of conifers in most communities.

Figure 17. A fenced aspen clone. This enclosure was designed to protect the developing suckers from grazing damage.

The condition of many hardwood wetland communities, especially riparian aspen and cottonwood stands have degraded in the last few decades, some substantially. It is also likely that the range of aspen has retreated as marginal clones have died out. Numerous clones have been observed over the last few years that are down to only a few remnant individuals and have no sprouting of replacements. Grazing, both by cattle, and deer/elk, are known to damage sprouts and inhibit development of shoots. Excess soil moisture, or drought (Perala 1990), and probably compaction, can inhibit sucker production of those species that sprout from existing root systems. Repeated cropping of shoots can lead to the exhaustion of carbohydrates (Perala 1990). Thus fencing has been promoted to protect declining clones from over-grazing.

Required rejuvenation disturbances in aspen clones, especially those associated with fire, have been reduced. Abundant suckers are produced by moderate to high-severity fire (Brown and DeByle 1989). Killing most trees in a clone favors sucker production and development because apical dominance is reduced and sucker-stimulating cytokinins are increased in the roots (Schier 1981). Cutting of trees also favors sprouting, and the number of suckers that develop is proportional to the degree of cutting (Perala 1990). While fire kills the overwood and reduces ground cover, the associated increases in soil temperature from solar radiation likely are the main reason for an increase in suckering. Initiation and development of suckers is optimum at 74 degrees F, where auxin is degraded and cytokinin production is promoted (Perala 1990).

Recommendations for aspen

The strategy of selecting and fencing high value sites where aspen is adapted and is either dying out or not reproducing appears sound. The silvics of aspen and other hardwoods and the need to manage natural disturbance (fire) and protect the site from excessive grazing are well documented (Fig 12). Knowledge of proper management of insects and diseases is taken from areas where hardwoods are a major forest type, such as Colorado and New Mexico, as very little knowledge about insects and diseases specific to the Blue and Wallowa Mountains has been documented.

1. Upon application of fire and/or silvics to help reestablish declining stands, maintain full stocking with ample vigor to reduce the susceptibility to insects and diseases and the conditions that favor their establishment.

2. Where possible, reduce the level of undesirable disturbances (soil compaction, overgrazing, tree wounding), and plan for those disturbances that promote stand health (fire, thinning).

3. Several canker-causing fungi are common in this species and, along with poplar borer galleries, contribute to stem breakage and tree mortality. Canker causing fungi include species of *Fusarium, Nectria, Ceratocystis, Cryptosphaeria, Phibalis,* and *Hypoxylon.* Wounded trees are more likely to be infected, as are stressed trees that have attracted vectoring beetles and woodborers. Different clones are likely to vary in disease susceptibility.   It is likely that some sites are predisposed to higher infection levels than others. A low level of cankering tends to promote a desirable level of diversity; excessive cankering will cause a clone to fall apart prematurely. Identification of hardy clones and their propagation may be desirable, especially to revegetate high hazard sites.

4. A variety of leaf and shoot blights infects aspen. Most of these are occasional problems that cause premature leaf drop. Some fungi may move back on the new shoots and cause lesions resulting in tip dieback. These are usually not a concern, although in certain years where conditions are favorable for infection and spread, damage may be dramatic. Effective management options to lessen infection are not available in most situations.

5. Leaf rusts will cause premature leaf drop which may impact streamside shading and wildlife use. While largely an annual localized event, infection patterns may show that certain sites are likely to frequently have high levels of infection due to site factors that favor production and spread of the fungus via airborne spores. Selection and breeding for rust resistant stock might be considered as part of the broadleaf tree improvement program for improving the genetic base is such sites.

6. Management of aspen to late and old structure clones will provide stem decay for cavity nesting birds.   When clones become overly-decadent, rejuvenation needs to be implemented. This is probably around age 100. By managing clones at different age classes within aspen sites (to the extent possible) several successional classes can be maintained at one time. Wounding trees will predispose them to *P. tremulae* infection. Inoculation would likely be successful if infection is not present and desired. This could be done by boring a hole in the stem and inserting a *P. tremulae*-impregnated dowel. Likewise, minimizing wounding will limit decay in mature stands.

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