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FOREST Pest LEAFLET

Stem rusts of pine

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Introduction

Stem rusts cause more damage to pine throughout the world than any other rust diseases of trees. They are caused by a well delimited group of rust fungi which cause similar and conspicuous symptoms. Damage by stem rusts may cause significant economic impacts in commercial forests by killing trees, causing stem distortions, or by reducing growth. In locations where infection levels can be high, susceptible species are avoided by reforestation specialists, arborists and horticulturists.

In British Columbia and at other locations in western Canada, stem rusts are represented by five species of the fungal family Melampsoraceae:

- White pine blister rust - *Cronartium ribicola*
- Western gall rust - *Endocronartium harknessii*
- Comandra blister rust - *Cronartium comandrae*
- Sweet-fern blister rust - *Cronartium comptoniae*
- Stalactiform blister rust - *Cronartium coleosporoides*

As the notorious white pine blister rust is dealt with separately in this series of Forest Pest Leaflets (No. 26), the remaining four are the subject of this leaflet.

Hosts

Native (***primary***) tree hosts for these four rusts in western Canada are jack pine (*Pinus banksiana*) and lodgepole pine (*P. contorta*). Western gall rust, comandra blister rust and sweet-fern blister rust also occur on ponderosa pine (*P. ponderosa*). Other pines, including several exotic species, may be infected.

- Western gall rust may infect mugo pine (*P. mugo*), bishop pine (*P. muricata*), Corsican pine (*P. nigra*), cluster pine (*P. pinaster*), Monterey pine (*P. radiata*), and Scots pine (*P. sylvestris*).
- Comandra blister rust may infect Scots pine and mugo pine.
- Sweet-fern blister rust may infect Bishop pine, Monterey pine, and perhaps other exotic pines.

Pathologists consider all pines as *primary* hosts. The essential ***secondary*** hosts for these rusts are:

- Western gall rust - none.
- Comandra blister rust - Comandra (*Comandra umbellata* var. *pallida* and *Geocaulon lividum*).
- Sweet fern blister rust - Sweet gale (*Myrica gale*).
- Stalactiform blister rust - Indian paintbrush (*Castilleja* species), cow wheat (*Melampyrum lineare*), lousewort (*Pedicularis bracteosa*), yellow owl's clover (*Orthocarpus luteus*), yellow-rattle (*Rhinanthus crista-galli*).

Distribution

Basically, each of these four hard-pine stem rusts extend across North America where the primary and alternate hosts both occur. Interestingly, their occurrence is limited to North America; thus, accidental introductions of these rusts to other continents could seriously threaten survival and quality of pine forests there.

Similarly, in British Columbia, stem rusts occur throughout the contiguous ranges of their primary and secondary host plants, although stalactiform rust is not found along the coast. Several areas of the province have experienced severe infection and damage levels. In some situations, infection levels of pine hosts are extreme, and in such cases decisions concerning reforestation and stand tending may be very difficult indeed.

Life cycles

A life cycle is the sequence of events in the life of an organism. Rust fungi, including the notorious wheat rusts and nearly all conifer rusts, have relatively complicated life cycles.

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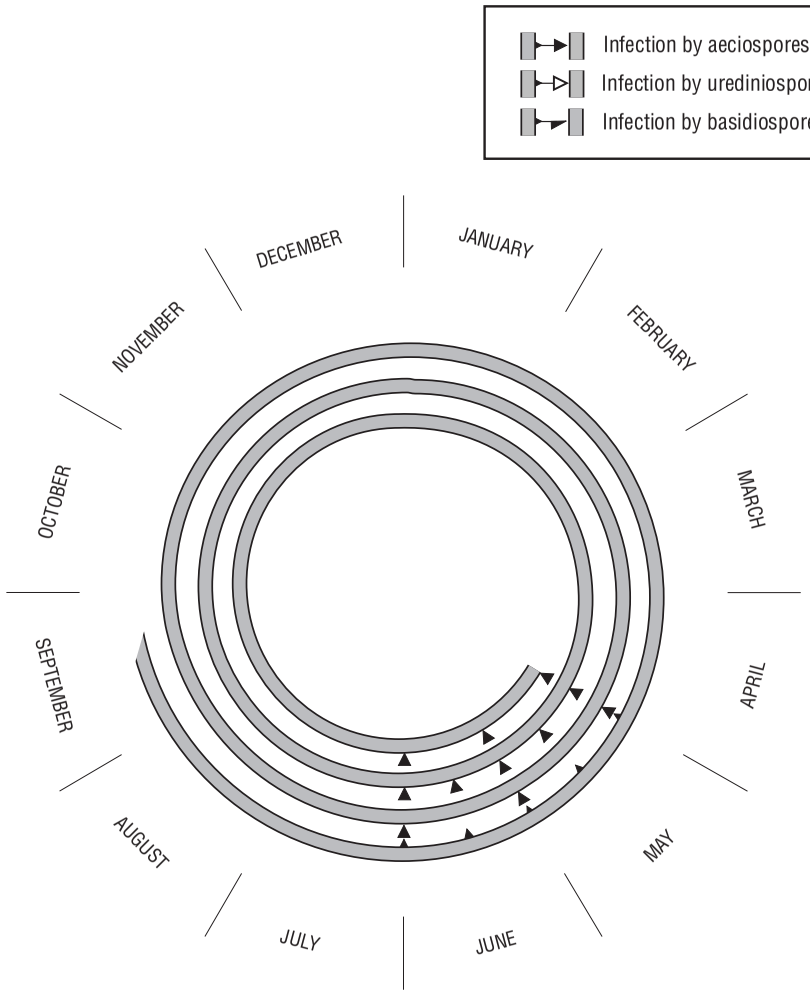


Fig. 1. Life cycle of western gall rust.

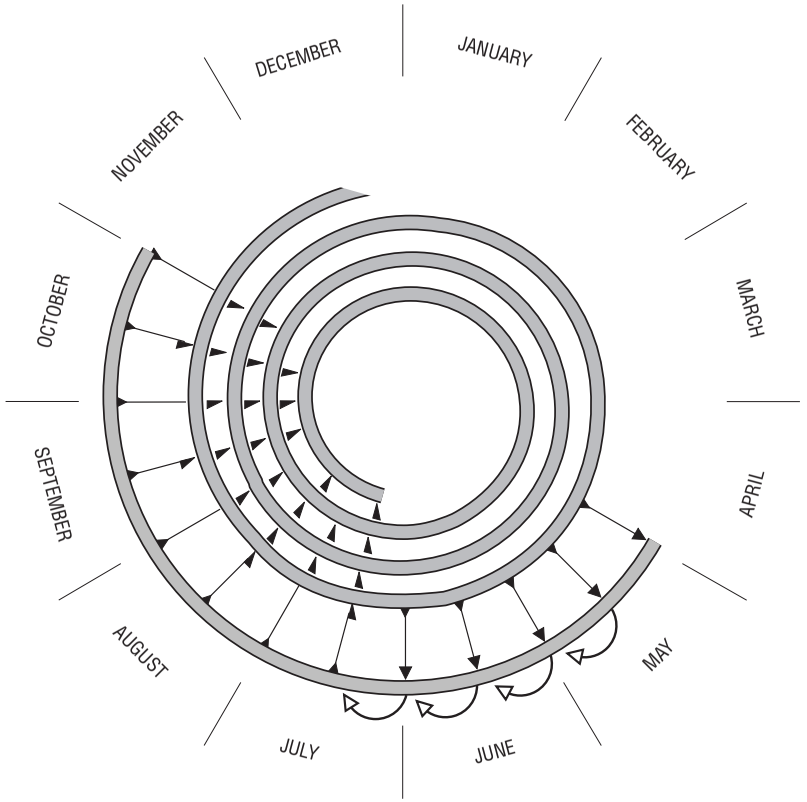


Fig. 2. Life cycle of comandra, sweet-fern and stalactiform blister rusts.

Knowledge of the life history and complete host range of a tree rust is most essential, especially for development of practical silvicultural or biological control methods.

Rusts are parasites typically requiring two botanically unrelated host plants in their life cycles. There are many types of life cycles in the tree rusts, but they may all be considered as variations of one basic cycle from which the others have evolved. Briefly, this basic cycle includes: the development of *pycnial* and *aecial* states on primary hosts, and the development of *uredinial, telial* and *basidial* states on secondary hosts; host-alternation from primary to secondary hosts by infection with *aeciospores*, and back from secondary to primary hosts by infection with *basidiospores*; and spread and intensification of the rust on secondary hosts by *urediniospores*.

Following are descriptions and diagrams of the two types of the life cycles occurring in Canadian stem rusts of pine: one of western gall rust (*Endocronartium*) which requires no secondary hosts, and the other of the blister rusts (*Cronartium* spp.) which require secondary hosts. The diagrams (Figs. 1 and 2) show the kind of host infected (primary or secondary host), type of spores causing the infection (aeciospores, urediniospores, or basidiospores), and time of initiation and duration of parasitism. Perennial parasitism is shown by an open spiral to indicate the indefinite duration of the disease in pine.

Western gall rust (Figs. 1, 3 and 4)

Western gall rust is the most common, most conspicuous and most destructive stem rust of hard pines in western Canada. Its life cycle is also the simplest known in western Canadian tree rusts: it is completed on pine alone, without any secondary hosts.

In spring and early summer, an orange powder consisting of millions of spores is released from galls of the diseased pines. These spore masses,

Fig. 3. Hundreds of rust galls caused by western gall rust have girdled and killed most branches of a mature lodgepole pine.

Fig. 4. Multiple infection of lodgepole pine by western gall rust; note the oblong or pear-shaped form of the galls.

Fig. 5. Stem of six-year-old Monterey pine almost girdled by sweet-fern blister rust. The spore blisters have ruptured and most of the aeciospores are shed.

resembling little clouds of dust, are dispersed by wind currents. After landing on other susceptible (hard) pines, especially after periods of rain, some of the spores will germinate and cause new infections. Depending partly on wind velocity and direction during spore dissemination, the disease may spread over long distances, sometimes hundreds of kilometres. The succulent elongating branch or cone tissue is the entry point for the fungus. Approximately 2 years after infection, the first symptoms begin to appear: irregularly round to pear-shaped galls. On these galls white blisters break through the bark each spring, releasing their orange spores after they burst. The life cycle of western gall rust is thus completed.

The galls of western gall rust are woody and perennial, growing larger each year and producing new crops of spore blisters until they have been attacked and killed by secondary insects and fungi. At that time the fungus dies and spore production ceases.

Comandra, sweet-fern and stalactiform blister rusts

(Figs. 2 and 5-10)

These stem rusts differ distinctly from each other in their requirements for specific secondary hosts, but only slightly in microscopic characteristics and symptoms. Their life cycles are essentially alike and will therefore be outlined together.

In spring and early summer, white blisters break through the bark of stem cankers or swollen branches of pine and release orange aeciospores. Often, wind disperses them, frequently over large areas. *The aeciospores cannot infect other primary hosts (pines), but only secondary hosts.* Specifically, aeciospores of comandra blister rust can infect only comandra, aeciospores of sweet-fern blister rust only sweet gale, and aeciospores of stalactiform blister rust only Indian paintbrush and a few other herbs of the figwort family (see “Hosts”). On the leaves of its secondary hosts, each rust causes irregular orange to brownish yellow spots. The urediniospores, teliospores, and basidiospores develop on the underside of the leaves within these spots. The urediniospores are formed during the summer approximately 2 weeks after infection. They serve to intensify the rust on its secondary hosts; they cannot infect primary hosts (pines). “Telial horns” (Fig. 10), consisting of columns of teliospores, develop on the leaves during mid-summer and fall. The teliospores germinate and produce basidiospores which may infect pines after being disseminated. *The basidiospores cannot infect other secondary hosts, but only primary hosts (pines).*

Basidiospores represent the weakest link in the life cycle. They are small, delicate, and unable to survive even a few hours of drought or high

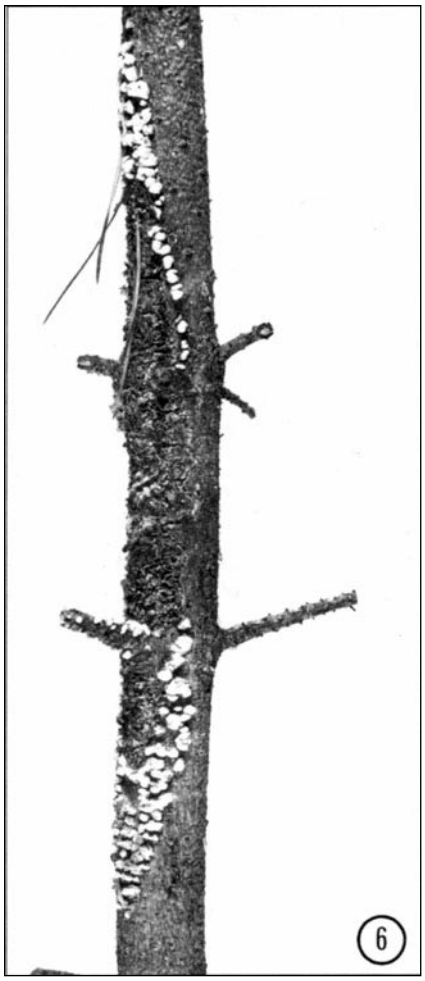


Fig. 6. Typical elongate canker of stalactiform blister rust with white spore blisters containing the orange spore masses.

temperature. Unless they land on susceptible pine shortly after they are disseminated and climatic conditions are suitable, they perish.

Only basidiospores can initiate the disease in pine. The point of initial infection on pines may vary with the rust species. The first disease symptoms (discoloration of the foliage followed by progressive swelling of the bark) appear approximately 3 years after infection. The pycnial stage probably forms during this time. It is a spermatial stage responsible for fertilization of cankers via insects, in order that aecial spores can be produced. It is rarely seen. In spring of the following year, white blisters appear and aeciospores are again liberated, marking the beginning of a new life cycle.

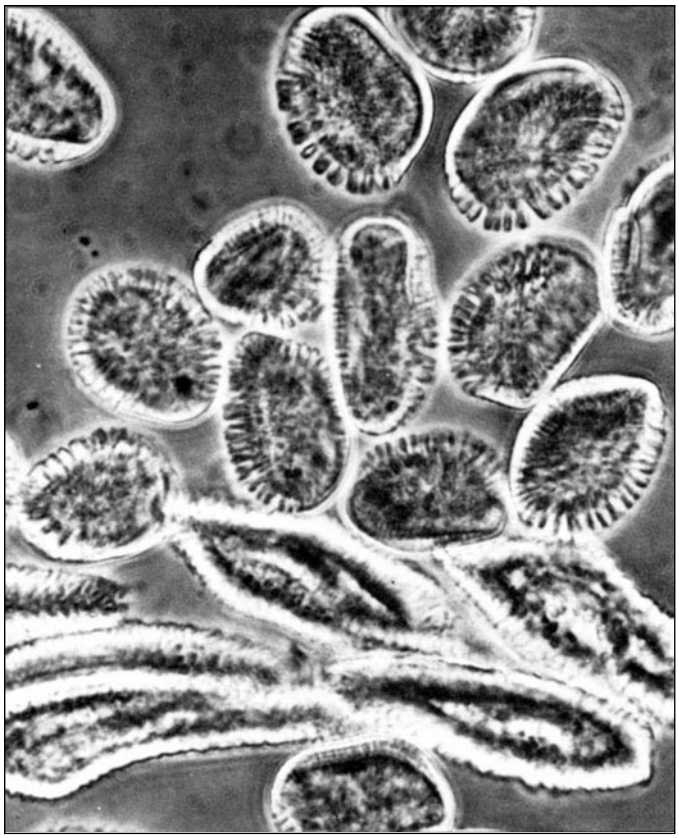


Fig. 7. Ellipsoid or egg-shaped aeciospores (right) and fusiform filament cells (left) of *Cronartium coleosporioides* (x 520).

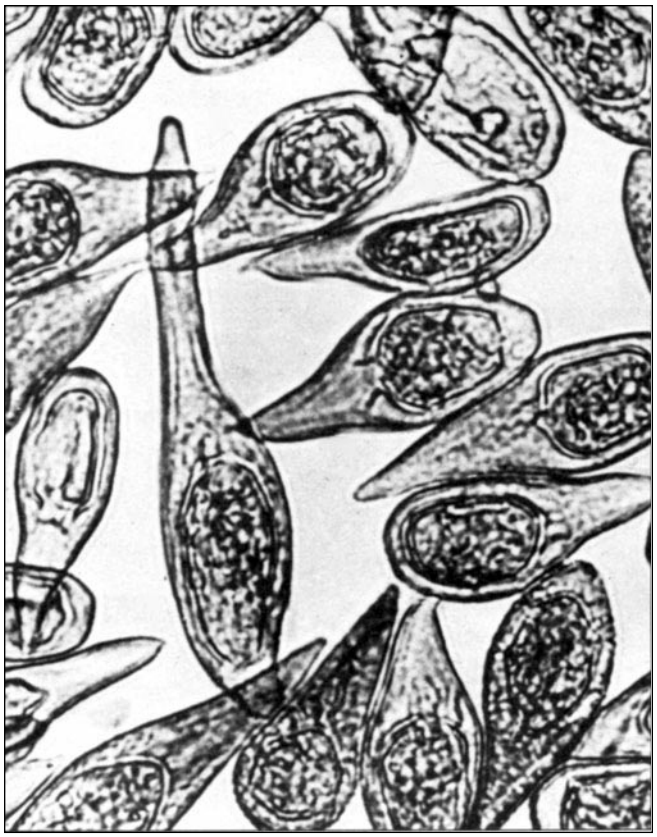


Fig. 8. Pear-shaped aeciospores of *Cronartium comandrae*. The aeciospores of other pine stem rusts (Fig. 7) are ellipsoid or egg-shaped (x 520).

As in western gall rust, the disease is perennial in pine. Annually, aeciospores are produced on pine until the affected stems or branches are dead from attack by secondary organisms. At that stage the fungus dies out, too, and no further crops of aeciospores are produced. Unlike western gall rust, the three blister rusts are entirely dependent on their secondary hosts for survival: pine infection can result only from basidiospores produced on nearby secondary hosts.

Recognition

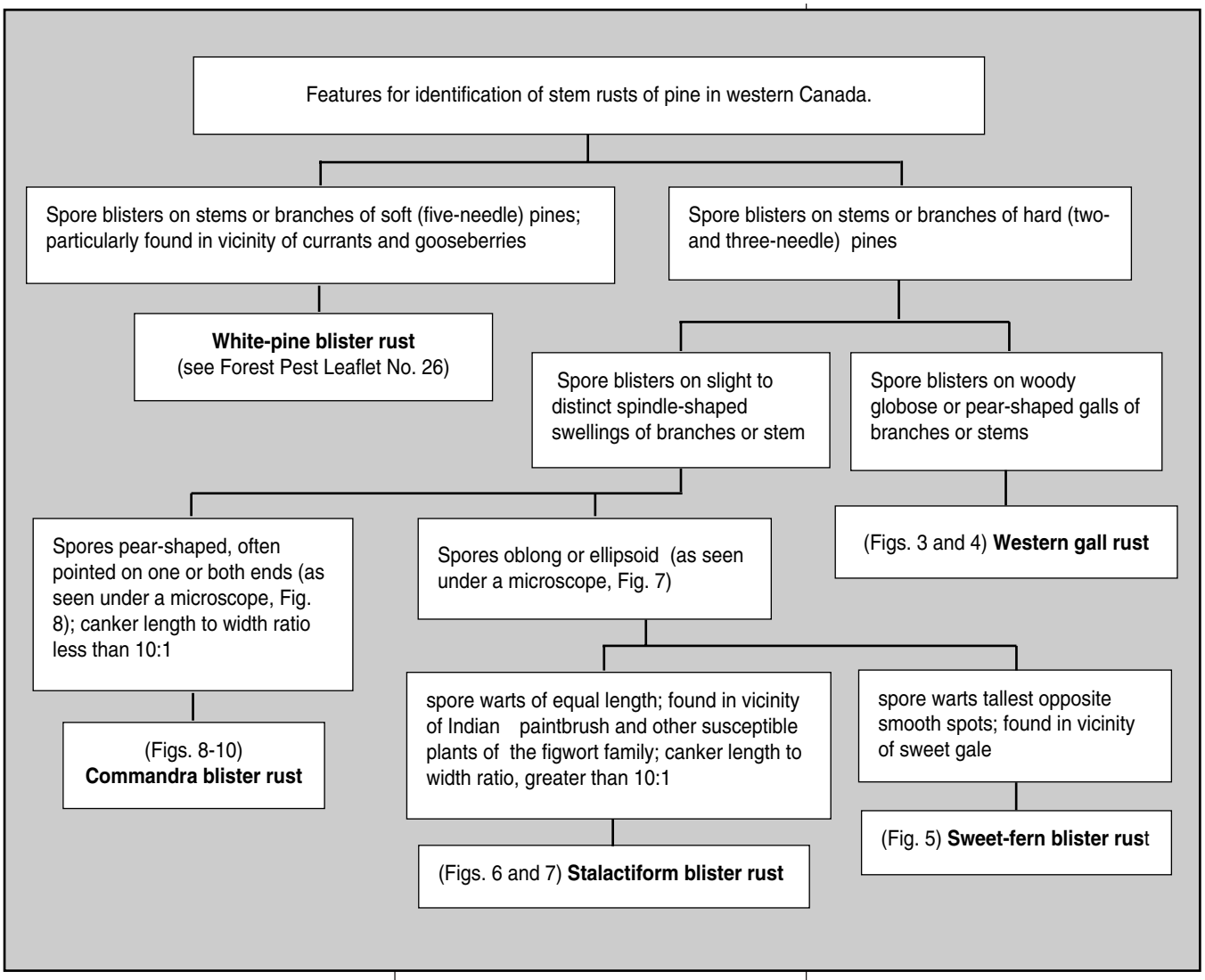
Flagging - the reddening of all needles of recently killed branches - is the most conspicuous indication of stem rust in a pine stand. But flagging may also be caused by other branch diseases. Other symptoms indicating stem rust are cankers (Figs. 5, 6 and 9) or roughened bark at the swollen base of dead or dying branches, trunk cankers with copious resin flow reaching lengths of 6 metres or more, or woody branch galls (Figs. 3 and 4) or gall-like excrescences (hip cankers) on stems. Rodents, attracted by the sugars in the thickened succulent bark of infected areas, feed on the diseased bark at the margins of rust cankers, generally causing severe resin flow. Frequently, such damage to pine has been ascribed to rodents alone, and rust has not been recognized as the primary cause. Except for western gall rust, symptoms alone are insufficient for identification of pine stem rusts.

The only reliable characteristic for identification of stem rust is spore blisters on the diseased stems and branches (Figs. 4, 5 and 6). These blisters contain the aeciospores, intergrown with threads (filaments) projecting from the inner walls of the blisters (Fig. 7). Since the blisters disintegrate and disappear by late summer, surveys of pine for the presence of stem rust should be carried out in late spring and early summer.

Rusted secondary hosts also are indicative of the presence of pine stem rust in an area. For instance, if Indian paintbrush (*Castilleja* spp.) were found rusted with *Cronartium*, one would expect at least some of the pines in the vicinity to be diseased with stalactiform blister rust. Pine stem rust (*Cronartium* spp.) on secondary hosts can be easily identified in the late summer or fall by the crowded groups of minute, yellow-brown hairs (telial horns) on the underside of diseased foliage (Fig. 10). Secondary hosts can thus be very useful for detection and identification of stem rusts in the field.

A key for preliminary identification of western Canadian stem rusts of pine is shown on the following page.

Stalactiform and sweet-fern rusts are very much alike, but they can be



identified reliably by determining their secondary hosts with inoculation experiments, or by careful observation of the warts on the aeciospores.

DAMAGE

Mortality and growth losses are the principal forms of damage resulting from pine stem rust infections, although none of the native blister rusts will completely prevent development of a merchantable stand. Intensity of damage in pine stands varies greatly, depending on susceptibility of the pine species and even of individual trees within a species, climate and (except in western gall rust) the proximity and abundance of secondary hosts. In seedlings and saplings, stem infections will girdle the tree relatively quickly (Figs. 5, 6 and 9), but in larger trees progress of the disease and subsequent death of the tree is slower. Branch infections near the stem must grow into the stem before girdling the tree and therefore damage is slower than direct stem infections. Damage by sweet-fern blister rust is more or less restricted to young trees; it is seldom serious in natural stands but has been very damaging to Monterey (Fig. 5) and bishop pine plantations in British Columbia. With the other stem rusts, trees of all sizes and ages are attacked but seedlings and saplings are especially susceptible. Trees that survive western gall rust in the seedling stage may continue to develop branch galls until a large proportion of the branches are killed (Figs. 3 and 4). The rust also affects the growth rates of pines, as well as lumber quality and quantity.

Pines are valuable timber trees in British Columbia. For instance, lodgepole pine, occurring from sea level to subalpine elevations and likely to be found on almost any forest site in western Canada, is used for railroad ties, mine timbers, poles, posts, fuel wood, rough construction, and planing-mill products such as siding, finish and flooring. It is also a valuable species in the manufacture of pulp.

CONTROL

Treatment of infected pines with systemic fungicides has been attempted, but without success.

Fig. 9. Typical spindle-shaped comandra rust canker on the main stem of a ponderosa pine seedling. The crackling and pitting of the bark on swollen areas is caused by aecia rupturing the bark. Seedlings with infections on main stems survive only a few years. (U.S. Forest Service photo by R.G. Krebill.)

Fig. 10. Comandra shoot covered with abundant telial horns of *Cronartium comandrae*. (U.S. Forest Service photo.)

Protective fungicides can work in nurseries, but these are unnecessary if alternate hosts or nearby gall rust infected pines are removed. Eradication of the secondary hosts is usually only economically feasible for nursery situations.

In young growth stands removal of infected trees and pruning of branches during spacing are the only practical means of control at present. In mature forests damage can be minimized by cutting in heavily rusted stands first, thus preventing some of the continuing spread and mortality from old cankers.

In nurseries, it is important that infected stock be destroyed and not shipped to prevent establishment of new infection centers. This is especially important where infection is caused by western gall rust, which lacks a secondary host. Nurseries of pine should not be established in areas where stem rusts or their secondary hosts are abundant. Pine plantations which have failed due to stem rust attack should be replanted with tree species other than pine.

There is variation in susceptibility to stem rusts among provenances and within families; therefore, a resistance selection or breeding program for disease resistance is feasible.

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