TREE NOTES

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Black-stain Root Disease of Ponderosa and Jeffrey Pines in California

Donald R. Owen

Forest Pest Specialist, 6105 Airport Road, Redding 96002. 530-224-2494. don_owen@fire.ca.gov

Black-stain root disease (BSRD) is a tree-killing disease of conifers caused by the fungus *Leptographium wageneri.* Although *L. wageneri* is taxonomically related to the blue-stain fungi, it colonizes host tissues in a different and more lethal fashion. A number of scientific names have been applied to the fungus, but they all refer to the same organism: the perfect state of the fungus has only been found once and is referred to as *Ophiostoma wageneri;* previously used scientific names include *Verticicladiella wagenerii* and *Ceratocystis wageneri.*

Three varieties of the fungus exist, each generally confined to different hosts. One variety attacks Douglas-fir, one attacks pinyon pines, and the other attacks ponderosa and Jeffrey pines. While some other conifers have been infected, only those trees mentioned above have suffered significant losses to the disease in California.

The ponderosa/Jeffrey pine variety of black-stain (caused by *L. wageneri* var. *ponderosum*) has only been found in the northern half of the state. In the Sierra Nevada, it has not been found south of Highway 50.

INJURY and STAND SUSCEPTIBILITY

Infection begins in the roots of a tree and advances toward the main stem. Fungal hyphae colonize sapwood tracheids, causing vascular wilt and a characteristic stain. As the disease progresses, less and less water is transported from the tree's roots to its foliage. Most infected trees exhibit symptoms of decline and typically are killed by bark beetles. In ponderosa pine, attacks by the red turpentine beetle may precede tree-killing attacks by the western pine beetle or mountain pine beetle and serve as an indicator that the tree is dying. The disease can kill a mature tree in less than two years or it may take many years. There is no way to cure a tree of the disease, although some trees survive infection.

Stands that are most likely to be damaged by black-stain root disease (high risk stands)

- **have a high percentage of ponderosa or Jeffrey pine in the overstory**
- **are overstocked**
- **are generally cooler, wetter sites; in westside forests, such sites are probably best classified as mixed conifer even though they are dominated by pine**
- **have a history of site disturbance which contributes to tree stress and increased activity by insect vectors**
- **have a pine overstory of merchantable size (generally > 40 years old).**

Any one of these conditions alone or even a majority of the conditions do not necessarily indicate a risk for black-stain root disease. In fact, it may be that most, if not all, of these conditions must be present in order for black-stain to cause significant tree loss. Under such situations, tree mortality can become a chronic problem, eventually resulting in nearly complete elimination of mature pine from an area. Although heavy losses typically take decades to occur, a constant stream of tree mortality is often incompatible with management goals.

SPREAD

Movement of the disease from infected to uninfected trees occurs in two general ways: 1) Root-feeding insects carry spores of the fungus 2) The fungus moves directly between trees via roots that are in contact or in very close proximity. Spores of the fungus are not wind or water borne, thus long distance spread is necessarily due to insect vectors. Pure, dense host stands provide the ideal conditions for spread. Logging activity and other site disturbances can also contribute to spread by causing an increase in vector abundance.

Expansion of disease centers can vary considerably depending on stand conditions. In the central Sierra Nevada, an average rate of expansion of 1m per year was found, with a range of 0 - 7m.

DIAGNOSIS

Tree and Stand Symptoms

Crown thinning is the single best indicator that a tree's roots are unhealthy. Generally, the lower branches are the first to show symptoms, but as disease progresses the entire crown may become involved (Fig. 1a & b). Needle retention and length will be reduced, as will shoot elongation. Needles will be restricted to the ends of branches, giving a "lion's tail" appearance. Needles

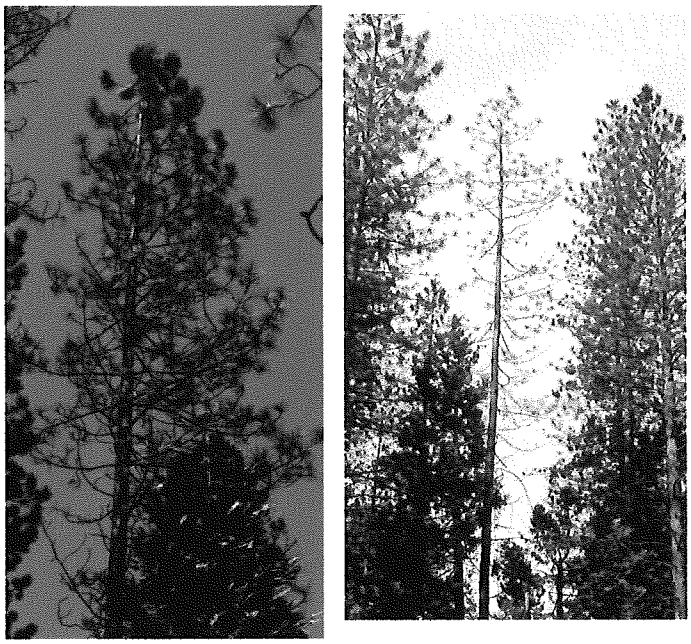


Figure 1. Ponderosa pines with black-stain root disease exhibiting a) moderate and b) severe crown thinning.

may be chlorotic, especially in advanced stages of disease. These crown symptoms are not specific to black-stain, but can also result from poor site conditions and other root diseases.

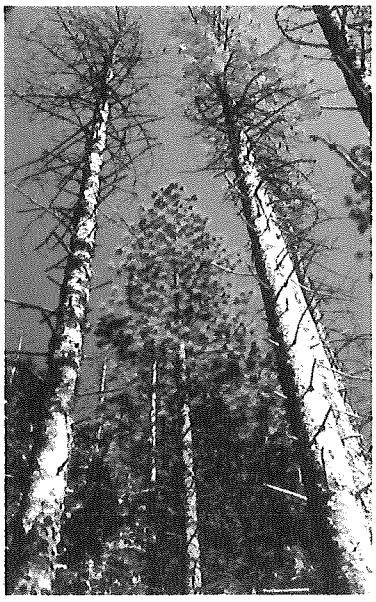


Figure 2. Dead and dying ponderosa pines on the edge of a black-stain root disease center.

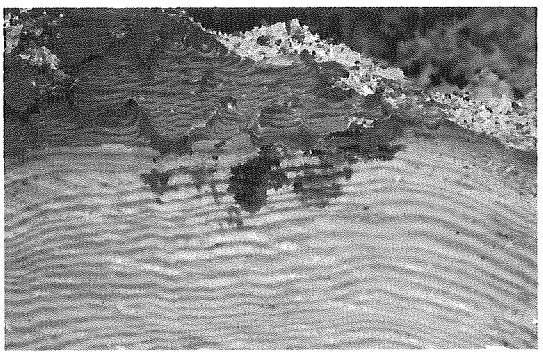
Because the disease will move from tree to tree through roots, mortality will typically involve a group of trees, referred to as a "disease center." Long-dead snags and fallen jack-strawed trees indicate where the disease started. Progressing outward there will be more recently dead trees, dying trees, trees with thin crowns, and finally trees without symptoms. This pattern of mortality and symptoms indicates the progression of the disease through the stand over time (Fig. 2). Black-stain and annosus root diseases can both produce this pattern. Numerous disease centers may be present in the general area. If the disease has been present in the stand long enough, disease centers may begin to coalesce. Managers should suspect root disease in areas where tree mortality, for no apparent reason, is a chronic problem. Bark beetles can also kill groups of trees, but if the beetles are acting alone, tree mortality tends to be concentrated in time, without evidence of there being an expanding center.

Confirmation of Black-stain

If black-stain root disease is present, it is usually easy to confirm. Under normal conditions, black-stain will progress to the root collar of the tree and slightly up the main bole before the tree is killed by bark beetles. Positive identification is made by finding the characteristic stain in the sapwood of one or more suspected trees.

The stain is distinguished on the basis of color, presence of resinosis, and its location in the sapwood (Figs. 3a & b). It is dark brown to almost black; typically, but not always, occurs in resin-soaked wood; and advances longitudinally through the outer sapwood, having an orientation in cross-section that is more tangential than it is radial. Black-stain found in the root collar and lower stem of living trees is often disassociated from insect attacks (attacks of the red turpentine beetle can be an exception).

Figure 3. Stain in the outer sapwood of a ponderosa pine infected by *Leptographium wageneri*: a) tangential cut and b) cross cut just



The best trees to sample for stain are those that are still alive, yet exhibit extreme crown thinning. If resin is present on the bark of the tree near ground level, this is the best site to sample. Resin on the bark is not that common with black-stain in ponderosa pine, but when it

is present it is a very good indicator of staining in the sapwood directly beneath. Use an axe, increment borer, or arch punch to sample the outer sapwood near ground level. It may be necessary to take several samples at various locations around the circumference of the tree to find stain. If no stain is found, try clearing soil from around roots and sampling them, or try sampling other trees. Black-stain can be identified from dead trees, but this is more difficult because of the presence of other stains and discoloration in the wood.

If black-stain cannot be found, it does not necessarily mean a tree is free of disease — it may mean the stain has not yet advanced to a level in the tree where it can be easily sampled or that another root disease, such as annosus, is present. During periods of drought, bark beetles may kill trees before the disease has had sufficient time to advance up the roots and reach the main stem. Under these conditions, a greater amount of sampling may be required to confirm the disease.

Bluestain is different from black-stain

Bluestain is a gray-blue stain that is pervasive in the sapwood of pines that are dying or have been killed by insects. It may also occur to a limited degree in living trees where portions of the cambium and sapwood are dead and obviously attacked by insects. Various fungi cause bluestain and different types of beetles serve as vectors. Bluestain fungi colonize wood in a radial direction. In cross-section, the stain typically appears wedge-shaped (Fig. 4), extending from the outer to inner sapwood.

Figure 4. Bluestain in ponderosa pine.

MANAGEMENT CONSIDERATIONS

The disease has not been found in young pine stands, is virtually non-existent in mixed conifer stands, and is rarer and appears to be less damaging in pine stands that are well spaced. Insect vectors are attracted to wounded trees, fresh stumps, and probably trees that are stressed. Logging activity results in an increase in vector abundance and provides them breeding habitat in the form of stumps. It may also result in soil compaction and root damage. Over stocked stands may be stressed due to competition, which can also increase vector activity. Stands with a high pine component provide the ideal environment for rapid disease spread.

Management of black-stain root disease is critical for those sites that have a history of the disease. Once black-stain has surfaced in a susceptible stand, treatments aimed at controlling the disease in the existing stand have generally proved unsuccessful. Long-term management is aimed at prevention. When black-stain-infected stands are regenerated, the disease dies out quickly and is not likely to become re-established for several decades. Seedlings can become infected, but the probability of this is low and probably of little consequence. If a diseased stand is regenerated and the new stand is allowed to grow into a susceptible state, chances are high that the disease will resurface as the stand approaches maturity. On sites with a history of black-stain, some general rules should be used to guide management decisions: encourage a mixture of tree species, keep stands from becoming over stocked, and limit stand treatments to times and activities that are less likely to promote the disease.

Pros and Cons of Control

Attempts have been made to stop the spread of black-stain in pine stands by removing all trees believed to be infected, either through clearcuts or partial cuts. To date, none of these efforts has succeeded. The possibility of success, however, is still debatable. Past attempts at control were typically conducted in high-risk stands with a high incidence of disease. Also, we now believe that logging practices can significantly influence disease spread and that this must be taken into account anytime logging is conducted in an area that has a history of black-stain.

Any attempts to control the disease must be viewed as experimental. The goal is to arrest the spread of the disease within the existing stand. For control to be effective, spread via both roots and vectors must be considered. Control probably has the best chance of succeeding in those stands where conditions are less than favorable for the disease and the disease is not widespread.

Because *Leptographium wageneri* requires a living host in which to survive, the fungus dies-out in infected trees that have been cut and is not likely to infect stumps of uninfected trees. If all infected trees are cut and a buffer strip of uninfected trees is cut around them, this should stop the underground spread of the fungus via roots. Although it may be possible to excise the disease in this manner, we currently have no way of controlling the vectors and preventing them from initiating new infections outside of cut areas. This is especially problematic when surrounding residual stands have high-risk characteristics. Such a situation should be a red flag that the disease is likely to become established in and spread among uncut trees. The ability of vectors to transmit the disease to uninfected hosts is undoubtedly influenced by vector abundance,

level of disease in the general area, stand characteristics, and logging practices.

Prevention

Encourage a Mixture of Tree Species

In stands where this is an option, long-term goals should be to reduce the pine component to one third or less of the species mix. On westside sites, advanced regeneration of shade tolerant species may already exist in the understory. Attempts can be made to preserve this regeneration when logging overstory pine and/or silvicultural systems can be used that will encourage regeneration and survival of alternate species. A dilemma, however, may exist when the overstory pine is clearcut, enhancing pine regeneration at the expense of other species. Small clearcuts, strip cuts, and other types of partial cutting when applied to a stand over a period of time, may be able to accomplish the same effect of a larger clearcut while at the same time better accommodating the reproduction of alternate species. Keep in mind, however, that repeated stand entries may encourage insect vector activity.

On eastside sites and in other situations where it is difficult or unreasonable to regenerate a mixed species stand, it may be necessary to accept a future stand dominated by pine. Indications are that stocking control early in the life of the stand and logging precautions will lessen the probability of black-stain in a pure pine stand.

Stocking

No specific recommendations exist for stocking, yet experience tells us that a higher than normal level of stocking increases the risk of black-stain. Reduced stocking may contribute to disease resistance for a couple of reasons. Competition from overstocking results in tree stress, potentially making trees more attractive and susceptible to insect vectors. Open stands will have warmer soil temperatures, and warm temperatures inhibit growth of L. wageneri. Ideal stocking levels will vary according to site quality.

Thinning a stand while it is still sub-merchantable is the preferable way to attain desired stocking. Thinning older stands, e.g. 30 years and older, is not recommended since site disturbance in these stands can promote disease. For older stands, it may be best to avoid intermediate entries that are well in advance of the final planned harvest.

Site disturbance

Research in coastal Douglas-fir has shown that timing of logging can be important both in terms of vector activity and disease incidence. Similar relationships probably exist for ponderosa pine. Vector populations are highest in the spring, thus logging during this time has the greatest potential for attracting vectors. Also, stumps that are created in the fall and spring provide ideal breeding habitat for vectors. It is not clear how long stumps remain viable as breeding habitat, but stumps that have a chance to dry and deteriorate prior to being colonized by the insects are probably less likely to contribute to vector population increases. For these reasons, it is recommended that logging be conducted from July to September. Chances of soil compaction and tree injury are also reduced during these months.

Soil disruption has been associated with black-stain in eastside pine stands on the Modoc National Forest. Thus, harvesting methods should minimize soil disruption and tree injury.

FURTHER READING

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Jesse Rios: Editor
CDF Forest Pest Management (916) 653-9476