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INLAND SPRUCE CONE RUST ON ENGELMANN SPRUCE IN THE NORTHERN REGION

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Several abnormal Engelmann spruce (*Picea engelmanni* Parry) cones were collected during the early fall of 1991 within portions of the Clearwater and Kootenai National Forests, located in northern Idaho and western Montana, respectively. Scales from abnormal cones were covered with orange-colored deposits (figure 1). These cones were dryer, light brown in color, with their scales opening sooner than non-affected cones. Normal cones were moist, light green in color, and without open scales. When affected cone scales were examined closely, extensive deposits of orange material were common on the inner surface as well, often associated with abnormally high resin production (figure 2). These orange deposits were determined to be aeciospore masses of a rust fungus when examined under the microscope (figure 3). Their morphology and appearance on spruce cones indicated that the spores were from the inland spruce cone rust (*Chrysomyxa pirolata* Wint.)(Ziller 1974).

Scales from severely-infected cones were open with little seed present. Most seed and attached wings were covered with aeciospore deposits (figure 4). Another characteristic of severely-infected cones was the abundance of rust-covered maggots that were dislodged when cones were shaken (figure 5). The maggots had caused extensive damage to the interior of cones, including mining of seed. Several different insects with maggot-type larvae are known to infest Engelmann spruce cones, including *Hylemya anthracina* (Czerny) (Anthomyiidae: Diptera), *Dasineura rachiphaga* Tripp or *D. canadensis* Felt (Cecidomyiidae; Diptera), and *Asynapta hopkinsi* Felt (Cecidomyiidae: Diptera)(Furniss and Carolin 1977; Hedlin and others 1980). Maggots were not reared to adults for identification. Rusted cones have previously been shown to be particularly attractive to cone insects; insects have also been implicated in spreading the disease by moving from rusted to healthy cones(Matthews and Maloy 1960).

Chrysomyxa pirolata produces pycnial and aecial spore stages on spruce cone scales; uredial and telial stages develop on the underside of leaves of alternate hosts (wintergreen: *Pyrola* spp. and single-delight: *Moneses uniflora* (L.) A. Gray)(Sutherland and others 1987). The fungus develops a perennial, systemic infection within alternate hosts. Production of urediniospores which repeatedly infect these hosts assure survival and spread of the rust independent of the spruce host. Basidiospores (from telia) produced on alternate hosts infect spruce cones in the early summer (June), about the time of pollination. Pycnia then develop on infected cones in early to mid-summer. Aecia

Figure 1. *Chrysomyxa pirolata* aeciospores on the external surface of Engelmann spruce cones from the Clearwater National Forest, Idaho.

Figure 2. Deposits of aeciospores and mycelium of *Chrysomyxa pirolata* on the inner surface of an Engelmann spruce cone scale from the Clearwater National Forest, Idaho. Note resin deposit near the margin of the scale.

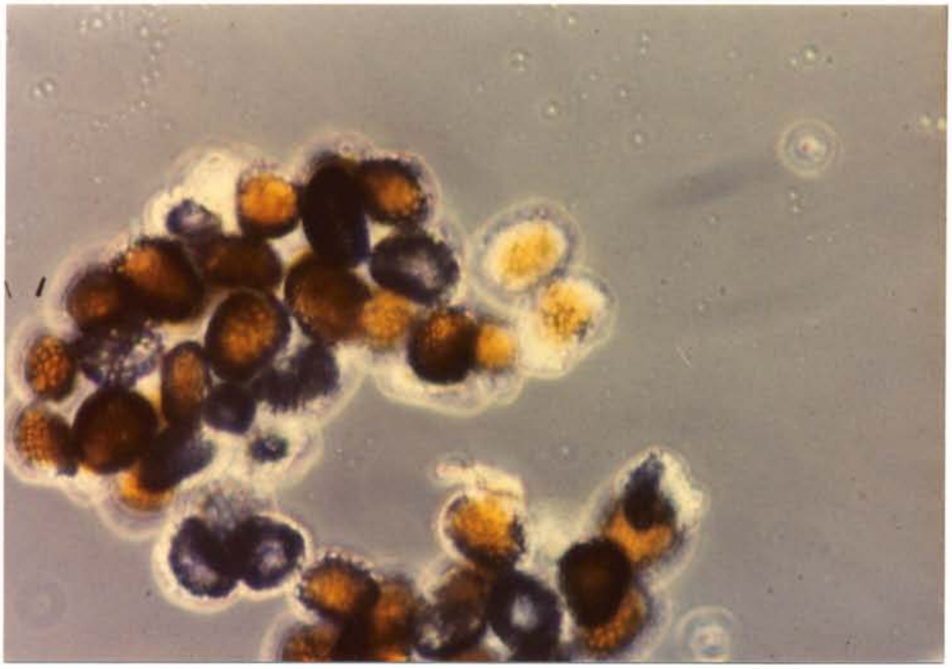

Figure 3. Aeciospores of *Chrysomyxa pirolata* (X400).

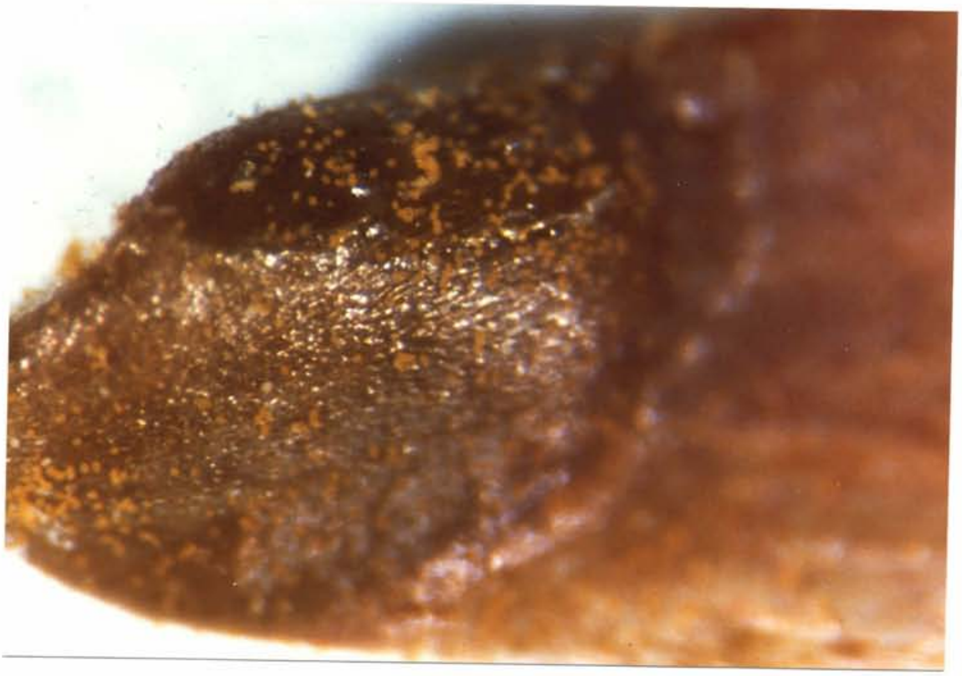

Figure 4. Aeciospores of *Chrysomyxa pirolata* on Engelmann spruce seed from the Clearwater National Forest, Idaho.

Figure 5. Insect maggot covered with aeciospores of *Chrysomyxa pirolata* infesting Engelmann spruce cones from the Clearwater National Forest, Idaho.

and aeciospores will form from midsummer through early fall (July-September) (Sutherland and others 1987; Ziller 1974). Wind-disseminated aeciospores infect alternate hosts in summer or early fall. During the following season, uredinia develop on the alternate hosts; telia capable of producing basidiospores are formed in the spring to early summer (May-June). In mid to late summer, diseased cones become light brown, dry and open prematurely, liberating aeciospores (Sutherland and others 1987). However, healthy cones are usually green and closed at this time. Cones may become either partially or completely infected. When they are partially infected, cone scales open prematurely on only part of the cone or within resinous areas of reduced development on one side of the cone. Partially-infected cones are slightly twisted with their scales distorted (Singh and Carew 1990).

On alternate hosts, uredia and telia form on the undersurface of leaves. Diseased plants exhibit atrophy over several years; they may become slightly chlorotic, and develop leaves that are more upright and whose upper surface is less shiny (becoming dull-green to gray) than those of healthy plants (Sutherland and others 1987; Ziller 1974).

Chrysomyxa pirolata causes reduced seed formation in diseased cones (Singh and Carew 1990; Sutherland 1981). In severely-infected cones, practically no seeds are produced (Singh and Carew 1990). Also, cone malformation and resinosis hinder seed extraction or dispersal (Nelson and Krebill 1970; Singh and Carew 1990). Seeds from diseased cones usually weigh significantly less and have reduced or abnormal germination (Singh and Carew 1990).

The inland spruce cone rust has previously been reported on Engelmann spruce in Colorado, Montana, Oregon, Washington, and British Columbia (Anonymous 1982; Conners 1967; Farr and others 1989; Lowe 1977; Savile 1950; Shaw 1973). However, no previous reports of this disease in Idaho were found, even though several alternate hosts of *Pyrola* spp. and *Moneses uniflora* have been recorded in the state (Sutherland and others 1987). This disease has probably occurred in Idaho for several years, but has not previously been reported. Spruce cone rust causes sporadic, localized epidemics in areas of the western United States (Nelson and Krebill 1982; Sutherland and others 1987). The disease is most damaging across Alaska and western Canada, where it infects Engelmann, black, and white spruce (Arthur 1934; Cash 1953; Sutherland and others 1987).

Control in natural stands is not practical nor usually necessary. Factors contributing to disease outbreaks have not been adequately quantified, but conducive moisture and temperature during periods of cone susceptibility are probably important (Summers and others 1986). This disease may become a potentially important problem in seed orchards, particularly if they are located in areas where alternate hosts occur (Nelson and Krebill 1970; Sutherland 1981). Tests of direct control using chemical fungicides indicated that either single or multiple applications of ferbam (ferric dimethyldithiocarbamate) during the period starting about 1 week before and through pollination significantly reduced disease incidence (Summers and others 1986). Fungicide treatments did not adversely affect seed yield per cone, although seed germination was reduced slightly. Direct control using fungicides is only cost effective in high-value seed orchards. In many cases, the most practical measure is for growers to exclude spruce cones which have signs of infection prior to seed extraction. Cone collectors should be alerted to the characteristics of this disease so that they do not collect infected cones. Exclusion of infected cones should be rather easy because of their coloration, premature drying and opening, and preponderance of resin.

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