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FOREST Pest LEAFLET

Pacific Forestry Centre

Needle and Broom Rusts of True Firs

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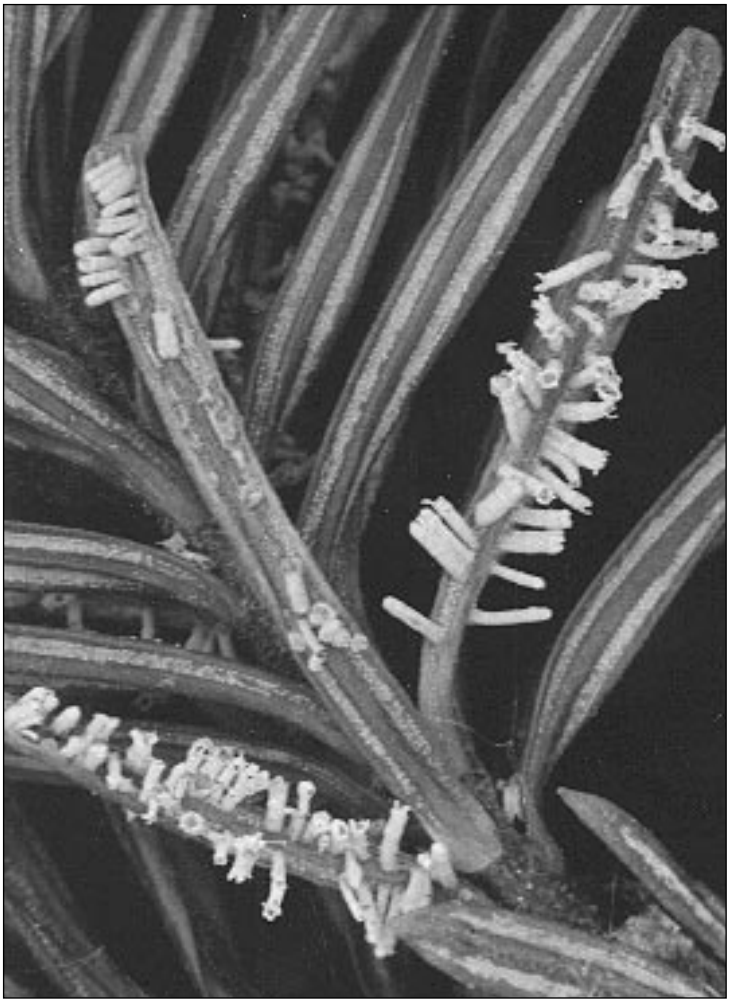
Introduction

Tree rust diseases affect many native and exotic plants growing in British Columbia (B.C.). They may affect foliage, branches and trunks of forest trees. Perhaps the best known rust disease in the province is the white pine blister rust caused by the fungus *Cronartium ribicola* (Leaflet No. 26). This disease killed millions of trees here during the first part of this century. Other rust diseases also continue to affect reforestation and management planning in B.C., especially for pines.

There are several known needle and broom rusts of true firs in the British Columbia - Yukon Region. These rust fungi, belonging to the family Melampsoraceae of the order Uredinales, include (in order of relative importance):

1. Fir-Broom Rust - *Melampsorella caryophyllacearum*



Mature spore tubes (aecia) of the fir-fireweed rust (*Pucciniastrum epilobii*) on the current year's foliage of alpine fir.

2. Fir-Fireweed Rust - *Pucciniastrum epilobii*
3. Fir-Bracken Rust - *Uredinopsis pteridis*
4. Hashioka's Fir-Bracken Rust - *Uredinopsis hashiokai*
5. Fir-Willow Rust - *Melampsora abieticapraearum*
6. Fir-Lady Fern Rust - *Uredinopsis longimucronata*
7. Fir-Blueberry Rust - *Pucciniastrum goeppertianum*
8. Fir-Oak Fern Rust - *Uredinopsis phegopteridis*
9. Fir-Ostrich Fern Rust - *Uredinopsis struthiopteridis*
10. Fir-Polypody Rust - *Milesina laeviuscula*
11. Fir-Oak-Fern Rust - *Hyalopsora aspidiotus*
12. Fir-Willow-Herb Rust - *Pucciniastrum pustulatum*
13. Conifer-Aspen Rust - *Melampsora medusae*
14. Fir-Cottonwood Rust - *Melampsora occidentalis*

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Hosts and distribution of important needle and broom rusts of true firs[1]

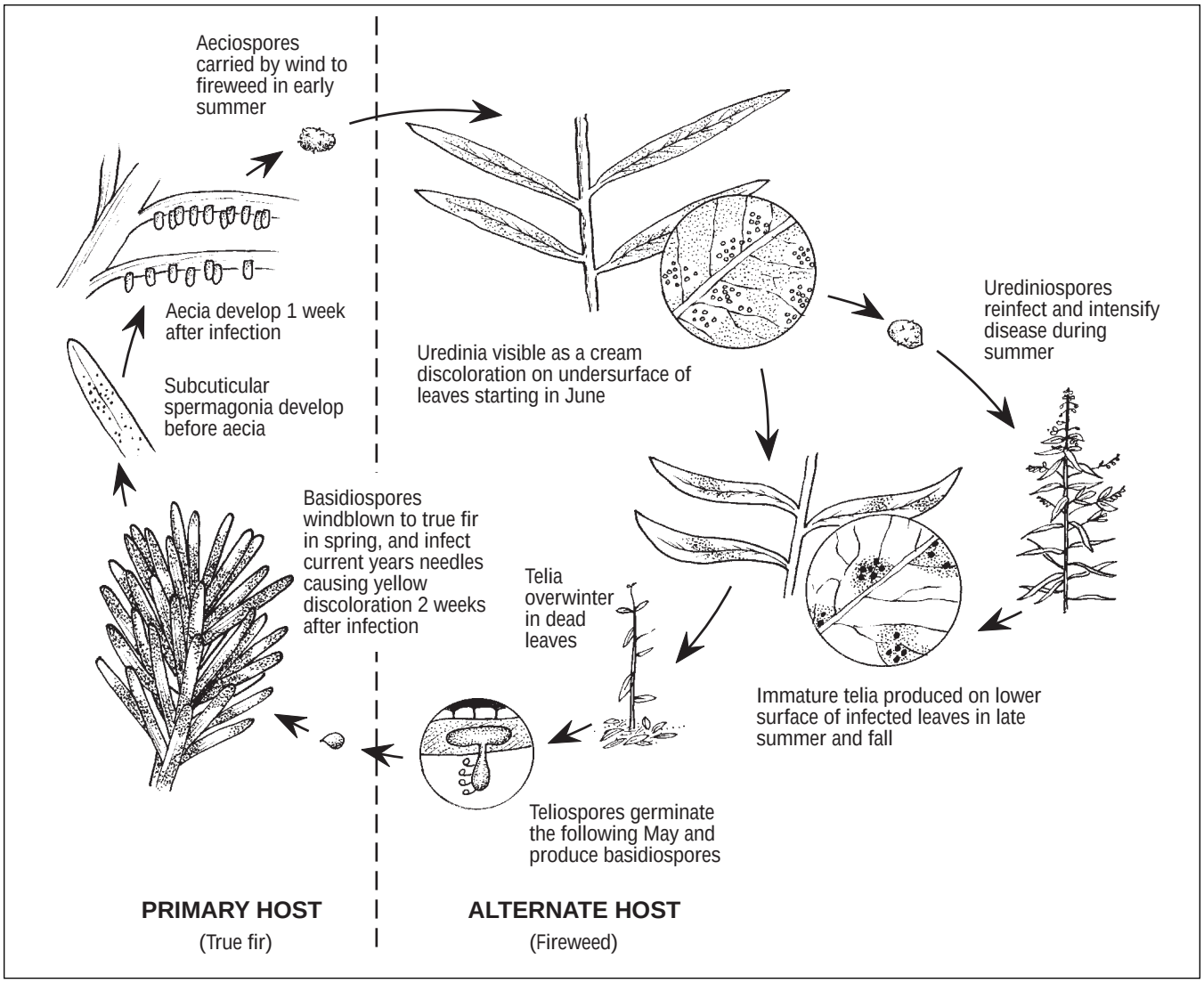
Name	Primary hosts	Secondary hosts	Distribution
1. Fir-broom rust	alpine fir	Chickweed (*Cerastium* spp., *Stellaria* spp.)	Range of true firs in North America, Asia, Europe
2. Fir-fireweed rust	alpine fir	Willow-herb (*Epilobium* spp.) especially fireweed, (*E. angustifolium*)	Northern hemisphere, In B.C., more common in the interior
3. Fir-bracken rust	grand fir alpine fir	Bracken fern (*Pteridium aquilinum*)	Northern hemisphere, South America, Africa; In B.C., more common on coast
4. Hashioka's fir-bracken rust	grand fir	Bracken fern	In North America known only in coastal B.C., Oregon, California; also known in Hawaii and Taiwan
5. Fir-willow rust	alpine fir	Willows (*Salix* spp.)	Common in North America; South America, Europe; In B.C. more common in the interior
6. Fir-lady fern rust	alpine fir, amabilis fir, grand fir	Lady fern (*Athyrium filix-femina*)	Widespread in North America
7. Fir-blueberry rust	alpine fir amabilis fir (on B.C. coast)	Blueberry, huckleberry, cranberry (*Vaccinium* spp.)	Widespread in North America, Europe, Japan.

[1]Listed in order of importance for British Columbia.

However, only the first seven rust fungi on this list cause appreciable damage.

Generally, these rusts are widely distributed throughout the northern hemisphere. Their incidence and importance vary from area to area and from year to year. While all native true firs are susceptible, some host species are infected more often than others. Because of their widespread distribution and their capacity for infecting true firs, foliage rusts have the potential to cause a lot of damage; fortunately, due to their complex life cycle, this threat is seldom realized.

This leaflet deals with the seven most important needle and broom rusts affecting true firs in British Columbia and the Yukon Territory. Additional information about broom rusts is contained in Forest Pest Leaflet No. 48. Information about other rust diseases can be found in the references given at the end of this leaflet.



An example of a life cycle: The fir-fireweed rust.

Hosts and distribution

Fir rust fungi alternate between primary hosts (fir trees) and secondary hosts (non-coniferous plants) in their complicated life cycle. These rusts occur on all native true firs: alpine fir (*Abies lasiocarpa*), amabilis fir (*A. amabilis*) and grand fir (*A. grandis*).

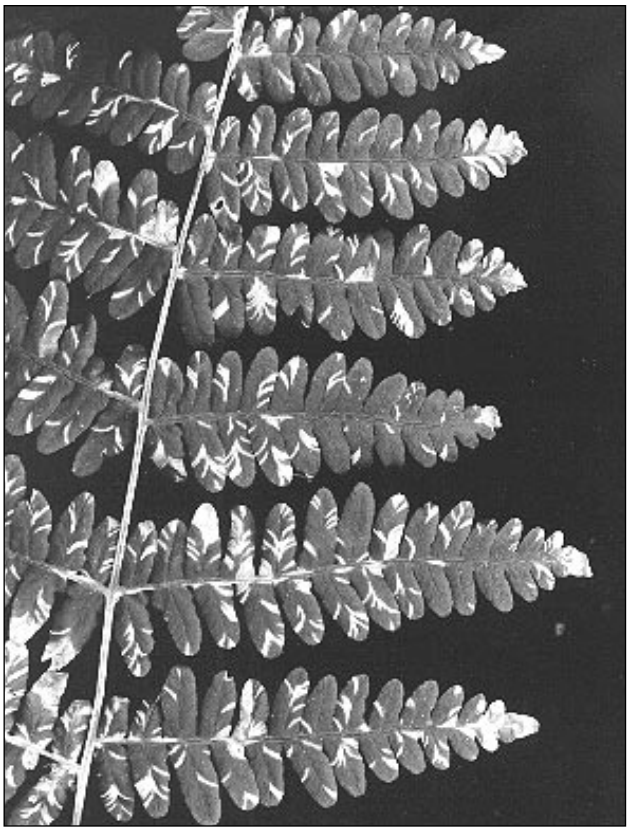
Life histories

The rusts are unique among the parasitic fungi in that most require two unrelated host plants on which to complete their complex life cycle. Normally, rusts pass through five reproductive states during the course of the cycle. The first two - *pycnial* and *aecial* - occur on the primary host. The others - *uredinial*, *telial*, *basidial* - occur on the secondary (alternate) host. Each state produces a specific type of spore (microscopic reproductive structure which functions like a seed).

Needle rusts are most commonly seen on young trees and on the younger branches of older trees. Once known, most signs and symptoms of these diseases on the secondary host plants are readily discernable. Knowledge of the life cycles of the seven most common rusts will be useful in identification. However, annual weather fluctuations and geographical location (e.g. elevation) will influence timing and intensity of the visible features of these rusts.

Fir-broom rust (*Melampsorella caryophyllacearum*). In spring, airborne basidiospores originating from leaves of chickweed may land on young needles of true firs where they germinate and start an infection. The infection becomes systemic in the young shoots. During early summer of the following year the infected shoots give rise to a proliferation of short shoots (known as brooms) bearing stunted, yellowish green needles. Pycnia and aecia (the latter in conspicuous yellow pustules) develop on these stunted needles which are shed in the fall. The airborne aeciospores may then be carried back to the leaves of nearby chickweed plants where they germinate and cause

Uredinial state of the fir-fireweed rust (*Pucciniastrum epilobii*) on fireweed showing (a) uredinia on the lower surface of a leaf and (b) discoloration on the upper surface of leaf.



Discoloration on the upper surface of bracken fern frond caused by the uredinial state of the common fir-bracken rust (*Uredinopsis pteridis*).

infection. During the spring of the following year, leaf and shoot blight develop from the infected chickweed foliage. Later, urediniospores are produced (as yellow spots scattered over the leaves on the chickweed), intensifying the rust disease. Finally, telia, and then basidiospores are produced; the true fir primary hosts may then be re-infected. The infection becomes systemic and perennial in the brooms.

Fir-fireweed rust (*Pucciniastrum epilobii*). During May and early June, the windblown basidiospores infect the new alpine fir foliage. These spores germinate and their germ tubes penetrate the needles where the mycelium develops. The pycnial state (microscopic), during which pycniospores are produced, develops on the underside of needles soon thereafter. The aecial state, with its conspicuous cylindrical spore tubes (aecia), is visible from the end of May until August when the infected needles die and fall from the branches. The orange aeciospores are disseminated by wind in early summer. They can not re-infect fir, only leaves of fireweed and other species of *Epilobium*. The uredinial state occurs on the lower surface of the fireweed leaves, showing up as yellow to brown discoloration. Urediniospores, which are produced from the middle of June until the end of summer, may intensify the occurrence of the disease on adjacent host plants. During late summer and early fall, the telial state is produced on the lower surface of the infected leaves. The rust then overwinters as immature telia in the fireweed leaves, which are now dead. The following May these telia germinate and produce basidiospores which are blown by wind to the primary host and the cycle starts over again.

The uredinial state of this rust sometimes becomes perennial in fireweed. In this case, the mycelium grows down the stem during summer to the roots where the rust overwinters. Thereafter, each spring the new shoots and leaves appear already infected with uredinia; consequently, this rust can continue to live on fireweed in the absence of the primary fir host.

Fir-bracken rust (*Uredinopsis pteridis*) and **Hashioka's fir-bracken rust** (*U. hashiokai*). Windblown basidiospores infect new foliage of true firs during May and June. The pycnial state, appearing as tiny droplets on infected needles, occurs about one month after initial infection. The aecial state does not normally become visible until the following spring. However, occasionally the aecia mature late the same fall and aeciospores are then produced. The aecia appear as white tubes hanging

from the undersides of infected needles. Aecia can be perennial and can sporulate up to four years in the same needle. The white aeciospores, produced between May and September, pass on wind currents to infect young bracken fern fronds. The uredinia, which develop about three weeks after the fronds have been infected, produce urediniospores which intensify and spread the disease on bracken ferns. These spores do not infect the primary host. During late summer and fall, telia develop from the same mycelia that gave rise to the uredinia, as pale spots between veins on blighted fronds. Teliospores in the telia overwinter in dead fronds and germinate the following spring, producing basidiospores. Basidiospores, which cannot reinfect bracken fern, are again windblown to firs where the life cycle starts over again.

Hashioka's fir-bracken rust occurs only on Vancouver Island. Physical differences between these two rusts are microscopic; these two diseases are distinguishable from each other only by inoculation and examination of urediniospores. Their life cycles are similar.

Fir-Lady fern rust (*Uredinopsis longimucronata*). This rust differs from the previous two rusts in three important ways:

1. It has a one-year life cycle;
2. It is annual on the needles of its primary host;
3. It is able to "short-cycle," that is, both urediniospores and teliospores can overwinter on dead fern fronds. Both can germinate in the spring; the teliospores produce basidiospores which infect firs, and the urediniospores infect new fern fronds.

Thus, the fir-lady fern rust can persist on its secondary host indefinitely in the absence of the primary host.

Fir-willow rust (*Melampsora abieti-capraearum*). Basidiospores from telial hosts (*Populus* or *Salix* spp.) infect aecial hosts in the spring, and aecia (preceded by pycnia) appear on fir needles approximately two weeks after infection. The aeciospores infect the telial hosts in summer, and uredinia appear on them approximately two weeks after infection. The urediniospores serve to spread and intensify the rust on *Populus* and *Salix* spp. by infecting new leaves, thus producing more uredinia throughout the summer. Heavy rust infections can cause orange discoloration and premature defoliation toward fall, uredinial production ceases, and telia develop instead. The telia overwinter in a state of dormancy in the dead leaves on the ground and germinate the following spring, at the time when the new shoots of the aecial hosts begin to emerge forth from their buds. The release of basidiospores from these germinating teliospores marks the end of the one-year life cycle of host-alternating Melampsora rusts in western Canada.

Witches' broom on evergreen huckleberry caused by the fir-blueberry rust (*Pucciniastrum goeppertianum*).

Host-alteration does not necessarily occur each year in the fir-willow rusts. Rust mycelium may overwinter on the uredinial host, chielfly in bud tissue.

Fir-blueberry rust (*Pucciniastrum goeppertianum*). The distinguishing features of this rust are the following:

1. Immature aecia may be visible on the current year's foliage of fir hosts during late summer. However, these aecia do not mature until the following spring or summer.
2. There is no uredinial state. As a result, this rust cannot intensify on the alternate host.

Summary of some characteristics of the seven most important needle and broom rusts of true firs in B.C. and Yukon

Disease	Shape of aecia	Color of aeciospores	Age of needles when aecia visible	Notes
1. Fir-broom rust	tubes	yellow-orange	new	Forms witches' brooms; broom foliage stunted, pale yellow.
2. Fir-fireweed rust	tubes	orange	new	Aecia visible May-August.
3. Fir-bracken rust	tubes	white	2+ yr. old[1]	Aecia visible Aug.-Feb.
4. Hashioka's fir-bracken rust	tubes	white	2+ yr. old[1]	Aecia visible Aug.-Feb.; found only in coastal B.C.
5. Fir-willow rust	pustules	orange	new	Aecia visible May-August.
6. Fir-lady fern rust	tubes	white	new	Aecia visible June-August.
7. Fir-blueberry rust	tubes	orange	1 yr. old	Aecia visible late summer-autumn

[1]Up to 4 years old according to Ziller (1974).

3. The telial state is perennial in the alternate host, causing witches' brooms with reduced leaves and abnormal reddish, thickened bark.

Recognition

Identification of rusts on true firs is very difficult. Some species cannot be identified except when found on their alternate host. Consultation with a specialist is recommended.

Thin foliage on the lower branches of fir trees may indicate past infections. However, this symptom is not reliable because the cause could be another disease agent or insect attack. Also, in the case of fir-broom rust, the brooms resulting from infection may be confused with those caused by other organisms.

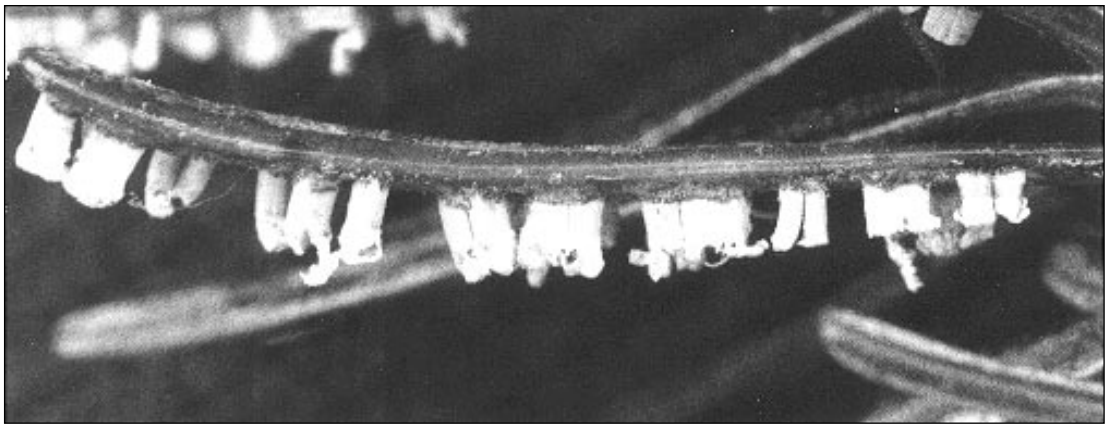
Damage

True fir rusts may cause growth deformation (brooms), or defoliation (premature needle drop), or both. As a result, wood volume and quality may be reduced, and trees are occasionally top-killed. However, the economic impact of these diseases has been insignificant, even though severe outbreaks of several of these diseases have occurred. The major threat is probably in forest nurseries, where there are high densities of susceptible host trees and where there tends to be high humidity, which favors the development of needle and broom rusts.

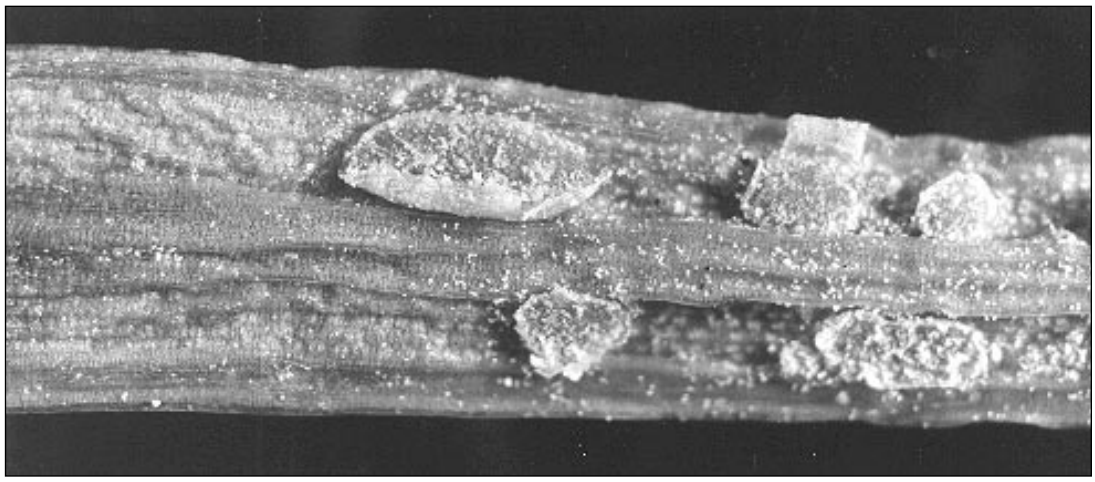
Control

Due to their complicated life cycles, an unusual sequence of weather conditions is required for these rusts to spread and intensify; dry windy weather is needed for dissemination of the spores, and then warm humid weather is needed for their germination. In addition, this sequence of conditions must occur at a specific point in the life cycles of these rust diseases. This seldom happens in the B.C. and Yukon region, so weather is an important control factor. Another important control factor is the requirement for both the primary and the secondary host; if either host is absent or rare, it is difficult or impossible for these diseases to spread and intensify.

Because needle and broom rusts are generally controlled by natural factors, they rarely cause economic losses in British Columbia or the Yukon; consequently, direct chemical or silvicultural control treatments are rarely, if ever, considered.



Mature spore tubes (aecia) of the fir-fireweed rust (*Pucciniastrum epilobii*) on the current year's foliage of alpine fir.



Overmature flat pustule-shaped aecia of the fir-willow rust (*Melampsora abieti-capraearum*) on the underside of an alpine fir needle.

Selected references

Baranyay, J.A.; Ziller, W.G. 1972. Broom rusts of conifers in British Columbia. Dep. Environ., Can. For. Serv. Pac. For. Res. Cent. For. Pest Leafl. 48, 6 p.

British Columbia Ministry of Forests and Lands. 1988. Protection manual. Vol. II. Pest Management. Chap. 7. Stem and Foliage Diseases, 41 p.

Cummins, G.B.; Hiratsuka, Y. 1983 (Rev.). Illustrated genera of rust fungi. Amer. Phytopath. Soc. (ISBN 0-89054-058-6), 152 p.

Finck, K.E.; Humphreys, P.; Hawkins, G.V. 1989. Field guide to pests of managed forests in British Columbia. For. Can., B.C. Min. For. Joint Publ. No. 16 (ISBN 0843-4719), 188 p.

Hunt, R.S. 1983. White pine blister rust in British Columbia. Environ. Can., Can. For. Serv. Pac. For. Res. Cent., For. Pest Leafl. 26, 7 p.

Lowe, D.P. 1989 (Rev.). Check list and host index of bacteria, fungi, and mistletoes of British Columbia. Can. Dep. Fish. and For., Can. For. Serv. Pac. For. Cent. Inf. Rep. BC-X-32.

Sinclair, W.A.; Lyon, H.H.; Johnson, W.T. 1987. Diseases of trees and shrubs. Cornell Univ. Press, Ithaca, N.Y., 574 p.

Wood, C. 1986. Distribution maps of common tree diseases in British Columbia. Can. For. Serv. Pac. For. Cent. Inf. Rep. BC-X-281, 68 p.

Ziller, W.G. 1974. The tree rusts of western Canada. Dept. Environ., Can. For. Serv. Publ. No. 1329, 272 p.

Additional Information

Additional copies of this and other leaflets in this Forest Pest Leaflets series, as well as additional scientific details and information about identification services, are available by writing to:

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