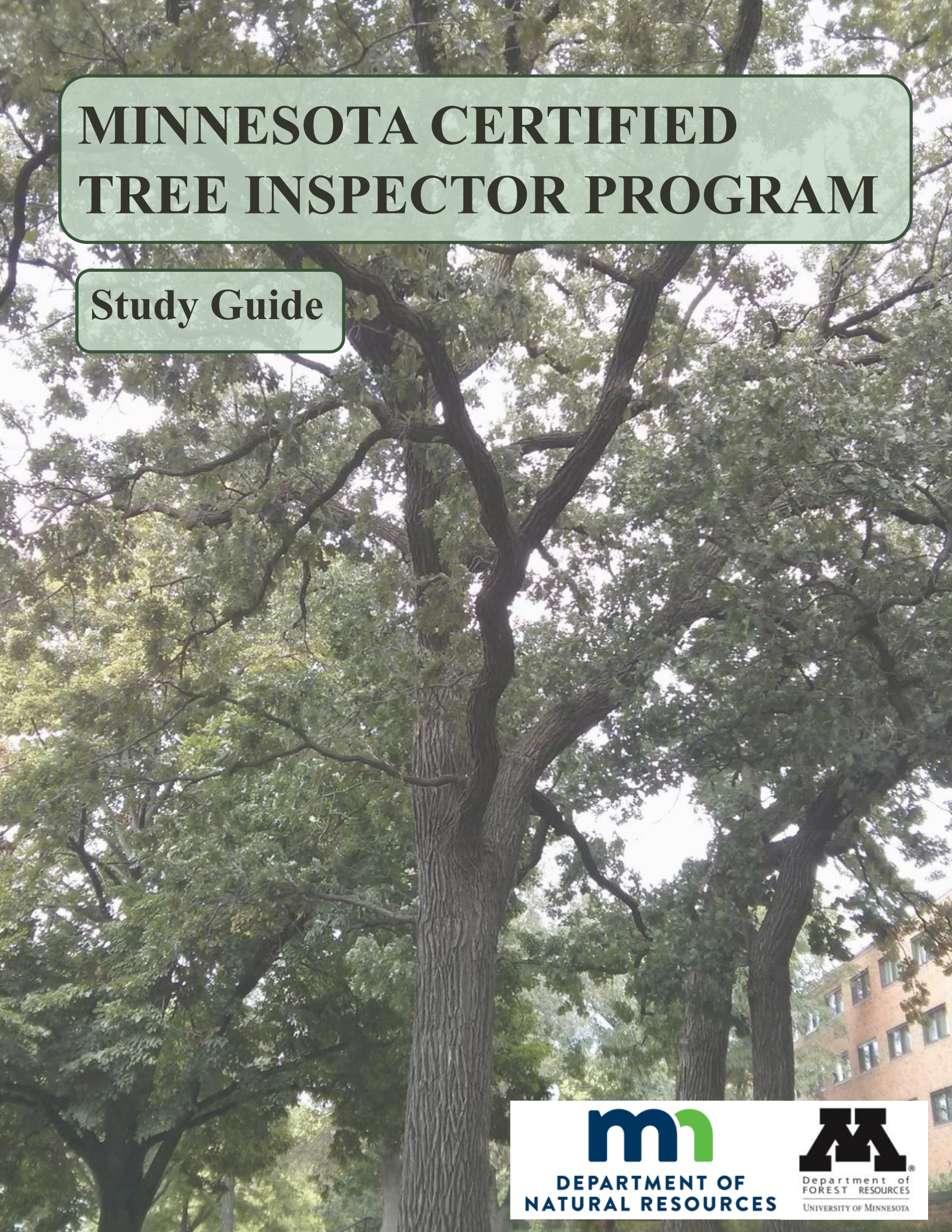
MINNESOTA CERTIFIED TREE INSPECTOR PROGRAM

Study Guide



DEPARTMENT OF NATURAL RESOURCES

Department of FOREST RESOURCES
UNIVERSITY OF MINNESOTA

USING THE MINNESOTA TREE INSPECTOR PROGRAM STUDY GUIDE

The materials included in this study guide, and accompanying study links, provide all essential information needed to answer the questions contained in the Certified Minnesota Tree Inspector Exam.

A **"Section Review Quiz"** is located at the end of many sections and topic areas. These quizzes focus on important sections or topics and represent the types of questions you'll find on the certification exam.

"**Supplemental Materials"** are also included in this manual. They are provided solely for individual study and reference. THESE MATERIALS ARE NOT COVERED IN THE TREE INSPECTOR EXAM.

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Supplemental

SECTION 1: PROGRAM OVERVIEW, DNR GOVERNANCE AND REGULATIONS

Minnesota Certified Tree Inspector Program:

Overview, Rules and Regulations

History & Overview:

Implemented in 1974 in response to Dutch elm disease and oak wilt, the Minnesota Tree Inspector Program has grown to serve hundreds of communities and is approaching 1,000 certified inspectors in 78 of Minnesota's 87 counties (Oct. 2013). In the face of new pressures the program has been broadened to include information on emerald ash borer as well as other invasives and diseases affecting Minnesota's natural and urban landscapes. Inspectors must pass an exam where they demonstrate proficiency in Dutch elm disease, oak wilt management, emerald ash borer, tree identification, firewood identification, best planting practices, and shade tree management. To retain certification, tree inspectors must attend six hours of annual pre-approved trainings or events. Qualifying events are determined by the University of Minnesota. A current list of qualifying events is found at www.mntreeinspector.com.

Certification FAQ's:

Why should I become certified?

There are many reasons people choose to become certified. The most common are:

- Professional development.
- Maintaining employment. Many tree care professionals, especially in the public sector (Park & Rec., S.W.C.D., public works employees, etc.) are required to have and maintain certification.
- Seeking employment. In both the private and public sector, it is increasingly common for employers to require Tree Inspector Certification as a prerequisite for a job interview.

How do I become certified?

To become certified as a new tree inspector, you must pass an examination that measures knowledge in shade tree pest identification and management. Most exams are given at the end of "New Tree Inspector Certification Workshops" or at the "Forest Pest First Detectors" workshop. Study manuals available at www.mntreeinspector.com on the "Resources" page.

New Tree Inspector Workshops are held twice a year. A person must receive a score of 70 percent or better to become certified. The workshop combined with your study packet provide the necessary information so you can demonstrate the following qualifications:

- Ability to identify all native tree species common to your area with or without leaves, and all felled or downed trees with bark intact.
- Knowledge and understanding of the biology of Minnesota's most common shade tree pests.
- Familiarity with symptoms of oak wilt and Dutch elm disease, and the ability to identify other problems affecting oaks and elms.
- Knowledge of proper sample collecting methods for disease diagnosis.
- Knowledge of the approved control methods for common tree pests.

Recertification FAQ's:

How do I recertify?

Tree inspectors must take one continuing education workshop every year by Dec. 31 to receive a certificate for the following calendar year. Tree inspector recertification is valid for one calendar year (Jan. 1 through Dec. 31). Your certification will expire if you do not attend a recertification workshop. If your certification lapses and you wish to be certified again, you must retake and pass the exam.

How do I recertify?

A total of 6 hours is needed annually for recertification through a qualifying workshop or event. Events that qualify toward recertification can be found atwww.mntreeinspector.com.

If you desire to seek recertification through an event other than the Shade Tree Short Course or other University of Minnesota sponsored workshops and the event meets the education criteria below, it could qualify for recertification. *In this instance you must submit an event or workshop agenda to the Tree Inspector Certification Program Coordinator for review and approval; it is recommended you do this at least two weeks prior to an event. Email treesins@umn.edu*

Sample agendas at a workshop qualifying for recertification can focus on any of the following:

- Biology of native or invasive plants, insects or disease pests, or disorders affecting shade trees
- Identification of symptoms characteristic of new insect, plant, and disease problems affecting shade trees other than those of Dutch elm disease and oak wilt
- Proper methods of collecting and submitting samples for possible new plant, insect, or disease diagnosis
- Identification of invasive pest threats to Minnesota trees, including but not limited to gypsy moth, emerald ash borer, sudden oak death, Asian longhorned beetle and others as appropriate
- Recognizing hazard trees (high, moderate, and low levels of risk associated with urban trees)
- Minimizing decay, storm damage, and maintenance damage to landscape trees
- Correcting structural defects in young trees
- Planting practices
- Diagnosing tree and shrub diseases, disorders, or damage

How often must I recertify?

Recertification is a yearly process. You must complete all 6 of your recertification hours by the expiration date printed on your Tree Inspector card. Recertification is valid until Dec. 31 of the following calendar year.

Firewood Regulations in Minnesota

Firewood movement in Minnesota is regulated through state and federal pest quarantines by the Minnesota Department of Agriculture (MDA). Minnesota has an exterior Quarantine for firewood. No firewood is allowed to enter the state of Minnesota without compliance agreements and written permission from the MDA. Firewood cannot leave a pest quarantine without certification, a compliance agreement, or written permission from the MDA. Any person violating these quarantine regulations is subject to civil penalties up to $7,500.00 per day of violation or misdemeanor penalties set forth in Minnesota Statutes Sections 18J.10 (2011) and may be subject to criminal penalties set forth in Minnesota Statutes Sections 18J.11 (2011).

What is firewood?

Firewood is defined as – ALL NON-CONIFEROUS wood in lengths less than 4 feet, for commercial or private use, split or not.

Firewood Movement

It's illegal to move uncertified hardwood firewood out of quarantined counties. Moving firewood can move harmful invasive species.

- Firewood cannot enter Minnesota from other states and Canada.
- Firewood cannot leave the emerald ash borer quarantine without Heat Treatment Certification from the Minnesota Department of Agriculture.
- Firewood cannot leave the *Lymantria dispar* quarantine without out compliance and inspection.
- Firewood can move around inside of a pest quarantine.
- Firewood can move outside of a pest quarantine if it did not originate from a pest quarantine.
- If firewood is moved into a pest quarantine, it is now regulated and cannot leave the pest quarantine.

Firewood Labeling

All firewood offered for sale must have proper labeling. Certified (Figure 1.) and non-certified (Figure 2.) label must include:

- Name (person or company)
- Address
- Contact number or email
- County of harvest
- Volume/weight of firewood in bundle

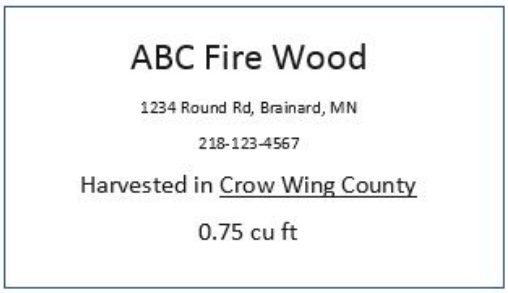


Figure 2. Non-Certified Label

Figure 1. Certified Label

What is certified firewood?

- The Minnesota Department of Agriculture's heat treatment certification means the firewood producer operates a kiln that has passed a rigorous inspection and testing process.
- Certified firewood has been heat treated, so the core of the firewood meets a minimum temperature of 140degrees for 60mins. This is the temperature threshold to ensure emerald ash borer does not survive in the firewood.
- Look for the certified safe-to-move logo at gas stations and other retail locations across the state.
- The Minnesota DNR does NOT Certify firewood. The Minnesota DNR no longer has a firewood vendor approval program.

Figure 3.Certified Logo

Firewood on DNR Lands

The Minnesota DNR makes their own rules for what wood is allowed on state lands. The following is allowed on state lands.

- Firewood purchases at a state park can be used only in the park it is purchased in.
- Firewood that has been certified by the Minnesota Department of Agriculture. Certified firewood may be used on any DNR lands in the state. Look for the certified safe-to-move logo on the firewood bundles when purchasing.
- If the firewood bundle is not certified, the wood must be harvested in the same county the state land is in. The county of harvest must be on the label.
- Dimensional lumber scraps that are kiln-dried, unpainted, unstained, and free of any metal or foreign substances.

Additional Information

- Minnesota DNR
  - https://www.dnr.state.mn.us/firewood/index.html
- Minnesota Department of Agriculture Firewood
  - https://www.mda.state.mn.us/plants-insects/firewood-information
- More questions about firewood? Contact Arrest the Pest
  - https://www.mda.state.mn.us/plants-insects/arrest-pest

What's In That Wood Pile?

Identifying 3 families commonly found in Minnesota firewood piles

Gary Johnson, Rebecca Koetter, Peter Gillitzer and Dave Hanson

Revised: January, 2016. Gary Johnson ; May, 2020. Ryan Murphy

Firewood identification and quarantine has been one of the most important tactics for managing oak wilt (OW) (Figure 1) and Dutch elm disease (DED) (Figure 2) in the Upper Midwest. Both of these fungal diseases can spread from standing dead and dying trees to healthy trees by insects (vectors) that are attracted to fresh pruning wounds or healthy trees. Logs or firewood from these trees can be a safe haven for many months for both the disease spores and those vectoring insects if the bark is not removed and/or the woodpile is tarped.

First identified in Detroit, MI in 2002 the emerald ash borer (EAB) has been killing both urban and rural trees (Figure 3). All MN native ashes of the genus *Fraxinus* (green, black, white) are susceptible to this aggressive insect and once again, monitoring the movement and storage of firewood is critical to a complete management program. The transportation of firewood from ashes killed by and harboring the borer is the main way the insect is spreading across Minnesota.

Figure 1: Oak tree infected with oak wilt. *Photo courtesy of Joseph O'Brien*

Figure 2: Elm tree infected with Dutch Elm Disease. *Photo courtesy of Dave Hanson*

Elm (*Ulmus* species), oak (*Quercus* species) and ash (*Fraxinus* species) have unique wood grain and bark characteristics. Often it is a combination of these characteristics that distinguish the exact species, and sometimes even odors and colors help. Very often, firewood piles have wood from both mature tree trunks as well as smaller, younger branches. Often, the bark from tree trunks and tree branches of the same species look very different, so firewood identification from bark samples alone can be difficult and confusing.

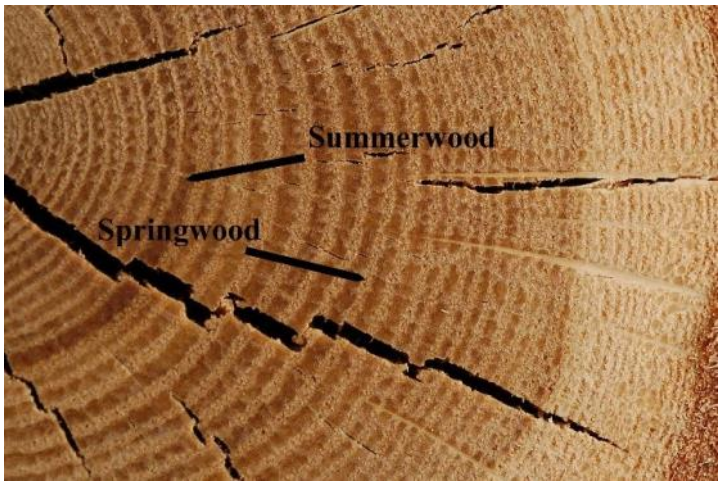
When bark is not enough to identify a piece of firewood, a close examination of the end grain is necessary. A sharp knife or a tri-cut pruning saw, a 10x hand lens, and a liquid that will enhance the end grain all help the process. Shellac or boiled linseed oil very effectively enhance end grain. Simply spray or brush the liquid on and the wood features (pores, rays, rings) become much more obvious. Even water works for a short time.

Figure 3: Epicormic sprouting that occurs ~2 years after EAB infestation. *Photo courtesy of Pennsylvania Department of Conservation and Natural Resources*

Types of End Grain

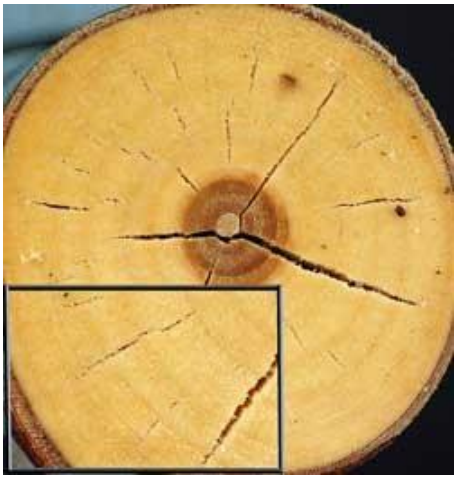
There are three types of end grain that are important when sorting through firewood piles and studying cross sections: ring porous, diffuse porous, and semi-ring porous. Of these three types only one type - **ring porous**- is important for identifying wood that may house a harmful disease or insect in Minnesota. All species in the oak family, elm family and ash family have ring porous wood. Identification by end grain type may be difficult but with enough practice you will be able to distinguish it from diffuse porous firewood.

Ring Porous: Distinct earlywood (larger pores) and latewood (smaller pores) within an annual growth ring.



Examples: Oaks, elms (including hackberry), ash

Diffuse Porous: Pores within Springwood and Summerwood are not distinctively different. Wood within an annual ring tends to look uniform.



Examples: Maples (including boxelder), birches, sometimes poplars, basswood (a.k.a. linden), ironwood, buckeye, black cherry

Elm family (including hackberry)

Ring Porous:
Springwood has 1-5 rows of large pores depending on species. *Earlywood* has small pores arranged in a wavy "tire track" pattern (Figure 5).

Sapwood: white to tan colored.
Heartwood: brown to reddish brown.

Cross-section of American elm (*Ulmus americana*) and Rock elm (*Ulmus thomasii*) bark: alternating bands of dark and light coloredthat give the appearance of "bacon strips" or sandwich cookies (Figure 5).

Figure 4: Elm leaves (including hackberry) have an inequilateral base. *Photo courtesy of Dave Hanson*

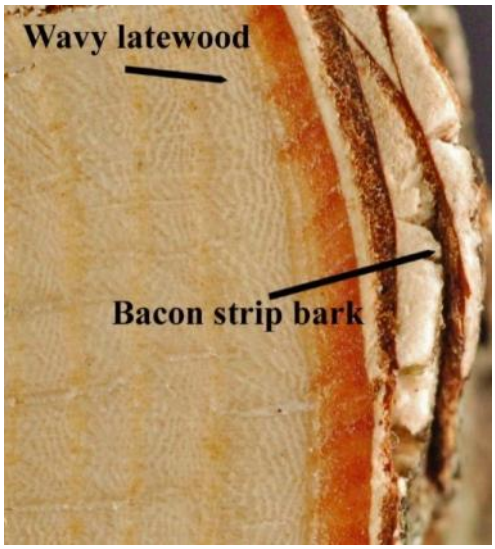


Figure 5: Alternating bands resembling bacon and summerwood arranged in "tire track" pattern. *Photo courtesy of Peter Gillitzer*

Figure 6: Corky hackberry bark. *Photo courtesy of Petr Kapitola*

Hackberry, often mistaken for elm, also has small summerwood pores arranged in a wavy "tire track" pattern; however, it is not susceptible to Dutch elm disease. Corky and rough bark is characteristic of this species (Figure 6).

Miscellaneous: Split sections of elms have stringy, long grain.

Oak family

Oak wilt is a fungal disease that attacks all species of oak in Minnesota including species in the **red oak group-** Northern red oak (*Q. rubra*), Northern Pin oak (*Q.* ellipsoidalis), Eastern pin oak (*Q. palustris*), and black oak (*Q. velutina*) and species in the **white oak group-** white oak (*Quercus alba*), bur oak (*Q. macrocarpa*), and swamp white oak (*Q. bicolor*). Red oak identification is most important because it is so susceptible to oak wilt and is the firewood most likely to have spore mats under the bark.

Red Oak Group

The smaller diameter pieces of wood have flat, gray, and smooth bark. Larger diameter pieces have ridged and furrowed bark.

Figure 7: Species of red oaks have pointed margins. *Photo courtesy of Dave Hanson*

Figure 8: Mature bark of red oak (*Q. rubra*) *Photo courtesy of Dave Hanson*

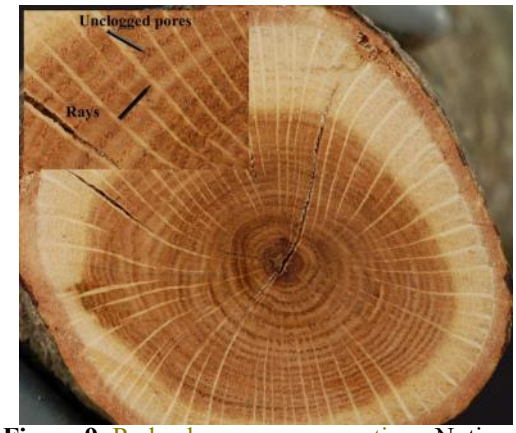


Figure 9: Red oak group cross-section. Notice earlywood pores are unclogged and some latewood pores are visible with a hand lens. *Photo courtesy of Peter Gillitzer*

White Oak Group

White oak group: Bark ranges from gray and platy (*Q. alba*) to deeply ridged and furrowed (*Q. macrocarpa*).

Figure 10: Species of white oaks have rounded lobes. *Photo courtesy of Dave Hanson*

Figure 11: Mature bark of bur oak (*Q. macrocarpa*) *Photo courtesy of Dave Hanson*

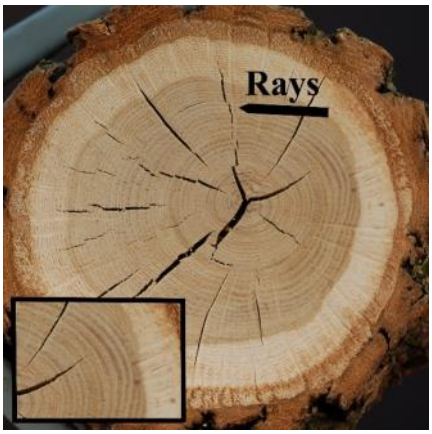


Figure 12: White oak group cross-section. Notice most earlywood pores look clogged or not visible to the naked eye and latewood pores are not visible with a hand lens. *Photo courtesy of Peter Gillitzer*

(Oak family continued)

Ring porous

Earlywood has 1-4 large pores wide. *Latewood* is darker and pores are very small.

Extremely large rays are visible to the naked eye.

Miscellaneous: Freshly cut or split red oak is very fragrant (fruity odor).

Ash family

Bark: green ash often deeply furrowed, narrow ridges, diamond to canoe shaped; ash gray to ash brown.

Leaves: 5-9 leaflets; compound

Ring porous

Earlywood has 2-4 large pores wide with abrupt transition to *latewood* which has very small pores.

Miscellaneous: Unlike oak, extremely large rays are absent to the naked eye.

Figure 13: Leaves of ash trees are compound. *Photo courtesy of Dave Hanson*

Figure 14: Mature bark of green ash *Photo courtesy of Dave Hanson*

Figure 15: Cross-section of green ash. Notice earlywood pores being 2-4 pores wide. *Photo courtesy of Peter Gillitzer*

Glossary:

Diffuse porous- all pores are of equal size and can be found evenly distributed throughout the growth rings

Heartwood- center of tree usually darker in color composed of dead cells but used as structural integrity of the tree.

Growth ring- contains two layers (springwood and summerwood) of cells resulting in one year of growth.

Ring porous- pore sizes found in springwood and latewood are very different in size forming a conspicuous band.

Sapwood- a layer of actively growing wood immediately under the bark extending to the heartwood.

Earlywood / Springwood- large cells formed when the tree is actively growing and are usually visible without a hand lens.

Latewood / Summerwood- small to tiny cells formed during slow growth and are not usually visible without a hand lens.

Tyloses- "balloon-like" swellings found in the earlywood pores in transition areas from heartwood to sapwood of some deciduous trees *e.g.* white oaks.

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Special thanks to Harlan Petersen, Assistant Extension professor, University Of Minnesota and members of the Minnesota Shade Tree Advisory Committee and Shade Tree Advocate Committee.

SECTION 3: DUTCH ELM DISEASE IN MINNESOTA

How to Identify and Manage Dutch Elm Disease

United States Department of Agriculture Forest Service - Northeastern Area

1998

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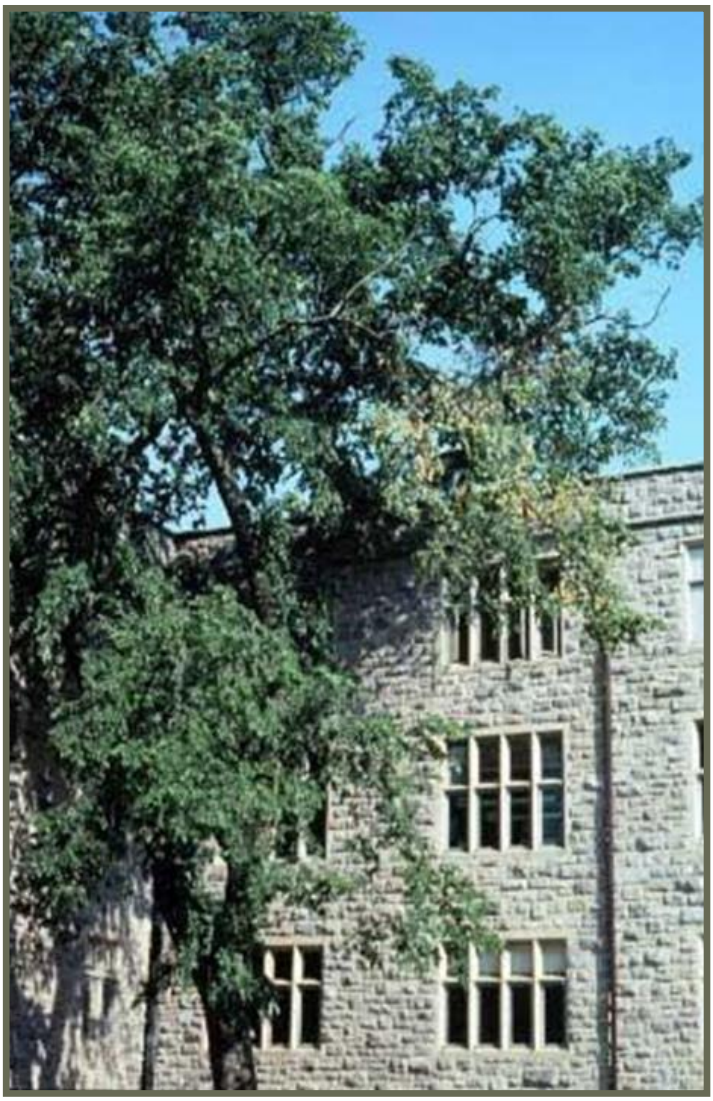
Cover photo: Branch flagging symptoms from a single point of Dutch elm disease infection in crown of elm. (*Photo courtesy of Dr. R. Jay Stipes*.)



Contents

Introduction

At one time, the American elm was considered to be an ideal street tree because it was graceful, long-lived, fast growing, and tolerant of compacted soils and air pollution. Then Dutch elm disease (DED) was introduced and began devastating the elm population. Estimates of DED losses of elm in communities and woodlands across the U.S. are staggering (figure 1). Because elm is so well-suited to urban environments, it continues to be a valued component of the urban forest despite the losses from DED. The challenge before us is to reduce the loss of remaining elms and to choose suitable replacement trees for the ones we cannot save.

This guide provides an update for urban foresters and tree care specialists with the latest information and management options available for Dutch elm disease.

Figure 1. This photo is all too typical of the devastation caused by Dutch elm disease. Once a tree in a row is infected, the disease can move through connected root systems to kill the entire row. *Photo courtesy of USDA Forest Service via Dr. R. Jay Stipes, Virginia Polytechnic Institute and State University*

Symptoms

DED symptoms are the result of a fungus infecting the vascular (water conducting) system of the tree. Infection by the fungus results in clogging of vascular tissues, preventing water movement to the crown and causing visual symptoms as the tree wilts and dies.

Foliage symptoms: Symptoms of DED begin as wilting of leaves and proceed to yellowing and browning. The pattern of symptom progression within the crown varies depending on where the fungus is introduced to the tree. If the fungus enters the tree through roots grafted to infected trees (see disease cycle section), the symptoms may begin in the lower crown on the side nearest the graft and the entire crown may be affected very rapidly. If infection begins in the upper crown, symptoms often first appear at the end of an individual branch (called "flagging") and progress downward in the crown (cover photo).

Multiple branches may be individually infected, resulting in symptom development at several locations in the crown (figure 2). Symptoms begin in late spring or any time later during the growing season. However, if the tree was infected the previous year (and not detected), symptoms may first be observed in early spring. Symptoms may progress throughout the whole tree in a single season, or may take two or more years.

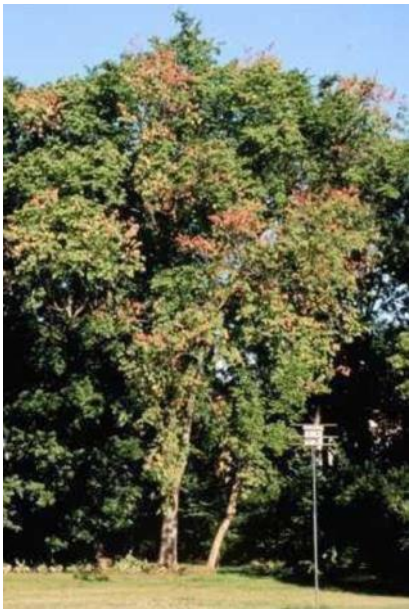


Figure 2. Branch death, or flagging, at multiple locations in the crown of a diseased elm. *Photo courtesy of Dr. Steve Katvich,USDA Forest Service, St. Paul,MN.*

Vascular symptoms: Branches and stems of elms infected by the DED fungus typically develop dark streaks of discoloration. To detect discoloration, cut through and peel off the bark of a dying branch to expose the outer rings of wood. In newly infected branches, brown streaks characteristically appear in the sapwood of the current year (figure 3). It is important to cut deeply into the wood or look at the branch in cross section for two reasons: (1) As the season progresses, the staining may be overlaid by unstained wood, and (2) if infection occurred in the previous year, the current sapwood may not be discolored.

Distinguishing Dutch Elm Disease From Other Problems

Other pest problems commonly observed on elm include leaf spot diseases, which cause dark spots of dead tissue in the leaves, and elm leaf beetles, which eat holes in the leaves. These problems are easily distinguished from DED. Elm leaf beetles do not carry the same Dutch elm disease fungus that elm bark beetles do.

Two other diseases, elm yellows and bacterial leaf scorch, are more easily confused with DED.

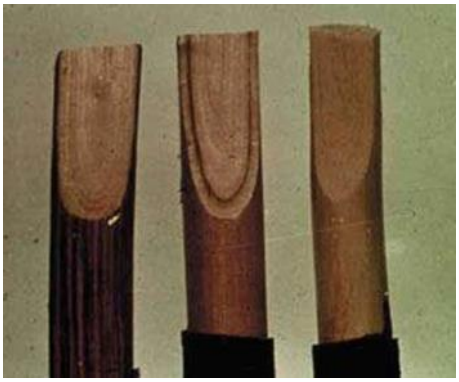


Figure 3. Brown streaking develops in sapwood of branches infected by Dutch elm disease fungus. Streaking is visible here (from left to right) in: (1) the newly formed sapwood, (2) spring sapwood overlaid by uninfected summer wood, and (3) is absent in an uninfected branch. *Photo courtesy of the America Phytopathological Society.*

Elm yellows. This disease, which is also called elm phloem necrosis, is caused by a phytoplasma (microscopic bacteria-like organism) which systemically infects the phloem tissue (inner bark) of the tree. It is a serious disease that causes tree death. Symptoms of elm yellows differ from DED in that the leaves turn yellow (not brown and wilted) and drop prematurely, and the symptoms appear in the entire crown at the same time. The brown streaking which DED causes in the sapwood is absent, but the inner bark develops a tan discoloration and a characteristic wintergreen odor.

Bacterial leaf scorch. This disease is caused by the bacterium *Xylella fastidiosa*, which infects and clogs the water conducting tissues of the tree. Infection by this bacterium causes a slow decline over many years. Once a tree is infected, symptoms recur annually. Symptoms of scorch are irregular browning along the leaf margin with a yellow border between green and scorched leaf tissue. Older leaves on a branch are affected first.

Disease Cycle of Dutch Elm Disease

The biology, or "disease cycle," of DED depends upon the host, the fungus and the means by which the fungus moves into new host trees (figure 4).

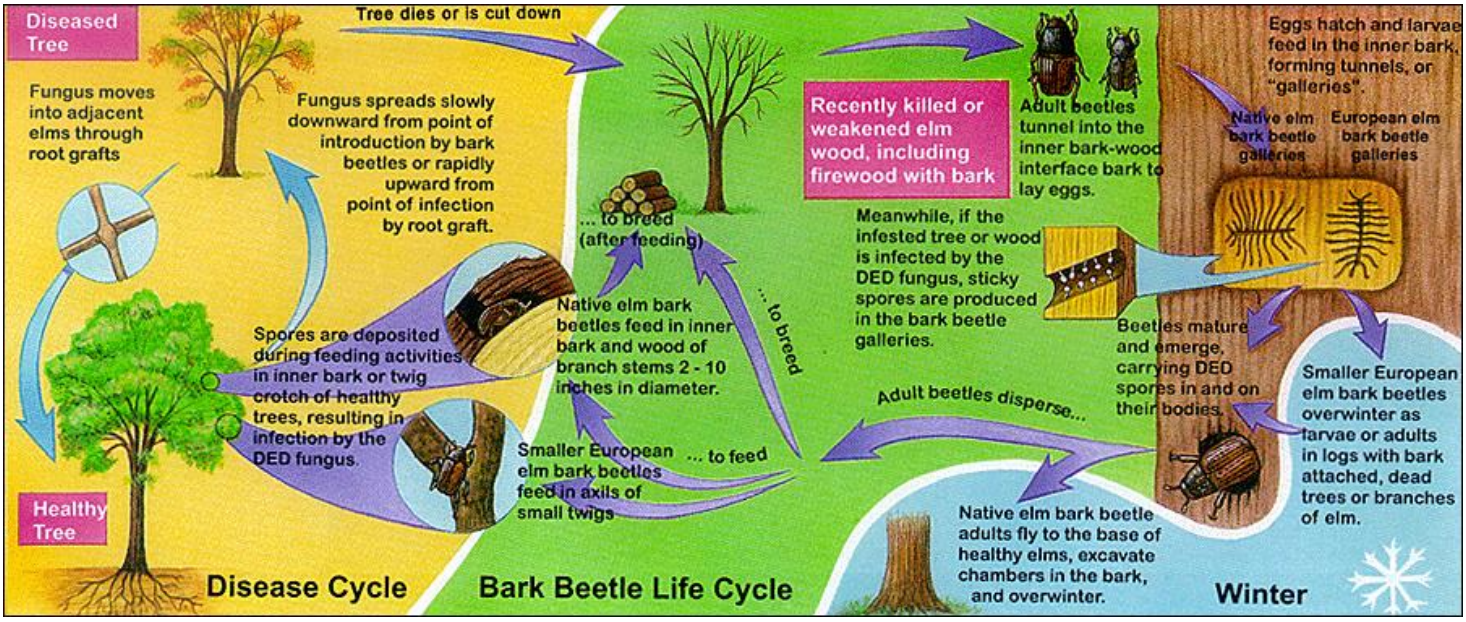


Figure 4. The disease cycle of Dutch elm disease is closely linked to the life cycle of elm bark beetles. *Artwork by Julie Martinez, Scientific Illustrator, St. Paul, MN*

The elm host. Native species of North American elms vary in their susceptibility to DED, even within species. American elm (*Ulmus americana* L.) is generally highly susceptible. Winged elm (*U. alata* Michx.), September elm (*U. serotina* Sarg.), slippery elm (*U. rubra* Muhl.), rock elm (*U. thomasii* Sarg.), and cedar elm (*U. crassifolia* Nutt.) range from susceptible to somewhat resistant. No native elms are immune to DED, but some individuals or cultivars have a higher tolerance (and thus may recover from or survive with infection) or resistance to DED. Many European and Asiatic elms are less susceptible than American elm.

In addition to genetic factors present in some cultivars and species, physical factors affect tree susceptibility. These factors include time of year, climatic conditions (such as drought) and vitality of the tree. Water conducting elements are most susceptible to infection as they are being produced in the spring, thus elms are most susceptible to infection after earliest leafing out to midsummer. Trees are less susceptible under drought conditions. Vigorously growing trees are generally more susceptible than slower growing trees.

The Dutch elm disease fungus. DED can be caused by either of two closely related species of fungi: *Ophiostoma ulmi* (Buism.) Nannf. (formerly called *Ceratocystis ulmi*) and *Ophiostoma novo-ulmi* Brasier. The latter, which is more aggressive in causing disease, was recently recognized as being a separate species. The DED fungus was first introduced to the U.S. on diseased elm logs from Europe prior to 1930. It is unknown when the more aggressive species became established in the U.S.; however, it was possibly present as early as the 1940's-1950's, and most likely caused much of the devastating mortality through the 1970's. The less aggressive species is becoming increasingly rare in nature, and the aggressive species is thought to be responsible for most of the current mortality. Although some local resurgence of DED has been observed, there is no evidence that it is due to a change in the pathogen. Localized resurgence is more likely due to the following: (1) a decrease in vigilance in monitoring and sanitation, (2) a build-up in populations of the insect vectors, or (3) ingrowth of susceptible host trees in the wild.

Spread by elm bark beetles. Overland spread of DED is closely linked to the life cycles of the native elm bark beetle (*Hylurgopinus rufipes* Eich.) and the smaller European elm bark beetle (*Scolytus multistriatus* Marsh.) (figure 5). Both beetles are attracted to stressed, dying or dead elm wood to complete the breeding stage of their life cycle. The adult beetles tunnel into the bark and lay their eggs in tunnels (called galleries) in the inner bark. The eggs hatch and the larvae feed in the inner bark and sapwood.

The larvae mature into adults and emerge from the elm wood. If the DED fungus was present in the wood that the beetles infested, the fungus produces sticky spores in the beetle galleries. Spores of the DED fungus are eaten by or stick to the adult beetles as they emerge from diseased trees. Adult beetles then visit healthy trees, feed in twig crotches or branch inner bark, and introduce the fungus into or near severed wood vessels as they feed.

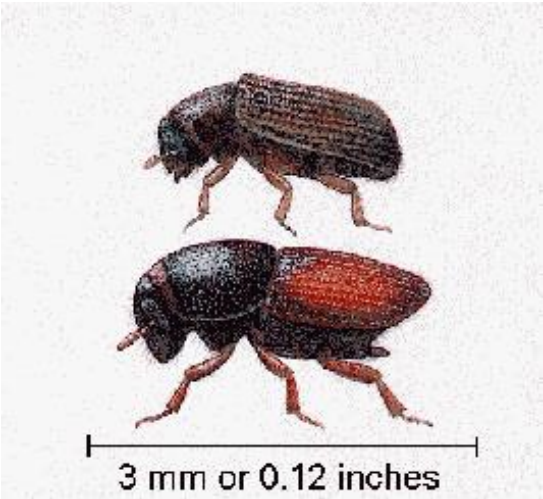


Figure 5. Overland spread of DED is closely tied to the life cycles of the Native elm bark beetle (top) and smaller European elm bark beetle (below). Note that the smaller European elm bark beetle is actually larger than the native elm bark beetle. *Artwork by Julie Martinez, Scientific Illustrator, St. Paul, MN*

The importance of the two bark beetle species as vectors of DED varies across the range of elms. In northern areas (northern parts of Minnesota, Wisconsin, Maine, New York and New England and most of Canada, where winter temperatures below -6° F are common), the native elm bark beetle is the predominant vector. In other parts of North America, the smaller European elm bark beetle predominates. The life habits of the adults of the two species differ considerably, which has implications for management opportunities. These differences are described below.

Smaller European elm bark beetles overwinter as larvae or adults within the stem of the tree where they hatched. They emerge as adults in spring to feed in twig crotches of healthy trees, where they can introduce spores of the DED fungus to the crown. High numbers of beetles frequently will feed in a single tree, resulting in multiple points of infection. The cycle is repeated when beetles then seek out diseased and dying wood to breed in throughout the growing season, completing two or more generations per year. They have the potential to rapidly build up high populations.

Adult native elm bark beetles tunnel into the bark on the lower stems of healthy elms to overwinter. In spring they emerge to feed in the inner bark of elm branches and small stems before beginning their breeding cycle. They repeat their life cycle as previously described. They can transmit the DED fungus to healthy trees during the construction of overwintering sites in fall, or, more commonly, during feeding in spring.

Once the DED fungus is introduced into the upper crown of healthy elms by bark beetles, it slowly moves downward, killing the branch as it goes. Disease progression may occur rapidly, killing the tree by the end of the growing season, or may progress gradually over a period of two or more years. It is also possible that the tree may recover. The success and rate of progression within the tree depends on tree size, time and location of infection in the tree, climatic conditions, and response of the host tree.

Figure 6. Where elms are closely spaced, the Dutch elm disease fungus may move down a row of trees through grafted roots. Removing trees without breaking root grafts may not keep the fungus from moving into adjacent trees. *Photo courtesy of Dr. Joseph O'Brien, USDA Forest Service, St. Paul, MN*

Spread through grafted roots. Roots of the same or closely related tree species growing near each other often cross each other in the soil and eventually fuse (become grafted) to each other.

The DED fungus can move from infected trees to adjacent trees through these grafted roots. Infections that occur through root grafts can spread very rapidly throughout the tree, as the fungus is carried upward in the sapstream. Root graft spread of DED is a very significant cause of tree death in urban areas where elms are closely spaced (figure 6).

Managing Dutch Elm Disease

DED is managed by interrupting the disease cycle. The most effective means of breaking the cycle is early and thorough sanitation to limit the population of the insects that transmit the fungus from tree to tree. Other useful means of affecting the disease cycle include using insecticides to kill the insect vector, breaking root grafts between trees, injecting individual trees with fungicides to prevent or halt the fungus, out early infections, and planting DED tolerant or resistant elm cultivars or other tree species.

Sanitation to reduce insect vectors. Many communities have been able to maintain a healthy population of mature elms through a vigilant program of identification and removal of diseased elms and (systematic of) weakened, dying or dead branches. Sanitation by prompt removal of diseased trees or branches reduces breeding sites for elm bark beetles and eliminates the source of the DED fungus. To be completely effective in interrupting the spread of the disease by elm bark beetles, stems and branches of DED infected trees must be de-barked, destroyed, or utilized before the bark beetles emerge. During the growing season, removal should be completed within 2 to 3 weeks of detection. During the dormant season, removal should be completed before April, when overwintering beetles may begin to emerge.

Wood from infected trees can be destroyed by chipping, burning or burying. Wood may be retained for use as firewood or sawlogs if it is de-barked or covered from April 15th to October 15th with 4 to 6 mil plastic. The edges of the cover must be buried or sealed to the ground. If it is impossible to destroy all elm wood before the beetles emerge, the wood can be sprayed with a registered insecticide until disposal is possible. If insecticides are used, consider potential exposure to chemical residues when burning or handling the treated wood. Many communities have regulations on the removal of diseased elms and storage of elm firewood; make sure your activities comply with local regulations.

Insecticides to kill insect vectors. In areas where the native elm bark beetle is the principal vector, sanitation may be augmented by applying a registered insecticide to the lower stem of healthy elms in late summer to early fall (i.e., at the first sign of autumn leaf color change) to kill adult beetles as they prepare overwintering sites. In areas where the smaller European elm bark beetle are common, spring feeding in twig crotches can be prevented by spraying the crowns of elm trees with a registered insecticide. However, this may not be a preferred treatment method because of the difficulty in getting thorough coverage of all susceptible twig tissue, the risk of insecticide drift and exposure, and high expense.

Insecticide registrations and recommendations are frequently updated, and may vary considerably between states. Cooperative Extension Services at land grant colleges and certified arborists are able to provide current insecticide recommendations.

Disruption of root grafts. Large trees within 25 to 50 feet of each other are likely to have root grafts. Breaking root grafts between infected trees and adjacent healthy trees is an important means to prevent movement of the fungus into the healthy trees. Root grafts should also be disrupted between the healthy tree adjacent to a diseased tree and the next healthy tree. It may even be desirable to sever grafts between very valuable trees before DED is observed in the vicinity, as a proactive measure.

Root graft disruption should be completed before the infected trees are removed. Otherwise the transpirational pull from healthy trees will rapidly draw in the contents of diseased tree's root system when the vascular tension on the roots of the diseased tree is released by severing the stem. Root graft disruption can be accomplished by use of a vibratory plow or any trenching machine equipped with the longest blade available (preferably five-feet long, but at least three-feet long). Biocidal soil fumigants may also be used to kill root grafts if no other alternatives are available. However, these chemicals are generally restricted use pesticides and may only be applied by professional pesticide applicators. In addition, biocidal chemicals may not be effective if soil temperatures are below 50 °F.

Injecting elms with fungicide. Certain fungicides, when properly injected, are effective in protecting elm trees from infection via beetle transmission. This treatment is expensive and must be repeated every one to three seasons, thus it is appropriate only for high value or historically important trees. The treatment itself also may pose risks to the health of the tree.

In order to be effective, the fungicide must be present at adequate concentration at all potential points of infection. Thus the dosage and means of application are critical to success. The injection of chemical into root flares in large volumes of water (macroinjection) provides thorough distribution of chemical in the crown (figure 7). Microinjection (injection of small volumes of concentrated chemical) is also an option, although it's efficacy compared to macroinjection has not been thoroughly researched. Preferably, injections should be done

Figure 7. Macroinjection of fungicide into the root flare of an elm. *Photo courtesy of Mark Stennes, certified arborist, St. Paul, MN*

soon after the earliest leaves have fully expanded, but may be done from then to the end of the growing season. Label rates of concentration for chemical application are updated to reflect the most recent findings on effectiveness; always follow the current label.

Harmful effects of fungicide injection have sometimes been reported and include occasional leaf "scorching" or loss. Elms generally recover from this damage. Also, drilling injection holes results in wounding which, if repeated annually, may eventually result in significant discoloration and decay. Following fungicide injection with a flush of clean water can reduce damage to the cambium. Some chemicals are able to protect trees for up to three seasons, thus minimizing the frequency of treatments.

Several fungicides are registered for injection to prevent DED infection. These chemicals vary in duration of protective effects, means of application, risk of damage to the tree, documentation of effectiveness, and cost. Certified arborists or Cooperative Extension Services at land grant colleges are able to provide current recommendations on product availability and effectiveness.

Eradicating Dutch elm disease from newly infected trees. If a new crown infection of DED is detected early enough, there is opportunity to save a tree through , fungicide injection, or both. Eradicative treatment is not possible on trees that have become infected via root graft transmission. Pruning, which can literally eradicate the fungus from the tree by removing it, has a high probability of "saving" a newly infected tree that has less than 5% of its crown affected. To be a candidate for eradicative , the infection must be a new infection (not a residual infection from the previous season) and be present only in the upper crown (not yet present in the main stem). Since infection may be more advanced than symptoms indicate, it is important to peel off the bark of infected branches and locate the staining, which indicates the presence of the fungus. All infected branches should be removed at a branch fork at least 5 feet, and preferably 10 feet, below the last sign of streaking in the sapwood (figure 8).

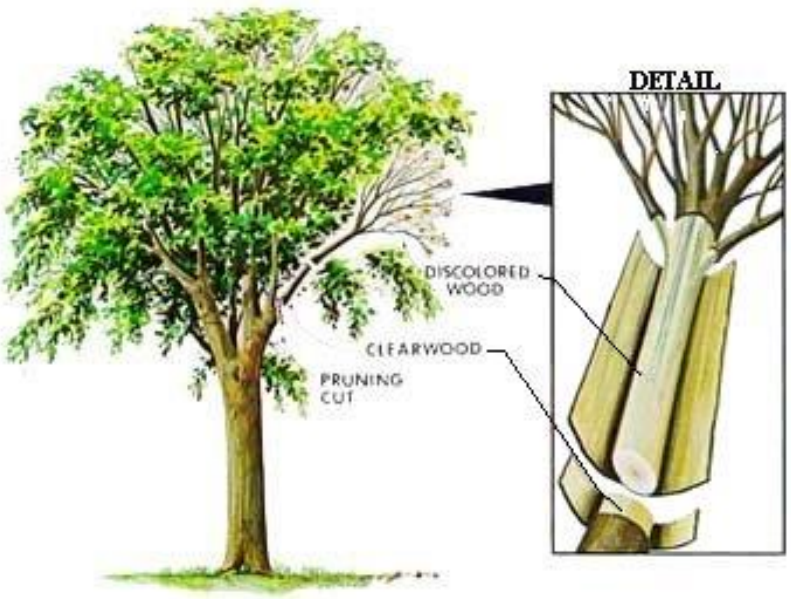


Figure 8. Eradicative of branches infected with DED may be effective if there is adequate length (5 to 10 feet) of clearwood between the infected tissue and the remainder of the crown, or if the tree has been properly treated with fungicide. *Artwork courtesy of Jim Lockyer, USDA Forest Service, Radnor, PA*

Whenever elm branches are pruned during the growing season, paint specifically formulated for use on trees should be applied to prevent attraction of elm bark beetles to the wounded trees. (Painting tree wounds is generally not recommended, except to prevent disease transmission in oaks and elms.)

Pruning is more likely to be effective if augmented by systemic injection of fungicides. Proper use of fungicides eliminates the need to eradicate all infected tissues from the tree, although all dead branches should eventually be removed. Whereas alone is not effective against residual infections, fungicide injection may be. If fungicides are used, they should be injected prior to removal of diseased branches. The keys to successful eradicative treatment are early detection and prompt treatment.

Planting Dutch Elm Disease resistant or tolerant trees. Planting trees with resistance or tolerance to DED is a valid management option. However, selecting only a few cultivars limits the genetic variability of the population. This could lead to increased risk of widespread losses if these cultivars are found to be susceptible to tree health problems such as poor adaptation to site, air pollution, other elm pests or pathogens (such as elm yellows or elm leaf beetle) or even other strains of DED which may eventually develop. Thus it is prudent to plant a mixture of suitable cultivars of as many elm genotypes as possible.

Santamour and Bentz (1995) recently published a checklist and brief description of elm cultivars in North America. The only true American elms on that list that are commercially available and have strong evidence of DED tolerance or resistance are the Princeton Elm, the American Liberty "multi-clone," and Independence, which is one of the cultivars in the American Liberty multi-clone. Two additional American elms, Valley Forge and New Harmony, were released by the USDA National Arboretum since the Santamour and Bentz listing was prepared. These two cultivars, which exhibit high tolerance to DED, should be available through retail nurseries by 2001.

Besides true American elms, there are many other hybrid elm crosses and species of elm that have high tolerance or resistance to DED. Several of these have attractive form, are well suited to urban environments, and are readily available (figure 9). Many of these are listed and described by Santamour and Bentz (1995) in the previously mentioned checklist.

Figure 9. Cultivars of elm selected for resistance to DED are available. This selection of *Ulmus japonica* demonstrates the potential these elms have as landscape trees. *Photo courtesy of Dr. Eugene Smalley, University of Wisconsin-- Madison*

In addition to careful selection of the tree species and cultivar, location and spacing are also important to reduce losses from DED. When selecting landscape trees and their locations, plant a mixture of tree species appropriate to the site. In addition to the species diversity, consider spacing of the trees. Future problems with root grafts can be avoided by carefully selecting planting location and maximizing tree species diversity.

Trees in Natural Stands or Wild Areas

Infected elms in wild areas and natural stands that are within or near urban areas often serve as a reservoir of elm bark beetles and DED fungus to infect high value landscape trees. Management is necessary in order to protect urban elms.

The most effective management option to reduce both the bark beetle vectors and the DED fungus is sanitation to promptly remove stressed, dead and dying elms as previously described. However, this intensity of treatment is often not feasible.

A "trap tree" method was developed in the 1980's to more cost effectively reduce populations of elm bark beetles. Under this method, DED infected elms which are still living are treated with an herbicide that kills the tree quickly and promotes rapid drying out of the bark. The bark beetles are attracted to the dying trees, but the rapidly drying bark is unsuitable for them to complete their lifecycle, and the bark beetle populations are reduced. However, treated trees may then become hazard trees with high risk of falling and causing personal injury or property damage.

Another option in wild areas or natural stands, other than accepting losses from DED, is to eliminate all elms and manage for alternative species. However, it is often desirable to retain elms for biodiversity, aesthetic, economic, or other reasons.

Deciding Which Management Practices to Use

Different management strategies will be applicable depending on whether you are working with a community program or trying to protect individual trees. In a community program, the objective will be to protect a population of elms. Individual landowners, however, may have no control over what neighbors do with their elms but may want to protect or save their own trees. The amount of money an individual or community is able to spend will also vary.

Where you have no control over the management of surrounding trees, the only options available are treatments to protect or save individual trees. Good sanitation practices and disruption of root grafts are necessary on individual properties, but these practices alone will not protect a tree from disease transmission by bark beetles from other properties. Preventive fungicide injection, eradicative and fungicide injection, and insecticide treatment are generally the only options available for individual trees.

In a community program, resources to spend on individual trees may be low, but there is more opportunity to manage populations of elms. Where there are continuous elms, root graft disruption is essential to halt the spread. Sanitation is key to reducing beetle and DED populations, and is effective. Community ordinances can be established to encourage prompt removal of diseased trees and prevent the storage of elm wood with bark intact. Education will help citizens understand the importance and benefits of working together to manage DED. As resources allow, preventive treatment, eradicative treatment and insecticides can be used to augment a program. If you are working with a community with a significant elm resource, become familiar with the literature listed below and with what has worked well in other communities.

The impact of DED on our urban forests has been massive. Despite the losses, elms should and will continue to be a component of many urban forests. We have an opportunity to consider what trees will compose the future urban forest, and we can learn from the past. Landowners and communities can and should choose carefully what types of trees to plant and where to plant them.

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Pesticide Precautionary Statement:

Pesticides used improperly can be injurious to humans, animals, and plants. Follow label directions and heed all precautions on the labels. Store all pesticides in original containers, out of reach of children and foodstuffs. Apply pesticides selectively and carefully. Do not apply a pesticide when there is danger of drift to other areas. After handling a pesticide, do not eat, drink or smoke until you have washed. Dispose of empty pesticide containers properly. It is difficult to remove all traces of a herbicide (weed killer) from equipment. Therefore, to prevent injury to desirable plants do not use the same equipment for insecticides that you use for herbicides.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

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Managing Dutch Elm Disease in Resistant American and Hybrid Elms

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2015

Introduction

Elm trees are more popular now than ever. Since Dutch elm disease (DED) was introduced to the United States, new selections of American elm and hybrid Asian elms have been selected and released. Now, improved commercial availability of disease-tolerant selections have put them on streets, in parks and backyards across the country.

Although often labelled "DED-Resistant", these elm trees are still susceptible to the disease and in some cases are killed by it. More often, though, their resistance, or more accurately, tolerance of the disease allows them to survive an infection in most cases while their wild siblings succumb.

Management

Scouting for Dutch Elm Disease

- Scan the canopy for signs of wilting, yellow or brown foliage or even leafless branches
- Use tools to get a closer look: binoculars, zoom lens, camera, etc.
- Know how to differentiate mechanical damage and breakage from wilting
- If transmitted by root grafts, symptoms may be seen in main stem and on lower branches

Foliar symptoms of DED in Accolade

Foliar symptoms of DED in Valley Forge

Safely Obtaining a Sample

- Collection from the ground – easiest and safest – use pole saw or pole pruners
- Collection from a ladder – use required PPE – and always tie in to the tree
- Other means - bucket truck, professional arborist

Processing the Sample and Diagnosis

- Peel bark or scrape with knife and look for vascular staining under the bark
- Cross section to determine when infected

Processing the Sample and Diagnosis


Peel bark or scrape with knife and look for vascular staining under the bark


Scraped samples of healthy Valley Forge elm (left) and stained, diseased Valley Forge (right)


Cross sections of diseased Accolade elm showing staining in branch (left) and main stem (right)

Submitting a Sample for Lab Confirmation

- Plant Disease Clinic – Department of Plant Pathology, University of Minnesota
- (612) 625-1275 and pdc@umn.edu
- DED Diagnosis and Culture - $59

Sanitation Pruning

- Prune off infected branches, preferably before or at main stem
- Sterilize tools after pruning and between trees with bleach solution or alcohol

Fungicide Treatment

- Depends on size and value of tree
- Severe infections in small trees might warrant replacement rather than treatment

Follow-Up

- Continue scouting and perform vigilant sanitation pruning

Long-Term

- Avoid monoculture, diversify elm plantings with multiple varieties and species
- Water weekly
- Avoid stress and construction damage by protecting root zones.

"Watering-bags" offer a convenient and reliable supply of water to newly planted trees.

Section Review Quiz: Dutch elm disease

1. Dutch elm disease (DED) is caused by:

A. the European elm bark beetle, *Scolytus multistriatus*.
B. the fungus, *Verticillium albo-atrum*.
C. the fungus, *Ophiostoma ulmi*.

2. The spread of Dutch elm disease is primarily caused by:

A. elm leaf beetles.
B. elm bark aphids.
C. elm bark beetles.
D. all of the above.

3. Early- season symptoms of Dutch elm disease from the year before can be confused with:

A. leaf miner and leaf beetle feeding damage.
B. defoliation caused by the cankerworm.
C. heavy seed production.
D. all of the above.

4. During the growing season, elm trees should be inspected for Dutch elm disease symptoms by the following approximate dates:

A. At least once: prior to June 1.
B. At least twice: by June 15 and by September 15.
C. At least three times: by June 15, July 15, and August 15.
D. At least four times: by April 15, June 15, July 15 and August 15.

5. Bark-intact elm wood can be rendered pest-risk free by:

A. chipping, debarking, burning, or burying.
B. stockpiling the wood at the nearest approved utilization site.
C. storing in a garage.
D. all of the above.

Click here to navigate to answer page

SECTION 4: OAK DISEASES IN MINNESOTA

Oak Wilt in Minnesota

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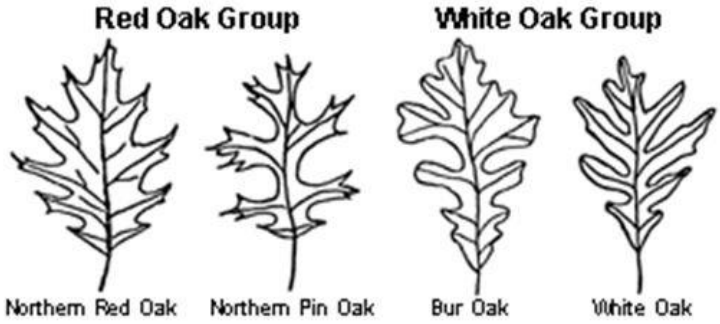
Introduction

Oak wilt, caused by the non-native fungus *Ceratocystis fagacearum*, is responsible for killing large numbers of oaks annually in Minnesota. Oaks are a valuable and abundant shade and forest tree in the state. Oak wilt is most severe in red oak group species such as northern red oak and northern pin oak (Fig. 1). Fortunately, this valuable resource can be protected by utilizing effective management techniques.

Oak wilt occurs in 24 states in the eastern United States and is not known to occur elsewhere. In Minnesota, the disease is currently found in an area bounded on the north by Pine County, on the west by Stearns and Nicollet counties, and south to the Iowa border (Fig. 2). The greatest concentrations of oak wilt are found in Sherburne, Anoka, Isanti and northwestern Dakota counties.



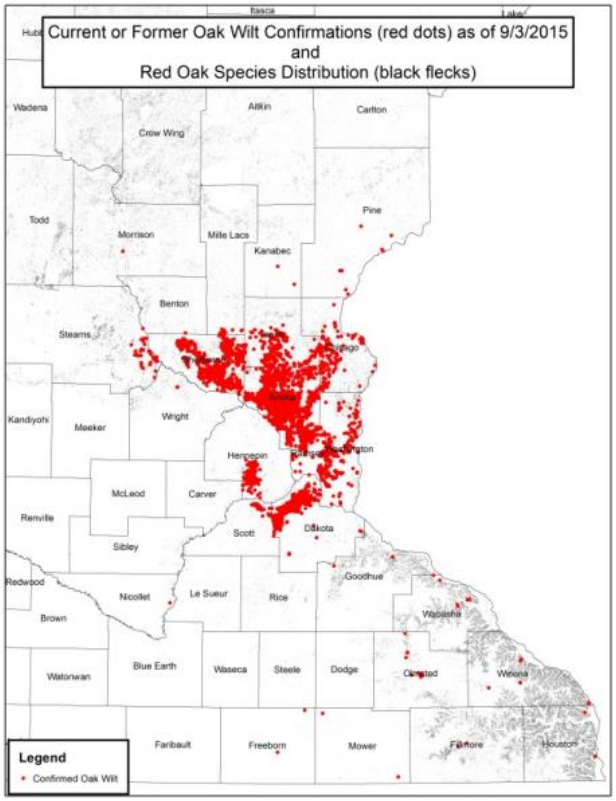


Figure 1. (left) The four most common species of oaks in Minnesota.

Figure 2. (above) Former or current oak wilt locations in Minnesota are shown as red dots.

Symptoms

Red oak group

Following infection, the fungus is quickly transported through the water-conducting system of red oaks and leads to rapid wilting. Wilting usually starts at the top or outer portions of the tree crown and quickly progresses downward.

Leaves take on a bronze to reddish brown discoloration beginning with the tip and margins, progressing toward the midrib and base of the leaf (Fig. 3A). A water-soaked appearance may develop on dark green leaves. Affected leaves are quickly cast and can be found on the ground around the dying tree.

Complete wilting and leaf loss can occur in as little as 4 weeks in branch infections or shortly after leaf-out the spring following root graft infection.

A dark bluish-gray discoloration may be observed on the wood surface when bark is peeled back from a branch with wilted leaves.

White oak group

Affected branches of bur oaks are scattered through the crown (Fig. 3B). Progressive development of the disease may occur year to year with tree death occurring between two and five years or longer after first symptoms develop. Bronzing and browning of leaves generally occurs from the tip and a portion of the leaf margin toward the midrib or base of the leaf, but symptoms may be irregular.

Figure 4. Cross-section of white oak branches show discoloration often seen as small dark dots in the wood just under the bark.

In white oaks, a single main branch or fork of the crown may exhibit wilting leaves during summer but no further symptom development may occur until the next year or following years (Fig. 3C). White oaks in Minnesota have been observed with very slowly progressing symptoms. A dark brown to black discoloration on the wood surface may be found when the bark is peeled back from a branch with wilting leaves. Walled-off fungal infections may also be observed in the cross section of an infected branch (Fig. 4).

Oak wilt lookalikes

Bur oak blight, another common and significant disease of bur oak in Minnesota, can be readily confused with oak wilt. Injury caused by **two-lined chestnut borer** can also be confused with oak wilt. **Anthracnose** may mimic some leaf symptoms of oak wilt, but usually occurs only in the lower crowns of trees.

Figure 3. Oak wilt symptoms on red (A), bur (B) and white oaks (C).

Oak Wilt Fungus Spread

The oak wilt fungus spreads from diseased to healthy trees either below-ground via connected roots or above-ground by insects. Most new infections are the result of fungus transmission through roots of adjacent trees that have grafted together. Frequency of root grafting depends on the oak species involved, the size of the trees, soil type and terrain. For example, root grafting is very common among northern pin oaks on sandy soils in flat terrain. The maximum distance over which root grafting may occur is also dependent on these same factors.

As a general rule, the probability of root graft spread decreases with distance from the diseased trees. For example, the majority of such spread in a Minneapolis-St. Paul urban study was found to occur within 30 feet, but wilt did occur in some trees up to 50 feet from the nearest infected tree. Root grafts may occasionally occur between different species of oak, including species from different oak groups.

Two species of sap beetles (Family *Nitidulidae*) (Fig. 5) are the primary insect transmitters of *C. fagacearum* overland from diseased trees to healthy trees in Minnesota. Insect transmission is important as it is the means by which new oak wilt centers are started.

Sap beetles are attracted to the volatiles produced by the sporulating fungal mats in the bark-wood interface (cambium) of oak wilt-killed trees (Fig. 6). Although mats are commonly produced during the spring and fall, the mats that are produced April through mid-July on red oaks that wilted the previous year are most important in disease spread. This is the same time period during which red oaks produce large diameter springwood vessels that are particularly susceptible to infection by *C. fagacearum*. In addition, the primary sap beetle vector species are strongly attracted to tree volatiles associated with fresh, wood-penetrating wounds. Thus, wounded oak trees visited by fungus-contaminated beetles can result in oak wilt spread, particularly during the spring months. Oak bark beetles (*Pseudopityophthorus* species) are important oak wilt vectors in some parts of the U.S., but are not considered important vectors in Minnesota.

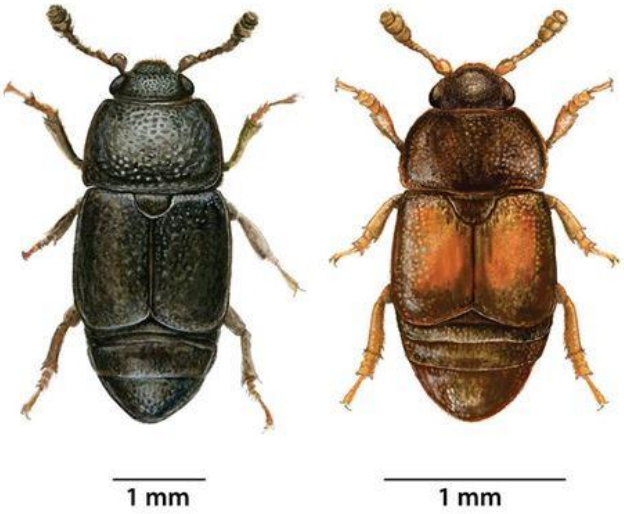


Figure 5. *Carpophilus sayi* (left) and *Colopterus truncates* (right).

Management Strategies

Individual control actions can be taken to stop the spread of the oak wilt fungus, but the coordinated use of several actions is the best strategy.

Accurate diagnosis of the disease is highly recommended before any control action is undertaken. Diagnosis can be done by an experienced tree care professional or by consulting the University of Minnesota's Plant Disease Clinic (http://pdc.umn.edu/).

Stopping belowground spread

Root grafts are most common between closely-related oak species (e.g., red oaks). Healthy trees of a different species can be found in oak wilt infection centers (e.g., bur oaks in a red oak infection center; Fig. 7). Cutting root connections between diseased and healthy oaks is the best way to prevent expansion of existing oak wilt centers. A vibratory plow with a 5-foot long blade is commonly used in Minnesota to cut the roots. Other equipment, such as a trenching machine, backhoe and mini-excavators can be used but are more disruptive to the site, require back-filling with soil, and often do not reach a 5-foot depth.

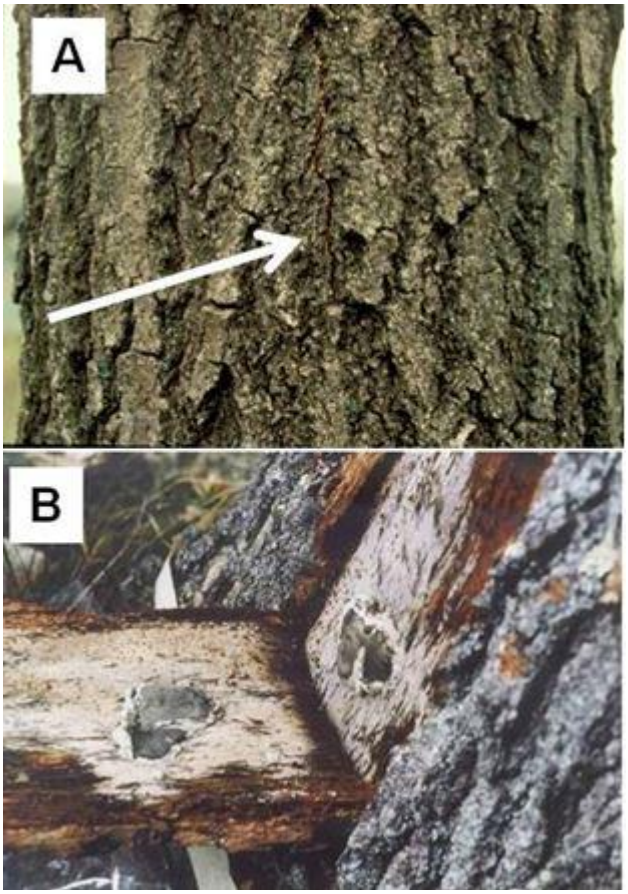


Figure 6. Diagnostics of oak wilt damage showing bark crack (A) and mirror image of sporulating mats (B).

In situations where oaks are near houses, retaining walls, or other structures, carefully digging with shovels has been done but is labor intensive.

Root cutting is done along pre-marked lines that are best placed by experienced tree care professionals. The primary control line is generally placed between the first and second ring (or tier) of healthy oaks out from the diseased trees (Fig. 8). This is because the healthy-appearing trees closest to the diseased trees may already have the fungus in their roots, even if they appear non-symptomatic. When only using a primary control line, the healthy oaks within that line can be removed after root cutting is finished. Alternatively, they may be monitored for several years and removed if they wilt.

A secondary control line may be placed between the diseased and healthy trees to preserve additional trees. This secondary control line often fails though and complicates management efforts.

After establishment of control lines, wilting and recently wilted red oaks should be felled and eliminated by debarking, burning, burying, or wrapping and sealing in four to six mil plastic until the end of September the year following tree wilt.

If not destroyed, the spores that may form on these oaks the following spring could be carried by sap beetles to wounded oaks and start new infection centers.

Figure 7. A healthy bur oak in the middle of an oak wilt infection center impacting northern red oaks, Wabasha County.

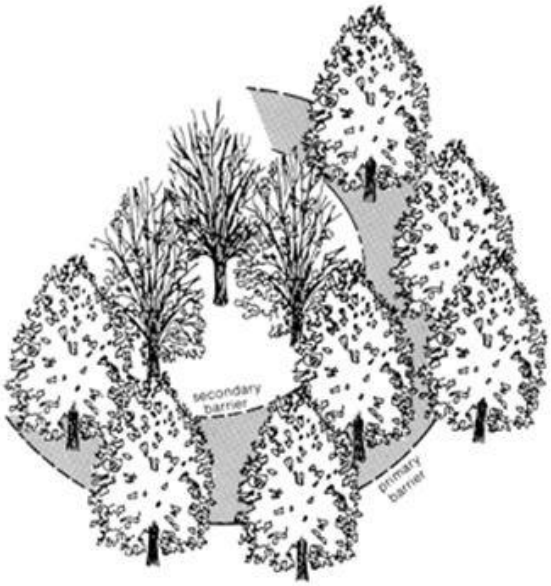


Figure 8. Diagram of root graft barriers around infected trees.

Preventing spread by insects

Avoiding wounding or cutting healthy oaks, particularly during spring and early summer, is important in preventing fungus spread by the sap beetles (Table 1). If branch pruning or tree felling must occur, immediate treatment of the cut surface with water-based paint, a pruning/wound sealer, or shellac is recommended.

Timely removal and proper treatment or disposal of diseased oaks is also critical for preventing insect spread. This is most important for oak wilt-killed red oak species because fungus mats are commonly produced on them. Trees that wilted during the growing season should be felled in the fall or winter and either treated on the property or promptly transported to an approved wood waste utilization site. Options for treatment on the property include debarking of the trunk, burying the main stem and large branches, or cutting logs into firewood lengths and stacking to allow for drying. If diseased trees or firewood are not removed before spring, the cut and stacked logs should be covered with four to six mil clear plastic and sealed at the ground line by late March of the year following tree wilt to prevent beetles from reaching the spore mats. The plastic then can be removed at the end of September of the year following tree wilt and the logs can be safely used for firewood.

Firewood

In general, people should not move logs or firewood from recently wilted oaks to areas where oak wilt is not present. Oak wilt mats may form on these logs. Long distance movements of firewood has resulted in the establishment of oak wilt in distant areas that previously had been unaffected by the disease.

Table 1. Risk of oak wilt fungus spread by sap beetles and advisory comments by general time of year in Minnesota.

Time of Year*	Risk of insect spread	Advisory notes
April through mid-July	High	Don't wound, prune or fell oaks in oak wilt counties during this time period. Immediately cover unavoidable wounds with paint or shellac.
Mid-July through late October	Low	Depending on weather conditions and insect populations, infections could occur but would be rare. Immediately treat pruning wounds, stump surfaces of felled trees and other wounds if desired.
November through March	Safe	Fungal pathogens and insect vectors are inactive

* Exact dates for beginning and end of each time period may vary from year to year. See current risk status at http://www.myminnesotawoods.umn.edu/2010/03/oak-wilt-risk-status-in-minnesota/

Chemical protection

Systemic injection with propiconazole by qualified arborists may prevent oak wilt symptoms for up to two years in healthy oaks if the oaks are not already infected with oak wilt. Propiconazole will not prevent movement of oak wilt through oak roots, and is not a substitute for severing root grafts. Propiconazole treatment of white oaks already exhibiting early symptoms of oak wilt (less than 30% of crown affected) can prevent further disease development for at least two years, but treatment of red oaks already showing symptoms is not recommended.

Integration of control methods

Early detection and accurate diagnosis of oak wilt should always precede implementation of on-site treatments. The greatest success in oak wilt control is obtained with coordinated use of multiple management actions. For example, an integrated management approach for a property with oak wilt could involve root cutting, treatment of high value trees with fungicides, removal of wilted red oaks that are potential oak wilt mat producers, and proper disposal of logs from wilted trees.

Summary

- In Minnesota, oak wilt covers a large area. Check the DNR website for an up-to-date oak wilt disease map.
- Management strategies include stopping belowground spread, preventing spread by insects, not moving firewood from oak wilt-infected areas, and chemical protection.
- Pruning, wounding, or felling oaks should be avoided from early April to mid-July.

Additional resources

Oak wilt risk status in Minnesota (MyMinnesotaWoods)

Plant Disease Clinic (University of Minnesota, Department of Plant Pathology)

How to recognize common diseases of oaks in the Midwest: a quick guide (US Forest Service-Northeastern Area, State and Private Forestry)

What is oak wilt? (Minnesota Department of Natural Resources)

Managing oak wilt: what are the options? (University of Wisconsin Extension)

Figure 9. Keep up-to-date on the current oak wilt risk status at MyMinnesotaWoods

Photo credits: Jennifer Juzwik and Brian Schwingle

This publication was reviewed by Joe O'Brien (US Forest Service) and Kyoko Scanlon (Wisconsin Department of Natural Resources).

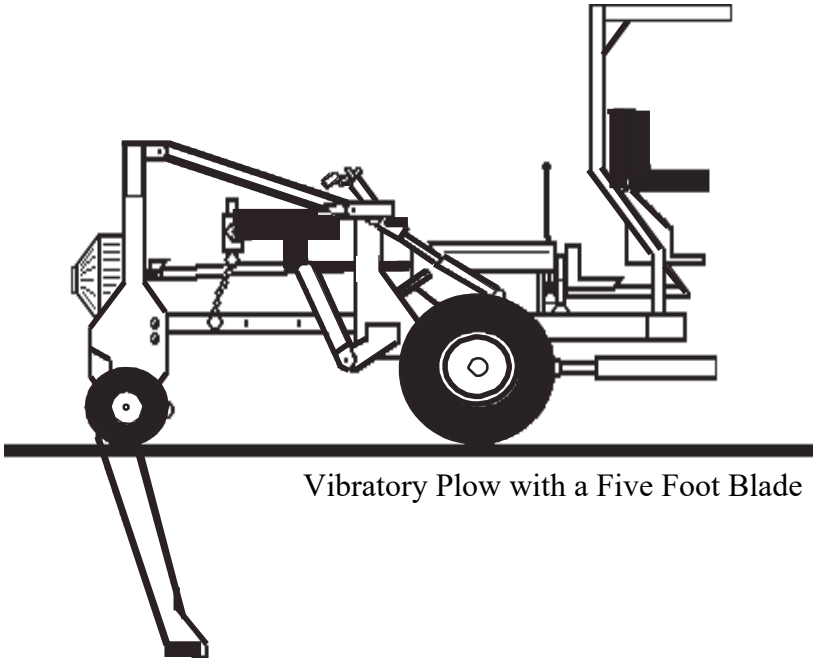
University of Minnesota Extension Publication original location:

https://extension.umn.edu/plant-diseases/oak-wilt-minnesota

Root Graft Barriers for Oak Wilt Control

Minnesota Department of Agriculture

2007



Vibratory Plow with a Five Foot Blade

Oak wilt is responsible for killing more shade trees each year in Minnesota than any other disease causing organism or fungus. Fortunately, it can be successfully controlled if proper measures are taken. Oak wilt, caused by a fungus (*Ceratocystis fagacearum*), attacks the vascular or water- conducting system of oaks, located in the outer ring of sapwood just beneath the bark. In an attempt to protect itself from the fungus, the tree produces gums and tyloses which plug the water conducting vessels. Unable to contain the faster fungus, the tree ultimately cuts off its water and nutrient supply between roots and crown. Visible symptoms (wilting and discoloration of leaves) begin at or near the tree's top or branch ends and progress down and in, accompanied by rapid defoliation. The oak wilt fungus spreads both overland and underground.

DO NOT PRUNE IN MAY OR JUNE. Overland, the oak wilt fungus is spread by picnic beetles (family *Nitidulidae*). These small insects can inoculate a healthy tree only in May or June, and then only when fresh wounds are present. Although less than l0 percent of the oaks dying of oak wilt are believed to be infected this way, it is the only way a new pocket of wilt can start. Control for this type of spread is easy -- oak trees should NOT be cut, pruned or injured from April 15 to July 1.

Root transmission is responsible for 90 percent or more of the trees becoming infected from oak wilt. Roots of adjacent oaks (of the same species) within 50 feet of each other are often grafted together, forming a common root system (see figure 1).

Figure 1. Oak roots often fuse (graft), forming a common root system on wooded sites. The oak wilt fungus can spread from infected to healthy oaks through these root grafts.

The oak wilt fungus spreads through a diseased tree's vascular system, down into its own roots, then through the root grafts into adjacent trees, infecting them as well. What can be done when oak wilt is diagnosed? The answer depends on the species of oak.

WHITE OAKS RESISTANT Trees in the white oak group are resistant to oak wilt. If they become diseased, they may take several years to die or possibly even recover. Bur oaks are intermediate in resistance. Diagnosis of oak wilt and control recommendations in white oaks should be made on an individual basis by a shade tree professional experienced in oak wilt control.

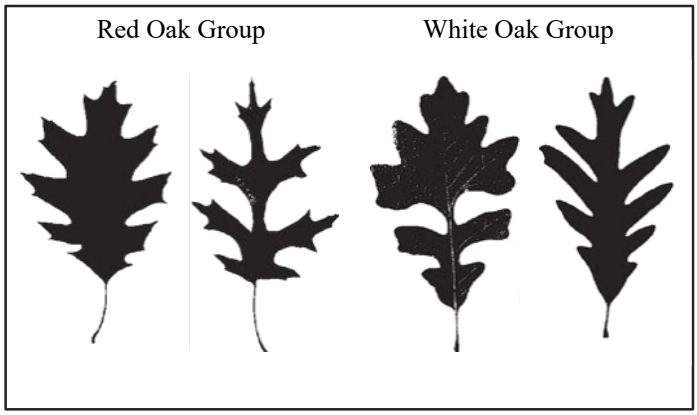
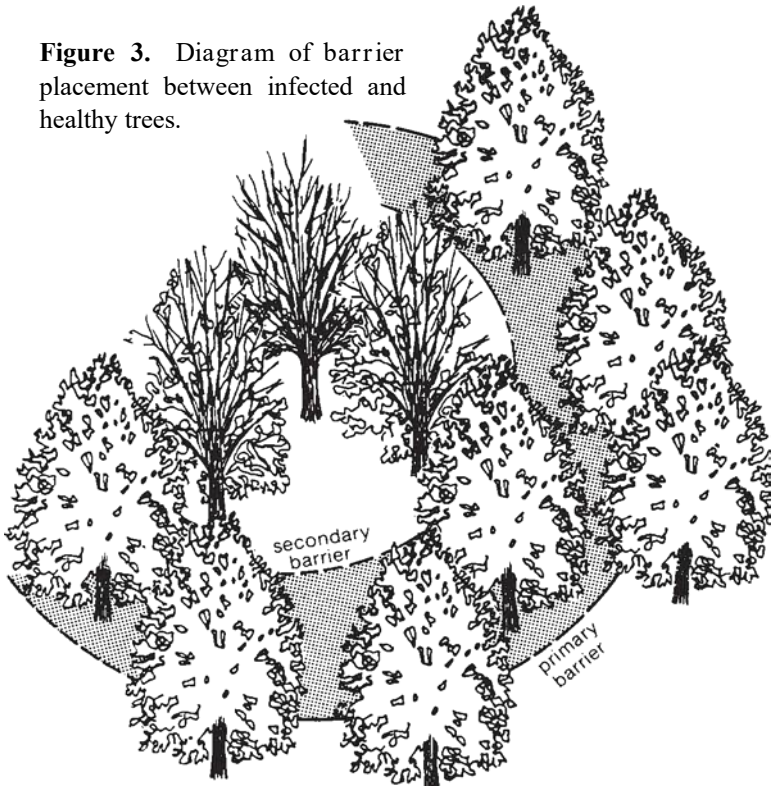


Figure 2. The four most common species of oak in Minnesota from left to right: northern red oak, northern pin oak, bur oak, and white oak.

RED OAKS SUSCEPTIBLE Trees in the red oak group are highly susceptible to oak wilt and do not recover if infected. Once symptoms appear, the tree will wilt completely within a few weeks. If other red oaks are nearby, steps should be taken immediately to prevent spread into healthy trees. When oak wilt symptoms are first noticed in red oaks, the fungus has already spread throughout the tree and into the roots. In fact, the fungus often has already infected the root system of adjacent trees, although they may still look healthy because visible symptoms are not yet apparent.

EFFECTIVE TRENCHING PROVIDES BARRIER Control involves severing or breaking the root connections between diseased and healthy oaks (root graft barriers). The most effective barriers are those placed between the first ring of apparently healthy trees adjacent to the infected ones, and the next set of healthy trees (called primary barriers - see figure 3). A barrier placed between diseased and the first apparently healthy oaks (called a secondary barrier) may not stop the disease because the oak wilt fungus may already be in the adjacent ring of trees, but symptoms are not yet visible. To be successful, all roots between infected and healthy oaks must be cut. Mechanical barriers involve physically cutting the roots with either a trencher or a vibratory plow. This work is most effective when a blade or trencher at least five feet long is used.

Figure 3. Diagram of barrier placement between infected and healthy trees.



A vibratory plow has a shaker attachment that vibrates a 1-inch thick steel blade up and down (see sketch on the front cover). Its action is similar to that of an electric knife. This machine is fast, and creates only a narrow slit in the ground. Since earth is not removed, backfilling is unnecessary. (Both the vibratory plow and the trencher are typically pulled by large, heavy tractors equipped with flotation tires to minimize soil disturbance.) This method is generally the most cost-effective.

A trencher has a boom or blade with a cutting chain that spins around, cutting a trench four to six inches wide. Its action is similar to that of a chainsaw. The trenching blade has a tendency to 'ride up' in the soil, and care should be taken to ensure it remains extended to its maximum depth. Because a trencher removes earth as it cuts, it is significantly slower than a vibratory plow. Persons hiring contractors with trenchers should ask whether the price includes backfilling the trench.

CHEMICAL BARRIER POSSIBLE Another option is a chemical barrier using a soil sterilant known as SMDC or Vapam. One- to two-inch-diameter holes 18 to 24 inches deep are drilled along the barrier line at four-inch intervals, a Vapam solution is poured into the holes, and the holes covered. Vapam kills all roots, including grass and other plants along a strip about 18 inches wide. Commercially, Vapam may be used only by companies licensed with the state for pesticide application.

Whichever barrier method is used, underground utility lines **must** be located in advance.

*Diseased trees **should not** be removed until the root graft disruption work is completed*, if trees wilted that same year. If Vapam is used, infected trees should be left standing for two weeks after application. Removing a tree before root systems are separated may actually speed up the spread of oak wilt. (Note: Trees which are structurally weak may present a hazard to people and property, and immediate removal may be warranted - if in doubt, check with a professional.)

EFFECTIVENESS VARIES Mechanical barriers are the most effective method of stopping the spread of oak wilt -- with a success rate approaching 85 percent (with a 5-foot blade). The success rate for chemical barriers is about 55 percent, and is recommended only in areas where use of a plow or trencher isn't feasible (inaccessible to plow, steep slopes, etc.). Correctly locating these root graft barriers is **extremely** important to their effectiveness. For the greatest success, seek the advice of a shade tree professional experienced in laying out these lines. Other factors which may affect the success of root graft barriers are soil type, tree size and spacing, and the history of disease in the area. (Note: a map of barrier locations can be invaluable if follow-up work is necessary.)

At first, costs for oak wilt control may seem excessive. But the alternative costs of doing nothing (loss of value of healthy trees dying from oak wilt, property value decline, tree removal and increased heating and cooling costs) may be far more expensive. Some contractors charge by the job, by the foot or by the hour. All have a minimum charge to cover the cost of equipment, insurance and transportation. Oak wilt control on a neighborhood or community level is strongly recommended; it can significantly decrease costs while increasing the effectiveness of control work.

Persons hiring contractors to do oak wilt control work on their property should ask for references, inquire about experience, and be sure the contractor is insured.

This brochure was originally developed by David Stephenson with technical assistance from D.W. French, professor of plant pathology at the University of Minnesota. Figure 3 used with permission of the University of Minnesota Extension Service. Figure 1 courtesy of Ken Holman. The oak wilt control program in Minnesota is a multi-agency effort involving the Department of Agriculture, Department of Natural Resources, Minnesota Extension Service, University of Minnesota, USDA Forest Service, and counties and communities across the state.

University of Minnesota- Forest Resources Extension & Outreach, 2007.

Adapted from Minnesota Department of Agriculture, RJH 1999 version.

Oak wilt reviewer, Jennifer Juzwik, USDA Forest Service- Research Plant Pathologist

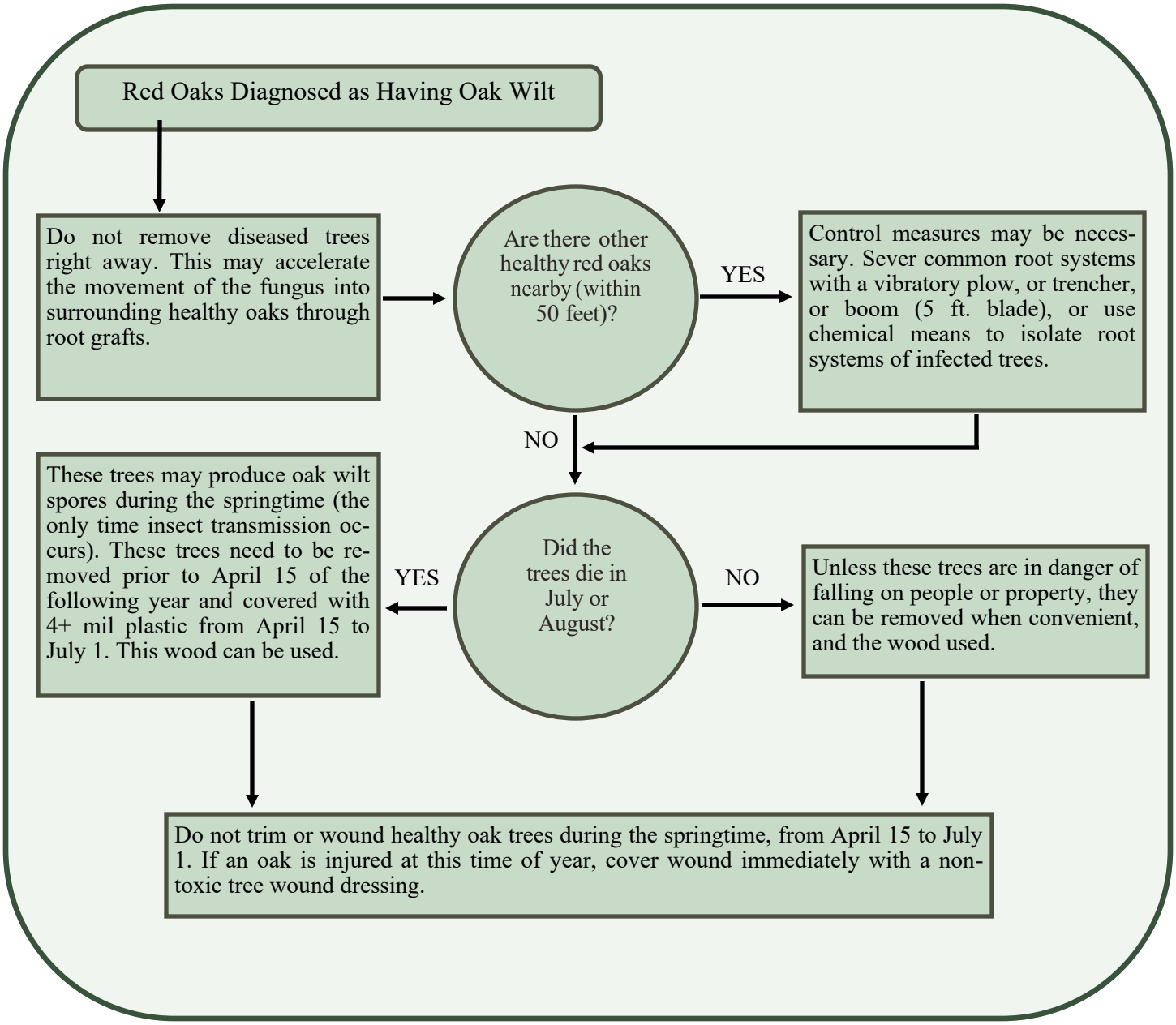


Figure 4. Flowchart - Oak wilt control in red oaks

Control: Dutch Elm Disease vs. Oak Wilt

Minnesota Department of Agriculture

1999

	Dutch Elm Disease	Oak Wilt
Spread	Over 90% is overland by beetles	Over 90% is through root grafts
Control emphasis	Bark beetle reduction	Root graft disruption
	Root Transmission and control	
When symptoms are first visible	The fungus is in the general area of the wilt symptoms (when infection is from beetles).	The fungus is throughout the tree and into the root system.
Control	1. Immediate removal to prevent movement of fungus into roots. Radical if wilt is very isolated. 2. If the infection is from root transmission, root graft disruption should be done first!	Root graft disruption if healthy oaks (of the same species) are nearby. Do not remove the tree first!
	Aerial Transmission and Control	
Beetle characteristics	1. Attracted specifically to elms 2. Can chew through bark 3. Can travel long distances 4. Active all summer 5. Breeds in dead or dying bark-intact elm wood	1. Not attracted specifically to oaks 2. Can only enter a tree through fresh wounds 3. Does not travel very far 4. Active primarily in springtime 5. Does not breed in oak wood
Control	Remove and dispose of all dead/dying bark-intact elm wood. This will remove the breeding sites of the beetle.	1. Don't prune in April, May and June! 2. Locate, remove and dispose of diseased oaks producing spores in early spring (March and April).

Pest Alert: Bur Oak Blight

United States Department of Agriculture Forest Service

Northeastern Area State and Private Forestry

NA-PR-02-11

2011

United States
Department of Agriculture
Forest Service
Northeastern Area
State and Private Forestry
NA–PR–02–11
May 2011

Bur Oak Blight

A serious leaf blight disease on bur oak has been recognized in several Midwestern States since the 1990s with Iowa reporting its first occurrence of this disease 6 or 7 years ago. A common leaf spot fungus, *Tubakia dryina*, was initially thought to be the cause of the blight on bur oak, but closer examination revealed a different story. Researchers in Iowa confirmed that this disease is caused by a new, and yet unnamed, species of Tubakia. The disease was named bur oak blight, or BOB for short.

There are now five known species of *Tubakia* that can infect bur oak in Iowa, but only one species causes dramatic leaf symptoms and tree mortality characteristic of BOB.

Hosts and distribution

BOB occurs only on bur oaks. Severe symptoms of BOB have been observed only on *Quercus macrocarpa* var. *oliviformis*, a variety of bur oak that produces smaller acorns. BOB occurs primarily on naturally established trees, and especially on mature trees on upland sites that appear to be remnants of savannah forests. Bur oak growing in dense forests and on bottomland sites is less seriously affected.

It is not clear if this new species of *Tubakia* is a recent arrival to this region or if a shift in climate (more early-season rain events) has made this disease more noticeable over the last two decades.

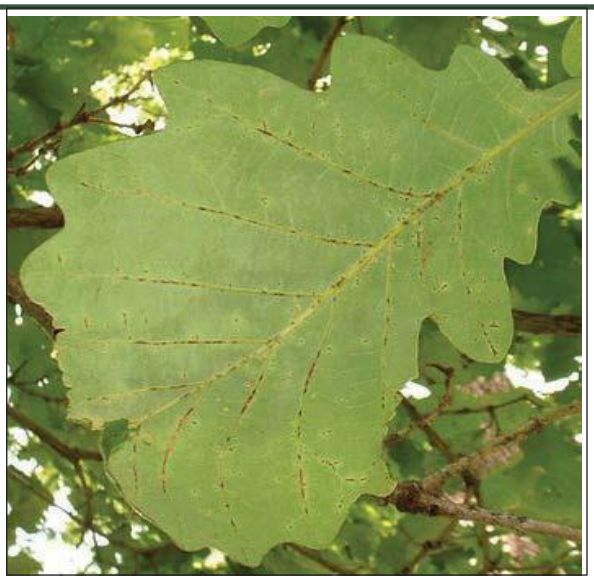


Figure 1. Purple-brown lesions develop along the veins on the underside of leaves.

To date, the BOB fungus is known to occur from northeastern Kansas and eastern Nebraska to central Minnesota and southwestern Wisconsin, and across most of Iowa. This disease is most severe in eastern Nebraska, Iowa, and Minnesota, which coincides closely with the distribution of *Quercus macrocarpa* var. *oliviformis*. A few affected trees have also been identified in Illinois and Missouri.

Symptoms

Leaf symptoms typically first appear in late July or August. Infected leaves develop purple-brown lesions along the midvein and major lateral veins on the underside of leaves (figure 1). As the lesions

increase in size, dark veins become noticeable on the upper leaf surface (figure 2). Large, wedge-shaped areas of chlorosis and necrosis develop on the leaf blade, and major leaf mortality may occur (figure 2). Individual lesions may coalesce and cause large areas of the leaf to die, giving it an overall wilted or scorched appearance (figure 3).The symptoms of wilting and leaf scorch resemble, and have been confused with, symptoms induced by oak wilt.

During the summer, black fruiting structures of the fungus form along the dark leaf veins and produce rain-splashed spores. These fruiting bodies can be seen with the aid of a 10X magnifying lens (figure 4). Later in the season, black pustules (fruiting bodies of the fungus) develop on the petioles of infected leaves (figure 5), and mature spores are seen in these pustules the next spring.

A unique feature of BOB is that some of the killed leaves remain on the tree during the winter (healthy bur oak trees shed all of their leaves in the fall). Not all infected leaves, however, remain attached. Some leaves drop off during the growing season and some are blown off by winter winds (figure 6). If BOB-infected leaves drop or are blown off, their petioles typically remain attached to the tree. The disease can be confirmed by microscopic examination of the pustules that form on the petiole base.

The disease tends to intensify from year to year in individual trees. If only a portion of the crown is affected, BOB symptoms usually start in the lower branches and progress up the tree. If a tree is seriously affected one year, it tends to be severely affected the next year. BOB appears to spread slowly, particularly from tree to tree. It remains a mystery why BOB does not spread more rapidly given the great abundance of spores that cause BOB and their spread by rain.

Not all stands of bur oak are seriously affected by this disease. Even within a seriously affected stand, not all trees are equally susceptible. Some trees may be severely infected while adjacent trees appear healthy (figure 7). This is likely due to variation in the resistance of individual bur oak trees to this disease.

Figure 2. Dark veins and large wedge-shaped lesions develop.

Figure 3. Large areas of the leaf may die, resulting in an overall wilted or scorched appearance.

Management

Over time, severely affected trees may die. Tree death is usually associated with severe blight over many years and damage caused by secondary invaders such as the two-lined chestnut borer and Armillaria root rot. Boosting tree vigor may prolong the life of affected trees and ward off invasion by secondary pests. Because the fungus overwinters on infected leaf petioles that remain on the tree, removing fallen leaves is not an effective management tool.

In preliminary studies, injections of the fungicide propiconazole (Alamo formulation) in late Mayor early June (prior to leaf symptoms) have reduced symptom development in the fall and the following year. With further study, fungicide treatments may have value in managing high-value landscape trees.

Sample Submission

When collecting samples for BOB testing, collect branch twigs with symptomatic and healthy leaves as well as petioles from several locations on the tree and wrap them in dry paper toweling (no plastic bags, please).

Submit samples to the National Plant Diagnostic Network (NPDN) Clinic in your respective State. To find a clinic near you, go to http://www.npdn.org/.

Figure 4. Black fruiting bodies form on dark leaf veins (lower right). Rain-splashed spores are produced under a protective hyphal shield (upper right, magnified 200X).

Figure 5. Black pustules develop on infected leaf petioles.

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Dr. Thomas C. Harrington, Iowa State University, Department of Plant Pathology, 221 Bessey Hall, Ames, IA 50011

Figure 6. Many dead leaves remain on the tree throughout the winter.

Figure 7. Affected trees typically occur next to unaffected trees.

Photo credits:

Dr. Thomas C. Harrington, Iowa State University

Jill D. Pokorny and **Joseph G. O'Brien**, U.S. Forest Service

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Section Review Quiz: Oak Diseases in Minnesota

1. Oak wilt is caused by:

A. a bacteria
B. sap beetles
C. a virus
D. a fungus

2. The primary emphasis of oak wilt control is:

A. prompt removal
B. reforestation
C. root graft disruption
D. elimination of beetle breeding sites

3. The "safe period" for oaks in Minnesota is July through the following April.

A. True
B. False

4. Wounding of oak trees should be avoided during April, May, and June because:

A. sap beetles, which carry the spores, are attracted to the fresh wounds
B. wind-blown spores could land on these fresh wounds
C. freshly wounded oaks can only be infected with oak wilt this time of year
D. a and c

5. Which of the following oak species die most rapidly from oak wilt?

A. red oak
B. northern pin oak
C. white oak (including bur)
D. a and b

6. The most effective method of root graft disruption is:

A. vibratory plowing or trenching with 60" blade or boom
B. soil sterilizing treatment
C. immediate removal of the diseased tree and stump
D. removing the healthy oaks closest to the diseased tree

Continued on next page →

8. Which statement below is FALSE?

A. Bur oak blight occurs primarily on naturally established, mature oaks.
B. Winter "leaf-cling" is a unique symptom to bur oak blight.
C. A healthy bur oak will often retain many of its leaves through a mild Minnesota winter.
D. In severe cases of B.O.B., death is usually caused by secondary "invaders" such as Armillaria root rot or two-lined chestnut borer.

Click here to navigate to answer page

SECTION 5: EMERALD ASH BORER

Emerald ash borer in Minnesota

Jeffrey Hahn - Extension entomologist, University of Minnesota

2013

The emerald ash borer (EAB), *Agrilus planipennis*, is a very destructive insect pest of ash trees (*Fraxinus* spp.), the only known hosts of this borer in North America. This exotic borer is a native of Asia with its natural range including China, Japan, Mongolia, Korea, the Russian Far East and Taiwan.

It was first discovered in North America in southeast Michigan in June, 2002, although it was likely introduced as much as 10 years earlier. It was first found in Minnesota in May 2009, in St. Paul. EAB has also been found in many other U.S. states and are shown here. It has also been discovered in the Canadian provinces of Ontario and Quebec.

Figure 1. An EAB adult - Photo Credit: Jeff Hahn

Figure 2. An EAB adult with wings open - Photo Credit: Jeff Hahn

Why is this insect important?

This destructive beetle has killed tens of millions of ash trees where it has been discovered. There are nearly one billion ash trees in Minnesota, the largest concentrations of ash of any state in the country. Not only are these trees abundant in our forests, but they are also an important component of our urban landscapes. Research has not found any resistance in our native ash. We could lose much of this resource.

How do I recognize this insect?

EAB is a slender, elongate insect about 1/3 to 1/2 inch long. It is widest just behind the head, gradually tapering back to the abdomen. It is a bright iridescent green to copper-green color, often with a copper colored area behind the head. Its body underneath the wings is a purplish-magenta color.

This borer is a type of metallic wood boring beetle (family Buprestidae) and is closely related to the bronze birch borer and the twolined chestnut borer, both native insects in Minnesota. EAB, however, is a little larger and much more brightly colored than these species.

Not every green insect you see is an EAB. There are several common insects that look similar, especially the six-spotted tiger beetle and the polydrusus weevil. A six-spotted tiger beetle is a similar size, about 3/8 to 1/2 inch long but with a conspicuous, large head and eyes. It is also a different shape with the abdomen being wider than the head. The polydrusus weevil is a small, 1/4 inch long, oval insect with a short snout. It has a black body covered with pale metallic green scales.

Also, not every insect you find attacking ash is an EAB as there are many native ash borers present in Minnesota. The most common are redheaded ash borer, bark beetles and clearwing borers. For more information see

native borers and emerald ash borer look-alikes (4.96 MB PDF).

The larvae have flat, slender, whitish colored bodies. They are 1 to 1 1/4 inches when fully grown. These larvae have a small brownish head that is just visible. They lack legs but do possess a pair of small pincher-like appendages on the tip of their abdomen.

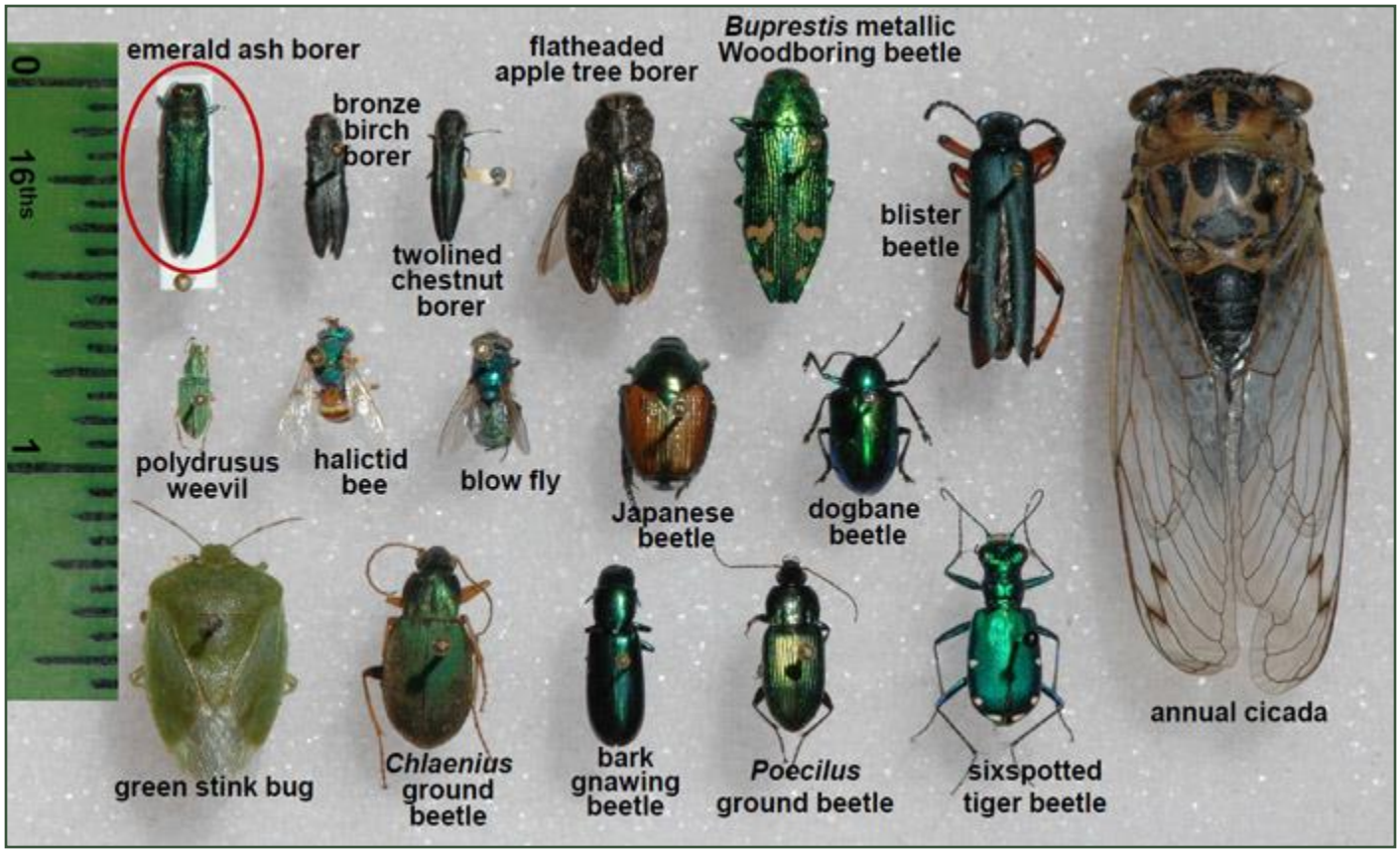


Figure 3 (above). Insects in Minnesota That May Be Confused With Emerald Ash Borer

Figure 4. An EAB larva - Photo credit: Pennsylvania Department of Conservation and Natural Resources - Forestry Archive

Symptoms and damage

Ash can tolerate small numbers of EAB larvae but trees are girdled and killed as the pest quickly increases in numbers. Trees are often killed in about four years, although it can take as little as two years.

When trees are first attacked by EABs, the symptoms are inconspicuous and hard to notice. During the second year, woodpecker pecks and thinning foliage begin to be apparent. By the third year, woodpecker activity is more common and canopy thinning is more pronounced. Vertical bark cracks (due to the tree trying to heal over old galleries) may also be present. Although woodpecker activity and vertical bark splits are not always caused by EAB, they are common symptoms in EAB infested ash trees. By the fourth year, the canopy has seriously declined and may even be dead.

When the adults emerge, the small, 1/8 inch D-shaped exit holes they create are characteristic of this insect, although they can be hard to see. If you were to remove the bark on

the trunk of a tree showing these symptoms, the S-shaped galleries formed by the larvae are also diagnostic of EAB activity. Epicormic sprouts may form on the lower trunk and major branches as the tree responds to emerald ash borer tunneling although this typically occurs when trees are almost dead and does not automatically indicate EAB.

All North American ash species are attacked, including all ash species found in Minnesota: green (*F. pennsylvanica*), black (*F. nigra*), and white ash (*F. americana*). Mountain-ash (*Sorbus.* spp.) are not true ash and are not attacked. Emerald ash borer attacks ash of different sizes from as small as one inch diameter to large mature trees. They prefer stressed and unhealthy trees, similar to the native bronze birch borer and twolined chestnut borer. However, unlike these insects, EABs will also successfully attack vigorously growing trees. Once an ash is attacked by EABs, it will be killed if it is not protected.

Keep in mind there are other problems that can cause an ash tree to decline. Go to What's Wrong With My Ash? for help in diagnosing an ash problem.

Figure 5. Woodpecker pecking is often a symptom of an EAB infested tree - Photo credit: Jeffrey Hahn

Biology

EABs generally have a one year life cycle although that can be extended to two years in a vigorously growing host. These insects overwinter as fully grown larvae in chambers constructed under the bark of ash trees. They pupate in early spring and emerge as adults, leaving characteristic D-shaped emergence holes. Depending on where you live in Minnesota, expect adults to emerge any time from late May to August.

Figure 6. An EAB-infested tree severely attacked by woodpeckers - Photo credit: Jeffrey Hahn

Figure 7. Vertical bark splits can be a symptom of an EAB infestation. - Photo credit: Jeffrey Hahn

After feeding on leaves, adults mate and females lay eggs on the bark or into small cracks. Eggs hatch in 7 to 10 days. The whitish larvae, called flatheaded borers, tunnel under the bark creating winding, S-shaped galleries in the phloem and outer sapwood. These tunnels girdle the trunk and branches, interrupting the flow of water and nutrients. The larvae feed until fall and then overwinter as prepupal larvae.

Figure 8. Examining a tree's canopy is not a good method for detecting EAB as there are other causes for ash to decline. - Photo credit: Jeffrey Hahn

Figure 9. EAB galleries. Note how they generally form an S-shape. - Photo credit: Jeffrey Hahn

What can I do to help?

First, don't transport firewood when you go camping or are buying it for home use. Buy the wood you need at local sites or at the campgrounds you are visiting. On its own, most EAB will generally move only about 1/2 to 1 mile a year from infested sites. But with help from people, it can travel hundreds of miles when carried in firewood and other wood products or nursery stock.

Next, be aware of what an EAB looks like as well as the symptoms of an EAB infested tree. Report any suspect insects or declining ash trees (see the following section "What can I do if I suspect I have found EAB?"). There have been many cases where the public was the first to find an initial infestation in an area.

Figure 9. D-shaped exit holes - Photo credit: Jeffrey Hahn

What can I do if I suspect I have found EAB?

First, use the diagnostic page (2,248 K PDF) to see if you can clearly rule out EAB. If, after you have gone through this page, you can't easily rule out EAB, then contact the Minnesota Department of Agriculture (MDA) on their Arrest the Pest phone line at 1-888-545-6684 to report your suspicions.

Should I be planting or removing ash?

Because of the overabundance of ash in urban landscapes and other sites, it is strongly recommended not to plant additional ash. Consider the other woody plant options that are available to Minnesotans. The more diverse the plantings of trees in the urban landscape are, the better neighborhoods can tolerate future pest problems.

However, if you have an ash in your yard and it is healthy, there is no reason to remove it. As long as it is a low maintenance plant, keep it in your landscape.

Should I treat my ash?

There are several factors to consider when deciding whether to treat your ash. First, if your ash tree(s) is within 15 miles of a known infestation, it is at a higher risk of being attacked by EAB. Currently, EAB has been confirmed in four counties in Minnesota: Ramsey, Hennepin, Houston, and Winona. If your tree(s) is beyond 15 miles from any known infestation, it is not advised to treat it until at least EAB is confirmed in your area. The further your ash is from a known occurrence of EAB, the less likely that it will become infested.

Also consider the health of your ash. The tree is a good candidate to protect if it still has most or all of its canopy. However, if it has lost half of its canopy or more, it is in poor health and treatment is very unlikely to be effective. Also consider the tree's importance to you. If it is a valued tree, then considering protecting it. Healthy, mature trees improve the attractiveness of a landscape, raise property values, help reduce energy costs, and decrease storm water runoff.

See also Managing Emerald Ash Borer: Decision Guide (764 K PDF)

The insecticides available for treating EAB have been shown to be effective in protecting ash in University research trials. Some products are available to residents so they can treat ash themselves. However, larger ash trees (> 15 inches d.b.h., i.e. at 4 1/2 feet above the ground) are generally best treated by a professional arborist. Trees do not build up any resistance because of the insecticide applications and need to be treated on a regular basis (every one to two years depending on the insecticide that is used). For specific information on insecticides available for treating EAB, see Emerald Ash Borer: Homeowner guide to Insecticide Selection, Use, and Environmental Protection (788 K PDF).

If you decide that you would rather not treat and protect your ash, consider removing the tree. Keep in mind that the larger the tree is, the more expensive it is to remove. Also, it is easier (and less expensive) to remove the tree while it is alive. Once an ash tree is dead, the branches become brittle making it much more challenging to cut down.

Any time you consider hiring a professional arborist to care for your trees, be sure to ask for certificates of insurance and local references. Get at least two estimates and don't rush into a decision because you are promised a discount. For more information, see How to hire a professional arborist to help care for your landscape trees.

For more information on EAB, see the Extension emerald ash borer page.

Signs and Symptoms of the Emerald Ash Borer

Mary Wilson - Michigan State University

Eric Rebek - Michigan State University Dept. of Entomology

Extension Bulletin E-2938

2005

Adult

Michigan State University

Michigan State University

- Bright, metallic green (Figs. A, B).
- 1/2 inch long, flattened back (Figs. A, B).
- Purple abdominal segments beneath wing covers.

Larva

D. Cappaert, MSU

- Creamy white, legless (Fig. C).
- Flattened, bell-shaped body segments (Fig. C.).
- Terminal segment bears a pair of small appendages.

Canopy Dieback

E. Rebek, MSU

E. Rebek, MSU

- Begins in top one-third of canopy (Fig. D).
- Progresses until tree is bare (Fig. E).

Epicormic Shoots

J. Smith, USDA APHIS PPQ

- Sprouts grow from roots and trunk (Figs. F, G).
- Leaves often larger than normal

Bark Splitting

J. Smith, USDA APHIS PPQ

A. Storer, Mich. Tech. Univ.

- Vertical fissures on bark (Fig. H) due to callous tissue formation (Fig. I).
- Galleries exposed under bark split.

Serpentine Galleries and D-shaped Exit Holes

D. Cappaert, MSU

D. Cappaert, MSU

- Larval feeding galleries typically serpentine (Fig. J).
- Galleries weave back and forth across the woodgrain.
- Packed with frass (mix of sawdust and excrement).
- Adults form D-shaped holes upon emergence (Fig. K).

Increased Woodpecker Activity/Damage

- Several woodpecker species (Fig. L) feed on EAB larvae/pupae.
- Peck outer bark while foraging (Fig. M).
- Create large holes when extracting insects (Fig. M).

Section Review Quiz: Emerald Ash Borer

1. Emerald ash borer is spread long distances primarily by:

A. Transporting infested firewood.
B. The adult beetle flying up to 50 miles per hour.
C. Infested tools.
D. Climbing spikes/gaffs.

2. Which are signs or symptoms of emerald ash borer infestation?

A. D-shaped exit holes.
B. Epicormic sprouts.
C. Crown decline.
D. All of the above.
E. Both "a" and "c"

3. Emerald ash borers are only present in the outer 1 inch of the bark/wood so once that is removed the remaining wood is useable or non-infested.

A. True
B. False

4. Which of the following trees is not attacked by emerald ash borer?

A. Green ash
B. Blue ash
C. Mountain ash
D. White ash

5. How does the emerald ash borer kill trees?

A. Defoliation
B. Sap-sucking
C. Feeds on shoots and twigs
D. Feeds in sapwood

6. Once an ash tree becomes infested with emerald ash borer:

A. It usually dies within one year.
B. There are chemical treatments that can prevent death if a tree doesn't have too much dieback.
C. The tree will likely survive if it is fertilized each year and watered regularly.
D. The adult insect can be killed with a foliar insecticide, thus preventing further damage.

Click here to navigate to answer page

SECTION 6: OTHER PESTS, PLANTS AND PROBLEMS

Gypsy Moth

Minnesota Department of Agriculture and MN Department of Natural Resources

What is Gypsy Moth?

The gypsy moth is an invasive forest pest from Europe that is one of the most damaging tree defoliators currently in the U.S. Aspen and oak top the list of over 500 preferred host species. Gypsy moth caterpillars feed on leaves of deciduous trees and are present in early to mid-summer.

Gypsy moths: female (left) and male (right).

Why are gypsy moths such a problem?

- They are voracious eaters and can completely defoliate entire trees.
- Outdoor recreation might be reduced as a result of bare trees, caterpillar presence on trees and roads, and feces falling from trees.
- Repeated defoliation can lead to the death of many trees, changing the mix of tree species and affecting dependent wildlife.
- Tree losses can impact forest and related industries.
- Because gypsy moths are nonnative, there are few natural enemies to keep them in check.

Gypsy moth caterpillars feeding on leaves

Gypsy Moth: History in the U.S. & Minnesota

The gypsy moth is a leaf-eating insect belonging to the insect order Lepidoptera, which includes butterflies and moths. Now ranked as one of America's most destructive pests of trees and shrubs, it was brought to Massachusetts from Europe in 1869 as part of a failed attempt to breed a hardier silkworm. The insect escaped from the lab and headed for the trees with disastrous effects.

Since the turn of the century, the gypsy moth has slowly spread westward from New England. The pest's ability to feed and survive on more than 300 types of trees and woody plants makes it well suited to North America's hardwood forests, and the lack of natural predators made its transition to our continent much easier.

Female gypsy moths cannot fly and have no choice but to deposit their eggs on objects near the trees they were feeding on as caterpillars. These objects might be firewood, car wheel wells, grills or any outdoor household article or lawn ornament. When these objects are moved from an infested area, the gypsy moth eggs "hitchhike" into other areas, hence the name gypsy moth.

The United States government realized early on that this insect would be a serious problem. In the early 1900s, a federal quarantine was placed on all trees in the infested area. Nurseries wanting to transplant trees from the quarantined area had to conduct a thorough inspection to ensure the moth wasn't hitching a ride.

Since the female moth cannot fly and the larvae can only move a few miles on the wind, the quarantine kept the moth isolated in the New England region for decades.

In recent years, and with a helping hand from people, the gypsy moth has expanded its territory, from western Pennsylvania all the way through Ohio, Michigan and Illinois, and into central Wisconsin. The moth deposits eggs on just about anything so people camping in infested areas during prime egg-laying periods (July through mid-August) are particularly likely to carry the pest home on camping gear or even on their vehicles. Fortunately, the moth has not arrived en masse in Minnesota - yet.

Gypsy Moth in Minnesota - Milestones

1969: First signs of gypsy moth appear in Duluth (egg masses and pupal cases)

1973: Annual trapping program begins with 550 traps set

1976: First male moth trapped in the state (Hennepin County)

2004: Minnesota joins the national Gypsy Moth Slow the Spread Program

Gypsy moth egg masses and caterpillars covering an infested tree. Photo by the MDA.

Gypsy moth: biology, life cycle, and identification

Scientific name: *Lymantria dispar*

Native range: southern Europe, northern Africa, central and southern Asia, Japan

Pest status: Gypsy moth is regulated in Minnesota. Lake and Cook Counties are under quarantine.

Life cycle

Egg: Eggs are laid in a fuzzy, tan-colored mass. The egg mass contains 500-1,000 eggs and is about the size of a quarter. Eggs are laid during late summer and hatch the following spring when the weather is right. Egg masses can be found on living and/or inanimate objects, including nursery stock, logs, roof eaves, in wheel wells or outdoor household articles like firewood and lawn chairs.

Caterpillar (larva): The caterpillar hatches from the egg and grows to a length of 2½ inches as it matures. Its body is covered with hairs to protect it from predators including curious humans. Be careful - if you touch it your skin might get irritated! Along its back the caterpillar has five pairs of blue spots near the head, followed by six pairs of red spots. It actively feeds on plant foliage from late spring through mid-summer, when it develops into a pupa.

Gypsy moth female, egg mass, and shed pupa case found on nursery stock through the annual detection trapping survey. Photo by the MDA.

Pupa: The pupa is an immobile stage of this insect's life. Though it appears inactive, it is very busy inside transforming from a caterpillar into an adult moth. Found mid-summer, it is dark reddish-brown, leathery in appearance, and often tethered to an object with silk strands. It can range in size from ¾ inch to 1½ inches long.

Adult Female: The adult female moth is white with brown jagged markings on her wings. Her wingspread ranges from 1 to 2 inches but she cannot fly because her body is so large and heavy with eggs. She releases a pungent sex attractant (pheromone) that only the male moths can smell so they can fly to her and mate. The female produces one egg mass and dies.

Adult Male: The adult male moth has feathery (plumed) antennae that are so sensitive they can "smell" a female a mile away. His body can be light beige to dark brown with black jagged bands on brown forewings. His wingspread ranges from only ¾ to 1½ inches yet he is a strong flyer and capable of mating with several females. Adult moths are typically active from late summer through early fall.

Gypsy moth egg mass on tree bark

Gypsy moth caterpillar (larva)

Female (left) & male (right) pupae

Female gypsy moth adult

Male gypsy moth adult

This chart shows the average developmental times for gypsy moth in Minnesota. The length of each life stage depends on weather conditions, which vary annually.

Identification

It is still rare to find gypsy moth in Minnesota. Usually the only way they are detected is when lured into survey traps that MDA field staff and other cooperators place throughout the state. Other species that are much more commonly found in Minnesota such as the Forest and Eastern Tent Caterpillars can be similar-looking to gypsy moth. Their defoliating larvae can also be pests, but they are not federally regulated pests like gypsy moth is.

Caterpillars

Gypsy moth larvae, or caterpillars, are often confused with the eastern tent and forest tent caterpillars, both of which emerge in the spring and are about the same size. To tell them apart, look at the older caterpillars.

Characteristic	Gypsy moths	Eastern tent caterpillars	Forest tent caterpillars
Markings	Five pairs of blue dots and six pairs of red dots down its back	White stripe down its back and blue markings down each side	Row of white foot print shaped marks down its back
Tent making	No noticeable webs or tents	Large silken tents found in branch crotches	Some silk along branches, but no tents
Habits	Move to bark cracks or other hiding places during the day	Hide in their tent during the day, leaving to feed at night	Cluster on bark during the day

Adult Moths

Adult male gypsy moths are brown to gray with dark markings in a scalloped pattern along the wing edge. They have large featherlike antennae used to pick up the female pheromone, or sex attractant. Female moths are white with small brown markings and are much larger than the males.

When might I see them?

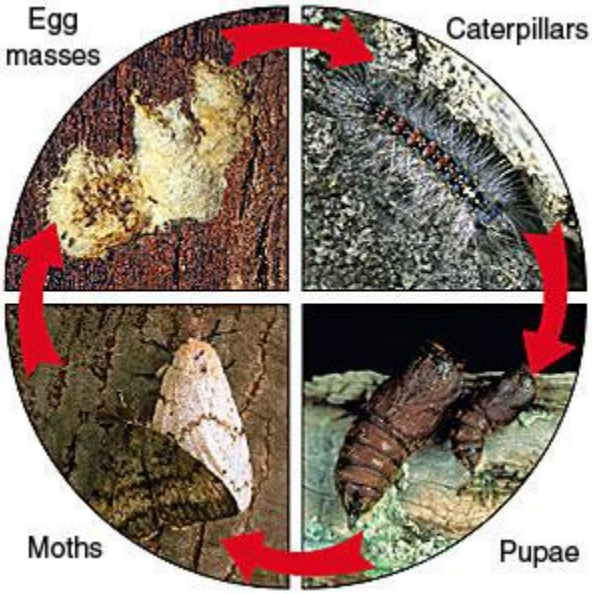
You are not likely to see any gypsy moths in Minnesota for a long time because there are so few of them present. But once an area is infested, the fuzzy, mustard-colored egg masses can be found anytime between August and April. The female moth cannot fly, but crawls along tree trunks and objects near host trees where egg masses are deposited in crevices, under loose bark, or in protected places on objects in infested areas. Female moths will lay eggs on car wheel wells, bumpers, yard furniture, etc. Depending on how far north they are, the eggs can hatch anywhere between late April and early June. After hatching, the young caterpillars climb to the top of a nearby tree to spin a silken thread and catch the wind to the nearest preferred host tree. There they feed until time to pupate in late June through July. The adult moths begin to emerge in July in the south and August in the north. The adults do not feed; they mate and die in one to two weeks.

It's not gypsy moth if you see…

- Silk tents or webs in the branches of trees - although newly hatched gypsy moth caterpillars do produce a thin silken thread that they use to surf the wind, they do not have a central nest and they do not make tents or webs.
- A solitary caterpillar - chances are it is not gypsy moth. Gypsy moth caterpillars are gregarious and usually occur by the hundreds.
- A moth attracted to light - gypsy moths are not attracted to light.
- Grain pest moths flying around in your kitchen - gypsy moths are not grain pests and would more likely be found outdoors.
- A white moth flying - female gypsy moths are cream to white in color (in contrast to the males that are brown), but the females do not fly.
- An adult moth that is feeding - gypsy moth feeding only occurs during the larval stage.
- Larvae that are present or feeding in the fall (like Fall Webworms) - gypsy moth larvae are only present and feeding the spring/early summer.

Management Strategies

Gypsy moth management has come a long way since the early days when infestations had to be burned or removed entirely by hand. Minnesota follows the national gypsy moth management strategies and participates according to results from the annual survey.



Gypsy moth life cycle

Generally infested Area

- Gypsy moth populations established and reproducing.
- Treat outbreaks locally to preserve high-value stands.
- Counties can be quarantined.

Slow the Spread Area

- Low-level moth populations present.
- Targeted treatments to decrease natural spread to less than 6 km/yr.

Gypsy Moth Management Zones Pre-infested Area

- No gypsy moth populations present.
- Find and eliminate start-up populations.

At this time, Minnesota is mostly in the pre-infestation zone. The STS Action Zone covers the Arrowhead region and a few counties in extreme southeast Minnesota.

Slow the Spread

Since 2004, Minnesota has been an official member of the U.S. Forest Service's Gypsy Moth Slow the Spread (STS) program. This program finances a regional effort to control the spread of the gypsy moth through trapping and treatment. It involves collaboration between state and federal government to reduce new areas of infestation. Survey methods, data collection, and reporting have all been standardized so that treatments are most effective.

As a part of the STS program, states located along the leading edge of the gypsy moth population have implemented a regional strategy to minimize the rate at which gypsy moth spreads into uninfested areas. As a direct result of their actions, the national spread rate has been dramatically reduced by more than 70% from the historical level of 13 miles per year to 3 miles per year. In just eight years, this program has prevented the impacts that would have occurred on more than 75 million newly infested acres. The benefits from the national strategy are experienced by the nation as a whole as well as individuals. They are:

- Reduction of spread of this destructive pest to 3 miles per year, preventing the infestation of more than 150 million acres over the next 20 years.
- Protection of extensive urban and wild land hardwood forests in the south and upper Midwest.
- Environmental protection through the use of gypsy moth-specific treatment tactics.
- Partnerships to promote well-coordinated, region-wide actions based on biological need.

Economic Benefits

An economic study commissioned by the STS Foundation and conducted in 2008 by Dr. Erin Sills of North Carolina State University revisited the costs and benefits of the STS program through adjustments to a similar study completed in 1990. The objectives of the study were to compare the costs of operating the program to the benefits received by residents and businesses affected by the gypsy moth. Dr. Sills concludes:

Considering household willingness to pay to avoid all impacts of gypsy moth (including impacts on developed recreation, and the impacts of nuisance and defoliation in yards, neighborhoods, and local parks in defoliated zones), the benefits are estimated to be three times as high as the costs of operating the program.

Gypsy moth caterpillars

The three national strategies - eradication, STS, and suppression - support management needs by expanding the management options available to state cooperators. The population models and treatments most commonly used within these programs are among a number of management options utilized in Minnesota.

Gypsy Moth: Annual Trapping Survey

Each year the MDA sets around 20,000 gypsy moth traps throughout Minnesota to find out where gypsy moth populations exist. The MDA's trapping survey program is closely tied to the insect's biology. The female does not fly so she uses a pheromone, or sex attractant, to lure the male moth to her for mating. Although humans can't detect the scent of the pheromone, it is a powerful attractant to the male gypsy moth.

The survey detects the presence of the moth. The traps are set before the adult moths fly, are monitored throughout the summer, and are removed after the flight season is finished. Data are collected about the location of the trap and the number of moths caught in it, if any. The data are then used to determine if gypsy moth infestations exist and to give an idea of how widely the population is dispersed.

MDA survey staff and cooperators deploy weatherproof cardboard traps. Triangular delta traps can be orange or tan in color and are the standard trap type used. Milk carton traps are green and are used in areas where the expected moth counts are higher than what the delta traps can accommodate (>15 moths). Both trap types have a lure inside that mimics the natural pheromone of the female moth. The male moth flies to the trap to mate but instead ends up ensnared in a sticky substance inside the delta trap or perishes from the pesticide strip in the milk carton trap.

Trapped moths

30–45 survey staff are employed each summer to set, check and remove the traps. It is a full-time seasonal position that requires considerable driving and the ability to work outdoors in all kinds of weather.

Milk Carton Trap

Delta Trap

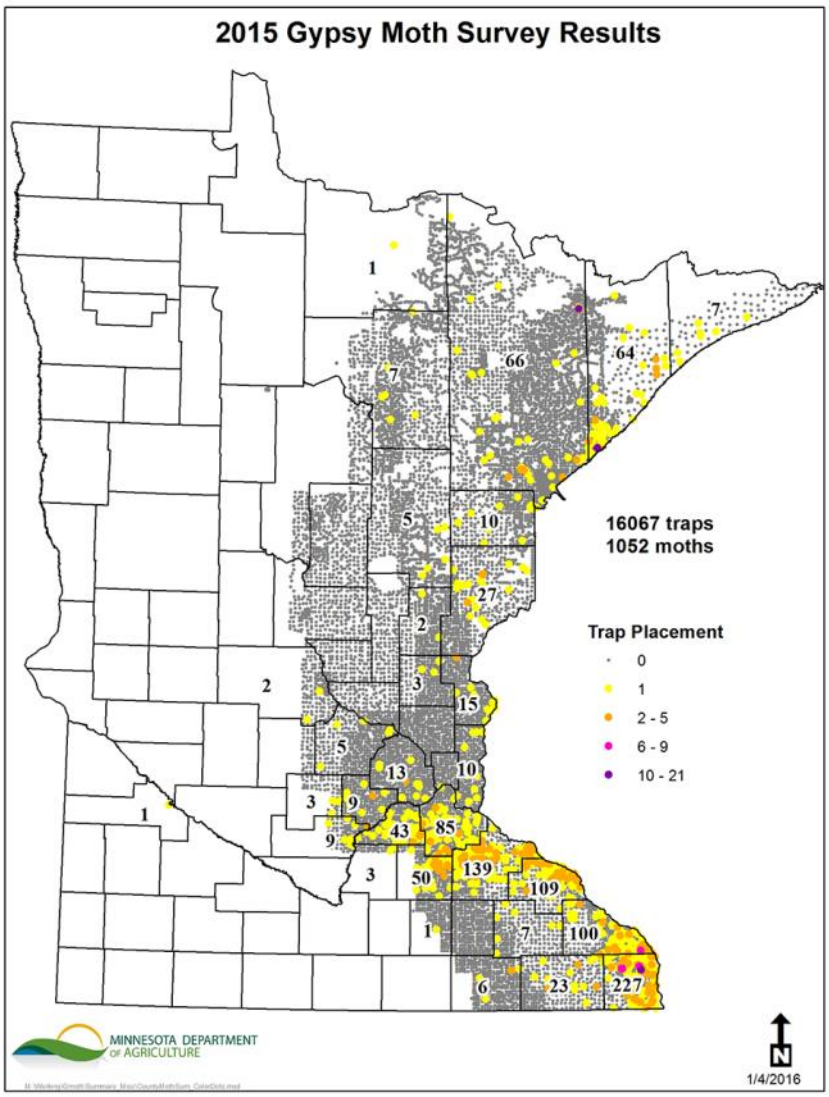
Trapping Survey in Minnesota

The gypsy moth trapping survey program concentrates on the eastern border of the state because the natural movement of the main population is moving westward from Wisconsin. Selected high-risk businesses also receive survey traps throughout the annually designated trapping survey project area.

Over the years, the trapping survey has shown us where gypsy moth populations are starting up, building, and moving.

View gypsy moth survey results from other years at the following address:

http://www.mda.state.mn.us/plants/pestmanagement/gmunit/gmtrapping.aspx



MDA Contact:

Arrest the Pest

888-545-6684

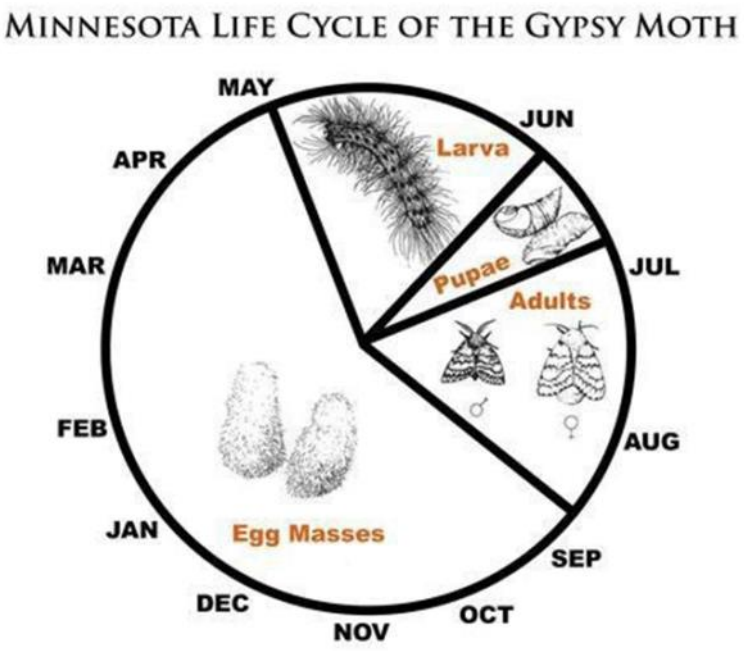
gypsy.moth@state.mn.us

Gypsy Moth Treatments

2016 Proposed Treatments

The Minnesota Department of Agriculture (MDA), in collaboration with federal, state, and local partners, is proposing to slow the spread of gypsy moth populations in St. Louis, Lake and Houston Counties. Surveys in 2015 revealed five distinct areas where monitoring traps caught a high number of moths. These results, combined with the trap records of previous years, and follow-up site surveys prompted MDA and the Minnesota Gypsy Moth Program Advisory Committee to develop a proposed treatment project for 2016.

In order to reduce current populations of gypsy moths and slow the growth of future generations of this forest pest, the MDA proposes to treat a total of about 1,135 acres of land with a biological insecticide called Bacillus thuringiensis var. kurstaki, or Btk, and about 5,744 acres with mating disruption. Five treatment blocks have been identified and named for their geographic locations: Ely in St. Louis County, Two Harbors in Lake County, and Houston, Mound Prairie, and Reno in Houston County (see maps at bottom of page). Habitat within the proposed treatment areas include many of the trees species considered susceptible to gypsy moth defoliation.



Gypsy moth caterpillar

For more information on the current proposed treatments for gypsy moth, visit the Minnesota Department of Agriculture site:

http://www.mda.state.mn.us/plants/pestmanagement/gmunit/gmtreatments.aspx

Visit the Minnesota Department of Agriculture Gypsy Moth Program online:

http://www.mda.state.mn.us/plants/pestmanagement/gmunit.aspx

Gypsy Moth Look-alikes

Similar Caterpillars

Caterpillars that look similar to gypsy moth

(f.g.l = full grown length)

Gypsy Moth caterpillars have very distinct markings: 6 pairs of red dots, 5 pairs of blue dots

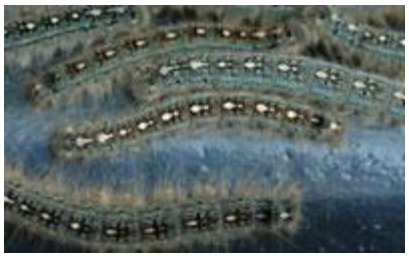
Gypsy Moth - f.g.l. = 2”

Fall cankerworm - f.g.l. = 1”

Whitemarked tussock moth - f.g.l. = 1 1/3"

Fall webworm - f.g.l. = 1"

Cecropia moth caterpillar - f.g.l. = 4"



Forest tent caterpillar - f.g.l. = 3/4”

Eastern tent caterpillar - f.g.l = 1 3/4"

Spiny elm caterpillar - f.g.l. = 2"

Yellownecked caterpillar - f.g.l. = 1 3/4”

Similar adult moths

Adult male gypsy moth

Adult female gypsy moth

Elm spanworm (night flyer)

White underwing moth

Pine tussock moth

White-marked tussock moth

Yellownecked moth

Pepper & salt moth (night flyer)

Cottonwood dagger moth

Sleepy underwing moth

American and Oriental Bittersweet Identification

U.S. Department of the Interior

U.S. Geological Survey

GLSC Fact Sheet 2007-2

2007

Invasive Species are one of the greatest threats to native ecosystems. They can crowd out native species and change the natural nutrient cycling processes that take place in ecosystems. One of the best ways to combat invasive species is by identifying small infestations and removing them.

One invader threatening midwestern ecosystems is oriental bittersweet (*Celastrus orbiculatus*). This woody vine was introduced to the eastern United States in the mid-1800s. It has spread from the east to the south and west and is now moving into midwestern natural areas. Oriental bittersweet can be found in a variety of habitats, from roadsides to interior forests and sand dunes. It has the ability to girdle and overtop adjacent vegetation – often to the detriment of native species. To halt the spread of oriental bittersweet, significant control measures are needed.

However, a native bittersweet species, American bittersweet (*Celastrus scandens*), can be mistaken for oriental bittersweet. Although American bittersweet is also a vine and climbs on nearby vegetation, it does not appear to grow as rapidly or as large as oriental bittersweet. In the northeastern United States, American bittersweet is declining because of habitat change and possible hybridization, while in the Midwest, it is still common.

Because the two bittersweet species look so similar, there can be difficulty knowing which plants to target for control. Using fruit and leaf characters, the two species can be discriminated from each other. However, certain traits are more reliable for correct identification than others. Classically, the position of the fruit and flowers on the stems has been cited as the most definitive means of discriminating between the species.

Oriental bittersweet has fruit and flowers located in the leaf axils along the length of the stem. American bittersweet, however, only has fruit and flowers in terminal clusters. There is also a difference in the color of the capsules surrounding the ripened fruit in the fall. Oriental bittersweet has yellow capsules, while those of American bittersweet are orange. Another difference in color is the pollen color of the male flowers. The pollen of oriental bittersweet is white while that of American bittersweet is yellow.

Some less definitive fruit traits for discrimination are size of the fruits and number of seeds per fruit. American bittersweet has generally larger fruit than oriental bittersweet. If fruits have a volume of greater than 250 mm3, there is a 90% probability of a plant being American bittersweet, while if the fruit has a volume of 115 mm3 or less; it has a 90% chance of being oriental bittersweet. Values in between these numbers overlap to

some extent between the species. Similarly, if the fruit has one or fewer seeds, it is 90% likely to be American bittersweet, while five or more seeds have a 90% chance of being oriental bittersweet. The greater number of seeds of oriental bittersweet gives it a reproductive advantage over the native species.

The problem with using fruit and flower traits for discriminating between the two species is that, for fruits, only mature female plants have this character available for identification. In terms of flowers, only mature male and female plants have these present, and only for a brief time of the year during the spring.

Vegetative traits apply to plants regardless of their sex or maturity. The most definitive vegetative trait is the posture of the leaves at leaf out of the first buds in the spring. The leaves of oriental bittersweet are conduplicate (two sides of the leaf folded against each other) and tightly packed in the bud when they emerge in the spring. The leaves of American bittersweet are involute (leaf margins rolled in like a scroll) and not as tightly packed in the bud.

Other leaf traits are not as reliable as the leaf-out posture. Although the ratio of length-to-width (length:width) of the leaves is generally greater for American bittersweet, this trait is quite variable. If the length:width of the leaf is greater than or equal to 2, there is a 90% chance of the plant being American bittersweet, while if the ratio is less than or equal to 1.4, there is a 90% chance of it being oriental bittersweet. The tips of the leaves of American bittersweet are also generally longer than those of oriental bittersweet. Plants with leaf tips of 1.5 cm or greater have a 90% chance of being American bittersweet, while plants with leaf tips of 0.3 cm or less have a 90% chance of being oriental bittersweet.

By using these traits, plants could be marked at the appropriate time of year (spring or fall) for control at a later point. In this manner the invasive species can be targeted without harming the native. The key on the next page summarizes the key traits for discrimination of these two species in the field.

Continue onto next page for identification key

Is plant in fruit? **Yes** → Are ripe fruit capsules orange? → *C. scandens*

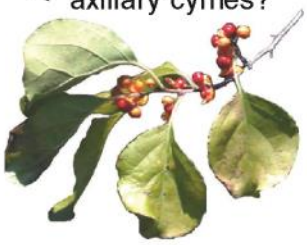
yellow? → *C. orbiculatus*

No ↓

Are fruit borne in

terminal panicles? → 

C. scandens

axillary cymes? → 

C. orbiculatus

Do fruits have ≤ one seed?* → *C. scandens*

≥ five seeds?* → *C. orbiculatus*

Is plant in bloom? **Yes** → Are flowers borne in terminal panicles? → *C. scandens*

No ↓

axillary cymes? → *C. orbiculatus*

Are flowers staminate? **Yes** → Is pollen

yellow? → 

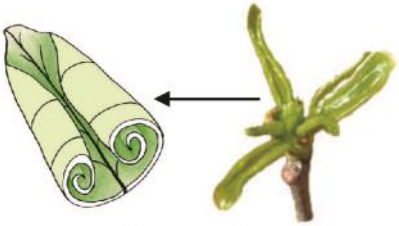
C. scandens

white? → 

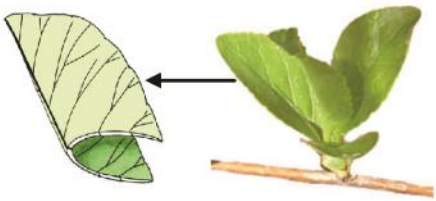
C. orbiculatus

Is plant leafing out? **Yes** → Are leaves

No ↓

involute? → 

C. scandens

conduplicate? → 

C. orbiculatus

Are mature leaves present? **Yes** → Is length:width ≥ 2.0?* → *C. scandens*

No ↓

Is length:width ≤ 1.4?* → *C. orbiculatus*

Is leaf tip > 1.5 cm?* → *C. scandens*

Is leaf tip < 0.3 cm?* → *C. orbiculatus*

If dormant season, only fruit characters applicable

* Indicates a 90% probability of correct identification based on the data collected for this study.
Colors in text boxes are to be used as a guide only, actual colors seen in the field may differ.

Collaborators: Noel B. Pavlovic, Stacey Leicht Young, Ralph Grundel, and Krystalynn J. Frohnapple

Pest Alert: Forest Tent Caterpillar

United States Department of Agriculture Forest Service

Northeastern Area State and Private Forestry

NA-PR-02-11

2005

United States
Department of Agriculture
Forest Service
Northeastern Area
State and Private Forestry
NA–PR–04–05
May 2011

Forest Tent Caterpillar

The forest tent caterpillar (*Malacosoma disstria* Hübner) is a native insect found throughout the range of hardwood forests in North America. It is more abundantly distributed in eastern North America, but is also common in western areas that have large stands of aspen. At times, this insect can be a damaging defoliator of trees. Trees that are defoliated often flush a new, smaller set of leaves in July. While forest tent caterpillar does not typically cause mortality to host trees, mortality can occur when populations interact with other disturbances, such as drought or insect outbreaks. Forest tent caterpillar larvae use silk to form trails and to create pads on host trees where they congregate and rest. However, they do not construct and reside within elaborate silken tents. A different species, the eastern tent caterpillar, forms these more defined tents in branch crotches of cherry and other trees in the rose family.

Figure 1. Forest tent caterpillar egg masses

Figure 2. Forest tent caterpillar larvae

Figure 3. Forest tent caterpillar pupa in cocoon

Hosts

Because forest tent caterpillar is found throughout much of North America, it is no surprise that it has a large host range. Depending on the geographic region, ash, aspens, basswood, birch, cherry, cottonwood, elms, oaks, red alder, sugar maple, swamp blackgum, sweetgun, water tupelo, and willow are all potential hosts. Forest tent caterpillar does not feed on red maple, sycamore, or conifers.

Description

Eggs are laid in dark masses (25–37 mm wide) that surround small twigs (figure 1). These masses may contain up to 350 eggs. Newly hatched larvae are 3 mm in length, black, and have

noticeable hairs. As larvae grow and become a more brownish color, two distinct characteristics develop. Pale bluish lines form along the margins of the larvae, and white spots (often described as footprints or keyholes) develop along the back (figure 2). Full-grown larvae are about 50 mm in length. Pupae are protected by a cocoon spun from pale yellow silk and are often found in protected areas (figure 3). Adult moths are light brown with two narrow dark bands on the forewings and have a wingspan between 25 and 28 mm (figure 4).

Figure 4. Forest tent caterpillar adult moth

Life History

Forest tent caterpillar populations usually cycle, remaining high for 3 to 4 years before dropping to low levels due to harsh weather, predation, disease, and/or starvation. Eggs hatch in the spring and larvae begin feeding on the newly expanded foliage of host trees. During this time, larvae can be seen following one another in straight lines and congregating. Larvae feed into June and then pupate in silken cocoons in protected areas or folded leaves. Adults emerge in July, locate hosts, mate, and lay eggs. Egg masses are deposited around small twigs of host trees and are often concentrated on trees near well-lit urban areas. The adult moths are nocturnal and are strongly attracted to light.

Management Options

Several options are available for managing forest tent caterpillar. Because trees usually survive defoliation, the first option to consider is doing nothing to manage the population. Environmental conditions as well as natural predators help regulate forest tent caterpillar populations after only a few years. If control is necessary, mechanical and insecticidal options exist. Mechanical options include placing barriers on trees, removing egg masses before they hatch, and removing larvae when they are congregated. Insecticides such as Bacillus thuringiensis (B.t.) can be used to protect weakened trees or to cover large areas where populations have remained high for consecutive years. Management decisions can be guided by egg mass surveys. For example, an average of 20 or more egg masses over 15 cm in diameter per tree indicates the likelihood of complete defoliation and may necessitate a management response.

Pesticide Precautionary Statement

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Note: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

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Photo Credits:

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Section Review Quiz: Other Pests, Plants and Problems

1. Choose the best answer, forest tent caterpillars will NOT feed on the following:

A. Sugar maples, oaks, or ash species.
B. Birch, alder, or conifers.
C. Red maple, sycamore, or conifers.
D. Cottonwood, sugar maples, or willow.
E. It's a trick question, forest tent caterpillars will feed on all tree and shrubs.

2. True or False: In regards to forest tent caterpillars, trees will usually survive defoliation and predators and environmental conditions usually help to regulate the population after only a few years. Doing nothing as far as management should be the first consideration.

A. True
B. False

3. Some traits that differentiate oriental bittersweet from native American bittersweet are:

A. Oriental bittersweet has fruit and flowers located in the leaf axis along the length of the stem. American bittersweet, however, only has fruit and flowers in terminal clusters.
B. In fall, the capsules that surround the ripened fruit of the oriental bittersweet are orange and in American bittersweet they are yellow.
C. In fall, the capsules that surround the ripened fruit of the oriental bittersweet are yellow and in American bittersweet they are orange.
D. Both a and b are correct.
E. Both a and c are correct.

4. True or False? You can determine with about 90% accuracy, the difference between American bittersweet and oriental bittersweet by simply counting the seeds in the ripened fruit.

A. True
B. False

5. The westward spread of gypsy moths is primarily due to:

A. the males, which can fly up to 10 miles per year.
B. the larvae, which can be carried by wind up to 20 miles per year.
C. the pupa, which can survive temperatures of minus 40 degrees F.
D. the egg masses, attached to vehicles, trailers, lawn furniture, and camping equipment.

Click here to navigate to answer page

SECTION 7: BEST PLANTING PRACTICES

Three Steps for Planting Trees & Shrubs

University of Minnesota, Department of Forest Resources

2013

A tree that lives to 125 years in the forest will on average live less than 10 years in downtown sites and 35 years in the suburbs (Moll, 1989). Poor planting practices can shorten a tree's life span. This fact sheet will help guide you through the best planting practices to insure the beauty and health of your trees and shrubs.

Step 1: Bringing your trees and shrubs home

Keeping roots moist is important during the move as moist roots help the tree establish quickly. Wrap the soil ball, container, or bare roots in a tarp or large garbage bag to trap moisture until planting time.

Step 2: Planting your trees and shrubs

Bare root trees/shrubs:

Bare root trees and shrubs come without any soil around the roots.

Make sure the planting hole is wide enough to fit all roots inside. Dig the hole deep enough so the first main lateral root is within 1 inch of the soil surface (Figure 1). A common planting error is digging holes too deeply.

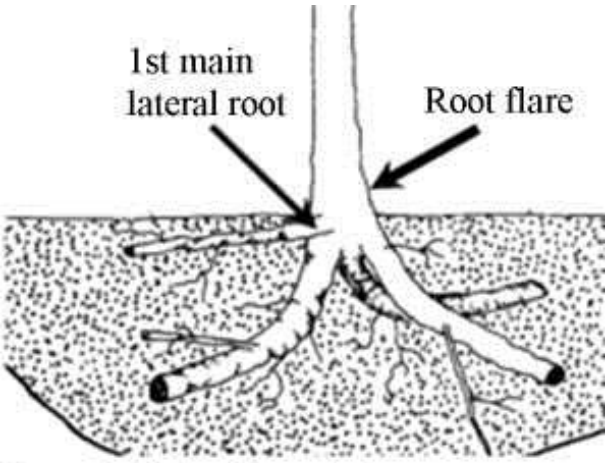


Image Credit: http://hort.ufl.edu

Figure 1. Proper planting depth

Containerized trees/shrubs:

Remove the tree or shrub from the container by lifting it up by the stem and tapping down on the rim of the container.

Then check to see if there is excess soil on top of the root system (often there is at least 4 inches of excess soil over the first main lateral root). Use a kabob skewer or straightened coat hanger to probe next to the stem into the soil ball until the first main lateral root is felt. If there is more than an inch of soil over those roots, use a saw to cut off the extra soil. Removing excess soil prevents future stem problems and promotes healthy root system.

Figure 2. Check for excess soil on top of the first main lateral root.

Next, check for encircling roots (Figure 3).

Remove encircling roots by sawing off the sides of the soil ball (Figure 4). This encourages a healthy, spreading root system.

Dig a hole that is at least double the diameter of the soil ball. Doubling the diameter of the hole makes it easier to position and water the plant. More water soaks into the loose soil, rather than running off the top of the soil surface.

Figure 3. Encircling roots.

Measure the distance from the first main lateral root to the bottom of the soil ball to determine the hole's depth and ensure that the first main lateral roots are within 1 inch of the soils surface.

Place the tree in the hole, making sure it stands straight and backfill the hole with the original soil.

Planting balled and burlapped trees/shrubs:

Balled and burlapped trees and shrubs come with burlap around the soil ball that is held together by a wire basket. These trees are often more mature than bare root and containerized trees.

Figure 4. Remove encircling roots by sawing off the sides of the soil ball.

Remove the wire and burlap from the top of the soil ball to check for excess soil over the first main lateral root. Remove excess soil if present.

Use the same steps in the containerized section for determining the hole's width and depth. Be sure all of the burlap is covered up when backfilling the hole.

Step 3: Caring for your tree/shrub

Mulch:

Create a mulch in a ring that is 2 to 4 inches deep and 6 feet in diameter around the tree. Keep the mulch off the trunk. This will help hold moisture in the soil and prevent trunk damage from lawn care machinery.

Stake (only trees that lean or fall over need to be staked):

Use two or three stakes to secure a tree. Attachments should be two-thirds of the distance from the ground to the first branch and stakes should be driven into the ground at least 18 inches deep. It is best to use a wide material such as canvas burlap or an old bicycle inner tube to loosely attach the tree trunk to the stakes. This allows the tree to move slightly without damaging the bark. After one growing season the tree will be established and stakes should be removed to allow for correct development.

Water:

Thoroughly water the tree at planting. Then water your tree a couple times a week for a total of 15-25 gallons per week until the ground freezes.

Protect trees from critter damage:

Create a tube around the tree's trunk using ¼ inch hardware cloth to protect it from critter damage. Extend the cloth at least 3 feet up, and don't let it touch the tree. Make sure hardware cloth is on your tree by late summer or early fall. Usually shrubs don't need protection, but fencing or hardware cloth around the shrub can prevent rabbit and vole damage.

Authors:

Lauren Stufft, Undergraduate Research Assistant; **Gary Johnson,** Technical Advisor**;**
& Jennifer Teegarden, Technical Advisor

References:

Moll, Gary. "The state of our urban forest." *American Forests* 95, no. 11/12 (1989): 61-64

Basic Tree & Woody Plant Structures & Forms

There are two basic tree structures and some common tree forms with which you should be familiar. These structures and forms are important during plant selection. Mindfulness in tree selection saves time in long term maintenance, reduces liability, decreases tree mortality and assures maximum benefit in plantings. Familiarity with basic structure and form also helps to inform decisions made when pruning for a maturity.

Some of the most important, non-aesthetic considerations are:

- Mature tree height.
- Apical dominance of mature tree.
- Relation to surrounding objects (i.e., buildings, above/below ground utilities).
- Root spread and encumbrance by hardscapes (sidewalks, malls, parking lots, etc.) within the root-zone and within drip-line.
- Some species tolerances for specific sites can also include:
    - Deicing salts and pH
    - Drought tolerance (hardscapes)

All photos on this page are courtesy of the University of Connecticut Plant Database.

Every tree is one of two basic structures and one of several basic forms. The first section defines and gives examples of the two structures. The second section defines some of the most common forms.

Section 1: Two Basic Structures

Decurrent: One basic type of growth is decurrent. A plant with decurrent growth does not have strong apical dominance. Instead multiple lateral branches compete for apical dominance, which tends to round out the plant form. Most hardwoods are thought of as having a decurrent growth habit. (See northern catalpa & white birch below)

Catalpa speciosa, Northern Catalpa

Catalpa speciosa, Northern Catalpa

Betula papyrifera, White Birch

Betula papyrifera, White Birch

Excurrent: The other basic type of plant form is excurrent. Plants categorized with this growth habit have strong apical dominance, a central stem, and pyramidal shape. Typically conifers are thought to have this type of growth habit but some hardwoods such as the tuliptree exhibit this characteristic.

Liriodendron tulipifera, Tuliptree

Liriodendron tulipifera, Tuliptree

Picea glauca, White Spruce

Picea glauca, White Spruce

Section 2: Common Forms

Rounded: A rounded growth habit is one that develops a nice globe shape.

Consider the bur oak pictured to the right. This is a splendid mature tree when planted in a location where it can attain its broad, rounded natural form. **When choosing plants for a site, mature size and form should be of primary concern.**

Oval: A plant growth form that is broadly elliptical or slightly "egg-shaped."

Syringa vulgaris, Japanese Tree Lilac

Catalpa speciosa, Northern Catalpa

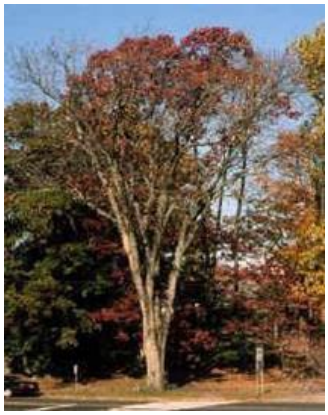
Aesculus hippocastanum, Horse Chestnut

Columnar: A columnar growth habit has a uniform width throughout and tapers very gently at the top. Many varieties of junipers and arborvitae share this growth habit. Many cultivars have been selected for their columnar growth habit to add variety in the landscape.

Thuja occidentalis

Pyramidal: A pyramidal growth habit is like a triangle with a wide base that gently tapers with height. Conifers may typically be thought of as having this growth type, but some deciduous trees do also.

Vase: The most well-known tree that portrays the vase shape is the American elm, *Ulmus americana.* The vase -like growth habit has a narrow base and fully expands with height. Below are some examples of the American elm.



Buried Root Systems and Tree Health

Gary Johnson - University of Minnesota Department of Forest Resources

Reprinted from the Minnesota Shade Tree Advocate, Volume 3 Number 4

Tree snapped at SGR compression point below ground.

Above-ground stem girdling roots

Dysfunctional root system - Apple tree failed in a wind storm

Stem girdling roots (SGRS) are those roots that grow either partially or completely against and compress (girdle) stem tissues of trees. Xylem and phloem (conducting) tissues in the stems become much smaller in diameter at the point/s of compression, compromising the transport of water, nutrients and photosynthates ("food"). Trees become stressed and more vulnerable to secondary problems (drought, insect attacks). Often, the compressed areas of the stems are weak points and far too often are the points of failure during windstorms. For instance, in the catastrophic windstorms of 1998 in Minnesota, 73.3%* of the lindens that were lost actually broke at compression points from SGRS, and most broke below ground. SGRs can and do form above ground, especially with maples and poplars. However, they can develop on most species below ground and out of sight. How can this happen? If a tree's root system has been buried too deep, the stem is subsequently buried. When rootsystems are buried too deep - with some trees, that's one inch of soil over the first, main order (first branch) roots - secondary woody roots grow upward, closer to the soil surface. Often, some of these roots end up growing against the stem tissues, either partially or completely encircling the stems.

Since 1997, the University of Minnesota Forest Resources Department has randomly sampled 303 trees (ash, maple, linden). Depths of soil over the first roots ranged from 0 to 13 inches. Analysis of the data later revealed a statistically significant relationship between depth of soil over the roots, condition of the trees and the frequency of stem girdling roots. As more soil was added over the root systems of those trees - for whatever reason - stem conditions declined and the frequency of stem girdling roots increased. So, deeper (planting) is not better. In the long run, it's worse for the long-term health and stability of the trees.

*Based on the storm damage research conducted by the Department Forest Resources, University of Minnesota, 1995-present.

Poor stem condition related to stem girdling roots and excess soil over root system.

Early fall color is a sign of potential root problems.

Strong Winds - Weak Trees - Lots of Debris

Gary Johnson & Eric North - University of Minnesota Department of Forest Resources

2013

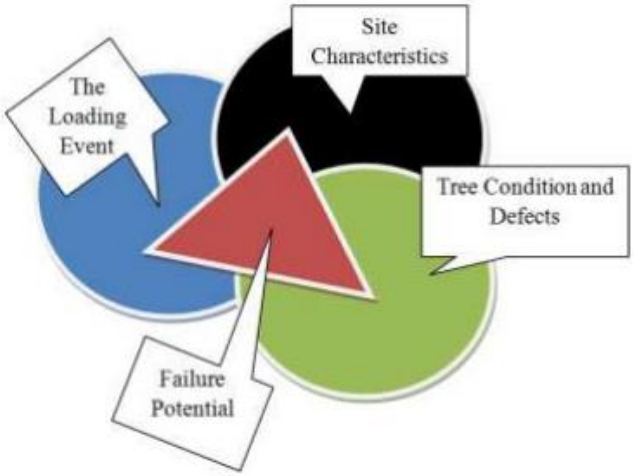
On June 21, 2013, the perfect storm swept through much of the southern two-thirds of Minnesota. In that path, community tree canopies were ravaged to different degrees with some communities only slightly damaged while others lost years of chlorophyll, shade in the summer and relief from winds in the winter. Unfortunately, many of those trees did some damage to sidewalks, curbs, cars, houses and utility lines on their way down. One month later, many communities and tree care companies are still scrambling to clean up the debris and begin the recovery process and once again there are those wondering if this damage could have been prevented.

The Storm Failure Triangle©

It's rare when one single event with one single force is the sole reason for all of the damage to trees. Tree damage typically ranges from a few broken branches to trees uprooted and blown to the next county with loading events ranging from 25-30 mph wind storms to raging winds accompanied by heavy rains or ice. When tornadoes sweep through an area, trees affected are often innocent bystanders than they are bad trees fraught with weaknesses or architectural problems. More commonly, trees that topple range from dense-canopied evergreens in windswept landscapes with water-soaked soils to majestic and mature shade trees perched in narrow boulevards.

The Storm Failure Triangle summarizes the main components of a weather loading event that result in some degree of damage by categorizing them as either:

1. The loading event
2. Site characteristics
3. Tree condition and any defects



<u>Loading Event:</u>

Any weather event that puts an unusual strain on a tree's architecture or stability. Loading events range from a common thunderstorm with winds greater than 25-30 mph to 130 mph down-bursts or tornadoes. Events may also include the weight of rain, ice or snow. The greater the loading on a tree, the greater the potential for damage or failure.

Unfortunately, there is no control over loading events but some damage can be lessened by avoiding planting or locating trees that are more vulnerable to some common loading events such as ice storms. However, avoiding tornadoes is out of the picture.

<u>Site characteristics:</u>

These include soil types, wind exposure or protection (friction), soil profile and saturation level, root plate space (narrow boulevard versus expansive lawn), plant competition.

There is some level of control in this category; the most notable is to avoid planting high density trees in open areas that have chronically saturated soils. Or, avoid planting trees that mature at a height of 60 feet in boulevards that are four feet wide.

Tree condition defects:

Often the most obvious and include size, presence and extent of decay, abnormal lean, included bark branch attachments, codominant leaders, canopy density, presence of static or dynamic cabling systems, live crown ratio, stem girdling roots, restricted rooting space, root loss due to construction activities and die-back.

This is the category with the greatest opportunity to mitigate much of the damage and failures that result from storms. Early and regular pruning can minimize architectural defects. Placing trees out of harm's way or protecting trees from unintentional vandalism, string trimmers or lawn mowers can reduce the frequency and extent of decay. Avoiding planting trees genetically prone to decay or poor architecture in high risk areas may not reduce the risk of damage or failure at the tree level but will reduce the frequency of damage to people and property.

Failure potential:

The likelihood that the tree will fail or incur some degree of damage. The more loading on a tree, the more site characteristics that compromise a tree's stability, health or condition and the more defects impacting a tree, the more likely failure or damage will result and the greater the severity.

The June 2013 Storm

The storm that swept through Minnesota on June 21 was not all that unusual. Straight-lined wind storms may not be very predictable here but they are not unexpected when the humid, warm days of summer arrive. June 21 was a bit unusual in the respect that the high winds (60 mph and greater) were accompanied by soaking rains (2.5 to more than 7 inches). Saturated soils, sandy through clayey, offered less friction and anchorage potential for the tree roots. A perfect storm.

Since 1995, the University of Minnesota's Department of Forest Resources has led the collection of storm damage data to trees as a result of loading events. When the storms hit Minnesota, two teams of researchers hit the streets and collected as much information as possible that related to the types of damage, the size and species of trees damaged and the site conditions. Damage was assessed in urban forests from Morris to the metro. Although not all data has been entered and analyzed, some familiar trends were revealed.

1. There was a high rate of complete failures, e.g., full or partial wind-thrown trees.

2. Most of the complete failures were attributed to (other than the high winds) saturate soils, dense-canopied trees, and trees with compromised root plates.

3. The same defects (consistently since 1995 when the research started) showed up in most of the abnormal failures or damages incurred by the trees: decay, included bark in branch attachments, and codominant leaders.

4. Small trees fared better than larger trees.

5. Boulevard trees failed more frequently than lawn or park trees.

6. Spruce and other dense-canopied conifers were over-represented in the complete failure categories.

Information is still being collected and there could be as many as 3,000 + trees evaluated this summer, significantly adding to the robustness of the conclusions drawn about damage and failure potentials. More importantly, lessons learned about mitigating some of the damage and failures will help both communities and property-owners avoid some of the monetary and environmental losses in the future.

At the conclusion of the 2013 season and analysis of all data collected, a summary article will be posted that will include some suggested management practices that reduce these losses to boulevards, parks and lawns.

Section Review Quiz: Best Planting Practices

1. The Storm Failure Triangle summarizes the three main components of a weather loading event that result in some degree of damage by categorizing them as either: the loading event, site characteristic, or tree condition and any defects.

A. True
B. False

2. Which of the following would be considered a loading event?

A. A storm with sever straight line winds.
B. Improper cabling or guying of tree limbs.
C. Heavy ice or snow storms.
D. All of the above.
E. A and C.

3. A percolation test is a method people use to determine a soil's ability to deal with drought or excessive water. Regarding this type of test, which statement below is most accurate?

A. A well-drained landscape soil should drain a 24" column of water within 24 hours.
B. A poorly-drained landscape soil can take up to 24 hours to drain a 24" column of water.
C. Regarding soils, no "significant" information can be obtained using a percolation test.
D. A well-drained soil should never take more than 12 hours to drain a 24" column of water.

4. Who sets the MINIMAL legal nursery pot size that 1 ½" caliper tree can be sold?

A. The Minnesota Landscape and Nursery Association (MNLA)
B. MnDot Landscape Inspection Manual
C. The Minnesota Shade Tree Advisory Committee (MnSTAC)
D. The American Standard for Nursery Stock.

5. "Box cutting" is an extreme solution to correct encircling or girdling roots in pot-bound nursery stock and most often leads to tree decline or mortality.

A. True
B. False

6. Which statement(s) below, accurately describe the benefit(s) of a community gravel bed?

A. The community gravel bed is one option fiscally challenged communities can utilize to grow more trees.
B. Fibrous root development, financial savings, and ease of planting "bare root" stock types are three reasons many communities have adopted the gravel bed system.
C. Adoption of the gravel bed system is one way to increase diversity of species in a community's public tree population.
D. Both B and C

Click here to navigate to answer page

Supplemental Materials

2016

Below is a list of supplemental materials. They are provided solely for individual study and reference. THESE MATERIALS ARE NOT COVERED IN THE TREE INSPECTOR EXAM.

MnDot Landscape Inspection Manual: 2013 Edition	http://www.dot.state.mn.us/roadsides/vegetation/pdf/landscapeinspectionmanual.pdf
American Standard for Nursery Stock, 2004 Edition	http://www.nj.gov/agriculture/divisions/pi/pdf/jgstandards.pdf
All You Need to Know About the Community Gravel Bed, 2013 Edition	https://trees.umn.edu/learn-more/gravel-beds
Minnesota Tree Inspector	http://www.mntreeinspector.com/
Minnesota Forest Pest First Detector Program	http://www.myminnesotawoods.umn.edu/forest-pest-first-detector/
Minnesota Shade Tree Short Course	https://issuu.com/mnstsc

Glossary

A

Adventitious Root — Root tissue that develops from newly organized meristems, sometimes associated with fill and/or stem decay.

Adventitious Shoot — Vegetative tissue that develops from newly organized meristems rather than latent buds; frequently associated with pruning wounds.

ANSI A300 — The American National Standards Institute standard for pruning trees and shrubs (corresponding secretariat: National Arborist Association, Manchester, New Hampshire).

Anthracnose — A type of plant disease that is typically a leaf and twig blight. Common on many hardwood species.

Apical Dominance — Relative superiority of the central leader to lateral branches; excurrent trees have strong apical codominance, as the central leader is superior in size to all other branches.

Arboriculture — The science and art of caring for trees, shrubs, and other woody plants in landscape settings.

B

Balled-and-burlapped nursery stock — Trees that have been either hand-dug or tree- spade-dug with a soil ball enclosing the roots. The soil ball is wrapped in burlap and may or may not be enclosed in a wire basket.

Bare-root nursery stock — Trees that are dug and shipped during dormant (leafless) seasons and have no soil harvested with the roots.

Best Practices — The best available techniques or treatments, considering the benefits and drawbacks, based on current knowledge.

Blight — A general term for plant disease causing rapid death or die-back.

Bracing — Connecting a weakly attached branch or leader to one or more, stronger branches or leaders for support. Braces are rigid, threaded steel rods inserted through the crotch attachment of two or more branches or leaders.

Branch — A secondary shoot or stem arising from the main stem of trunk.

Branch Angle — The angle of attachment between two stems; also referred to as crotch.

Branch Attachment — The structural linkage of branch to stem.

Branch Bark Ridge — The raised area of bark in the branch crotch that marks where the branch wood and the trunk wood meet.

Branch collar — The shoulder or enlarged area at the base of a branch by the annual production of overlapping layers of branch and stem tissues.

Branch Crotch The point where smaller branches unite with larger branches, or where co-dominant leaders meet. Also known as the ***branch union.***

C

Caliper Synonym for trunk diameter used to measure the size of nursery stock; by convention, measured 15 cm (6 in.) above the ground for stems less then or equal to 10 cm. (4 in.) and at 30 cm. (12 (in.) above ground for stems greater than 10 cm. (4 in.) Contrast with diameter breast height (D.B.H.).

Callus Tissues produced on woody plants as a response to wounding (also known as callus tissue).

Canopy The part of the crown composed of leaves and small twigs.

Cambium The dividing layer of cells that forms sapwood, or xylem, to the inside and bark or phloem, to the outside.

Candle New shoot growth of pines at a stage where needles have not elongated.

Canes Stems of a multiple-stemmed shrub.

Chlorosis / Chlorotic Foliage that has yellowed due to disease or mineral deficiency.

Co-dominant leaders More than one main leader in a tree that typically has only one leader.

Compartmentalization A physiological process which creates chemical and mechanical boundaries to resist organisms, such as decay fungi. It results in the separation of healthy tissues and infected tissues by reaction and barrier zones. Some species are "good" compartmentalizers and some are "poor."

Conifers Trees or shrubs that produce seed cones and pollen cones instead of fruits and true flowers.

Conk A type of fruiting structure formed by certain fungi. It is often "bracket like" and is often referred to as "bracket" or "shelf" fungus.

Container nursery stock Trees that have been either grown their entire lives in containers or field-potted into containers.

Critical root zone A way to define the protection zone for an individual tree. It is commonly calculated as the roots and soil within 1) the dripline, or 2) an area defined by a circle with a diameter 24 to 36 times the d.b.h. of the tree (1 to 1.5 feet of radius for each inch of d.b.h.).

Cultivar An assemblage of cultivated individuals distinguished by any useful, reproducible

D

D.B.H Literally, diameter at breast height. The d.b.h. is measured 4.5 feet from the ground on the uphill side of a tree.

Decay The degradation of woody tissue caused by biological organisms.

Deciduous Denotes a tree which sheds its leaves annually

Decurrent More than one leader or, not showing strong apical dominance. Trees and shrubs with decurrent growth habits are rounded to oval and broad in appearance.

Decline General loss of vigor. It is usually accompanied by crown symptoms, such as, crown or branch dieback.

Defect Visible sign that a tree or part of a tree is failing or has the potential to fail. Any structural weakness or deformity in the tree's branches, stem or root system.

Defoliation A loss of the current years or a past years foliage (leaves).

Diameter Breast Height (DBH) Diameter at Breast Height (measured at 4 1/2 feet above soil grade). DBH is required for determining tree value. Multi stemmed trees require diameters for each stem. In addition, the stem diameter must be factored by the relative crown ratio of the stem.

Dieback Death of a branch or branches, generally from the tip or top towards the main stem.

Disease An unfavorable change of the function or form of a plant from normal, caused by a pathogenic agent or unfavorable environment.

Dominant Leader The stem or "leader" that grows more vigorously than competing leaders.

Drop-crotching Drop-crotch pruning is the removal of a leader by cutting back to a lower, side branch that is at least 1/3 the diameter of the leader being removed. Also referred to as *Crown Reduction.*

E

Elevating Removing the lower branches of a tree or shrub. Also referred to as *Crown Raising.*

Embedded Bark Pattern of development of branch junctions where bark is turned inward rather than pushed out. See Included Bark.

Epicormic Branches or Sprouts Branches or sprouts that form on as a result of a serious disturbance, such as, improper pruning, disease or extensive dieback in the crown. Epicormic <u>*branches*</u> typically form weak branch unions with their stem.

Excurrent One main leader. Trees and shrubs with excurrent growth habits are upright and/or pyramidal in appearance.

Evergreens Trees or shrubs that retain their green leaves throughout the year. They may be conifers or true flowering plants.

F

Flush cuts Removing branches by cutting off the branch collar. *This practice is never recommended.*

Foliage Leaves of a plant or tree.

Fungicide A chemical that kills fungi.

Fungus Any number of organisms considered by some authorities to be lower plants; which lack chlorophyll

G

Gall *(burls)* Pronounced swellings on woody plants caused by certain insect and disease organisms.

Girdled To destroy or remove tissue, particularly living tissue in a rough ring around a stem, branch or root. Can be caused by mechanical means or pathogens. Affects water and nutrient uptake.

Genera Branch and trunk architecture resulting in a canopy form that resists failure.

H

Hardscape The pavement, irrigation system, and other structural elements of a landscape.

Heading Cut Pruning a currently growing of one-year shoot back to a bud, or cutting an older branch or stem back to a stub or lateral branch not sufficiently large enough to assume the terminal role.

High risk trees Trees that either have dead, broken, hanging or diseased branches that if they fell could cause injury to a target (person, building or other property).
Trees, that for whatever reason are, likely to completely fail and cause injury to a target. Dead trees, trees with damaged or decayed roots, trees with extensive decay, and trees that are damaged beyond repair are considered high risk trees.

I

Included Bark or Embedded Bark Included bark occurs when bark is included into the attachment between two stems, preventing the joining of wood tissue in the area between the stems. Included bark attachments always have an extremely narrow angle between the stems, resembling the letter "V" (rather than the letter "U" or "L" typical in strong attachments). As stems having included bark increase in size, pressure is exerted from the stem expansion and a crack often develops in the crotch between the stems. Included bark attachments have a higher potential for failure in later years.

Internode The area between nodes – typically A one year growth increment.

L

Lateral branches A branch or twig growing from a parent branch or stem.

Leader A dominant, upright stem, usually the main trunk. There can be several leaders in one tree.

Leaf spot A leaf disease characterized by numerous distinct lesions.

Lesions A defined necrotic (dead) area.

Live Crown Ratio The relative proportion of green crown to overall tree height. Live crown ratio is the ratio of percentage of foliage compared to a tree of the same species with a full crown.

Loam A soil texture classification having less than half as much clay as sand or silt and that combines the desirable attributes of each particle size; considered the ideal soil texture for most plants.

M

Mature Trees Trees that have reached at least 75% of their typical final height and spread.

Morphology The gross characteristics of plants.

Mycorrhizae Beneficial fungi that provide water and nutrients to roots and receive carbohydrates from roots.

N

Necrosis Death of plant cells usually resulting in browning or darkening of the tissue.

Node Points on a stem where buds are located.

P

Permanent Branches (Permanent Limbs) Branches that will remain on the tree for many years, perhaps throughout their lives.

Phenology Plant developmental stages at different times of the year.

Photosynthesis The transformation, in the presence of chlorophyll and light, of carbon dioxide (from air) and water (primarily from soil) into a simple carbohydrate and oxygen.

Phloem The tissue of the inner bark responsible for the transport of elaborate food stuffs.

Primary Root Plate A radial distance from the base of the tree equal to three times the tree diameter (*DBH*). This represents the critical area where root cutting will compromise the structural stability of the tree. Whenever healthy trees fail due to extreme soil saturation and/or high gusting winds, the root plate is generally a visible root ball, where the roots fail.

Prune To remove dead or living parts from a plant to improve its form.

R

Raising Selective pruning to provide vertical clearance; also known as lifting.

Reducing Pruning to decrease height or spread on entire tree or one section; also referred to as reduction or reduced pruning.

Reduction Cut (Drop-Crotch Cut, Lateral Cut)- Reduces the length of a branch or stem back to a live lateral branch large enough to assume the apical dominance- typically at least one-third the diameter of the cut stems.

Rejuvenation pruning The removal of all canes on an overgrown shrub to encourage new shoot development.

Renewal pruning Removing the oldest and / or largest canes of a shrub to encourage light penetration into the interior of the plant, and to stimulate new growth.

Resistant Able to withstand without serious injury, attack by an organism, or damage by a non-living agent. This DOES NOT mean immunity.

Root collar The point of attachment of major woody roots to the tree trunk, usually at or near the ground and associated with a marked swelling of the tree trunk.

Root Ball Refers to the root system of a container or balled-in-burlap nursery sack.

S

Sapwood The softwood just beneath the bark of a tree.

Shearing or Shaping A type of aesthetic pruning performed more commonly on shrubs or evergreens to create a sculpted appearance; usually done with a hedge shears.

Sign Observable indicator of a pathogen, insect or animal that is the causal agent.

Silviculture The art of establishing, growing, and regenerating a forest.

Species A group of plants that resemble each other closely and that interbreed freely.

Spreaders A section of wood that is wedged between two narrow-angled branches in order to force them into a wider angle; usually only left on for one growing season.

Stem A woody structure bearing foliage and buds that gives rise to other stems.

Suckers Vigorously-growing, vertical shoots that arise from the base of trees or shrubs, or from underground stems or roots.

Susceptible Unable to withstand attack by an organism or damage by a non-living agent without serious injury.

Structural Pruning Pruning that influences the orientation, spacing, growth rate, strength of attachment, and ultimate size of branches and stems.

Symptom The evidence of disturbance in the normal development and function of a host plant. Examples: chlorosis, necrosis, galls, brooming, stunting etc.

Systemic Affecting or distributed throughout the whole plant body.

T

Taper The change in diameter over length of trunks and branches; Important to mechanical strength.

Terminal *(branch)* A branch in the dominant vertical position on the top of a tree or end of a limb. If a terminal branch is lost, a lateral can assume the terminal role.

Topping The indiscriminate heading-back of all leaders on a tree. Also known as dehorning, stubbing, stub-cutting, hatracking etc.

Transplant Shock Reduction in growth and vigor that may occur following relocation of a plant from one site to another.

Trunk The part of a tree between the root collar and the first branch of the crown.

U

Undercut Using a saw to remove a branch by beginning the cut under the branch and sawing upwards. This is a common pruning technique for removing narrow angled branches.

V

Vector An organism, usually an insect that transmits a pathogen from one host to another.

Vertical mulching The addition of organic matter and/or fertilizer into holes drilled within the critical root zone to improve tree condition.

Vibratory plowing A process that severs roots to a depth of up to 5 feet. It is sometimes required in areas where diseases may be transmitted through root grafts.

W

Watering Bags ***See "Tree watering bags" (above)***

Watersprout Similar to suckers, except they arise from stems and branches

Wetwood A discolored, water-soaked condition of the heartwood of some trees presumably caused by bacterial fermentation. Often associated with distinctive odor, gas production, and an exudation called slime flux.

Witches' Broom An abnormal cluster of twigs and branches caused by certain pathogens.

Wound The opening that is created any time a tree's protective bark covering is penetrated, cut, or removed. Wounding inures or destroys living tissue.

Woundwood Differentiated woody tissue that forms after initial callus has formed around margins of a wound. Wounds are closed primarily by woundwood.

X

Xylem Tissue produced by the activity of the cambium and composed of tracheids, wood fibers, and parenchyma cells, which function to transport and store water and mineral elements as well as to provide mechanical support.

Section Review Quiz Titles	QUIZ ANSWERS:
Firewood Regulations and Identification	1. A 2. B 3. D 4. B
Dutch Elm Disease	1. C 2. C 3. D 4. C 5. A
Oak Diseases in Minnesota	1. D 2. C 3. B 4. A 5. D 6. A 7. C
Emerald Ash Borer	1. A 2. D 3. A 4. C 5. D 6. B
Other Pests, Plants and Problems	1. C 2. A 3. E 4. A 5. D
Best Planting Practices	1. A 2. E 3. A 4. D 5. B 6. D