Heterobasidion Root Disease (Annosum Root Rot) and Red Pine Pocket Mortality in Wisconsin

Biology and Management

Photos:
Left: Red pine pocket mortality aerial view
Upper right: A pocket created by Heterobasidion root disease
Lower right: Fruit bodies of Heterobasidion root disease

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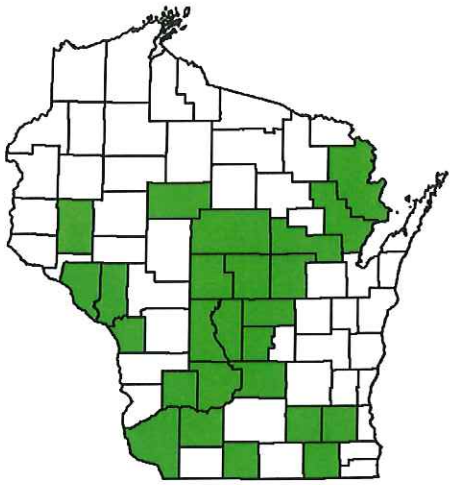
Heterobasidion Root Disease

Introduction: Annosum root rot, recently renamed as Heterobasidion Root disease(HRD), was first identified in **Wisconsin in 1993** and is considered among the most important and destructive diseases affecting conifers in the north temperate regions of the world. It is caused by the fungus, ***Heterobasidion irregulare (formally H. annosum).*** Although many woody species have been reported as hosts in the world, HRD has been most commonly observed on red and white pine plantations in Wisconsin.

Known Locations: Heterobasidion Root Disease has been observed in 25 counties including Adams, Buffalo, Columbia, Dunn, Grant, Green, Iowa, Jefferson, Juneau, LaCrosse, Marathon, Marinette, Marquette, Oconto, Portage, Richland, Sauk, Shawano, Taylor, Trempealeau, Walworth, Waukesha, Waupaca, Waushara, and Wood counties. Infection has been observed on overstory red and white pines, and understory balsam fir, jack/red/white pines, white spruce, red cedar, cherry, oak, and buckthorn. Of those, mortality has been observed on jack/red/white pines, balsam fir, and red cedar.



Counties where HRD has been found

Symptoms & Signs:

Crown symptoms typically appear 3-8 years after a thinning. Infected trees will have thin crowns, reduced height, diameter, and shoot growth. "Infection centers" develop as the disease progresses and may contain one to many dead trees surrounded by recently dead or dying trees.

Fading and dead trees may have fruit bodies (spore-producing structures) in the root collar area. These are often so low on the tree they are buried among soil and fallen needles. Young fruit bodies appear in mid summer and look like popcorn. By fall, they are bracket-shaped - reddish brown on the top and white on the lower surface. Fruit bodies are perennial yet undergo partial deterioration each year.

Popcorn stage of *Heterobasidion irregulare* fruit body, typically seen in summer.

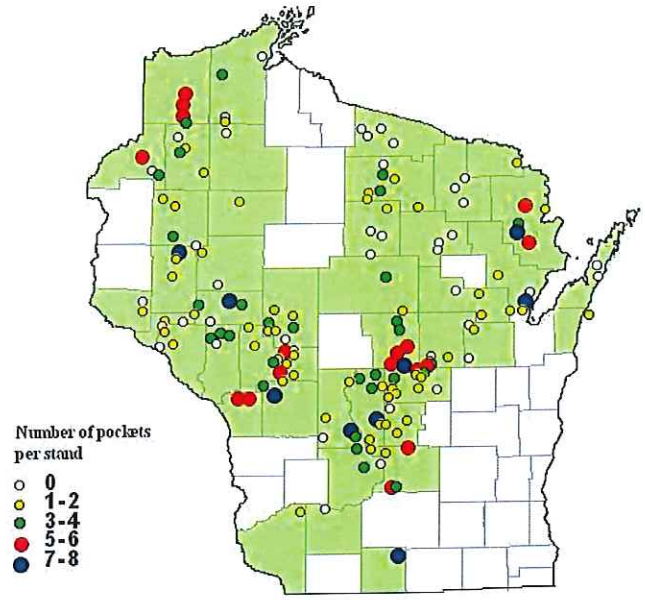
***H. irregulare* fruit body in the fall**

Underside of *H. irregulare* fruit body

Red Pine Pocket Mortality

Introduction: Red pine pocket mortality, caused by **a complex of insects and the fungi *Leptographium terrebrantis and L. procerum*** was first identified in **Wisconsin in 1975.** National distribution of this syndrome is unknown. **Thinned, plantation-grown red pines between the ages of 30-45** are most likely to show symptoms of this syndrome.

Known Locations: **Red pine pocket mortality** was observed in **109** of 157 **red pine plantations** in a 2002 survey. The number of pockets per plantation varied between 0-8. Red pine is the only species that has shown symptoms of this syndrome.



Symptoms & Signs:

Pockets typically start small with one to a few dead trees surrounded by trees that have reduced shoot growth and thin crowns. Each year, a few trees on the pocket edge may die and the edge of the pocket expands. Over time, pockets can become quite large; 4-acre pockets have been observed.

Pitch tubes, which are signs of attack by the red turpentine beetle, *Dendroctonus valens,* can be present on the lower bole of trees in the pocket margin. The wood in the vicinity of the pitch tubes and in the root collar area may be stained blue-black. Emergence holes of the pine engraver, *Ips pini*, are often evident on the dead trees within the pockets.

Pitch tubes caused by feeding of the red turpentine beetle, *Dendroctonus valens*

Blue-black discoloration caused by *Leptographium* spp.

Emergence holes caused by the pine engraver beetle, *Ips pini.*

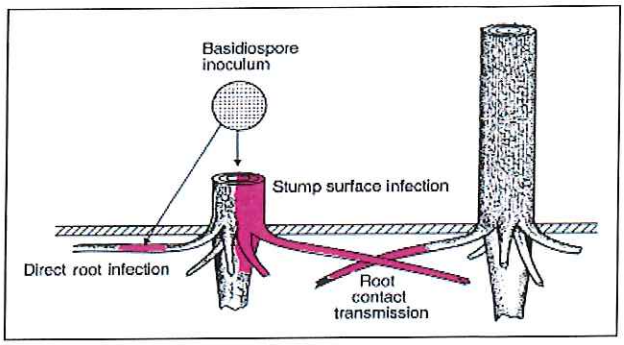
Heterobasidion Root Disease

Biology: Infection most often occurs when basidiospores, produced by the fruit body, land and germinate on the surface of a freshly cut stump. This infection process creates a strong relationship between Heterobasidion root disease and thinned stands.

Basidiospores are most often produced when the temperature is between 41° - 90° F (5° - 32° C) and can be carried in the wind over hundreds of miles; most spores are deposited within 300 feet (90 meters).

The fungus colonizes the stump tissue, moves into the root tissue and progresses from tree to tree via root contact at the rate of approximately 3.2- 6.5 feet per year (1-2m/yr). Infection through root and lower stem wounds can also occur. This has been observed in Wisconsin on white pine regeneration in a red pine plantation.

The pathogen degrades both the lignin and the cellulose and causes a stringy yellow decay in the roots and lower stem.



Infection occurs through freshly cut stump.
From: Annosus Root Rot in Eastern Conifers, K. Robbins, 1984. FIDL 76.

Stringy, yellow decay caused by *Heterobasidion irregulare.*

Impact: Infected trees will have reduced height, shoot and diameter growth and thin foliage. These symptoms typically appear 3-8 years after a thinning. As decay advances through the root system and into the lower stem, the tree will become more susceptible to wind throw and eventually die. Seedlings and saplings of red, white, jack pines, balsam fir, white cedar as well as some deciduous trees in close proximity to infected overstory have been found infected in Wisconsin. The number of infection centers in a stand can vary widely. Infection centers create gaps in the forest canopy where brush and early successional trees can regenerate.

Both Heterobasidion root disease and red pine pocket mortality can occur in the same stand and even within the same pocket.

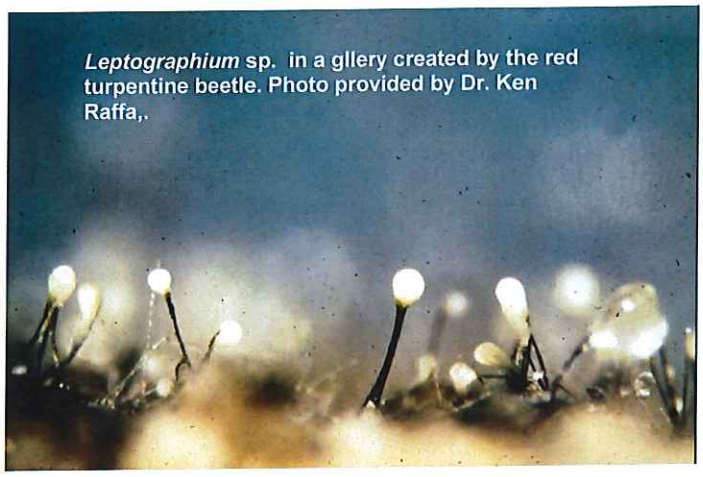
Infected white pine seedling with several *Heterobasidion irregulare* fruit bodies.

Site Factors/Stand History: In the southeastern United States, **disease development is more common on land formerly used for agriculture and with a pH >6** than on old forest soils. **Sandy or sandy loam soils at least 12 inches (30 cm) deep, with good internal drainage and a low seasonal water table** are also considered sites **favorable for disease development.** The influence of site factors on disease progression has not yet been studied in Wisconsin. Heterobasidion root disease is most damaging in plantation-grown conifers where thinnings provide infection courts (fresh stumps) and root grafts provide a pathway for the disease to move from tree to tree.

Red Pine Pocket Mortality

Biology: Insect vectors including root collar weevil (*Hylobius radicis),* pales weevil (*H. pales)*, red turpentine beetle (*Dendroctonus valens)*, pitch-eating weevil *(Pachylobius picivorus)*, and *Hylastes porculus*, feed on freshly cut stumps, the lower stem and roots of red pine, transmitting the fungus *Leptographium terebrantis* and *L. procerum* into the lower stem and root system. Once established in the communal root system of a red pine plantation, **Leptographium spreads** to healthy trees via root connections. Trees infected with Leptographium are stressed by a decrease in water conduction and a decrease in the production of defensive compounds. These stressed trees continue to attract lower stem feeding beetles, particularly the red turpentine beetle. **Bark beetles** (*Ips pini* and *I. grandicollis)* are ultimately responsible for tree mortality

Red Turpentine Beetle, *Dendroctonus valens*. Photo provided by Dr. Ken Raffa,



Leptographium sp. in a gllery created by the red turpentine beetle. Photo provided by Dr. Ken Raffa,.

Impact: Infected trees will have reduced height and diameter growth. As disease progresses, successful invasion by the pine bark beetles occur. Infestation by the pine bark beetle kills the tree. Red pine pocket mortality has NOT been observed in jack or white pine plantations. White pine regeneration within pockets also appears to be unaffected by this syndrome. The number of infection centers in a stand can vary widely. Infection centers create gaps in the forest canopy where brush and early successional trees can regenerate.
Both Heterobasidion root disease and red pine pocket mortality can occur in the same stand and even within the same pocket.

White pine regeneration in a red pine pocket.

Site Factors/Stand History: Studies attempting to identify site factors associated with red pine pocket mortality are ongoing. Red pine pocket mortality is a disease of plantation-grown red pine. Red pine pockets are more common in stands that have been thinned than in unthinned stands; root grafts provide a pathway for Leptographium to move from tree to tree.

Heterobasidion Root Disease

Management:

I. If Heterobasidion root disease is scattered throughout a stand:

1. Expect tree mortality in pockets and growth loss in trees around the pocket margin.
2. During thinnings or salvage operations, it is recommended that dead trees and the bottom 8 feet of trees that are showing dieback and/or yellowing of the foliage (fader trees) be left on the site to minimize the movement of fruit bodies to uninfected areas of the state.
   Note: Currently, field studies are under way to investigate the frequency of fruit body formation on dead and fader trees that are infected with Heterobasidion root disease in southern Wisconsin. Once completed, these studies will provide us with more data to assess the risk of introduction of the disease in a new area through infected wood with fruit bodies.
   The top part of fader trees can be utilized. Minimize felling and skidding wounds.
3. Cutting and burning dead trees and the bottom 8 feet of fader trees on the site will aid in reducing the formation of fruit bodies.
4. Apparently healthy trees outside the pocket, extending ½ to 1 chain (1 chain = 66 feet) from the perimeter of the last faders may be harvested to utilize the wood before the trees succumb to the disease. At this point, it is believed that the disease spreads approximately 3.5-6.5 feet per year (1-2 m/year), which gives an estimated expansion of ½ to 1 chain in 10-15 years. This operation will probably not be effective in preventing or delaying the further spread of the disease through root connection.

4a. A clear cut of the stand may be considered if the infection is extensive (pockets are coalesced).

5. To limit the formation of new infection centers during thinning, there are two options: **1)** Treat all freshly cut stumps with a fungicide. Fungicide applications will help prevent new infections but will **not stop the movement of Heterobasidion root disease through root systems that are already infected. 2)** Provide no treatment to the stumps and expect some additional infection. A native decay fungus, *Phlebiopsis gigantea*, has been known to invade freshly cut stumps and successfully compete against Heterobasidion root disease fungus. The percentage of stumps protected naturally by *P. gigantea* is unknown.
6. Start the thinning/harvesting with healthy stands, and then move to infected areas.
   Cleaning of logging equipment (tires, cutting head, etc) with pressured water prior to leaving the harvest site may be considered to minimize the risk of the spread of Heterobasidion root disease to a new location.
   Note: The significance of equipment contamination on the long-distance introduction of this disease is unknown. Spores of Heterobasidion root disease appear to stay alive in dry soil for one year or longer. Since harvesting equipment inevitably creates wounds on stems and roots, and the pathogen could enter through a wound and infect a tree, at this point, washing at least contacting parts of the equipment before entering uninfected areas is believed to be a good cautious approach.
7. After harvest, infected sites may be replanted or naturally regenerated to conifers. In the southeastern United States, regeneration losses have been documented to be a total of approximately 5% with additional disease development following thinnings. This data is not yet available for Wisconsin. Some losses of regeneration are expected for our area as mortality of red and white pine regeneration within disease centers of Heterobasidion root disease has been observed. Some deciduous trees are susceptible but tend to sustain lower mortality; conversion to hardwoods, if appropriate for the site, should be considered.
   Note: Field studies to investigate the survival of regeneration of a variety of native conifer and deciduous tree species are in progress in Wisconsin.

Red Pine Pocket Mortality

Management options:

The biology of RPPM is not fully understood, and at this point, there is no specific control that is proven to be effective to limit the further spread of this problem. During thinnings, harvesting trees that are showing dieback (fader trees) along the margin of the pocket will help reduce economic losses. Harvesting additional healthy trees along the pocket margin and into the healthy stand will delay the appearance of crown symptoms in the stand. However, it is likely that the dieback and mortality of additional trees will eventually occur. When salvage harvesting is considered, foresters and landowners should choose a practice that would best suit their long-term forest management plan and management objectives. Management options are listed below. Some of the options presented here include practices that have been performed on an experimental basis in a hope of reducing the risk of further spread of the problem, however the effectiveness of these approaches is unknown.

I. Harvesting options

a) **Leave the pocket as a natural opening.**

b) **Cut dead trees and trees that are showing dieback and/or yellowing of the foliage (fader trees) within and adjacent to the pocket.**
This practice will not only capture wood value prior to tree mortality, but help reduce the population build-up of bark beetles in the stand. Bark beetle population increases dramatically during dry summers especially when breeding materials are left on site. Breeding material includes recently cut or killed trees, stressed trees, or logging slash greater than two inches in diameter. If cutting is conducted from March through August, it is recommended that logs and large slash be removed from the site within 3 weeks.

c) **Cut dead trees and trees that are showing dieback and/or yellowing of the foliage (fader trees), and also cut a buffer area around the pocket.**
Apparently healthy trees outside the pocket, extending ½ to 1 chain (1 chain = 66 feet) from the perimeter of the last fader trees may be harvested to utilize the wood before the trees succumb to the disease. A pocket created by RPPM often expands over time. Based on field observations in Central Wisconsin, it is estimated that a pocket expands approximately ½ chain in 5-7 years, and at least 1 chain in 10-15 years. A clearcut buffer area of ½ chain or 1 chain from the perimeter of the pocket can be created for a pre-salvage purpose. It is unlikely that creating a buffer area around the pocket margin will stop or delay the spread of a pocket created by RPPM. The distance that needs to be clearcut would be adjusted depending on when the next entry is planned and what your land use objectives are. For example, if the next entry isn't planned until 15-20 years later, a larger clearcut buffer area may be preferred to capture wood value. On the contrary, if a landowner's primary land use goal is wildlife habitat or visual quality, clearcutting a buffer area may not be a preferred option or clearcutting a smaller buffer area may be a more attractive option.

Cutting fader trees will not only capture wood value prior to tree mortality, but help reduce the population build-up of bark beetles in the stand. Bark beetle population increases dramatically during dry summers especially when breeding materials are left on site. Breeding material includes recently cut or killed trees, stressed trees, or logging slash greater than two inches in diameter. If cutting is conducted from March through August, it is recommended that logs and large slash be removed from the site within 3 weeks.

Heterobasidion Root Disease

Management (Continued from page 5):

II. If Heterobasidion root disease is rare in a stand (one center) or if centers are widely spaced with large (>40a) blocks of healthy conifers in-between centers:

1. During thinnings or salvage operations, it is recommended that dead trees and the bottom 8 feet of trees that are showing dieback and/or yellowing of the foliage (fader trees) be left on the site to minimize the movement of fruit bodies off site to uninfected areas of the state.
   Note: Currently, field studies are under way to investigate the frequency of fruit body formation on dead trees and fader trees that are infected with Heterobasidion root disease in southern Wisconsin. Once completed, these studies will provide us with more data to assess the risk of infected wood on the further spread of the disease.
   The top part of fader trees can be utilized. Minimize felling and skidding wounds.
2. Cutting and burning dead trees and the bottom 8 feet of fader trees on the site will aid in reducing the formation of fruit bodies.
3. Apparently healthy trees outside the pocket, extending ½ to 1 chain (1 chain = 66 feet) from the perimeter of the last faders may be harvested to utilize the wood before the trees succumb to the disease. At this point, it is believed that the disease spreads approximately 3.2-6.5 feet per year (1-2 m/year), which gives an estimated expansion of ½ to 1 chain in 10-15 years. This operation will probably not be effective in preventing or delaying the further spread of the disease through root connection.
4. To limit the formation of new infection centers during thinning, it is recommended that all freshly cut stumps be treated with Sporax (sodium tetraborate decahydrate[1]). Sporax will help prevent new infections but will **not stop the movement of Heterobasidion root disease through root systems that are already infected.**
5. Start the thinning/harvesting with healthy stands, and then move to infected areas. Cleaning of logging equipment (tires, cutting head, etc) with pressured water prior to leaving the harvest site may be considered to minimize the risk of the spread of Heterobasidion root disease to a new location.
   Note: The significance of equipment contamination on the long-distance introduction of this disease is unknown. Spores of Heterobasidion root disease appear to stay alive in dry soil for one year or longer. Since harvesting equipment inevitably creates wounds on stems and roots, and the pathogen could enter through a wound and infect a tree, at this point, washing at least contacting parts of the equipment before entering uninfected areas is believed to be a good cautious approach.
6. After harvest, the site may be planted or naturally regenerated to conifers. In the southeastern United States, regeneration losses have been documented to be a total of approximately 5% with additional disease development following thinnings. This data is not yet available for Wisconsin. Some losses of regeneration are expected for our area as mortality of red and white pine regeneration within disease centers of Heterobasidion root disease has been observed. Some deciduous trees are susceptible but tend to sustain lower mortality; conversion to hardwoods, if appropriate for the site, should be considered.
   Note: Field studies to investigate the survival of regeneration of a variety of native conifer and deciduous tree species are in progress in Wisconsin.

Red Pine Pocket Mortality

Management options (Experimental) (Continued from page 6):

I. Harvesting options (Continued)

Caution: The following two options (options d and e) are at this point highly experimental. The effectiveness of the following practices has not been proven. Furthermore, there are some scientific articles that point out some negative effects of these practices. Details of the negative effects by pursuing the following practices are explained below. Discussions with a forester and/or a forest health specialist would be recommended before these practices are pursued.

d) Cut dead trees and trees that are showing dieback and/or yellowing of the foliage (fader trees), cut a buffer area around the pocket, and create root graft barriers around the buffer area by severing the root system. Apparently healthy trees outside the pocket, extending ½ to 1 chain (1 chain = 66 feet) from the perimeter of the last fader trees may be harvested to utilize the wood before the trees succumb to the disease. A pocket created by RPPM often expands over time. Based on field observations in Central Wisconsin, it is estimated that a pocket expands approximately ½ chain in 5-7 years and at least 1 chain in 10-15 years. A clearcut buffer area of ½ chain or 1 chain from the perimeter of the pocket can be created for a pre-salvage purpose. Root severing is conducted using a trencher (ditch witch) or a vibratory plow. A large-scale field study to evaluate the effectiveness of root severing on the control of RPPM was conducted in Wisconsin as a cooperative project between the University of Wisconsin, Department of Entomology and the Wisconsin Department of Natural Resources, and field data collection was completed. The analysis of the data is in progress.

Note: This practice will inevitably create wounds on roots and may provide additional entry courts for Heterobasidion root disease if the fungus exists in the site. Thus it is not recommended in or near a stand where Heterobasidion root disease is suspected.

Cutting fader trees will help reduce the population build-up of bark beetles in the stand. Bark beetle population increases dramatically during dry summers especially when breeding materials are left on site. Breeding material includes recently cut or killed trees, stressed trees, or logging slash greater than two inches in diameter. If cutting is conducted from March through August, it is recommended that logs and large slash be removed from the site within 3 weeks of cutting.

Roots are severed using a trencher

Right after the site is trenched.

Heterobasidion Root Disease

Management (Continued from page 7):

III. If Heterobasidion root disease is not present in the stand:

Once the disease exists in a stand, it is very difficult to control it. **Prevention of this disease is the best approach.** If you are planning a thinning, consider treating freshly cut stumps with fungicides. Stumps must be treated as soon as possible after cutting and no later than one day after cutting. Fungicides will help prevent new infections, but will not stop the growth of the pathogen if the stump is already infected. There are factors that influence the risk of infection by Heterobasidion root disease. A risk-based fungicide treatment guide is available for landowners and property managers in Wisconsin to determine whether fungicide treatment is warranted in a particular stand. For more information about the guide, visit http://dnr.wi.gov/ key word "annosum".

Currently the only product that is available in Wisconsin to prevent Heterobasidion root disease is Cellu-Treat (disodium octaborate tetrahydrate). Cellu-Treat is a water-soluble powder and can be applied using a backpack sprayer or an attachment to a harvester.

Where to purchase fungicides

Cellu-Treat: available in 25-lb bucket or 50-lb bag from Nisus Corporation. As of December 2014, the cost for a 25-lb bucket is $90.00 plus shipping.
Nisus Corporation - Phone: 1-800-264-0870 Website: www.nisuscorp.com

Cellu-Treat Local Distributor:

Crop Production Services, Plainfield	Phone: 715-335-4900
Servco FS, Antigo	Phone: 715-627-4844; 800-807-9900

Cellu-Treat application using a backpack sprayer

A perforated sawbar Liquid fungicide is sprayed through small holes at the time of felling

Red Pine Pocket Mortality

Management options (Experimental) (Continued from page 8):

I. Harvesting options (Continued)

e) **Cut dead trees and trees that are showing dieback and/or yellowing of the foliage (fader trees), cut a buffer area around the pocket as described above, and treat the stumps with a herbicide, such as Garlon 4 (Triclopyr), Tahoe 4E (Triclopyr)[1] or other products that are labeled for cut surface applications.**

Apparently healthy trees outside the pocket, extending ½ to 1 chain from the perimeter of the last faders may be harvested to utilize the wood before the trees succumb to the disease. A pocket created by RPPM often expands over time. Based on field observations in Central Wisconsin, it is estimated that a pocket expands approximately ½ chain in 5-7 years, and at least 1 chain in 10-15 years. A clearcut buffer area of ½ chain or 1 chain (1 chain = 66 feet) from the perimeter of the pocket can be created for a pre-salvage purpose. Herbicide treatment of the stumps may promote root death and discourage the spread of the fungus, *Leptographium* spp. The effectiveness of this treatment on the control of RPPM is unknown.

Note: There are some reports that the use of herbicides may increase the risk of introduction and spread of Heterobasidion root disease. This treatment may compromise the management of Heterobasidion root disease, thus it is not recommended in or near a stand where Heterobasidion root disease is suspected.

Cutting fader trees will help reduce the population build-up of bark beetles in the stand. Bark beetle population increases dramatically during dry summers especially when breeding materials are left on site. Breeding material includes recently cut or killed trees, stressed trees, or logging slash greater than two inches in diameter. If cutting is conducted from March through August, it is recommended that logs and large slash be removed from the site within 3 weeks.

II. Although rarely practical, removing freshly cut stumps will reduce feeding sites for the root collar weevil and the red turpentine beetle. These beetles are considered to be vectors that transmit the root disease.

Relationship to Thinning:

Red pine pockets are more common in thinned stands than in unthinned stands. The increased activity of the insects known to vector *Leptographium* spp. and/or the change in microclimate following a thinning, are likely related to the initiation of this syndrome in thinned stands.

Thinning is a necessary management tool used to maintain healthy and vigorous red pine plantations. Overstocked or very dense stands of red pine are more susceptible to attack by bark beetles. Thus, **continue to thin red pine plantations as planned by a professional forester.**

Relationship to Mixed Plantings:

RPPM has only been observed affecting red pine. Observations of stands where rows of white pine were mixed with rows of red pine have shown that pocket mortality is limited to red pine, even when growing in close proximity to white pine and other tree species. Consult with a professional forester regarding your options for mixed plantings.

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[1]You are responsible for using chemicals according to the manufacture's current label directions. Not following label directions is a violation of the federal law. Follow directions exactly to protect the environment and people from chemical exposure.
Reference to a particular product is provided for the reader's information and is not an endorsement of one product over other similar products.

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