than 0.5 acres, coalescing centers can occupy several acres. Once established, root rot centers persist for decades, slowly expanding at the rate of less than 1 foot/year. Tomentosus root rot can remain active in roots of dead trees and stumps for at least 30 years, suggesting that sites, once infected, will remain so for decades.

Impacts

Infected trees exhibit growth reduction,

Figure 8. Bole breakage from decay of root system and lower bole.

Figure 9. Uprooting of tree from decay of root system.

root and butt decay, premature uprooting, or mortality depending on age. Younger trees may be killed outright while older trees may persist in a slowly deteriorating condition for many years. Cull losses of the butt log of mature trees can be substantial. Older infected trees are prone to bole breakage (Figure 8) and uprooting (Figure 9) because of extensive decay of root systems and the lower bole. Examination of exposed broken roots for pitted decay and identification of fruiting bodies is essential for a positive identification of tomentosus root rot.

In managed stands, impacts from tomentosus root rot are expected to increase during subsequent rotations because of the persistence of root rot within infected stumps. Spruce seedlings that are established on sites with a previous history of tomentosus root rot become infected through root contacts with diseased stumps. On severely infected sites, mortality from the disease can be substantial and result in insufficient stocking. As a result, the presence of tomentosus root rot can limit the selection of species for regeneration on managed sites.

In unmanaged forests of Alaska, the pathogen causes openings in the forest canopy through the death of small groups of spruce trees. Dead standing and uprooted trees alter and diversify forest structure, tree species composition, and wildlife habitat.

Management

Management of the disease will depend on the objectives of the landowner. A reliable detection survey is an important first step for assessing incidence and severity of tomentosus root rot on a site. Stump top surveys can be used on recently cut-over lands to assess fungal incidence. Surveys to evaluate conifer regeneration for mortality from tomentosus root rot can be conducted at regular intervals.

In stands where root disease incidence is high enough to warrant action, three general strategies can be applied: alternative species selection, reducing or removing inoculum, and avoidance planting.

- Selection of alternate species involves establishing less susceptible species on an infected site for a rotation. This treatment is aimed at reducing root disease on a site by "starving out" the pathogen. In order of susceptibility, spruce is considered highly susceptible, lodgepole pine is moderate, and all hardwood trees are immune.

- Inoculum reduction involves removal of diseased stumps and most of their root systems, either by push-falling or stump extraction after harvesting operations. Trials are underway to assess the effectiveness of this treatment. Also, research suggests that thinning of diseased trees from a site can increase the rate of root rot spread to surrounding residual trees.

- Avoidance planting involves leaving a minimum 15 foot buffer zone around diseased stumps when reestablishing a highly susceptible species, such as spruce, on an infected site. Identification of diseased stumps is essential for avoidance planting to be effective.

Tomentosus Root Disease
by Lori Trummer
Forest Pathologist, USDA Forest Service
Alaska Region, State and Private Forestry

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Additional information on this disease can be obtained from:

Forest Health Protection
State and Private Forestry
USDA Forest Service
3301 C Street, Suite 522
Anchorage, AK 99503

Phone: (907) 271-2575
FAX: (907) 271-2897

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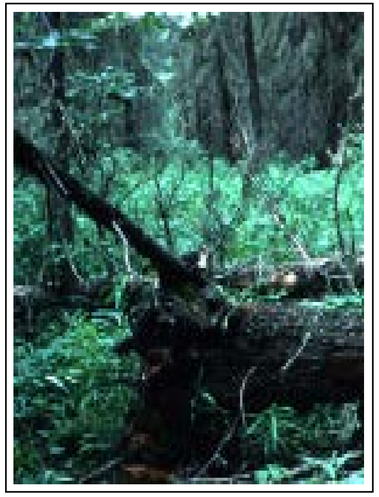
Tomentosus Root Rot



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Tomentosus Root Rot

Tomentosus root rot is an important disease of spruce throughout south-central and interior Alaska. Although widespread across the boreal and sub-boreal forests, the disease is absent from southeast Alaska. Infected trees exhibit growth reduction, decay of the root system and lower bole, premature uprooting, or mortality. All native spruce species (Picea spp.) in Alaska are highly

Figure 1. Thin crown of a mature spruce tree infected with tomentosus root rot.

susceptible to infection and lodgepole pine (Pinus contorta) is considered moderately susceptible. Hardwood species, including paper birch (Betula papyrifera) and trembling aspen (Populus tremuloides), are immune to infection. This leaflet will familiarize you with the tree disease, briefly explain the biology of the causal fungus, and provide options for disease management.

Identification

Tomentosus root rot is caused by the fungus Inonotus tomentosus. Symptoms of infection include thin chlorotic crowns, reduced leader growth, stunted upper branches, and stress cone crops (Figure 1). Crown symptoms are often not visible until decay is well advanced in root tissues. Infected trees may also exhibit resin flow on the lower bole and root collar.

Figure 2. Lower surface of a tomentosus conk with pores that continue part way down the central stem.

Figure 3. Upper surface of a tomentosus conk.

Fruiting bodies or conks are produced annually in the fall after periods of wet weather. Conks develop on the ground, arising from infected roots around diseased trees, and can be easily overlooked. Conks are leathery, small (1 to 4 inches in diameter), round to oval, stalked, and have pores rather than gills on the underside that continue part way down the stem (Figure 2). The lower surface is cream to yellow-brown while the upper surface is tan to yellow-brown with a velvety or hairy texture (Figures 2 and 3).

The early stage of root decay is characterized by a red-brown to pink stain in the heartwood of infected roots. Wood with advanced decay contains elongated spindle shaped pits, typically 1/4 to 1/2 inch in length, that may be empty or filled with white tissue. The pitted decayed wood may be intermingled with areas of

Figure 4. White pitted rot of spruce wood with advanced decay.

Figure 5. Characteristic honeycombed appearance of an infected root with advanced decay.

red-brown firm wood (Figure 4). The cross-section of infected roots have a characteristic honeycombed appearance (Figure 5). Stain, decay, and honeycomb

Figure 6. A stump surface that exhibits pink stain and pitted advanced decay caused by I. tomentosus.

pits are diagnostic characteristics that can be used to identify the presence of tomentosus root rot on stump surfaces or uprooted trees in the absence of fruiting bodies (Figures 6 and 9). Since other wood decay fungi can appear to have similar decay patterns, careful diagnosis is important.

Life History

The fungus spreads through root contacts between healthy and infected root systems, particularly in the small feeder roots. The fungus is able to grow on the exterior of roots and directly penetrate through the bark of roots less than 2 inches in diameter. There is evidence that the pathogen is spread by basidiospores that are produced in conks. Although the role of spore dispersal in the spread of the fungus is unclear, spores clearly do initiate new infection centers.

Once the fungus is established in the woody tissue of a root, it slowly advances through the root system, eventually progressing to the root collar, and colonizing the heartwood in the lower stem (Figure 7). Stain and decay can occur throughout the root system and a distance of 8 to 10 feet up the main stem. After a root system is sufficiently colonized by the fungus, fruiting bodies may be produced annually (Figure 2).

Tomentosus root rot affects groups of trees in progressively expanding disease centers. A disease center can be recognized by uprooted trees or standing dead trees near the middle and living, but infected trees in various stages of decline, near the edges. Although the individual root rot centers are typically small, less

Figure 7. A young spruce tree killed by tomentosus root rot. Note the extensive stain and decay of several major roots and up the stem.