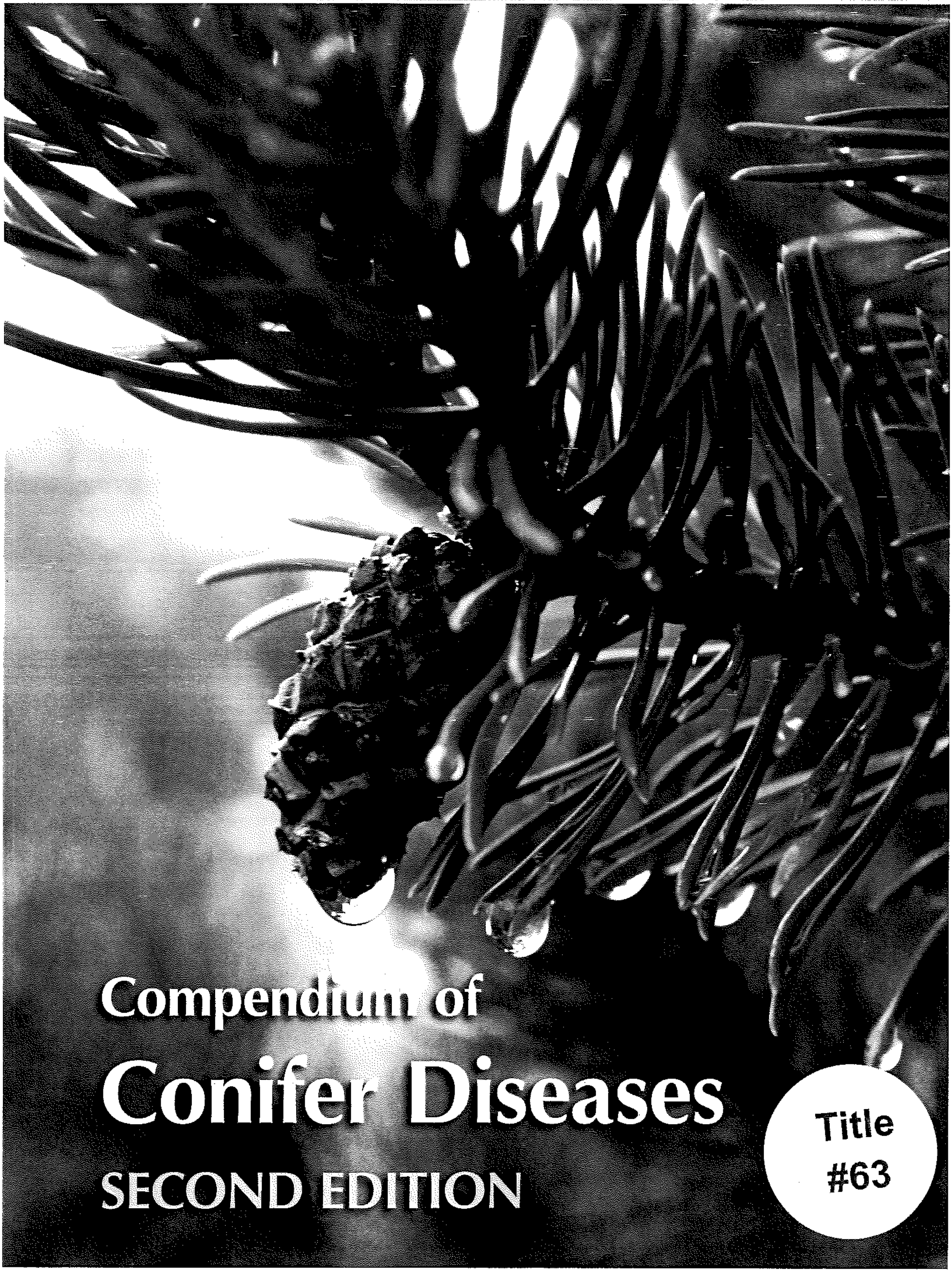

Compendium of Conifer Diseases

SECOND EDITION

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Heterobasidion Root and Butt Rot

Other names: Annosum or annosus root and butt rot; rotticka (Swedish); le fomes, pourriture rouge, maladie du rond (French); Wurzelschwamm, Wurzelfäule (German); podredumbre roja del pino (Spanish); mal del rotondo (Italian)

Causal agents: In Eurasia: *Heterobasidion abietinum* Niemelä & Korhonen, *H. annosum* (Fr.:Fr.) Bref. sensu stricto (s.s.), *H. parviporum* Niemelä & Korhonen; in North America: *H. irregulare* Garbelotto & Otrosina, *H. occidentale* Otrosina & Garbelotto (syns. *H. annosum* (Fr.:Fr.) Bref., *Fomes annosus* (Fr.:Fr.) Cooke., *Fomitopsis annosa* (Fr.:Fr.) P. Karst., *Polyporus annosus* Fr.:Fr., *Trametes radiciperda* R. Hartig, *Spiniger meineckellus* (A. J. Olson) Stalpers)

Hosts: *Heterobasidion annosum* and *H. irregulare* reported on many conifers, including species of *Calocedrus, Juniperus, Larix, Pinus, Pseudotsuga,* and less often on broadleaved trees; *H. abietinum, H. parviporum,* and *H. occidentale* on many conifers including *Abies, Picea, Pseudotsuga, Larix, Sequoia, Sequoiadendron,* and *Tsuga* spp.

Distribution: *Heterobasidion abietinum,* central and southern Europe; *H. annosum* s.s., Europe; *H. parviporum,* central and northern Europe and parts of Asia; *H. irregulare,* wide distribution in North America and limited to the west coast of central Italy; *H. occidentale,* only western North America

Symptoms and Diagnosis

Heterobasidion spp. are fungi that cause either root or butt rot on many coniferous trees (Table 2). They are classified as white-rot wood-decay fungi capable of degrading wood lignin. The advanced decay is soft and spongy and often contains characteristic white cellulose pockets and black specks. Colonization by *H. annosum* s.s. and *H. irregulare* is limited mostly to the roots and root collars of pines and junipers, causing excessive resin exudation and tree death. Conversely, colonization by other *Heterobasidion* spp. affects both the roots and the buttresses of infected trees (Fig. 44). When the heartwood is colonized, the tree may stay alive for decades without any external symptoms. When the sapwood is colonized, trees undergo a progressive and long decline resulting in slow growth rates and thin and chlorotic canopies, often culminating in death. The disease tends to occur in patches that expand progressively with time and that are known as "root disease centers." Such disease centers are especially conspicuous in pine stands because pines are highly susceptible to the disease (Fig. 45).

Other root rot fungi, including *Armillaria* and *Coniferiporia* spp., may cause similar symptoms, and a positive field diagnosis of Heterobasidion root rot is possible only when fruit bodies are found. Fruit bodies are perennial; and in dry sites, they are known to develop only under the duff layer, on roots of dead trees, or in hollow cavities within stumps (Fig. 46). In moist sites, they may also develop slightly above the root collars of

TABLE 2. ***Heterobasidion*** **spp. That Infect Conifers, Their Principal Hosts, Form of Damage, and Distribution**[a]

Species	Main Hosts	Damage	Distribution
abietinum	*Abies* spp.	Root and butt rot	Central and southern Europe
annosum sensu stricto	*Pinus* spp.	Death	Europe
irregulare	*Pinus, Juniperus, Calocedrus* spp.	Death	North America, Italy
occidentale	*Abies, Picea, Tsuga, Sequoia, Pseudotsuga* spp.	Root and butt rot	Western North America
parviporum	*Picea* spp.	Root and butt rot	Central and northern Europe, Asia

[a] Prepared by E. Hansen.

dead trees or on the aboveground portions of stumps. Fruit bodies can be more than 30 cm long and display a light buff-colored pore layer. Older specimens have several strata visible in cross section. The pore surface can face either downward or upward, depending on growing conditions. The upper surface is normally woody or leathery and dark brown. Small, developing or abortive fruit bodies may appear as pustules resembling popcorn growing on the bark of pine species. The distinctive conidiophores are normally not seen under natural conditions, but they are produced abundantly by pure cultures in vitro or on the surface of infected wood kept under moist conditions.

Effects on Tree and Forest, Ecological Role

Heterobasidion spp. are among the most destructive fungal pathogens of managed coniferous forests in the northern hemisphere. From the ecological point of view, these fungi increase species diversity in coniferous forests, in particular favoring natural regeneration of less susceptible tree species in the canopy gaps that they cause. Impact may be greater in denser or older stands.

Fig. 44. Butt rot in Norway spruce caused by *Heterobasidion parviporum* in Sweden. (Courtesy K. Korhonen–© APS)

Taxonomic Status

Until recently, *Heterobasidion* spp. responsible for root and butt rot diseases were regarded as belonging to the species *H. annosum* (Fr.:Fr.) Bref. sensu lato. Their current status as separate species is supported by partial reproductive isolation, host preference, slight morphological differences, and a broad range of phylogenetic analyses. Although all species are somewhat partially interfertile, reproductive isolation is maintained by allopatric geographic separation, in particular between Eurasian and North American species. In sympatric species, species boundaries are reinforced by marked host preferences on live trees. However, both North American species can be found together or individually on stumps and on live alpine larch. In these instances, interspecific hybridization between the two sibling taxa has been reported. Hybrid swarms between *H. annosum* s.s. and *H. irregulare* have been reported in central Italy. Hybrid individuals are not reproductively isolated from the parental species but tend to backcross with them. Because of this process, their genome and phenotype, although admixed, become very similar to the genome and phenotype of the species with which they backcrossed.

Disease Cycle

Heterobasidion spp. produce both asexual and sexual spores. Asexual spores (conidia) are not airborne, and their role in the infection process is not well understood. Sexual fruiting bodies instead produce large numbers of wind-dispersed spores (basidiospores). Airborne spores are known to infect the top surfaces of freshly cut stumps. These fungi progressively colonize both the aboveground portions of infected stumps and their underground root systems. Live trees can be infected either through direct infection of wounds on stems or roots or through contagion from infected roots of a neighboring tree or stump.

Once established in a stand, whether through stumps from thinning or wounds on trees, the fungus grows along the root system at a rate of 0.2–2 m per year. One fungal individual (genet) can form a fairly large disease center up to 30 m or more in diameter. However, most disease centers of *Heterobasidion* spp. in managed forests are small, indicating the importance of spore infection in the spread of these fungi.

The incidence of disease is exacerbated by human activities in the forest, particularly harvest operations. Thinning operations cause injuries to the roots of remaining trees and generate fresh stump surfaces, both of which provide infection courts. Occasional stress, caused, for example, by drought or air pollutants, may facilitate root infection. The rate of colonization

Fig. 45. Root disease center caused by *Heterobasidion irregulare* in a *Pinus pinea* stand in central Italy. (Courtesy P. Gonthier and M. Garbelotto–© APS)

Fig. 46. *Heterobasidion parviporum* fruit body in a hollow cavity in a *Picea abies* stump. (Courtesy P. Gonthier and M. Garbelotto–© APS)

of the root system is very dependent on the soil type and is particularly rapid in former agricultural soil and in other soils with a sandy matrix and high pH levels. Peat soils are almost free of the disease.

Disease Management

When *Heterobasidion* spp. are present, it is important to prevent spore-driven infection of cut stumps and tree wounds. The number of thinnings should be kept to a minimum, and all forest operations should be carried out carefully in order to minimize root damage. Stands should be thinned during periods of low sporulation, that is, winter in the north and summer in the south. Infection can further be controlled by treating fresh stump surfaces with chemical or biological agents, including urea, borax, or spores of the antagonist fungus *Phlebiopsis gigantea*.

Spread of these fungi in a stand can be slowed by employing wide spacing among planted trees, growing mixed stands, and avoiding the cultivation of susceptible trees on hazardous sites. In a stand where the disease is already present, it is frequently worthwhile to reduce the time of stand rotation. Mechanical removal of stumps or rotation with a resistant tree species can also significantly reduce inoculum levels on infested sites. Note that total eradication of *Heterobasidion* spp. in managed forests is difficult, but economic losses can be kept at an acceptable level with proper management.

Although medium- and long-distance movement of *Heterobasidion* spp. appears to be rare, there are a few documented cases of such events, including the movement of *H. irregulare* from the United States to Italy, presumably in infected wood.

Heterobasidion Root Rot in Christmas Trees

Heterobasidion root rot is an increasing problem in Christmas tree plantations in western North America and some locations in Scandinavia. In the U.S. Pacific Northwest, the disease appears to be related to the increased production of true firs, such as noble (*Abies procera*) and Fraser (*A. fraseri*) firs, which are highly susceptible to this disease, coupled with the common practice of planting seedlings next to stumps from the previous crop (Fig. 47). Although rarely seen on Douglas-fir Christmas trees, annosus root rot has been observed on Douglas-fir in sites where it was planted next to noble fir stumps from the previous rotation. Losses of 20% have been observed in some noble and Fraser fir plantations in the Pacific Northwest.

Aboveground symptoms can include decreased leader growth, needle yellowing, branch flagging, and the death of trees. Symptoms may appear within 3 years of planting, but most of the time they appear near the end of the 8- to 10-year period between planting and harvest. The highest levels of disease are typically seen following multiple rotations of true fir. The dark staining of the older wood in the cut trunk of the tree is diagnostic for this disease. In many cases, infected trees do not show any aboveground symptoms at harvest. However, colonization of the stems can adversely impact the ability of displayed trees to take up water, reducing their postharvest quality.

Fig. 47. Noble fir Christmas trees planted near stumps of the previous crop and killed by annosum root rot. (Courtesy G. Chastagner–© APS)

Aboveground symptoms of annosus root rot can be confused with symptoms of other root diseases caused by *Phytophthora* and *Armillaria* spp. and some types of environmental stress.

In the Pacific Northwest, high numbers of spores are present during harvest of trees in the fall, creating an ideal situation for increased disease incidence when seedlings are planted next to freshly cut stumps. Treatments of stumps at harvest with chemicals, such as borax, and removal of stumps prior to replanting are effective ways of limiting disease development. Growers can determine whether the disease is present in a plantation by examining the cut surfaces of the trunks of harvested trees for evidence of staining. In "you-cut" plantations, where it is not practical to ask customers to treat the stumps at the time they harvest trees, it is often recommended that growers go back and recut the stumps and treat them properly after the harvest season. Although limited data is available to support the practice, some growers simply kick dirt and duff from the ground beneath a tree onto the surface of the stump at the time of harvest as a biological approach to limiting infection of stumps.

Selected References

Chastagner, G. 2004. Stump removal reduces Annosus root rot losses. Christmas Tree Lookout 37(1):22-25.

Dart, N. L., Chastagner, G. A., and Peever, T. L. 2007. Spread of *Heterobasidion annosum* in Christmas tree plantations of the United States Pacific Northwest. Phytopathology 97:551-556.

Garbelotto, M., and Gonthier, P. 2013. Biology, epidemiology, and control of *Heterobasidion* species worldwide. Annu. Rev. Phytopathol. 51:39-59.

Hodges, C. S. 1969. Modes of infection and spread of *Fomes annosus*. Annu. Rev. Phytopathol. 7:247-266.

(Prepared by M. Garbelotto, P. Gonthier, and G. Chastagner)