

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 Annosum root rot
Lower right: Annosum fruit bodies





**Wisconsin Department of Natural Resources
Division of Forestry
Forest Health Protection
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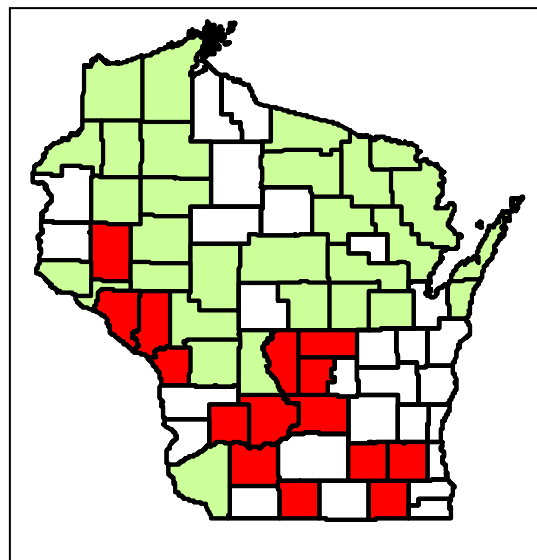
Aerial survey services provided by the Wisconsin DNR , Aeronautics Services within the Division of Administration and Technology.
All photos taken by DNR Forest Health Protection Staff unless otherwise indicated.

Annosum Root Rot

Introduction: Annosum root rot, caused by the fungus, *Heterobasidion annosum* 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. Over 200 woody species have been reported as hosts. **Red, white and jack pine and white spruce** are the species most likely to be infected; particularly in plantation-grown stands subjected to thinning.

Known Locations: Annosum root rot has been observed in fifteen counties including Adams, Buffalo, Columbia, Dunn, Green, Iowa, Jefferson, LaCrosse, Marquette, Richland, Sauk, Trempealeau, Walworth, Waukesha and Waushara. Infection has been observed on red, white and jack pine.

-  Counties surveyed for Annosum root rot.
-  Counties where Annosum root rot has been found



Symptoms & Signs:

Crown symptoms typically appear 2-3 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 annosum* fruit body, typically seen in summer.



H. annosum fruit body in the fall

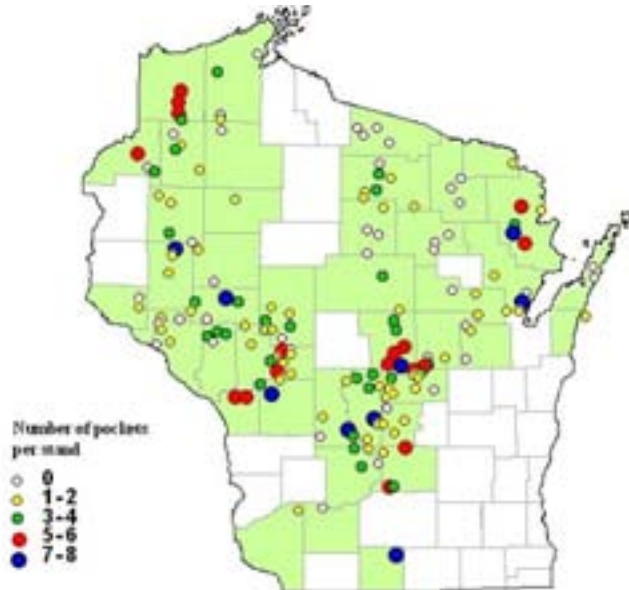


Underside of *H. annosum* fruit body

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*.

Annosum Root Rot

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 Annosum root disease and thinned stands.

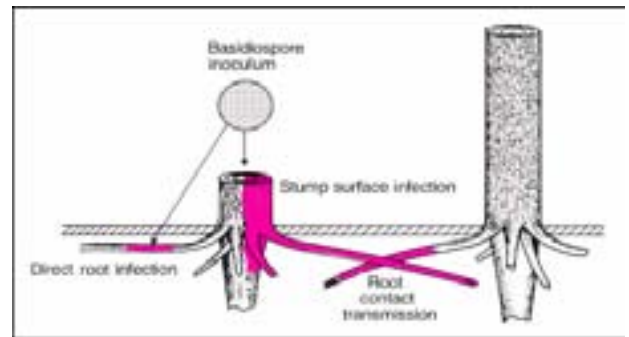
Basidiospores are most often produced when the temperature is between 41° - 90° F (5° - 32° C) and can be carried in the wind over hundreds of miles; most spores are deposited within 300 feet (90 meters).

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.

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

Impact: Infected trees will have reduced height, shoot and diameter growth and thin foliage. These symptoms typically appear 2-3 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. Red, jack and white pine seedlings and saplings in close proximity to infected overstory may also become infected. 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 Annosum root rot and red pine pocket mortality can occur in the same stand and even within the same pocket.

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. Annosum root rot is most damaging in plantation-grown conifers where thinnings provide infection courts (fresh stumps) and root grafts provide a pathway for Annosum to move from tree to tree.



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



Stringy, yellow decay caused by *Heterobasidion*



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

Red Pine Pocket Mortality

Biology: Insect vectors including root collar weevil (*Hylobius radialis*), 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

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 Annosum root rot and red pine pocket mortality can occur in the same stand and even within the same 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.



Annosum Root Rot

Management:

I. If Annosum 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 Annosum root rot 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 $\frac{1}{2}$ 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 $\frac{1}{2}$ 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 Sporax (sodium tetraborate decahydrate¹). Sporax will help prevent new infections but will **not stop the movement of Annosum 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 Annosum root rot 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 Annosum root rot to a new location.
Note: The significance of equipment contamination on the long-distance introduction of this disease is unknown. Annosum spores appear to stay alive in dry soil for one year or longer. Since harvesting equipment inevitably creates wounds on stems and roots, and the Annosum fungus 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 Annosum pockets 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 $\frac{1}{2}$ 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 $\frac{1}{2}$ chain in 5-7 years, and at least 1 chain in 10-15 years. A clearcut buffer area of $\frac{1}{2}$ 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.

Annosum Root Rot

Management (Continued from page 5):

II. If Annosum 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 Annosum root rot 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 Sporex (sodium tetraborate decahydrate¹). Sporex will help prevent new infections but will **not stop the movement of Annosum 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 Annosum root rot to a new location.
Note: The significance of equipment contamination on the long-distance introduction of this disease is unknown. Annosum spores appear to stay alive in dry soil for one year or longer. Since harvesting equipment inevitably creates wounds on stems and roots, and the Annosum fungus 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 Annosum pockets 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 $\frac{1}{2}$ 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 $\frac{1}{2}$ chain in 5-7 years and at least 1 chain in 10-15 years. A clearcut buffer area of $\frac{1}{2}$ 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 is in progress in Wisconsin as a cooperative project between the University of Wisconsin, Department of Entomology and the Wisconsin Department of Natural Resources. The study is scheduled to be completed in 2009.

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

Annosum Root Rot

Management (Continued from page 7):

III. If Annosum is not present in the stand:

If you are planning a thinning, consider treating freshly cut stumps with Sporax (sodium tetraborate decahydrate¹). Sporax will help prevent new infections. The risk of infection by Annosum will be higher when a stand is closer to infected stands. The known locations of Annosum root rot are listed in this publication. These locations are based on the surveys conducted in randomly selected plantations in 2003 and confirmed reports of Annosum. Since the probability of additional infection centers being present in Wisconsin is high, this treatment is recommended throughout the state of Wisconsin. In counties where Annosum root rot is confirmed, or are adjacent to a county where the disease is confirmed, it is extremely important to pursue this practice. Once the disease exists on a stand, it is very difficult to control it. **Prevention of this disease is the best approach.**

Preventive Treatment:

Sporax has been used successfully to prevent establishment and growth of *Heterobasidion annosum* in cut stumps of conifer tree species that are **not** already infected. Sporax is a product currently registered by the EPA for this use in Wisconsin. **Stumps must be treated as soon as possible after cutting and no later than one day after cutting.** Sporax is typically applied from a container with a perforated lid. One pound of Sporax will cover 50 square feet of stump surfaces. This is equivalent to 260, 6-inch (15 cm) diameter stumps or 60, 12-inch (30 cm) diameter stumps.

Sporax is available in 25-pound bags from Wilbur-Ellis Company.
As of January, 2006, the cost for a 25-pound bag is \$61.25 plus shipping.
Shipping cost per bag will be reduced when multiple bags are purchased as one order.
Wilbur-Ellis Company
P.O.Box 15289, Sacramento, Ca, 95851-0289
Phone: 1-800-426-3491
Website: www.wilbur-ellis.com



Sporax is available in a 25-pound bag



Sporax is applied salt-shaker style on the surface of a freshly cut stump.

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 Annosum root rot. This treatment may compromise the management of Annosum root rot, thus it is not recommended in or near a stand where Annosum root rot 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.

¹You 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.

Contact information

For further information, or to report the presence of Annosum root rot or Red Pine Pocket Decline, contact a member of the DNR Forest Health Protection staff.

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To order a copy of this publication, contact your DNR regional forest health specialist or Kyoko Scanlon.

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