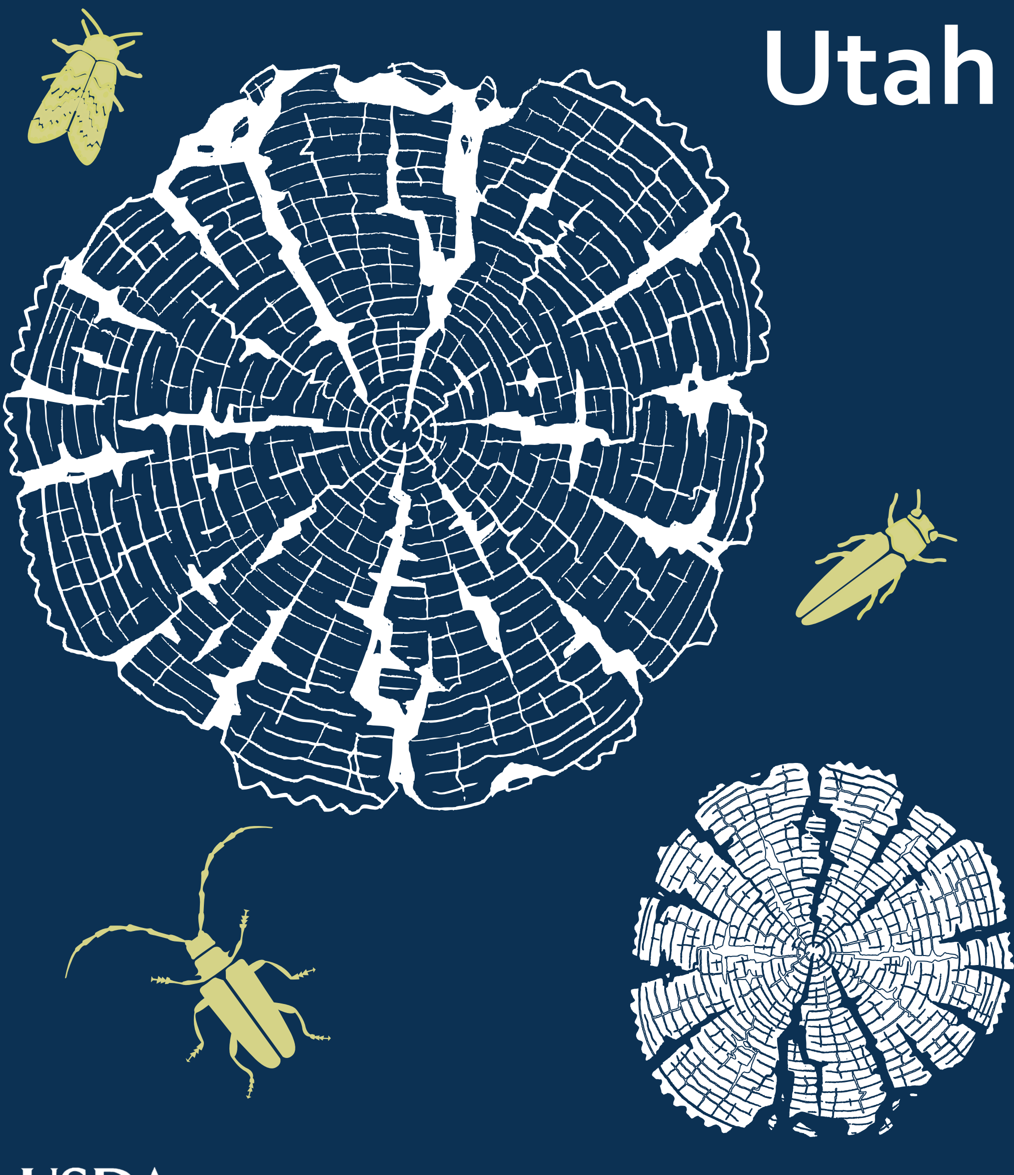
Invasive Pests of Landscape Trees in Utah



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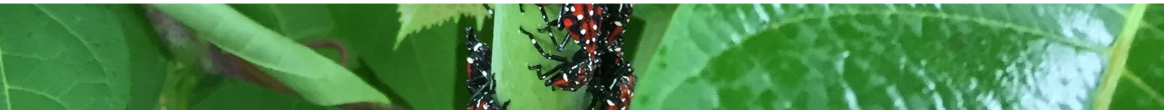

Invasive Pests of Landscape Trees in Utah

2020

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Acknowledgments
Thanks to Alana Wild and Dawn Holzer (USDA APHIS PPQ) and Kristopher Watson and Joey Caputo (Utah Department of Agriculture and Food) for reviewing previous drafts and providing helpful comments and suggestions. Funding was provided by the U.S. Department of Agriculture - Animal and Plant Health Inspection Service - Plant Protection and Quarantine.

Inside Cover Photo Credit: Emelie Swackhamer, Penn State University

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UTAH FIRST DETECTOR PROGRAM

Invasive species are a leading and growing threat to our nation's agricultural and natural resources. Thousands of invasive species have been introduced into the U.S., and the associated damage and management costs are estimated to exceed $138 billion per year. In response to this threat, the Utah Plant Pest Diagnostic Lab (UPPDL) created the Utah First Detector Program to prepare citizen responders with the knowledge and skills necessary to identify invasive pests, collect and submit high quality samples to the UPPDL, and notify the appropriate authorities when necessary. The UPPDL is a service of USU Extension and the Department of Biology at USU. The UPPDL is staffed with highly skilled and experienced professionals that provide rapid and accurate identification of pest-related problems.

The primary goal of the Utah First Detector Program is to create a network of well-trained citizen volunteers ("First Detectors") to assist with ongoing invasive pest detection and outreach efforts. The target audience for the Utah First Detector Program includes certified arborists, tree and lawncare professionals, forestry and natural resource professionals, conservationists, Master Gardeners, Extension personnel, state agricultural inspectors, and others with an interest in pest detection and response.

The UPPDL and USU Extension work closely with other federal and state agencies to address invasive pest threats, including the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA APHIS PPQ) Program, and the Utah Department of Agriculture and Food (UDAF). The Utah First Detector Program is an extension of the Utah Cooperative Agricultural Pest Survey (CAPS) Program, which is part of the larger national CAPS program. For more information about the Utah CAPS program, visit http://utahpests.usu.edu/caps.

SUBMITTING SAMPLES

Submitting Digital Images

Send high-resolution images as an email attachment to one of the labs listed below. Images should be in focus, contain a ruler or other object for scale, and contain different parts/views of the insect and/or plant symptoms.

Submitting Physical Samples

Live insects can escape from containers; therefore, it is very important that you kill (do not squish) insects before submitting them to a qualified professional. Place the insect into a spill-proof jar or vial containing rubbing alcohol (hand sanitizer or white vinegar are suitable alternatives). You can also freeze insects before placing them into a sealable crush-proof container. If submitting plant material, handle it as if it contains a live pest (i.e., secure plant material so that an emerging pest could not escape). Wrap plant material in paper bags or newspaper. Secure samples using packing material to avoid breakage/damage. Samples containing plant material should be sent overnight.

Include with your submission, the date, collection location, email address, phone number, and physical address in case we have follow-up questions. Mail the sample(s) to one of the labs listed below as soon as possible to prevent drying or deterioration of the insect or plant material.

Utah Plant Pest Diagnostic Laboratory
Utah State University
5305 Old Main Hill
Logan, UT 84322-5305
Phone: 435-797-2435
Email: caps@usu.edu or utahpestlab@gmail.com
Website: http://utahpests.usu.edu/uppdl/

UTAH PESTS

Utah Department of Agriculture and Food
Plant Industry and Conservation Division
350 N. Redwood Road
Salt Lake City, UT 84114
Phone: 801-982-2311
Email: agriculture@utah.gov
Website: https://ag.utah.gov/farmers/plants-industry/

UDAF
UTAH DEPARTMENT OF AGRICULTURE & FOOD

DUTCH ELM DISEASE

Present in Utah

Background

Dutch elm disease (DED) is caused by two closely related fungi, *Ophiostoma novo-ulmi* and *O. ulmi*. These pathogens are primarily spread to hosts by elm bark beetles, but can also spread from infected to healthy trees through root-to-root contact. DED was first discovered in the Netherlands in 1921 and in the U.S. in Ohio in the 1930s. It is thought to have arrived to the U.S. on shipments of elm logs from France. DED is now found throughout much of North America, and was first recorded in Utah in 1982.

Plant Hosts & Susceptibility

All elm species (*Ulmus*) native to North America are susceptible to DED. American elm (*U. americana*) is highly susceptible; however, cultivars have been bred that have a greater tolerance to the disease (see table on page 12). European elms, such as camperdown elm (*U. glabra* 'Camperdownii'), are moderately susceptible, and Asiatic elms, including Siberian elm (*U. pumila*) and Chinese or lacebark elm (*U. parvifolia*), are resistant. In Utah's planted landscapes, Siberian elm is the most common elm species, along with sparse plantings of American elm and camperdown elm.

Description & Life Cycle

Three species of elm bark beetles can spread the fungi that cause DED, including the native elm bark beetle (*Hylurgopinus rufipes*), European elm bark beetle (*Scolytus multistriatus*), and banded elm bark beetle (*S. schevyrewi*). Only the European and banded elm bark beetles are associated with the disease in Utah.

The adults of both species are tiny and brown. They overwinter as larvae inside the host tree and emerge as adults in spring, seeking out healthy elms to feed in crotches of young twigs ("twig-feeding" stage). The adults then mate and lay eggs under the bark of diseased, stressed, or dying trees. After the eggs hatch and larvae mature, new adult beetles emerge from the trees to repeat the life cycle. There are two to three generations of elm bark beetles per year in Utah.

Beetles that emerge from previously-infected trees carry fungal spores on their bodies. Infection of susceptible elms happens during the twig-feeding stage. Spores are deposited on the feeding site, germinate, and form a mass of fungal mycelia that grows through the conductive tissues (xylem). The tree tries to stop the fungus by producing plug-like structures (tyloses), which block the flow of water.

The pathogen can also spread via root-to-root contact with adjacent elms that are within 50 feet. These infections have a tendency to spread upward and more rapidly through the tree than beetle-vectored infections, which tend to spread downward.

Injury Symptoms

Symptoms of DED include wilting, yellowing (flagging) branches within the crown, and browning of foliage. They may appear anytime during the growing season and intensify during and after drought. Symptoms can also include dark streaking or staining in the xylem in newly-formed branches and stems. Beetle-vectored infections often develop symptoms in the upper crown first, whereas root-graft infections tend to show symptoms in the lower crown first. Some trees die within weeks of becoming infected, whereas others will struggle for years before eventually succumbing. Note that other biotic and abiotic diseases in Utah can cause flagging, including elm anthracnose, cankers, drought, elm yellows (also known as elm phloem necrosis), and nutrient deficiencies such as iron chlorosis.

Monitoring

Monitor trees regularly for signs of DED and beetle infestations. Review the chapter on elm bark beetles for more information about visual inspections and trapping.

Management

Don't move firewood. Avoid transporting harmful tree pests by buying local firewood or gathering firewood on site, if permitted.

Plant resistant varieties. See table on page 12 for American elm cultivars and other elm species that have shown greater tolerance to DED.

Remove and destroy infected trees. Diseased branches can be pruned out if the infestation is caught early; otherwise, remove trees at ground level if more than 5% of the tree canopy is affected. Remove at least 10 feet below the last area of streaking and immediately destroy the branches and disinfect the pruning tools using a 10% bleach solution. Closely examine the entire branch circumference to be certain the fungus has been removed. Pruning should be done in late fall or winter when beetle activity is low. Properly dispose of tree trunks and branches by either burning, burying, chipping, or debarking cut wood.

Prevent disease spread from root grafts. In areas where root grafts between elms are likely to occur, dig a trench 36 to 40 inches deep. Re-fill the trench with soil and immediately remove the diseased elm(s). Note that if more than 25% of a tree crown is damaged by DED, root severing may not save adjacent trees.

Use preventive fungicides. Protect high-value or specimen trees that have less than 5% damage with a yearly fungicide injection. Injections are not recommended for trees with root-graft infections. Only experienced and licensed applicators should perform tree injections to prevent tree damage and ensure efficacy.

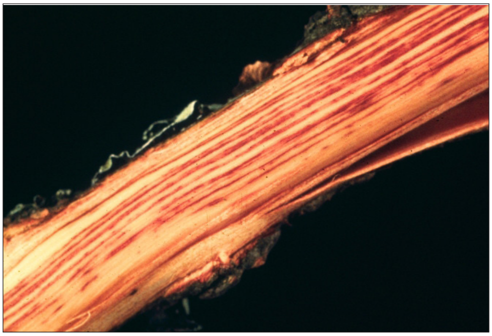
Apply insecticides when necessary. Insecticides can kill the beetles that transmit DED. For more information, review the chapter on elm bark beetles in this guide.

Symptoms of Dutch elm disease include wilting and yellowing foliage. Petr Kapitola, Central Institute for Supervising and Testing in Agriculture, Bugwood.org

Yellowing and thinning of canopy due to Dutch elm disease. Joseph OBrien, USDA Forest Service, Bugwood.org

Flagging of foliage in an elm tree affected by Dutch elm disease. Joseph OBrien, USDA Forest Service, Bugwood.org

Close up view of wilting leaves. Minnesota Department of Natural Resources - FIA, Minnesota Department of Natural Resources, Bugwood.org



Streaking of vascular tissue due to Dutch elm disease. North Carolina Forest Service, Bugwood.org

Dark rings are symptomatic of Dutch elm disease. Bruce Watt, University of Maine, Bugwood.org

Portion of elm wood affected by Dutch elm disease showing galleries created by the vector, European elm bark beetle. William M. Brown Jr., Bugwood.org

Vascular discoloration caused by Dutch elm disease. Penn State Department of Plant Pathology & Environmental Microbiology Archives, Penn State University, Bugwood.org

Coremia (spore-bearing bodies) of Dutch elm disease in an elm bark beetle gallery. Joseph OBrien, USDA Forest Service, Bugwood.org

Portion of an elm tree suffering from Dutch elm disease, with bark beetle galleries underneath the bark. William M. Brown Jr., Bugwood.org

Trenching around newly removed elms to prevent root graft transmission of Dutch elm disease. Whitney Cranshaw, Colorado State University, Bugwood.org

Elms resistant or tolerant to Dutch elm disease.

Species	**Cultivar**	**Resistant**	**Tolerant**
Ulmus americana (American or white elm)	Jefferson		X
	Lewis and Clark		X
	New Harmony		X
	Princeton		X
	Valley Forge		X
	American Liberty	X	
	Independence	X	
	Delaware	X	
U. davidiana (David or Japanese elm)		X	
U. parvifolia (Chinese or lacebark elm)	Allee	X	
	Athena	X	
	Dynasty	X	
	Everclear	X	
U. pumila (Siberian elm)		X	
U. pumila x *Ulmus japonica*	Cathedral		X
U. carpinifolia x *Ulmus parvifolia*	Frontier	X	
U. japonica x *U. pumila*	New Horizon	X	
	Sapporo Autumn Gold	X	
	Vanguard	X	
Ulmus 'Urban' x *U. wilsoniana* 'Prospector'	Patriot	X	
U. glabra x *U. carpinifolia*	Pioneer	X	
U. wilsoniana	Prospector	X	
U. japonica x *U. wilsoniana*	Accolade	X	
	Danada	X	
U. glabra x *U. carpinifolia* x *U. pumila*	Homestead	X	
U. japonica x *U. pumila* x *U. wilsoniana* (cross between 'Accolade' and 'Vanguard')	Triumph	X	

THOUSAND CANKERS DISEASE

Present in Utah

Background

Thousand cankers disease (TCD) is a deadly disease of walnuts and is caused by the fungus *Geosmithia morbida*, which is spread (vectored) by the walnut twig beetle (WTB), *Pityophthorus juglandis*. The beetle is indigenous to the native range of the Arizona walnut (*Juglans major*) and includes Arizona, New Mexico, and Chihuahua, Mexico. The pathogen-vector complex was identified in Colorado 2008, but mortality of walnuts in Utah was first noticed in the late 1980s. The disease's common name refers to the necrotic lesions (cankers) that form around the beetle galleries in the bark and phloem. TCD is established in Utah, Arizona, California, Colorado, Idaho, New Mexico, Oregon, and Washington, and has been detected in North Carolina, Pennsylvania, Tennessee, and Virginia.

Plant Hosts & Susceptibility

Hosts include black walnut (*Juglans nigra*), California walnuts (*J. hindsii*, *J. californica*), and English (Persian) walnut (*J. regia*). Black walnut and its hybrids are very susceptible to TCD; California walnuts and English walnuts are moderately susceptible; Arizona walnut (*J. major*) is considered resistant.

Description & Life Cycle

WTB is a tiny bark beetle that is about 1/16 inch long and reddish-brown in color. It can be distinguished from other bark beetles by having four to six concentric ridges on the pronotum (shield-like cover over the head). There are likely two to three overlapping generations. They overwinter as larvae or adults beneath the bark and then emerge from trees, heavily contaminated with fungal spores, the following spring when temperatures exceed 65°F. The adults then feed on new walnut trees, mate, and lay tiny eggs, preferentially on large limbs and trunks, all the while depositing spores. After the eggs hatch, the larvae tunnel into the cambium, where they feed for four to six weeks until pupation. The larvae are C-shaped, white, and about 3/16 inches long when mature. The spores of *Geosmithia* germinate and hyphae colonize the area surrounding the beetle galleries, forming small cankers.

Injury Symptoms

It may take several years before TCD is noticed. Symptoms generally begin in the crown and include yellowing leaves, flagging and wilting foliage, thinning crown, dead branches, and thousands of small cankers that develop around beetle feeding sites (push-pin sized holes) and merge to form several larger cankers. Cankers may bleed, ooze, and develop stained areas on the outer bark. Other symptoms include egg galleries (horizontal across the wood grain) and larval galleries (vertical along the wood grain). Trees usually succumb within three years of first symptoms.

Monitoring & Disease Diagnosis

Early detection of infested trees is important. The presence of WTB can be detected with the use of funnel traps containing pheromone lures, which are available commercially, with antifreeze placed in the trap cup. Place the trap nine to 15 feet away from the host tree and about nine feet above the ground. Do not hang the traps directly from the host tree as this can cause the tree to be attacked by WTB. Traps should be deployed when WTB are active, usually from March through November.

Management

Don't move firewood. Limit the movement of firewood to prevent the introduction of forest pests to new areas. WTB can survive undetected beneath the bark of dry wood for up to seven months.

Maintain healthy trees. Healthy trees are generally less susceptible to pests. Promote tree health by using good cultural practices, such as proper irrigation and fertilization.

Remove and destroy infested trees. Sanitation is the primary strategy for managing this disease complex. Trees that are not heavily infested can be pruned during the winter months before beetles are active. Burn the pruned branches to reduce disease inoculum. Infested trees that have less than 50% live crown should be promptly removed and burned.

Biological control. Known biological control agents include parasitic wasps (*Neocalosoter* and *Plastonoxus*), snakeflies (order Raphidoptera), predaceous beetles (*Narthecius simulator*, *Parandrita cephalotes*, and *Temnochila chlorodia*), and entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium brunneum*).

Avoid pesticides. Chemical control is not recommended for the beetle or the pathogen. Insecticides have not been shown to reduce tree mortality rates and do not prevent the progress of the fungal disease.

Branch with dieback associated with infestation of walnut twig beetle. Whitney Cranshaw, Colorado State University, Bugwood.org

Crown thinning and dieback associated with thousand cankers disease. Curtis Utley, CSUE, Bugwood.org

Large trunk cankers are common with thousand cankers disease. Whitney Cranshaw, Colorado State University, Bugwood.org

Branch cankers can develop around beetle galleries. Ned Tisserat, Colorado State University, Bugwood.org

Close up view of branch canker that developed around a beetle gallery. Ned Tisserat, Colorado State University, Bugwood.org

Walnut twig galleries and cankers with push-pin sized holes indicating beetle feeding sites. Ned Tisserat, Colorado State University, Bugwood.org

Canker on walnut seedling. Curtis Utley, CSUE, Bugwood.org

Walnut twig beetle adults on penny for scale. Whitney Cranshaw, Colorado State University, Bugwood.org

PINE WILT DISEASE

Not known to occur in Utah

Background

Pine wilt is a tree-killing disease caused by the beetle-vectored pinewood nematode (PWN) (*Bursaphelenchus xylophilus*). Because the nematode is native to North America, native pines may harbor them, but these trees are rarely affected by the disease. Primary susceptible hosts in the U.S. include non-native pines, such as Scotch, Austrian, and mugo. Pine wilt has spread beyond the U.S. to become a destructive disease to the native and non-native ranges of these hosts in parts of Portugal, Spain, China, Taiwan, Korea, and Japan. In the U.S., pine wilt was first reported killing Austrian pines in Missouri in the late 1970s, and is currently most prevalent in the Midwest (Kansas, Nebraska, South Dakota, and Colorado). Pine wilt can potentially be a problem anywhere susceptible pine trees are planted, especially during hot and dry conditions. It is currently not known to occur in Utah.

Plant Hosts & Susceptibility

Scotch/Scots pine (*Pinus sylvestris*) is considered the most susceptible host to pine wilt, followed by Austrian (*P. nigra*), mugo (*P. mugo*), and Japanese black (*P. thunbergii*) pines. The native eastern white pine (*P. strobus*), is moderately susceptible. All native western U.S. conifers are resistant.

Susceptible host trees that are over 10 years of age, and/or under stress from drought, nutrient deficiency, or other factors, are more likely to succumb to this disease.

Description & Life Cycle

PWN are transmitted from infected trees to healthy trees by several species of wood-boring insects known as pine sawyers or longhorned beetles (*Monochamus* spp.). Adult beetles are black to brownish-gray with variable white markings, about one inch long, and have antennae that can extend one to three times the body length. In temperate climates, adults are active from May to September, laying eggs on conifer bark that hatch into roundheaded larvae. The larvae feed within the cambium and sapwood, pupate near the bark, and emerge as adults in a time period from 50 days to two years. Adult beetles that harbor PWN carry them in the tracheae of their respiratory system, and transmit them via one of two pathways — primary transmission, which results in pine wilt disease, or secondary transmission, which contributes to population density.

Primary transmission occurs when nematodes are introduced into healthy trees. After pine sawyer adults emerge from a host tree, they feed on succulent twigs of healthy pines for a brief period before mating. This feeding creates tiny wounds, and if PWN are present within the beetle, the nematodes emerge and enter the tree through the fresh wounds. PWN then travel through the sapwood to feed on plant cells within resin ducts in cortical and xylem tissue. This feeding causes air pockets that disrupt the flow of water, leading to wilt. Within the tree, PWN develop from egg to adult within as few as five days, and after several weeks, there may be hundreds of thousands of individuals spread throughout the crown and roots of the infected tree. As the tree weakens, the nematodes switch to a dispersal phase, and seek out pine sawyer beetle pupae near the bark surface. The PWN colonize the beetle's respiratory system, and are carried to new hosts after adult beetles emerge.

Secondary transmission of PWN is the most common phase of nematode survival and dispersal. Pine sawyer beetles only lay eggs on weakened or dying trees, or on freshly-cut logs with intact bark. During egg-laying, nematodes leave the beetle and enter the host. PWN that are spread in this manner survive and reproduce within the dead or dying host by feeding on fungi that typically invade trees or logs attacked by borers. Although this secondary transmission is not a strong contributor to tree death, it provides large reservoirs of nematodes for later dispersal to healthy trees.

Injury Symptoms

Symptoms of infected trees are typically expressed from the tree canopy downward. Initially, needles fade from green to gray to tan/brown, and eventually all needles and shoots will wilt. Trees may succumb to pine wilt within a year of infection, but hot, dry conditions may speed this to just a few weeks. After the tree dies, the brown needles will remain attached, and the wood becomes brittle and dry. Trees infested with pine wilt disease may develop a blue stain in the wood, resulting from blue- or black-stain fungi (*Ceratocystis* and *Ophiostoma* spp.) that invade dying trees. This is not a diagnostic feature as staining can also result from other factors.

Monitoring & Disease Diagnosis

Multi-funnel traps baited with a blend of ipsenol, ipsdienol, ethanol, and α-pinene can be used to monitor pine sawyer beetles. For visual inspections of susceptible trees, look for adult beetles feeding on needles and bark of twigs, or inspect trees or logs with intact bark for coarse sawdust and large, round exit holes.

For trees with suspected pine wilt disease, diagnosis requires the use of a microscope to identify nematodes that emerge from infected wood. Nematodes can be recovered by first collecting either six to eight inch sections of symptomatic limbs that are greater than one inch in diameter, or wood chips by drilling a large-diameter (½ to one inch) bit into branches or trunk. The limb sections or chips are then soaked in water for 24 to 48 hours, and a sub-sample of the water is collected for microscopic viewing. Several nematode species can occupy dead or dying pine trees; however, non-target nematodes can be reduced by removing the bark before soaking limbs or chips in water. Further, several species of *Bursaphelenchus* may be present in the wood, but only *B. xylophilus* causes pine wilt. Note also that nematodes may not be evenly distributed throughout the tree, so samples should be taken from different areas of the tree. If you suspect pine wilt disease in Utah or need help with identifying nematodes from symptomatic trees, contact the Utah Plant Pest Diagnostic Lab. Wood cores should be taken from the trunk, placed in a container with water, and then shipped overnight. Contact the lab prior to shipping.

Management

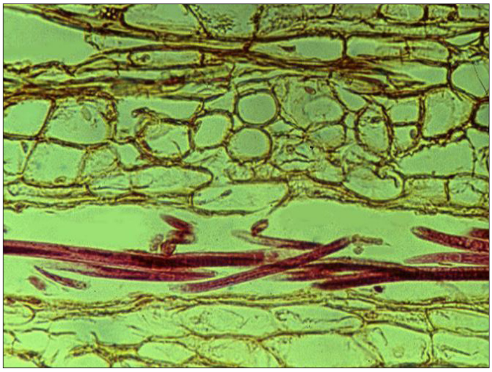
Although this disease has not been detected in Utah, the changing climate may contribute to future incidence since pine wilt disease is more severe in cases of high temperature and drought. Therefore, taking a pro-active stance of proper sanitation and pine tree care in Utah is encouraged.

Maintain healthy trees. Healthy trees are more resistant to damage. Use of mulch, fertilization based on soil testing, and providing irrigation to trees during dry periods can help promote and maintain vigorous trees.

Remove and destroy infested trees. Trees killed by pine wilt should be removed at ground level and destroyed before beetles emerge the following spring. Infested trees can be chipped, burned, or buried. Chips can be used for landscaping purposes since beetles cannot obtain the nematode from the chips, and nematodes within the chips cannot spread on their own. Do not save infested wood for firewood, transport infested logs, or store fresh pine wood near susceptible pine trees, since pine sawyer beetles (which may harbor PWN) can lay eggs in pine logs with intact bark, and the nematodes transmitted in this manner can survive within the logs by feeding on blue-stain fungi (if present).

Limit planting of susceptible pine trees. When planting new trees, consider deciduous trees or conifer trees that are native and well-adapted to site conditions. Avoid planting highly susceptible pine trees, such as Austrian and Scotch pines.

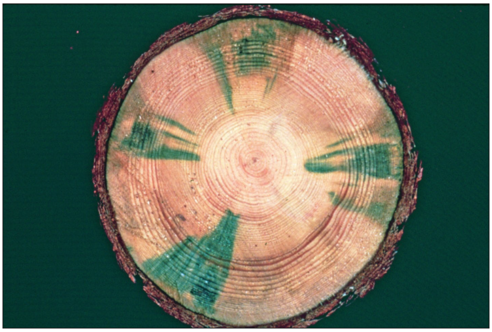
Apply pesticides when necessary. Pine wilt has not been detected in Utah, so there is no current need for chemical control of this disease. There are no chemical treatments to cure trees with pine wilt, and foliar or trunk applications targeting pine sawyer beetles are not recommended, since adults are present all season long. In areas of the U.S. where this disease occurs, trees have been protected via trunk injection with a product that kills or immobilizes the nematodes. Abamectin, a chemical produced by the soil bacterium, *Streptomyces avermitilis*, or emamectin benzoate, is applied by a professional applicator prior to infection during warm, fall weather. Yearly injections provide the greatest protection, while injections every other year have also provided good control.



Pine wilt nematode is a microscopic, worm-like organism that feeds on plant cells. Mactode Publications, Mactode Publications, Bugwood.org

Close up of pine wilt disease. USDA Forest Service - Region 2 - Rocky Mountain Region, Bugwood.org

Damage on Japanese red pine caused by pine wilt disease. USDA Forest Service - North Central Research Station, Bugwood.org



Blue stain caused by the pine wilt nematode. USDA Forest Service - North Central Research Station, Bugwood.org

Damage on Scots pine caused by pine wilt disease. USDA Forest Service - North Central Research Station, Bugwood.org

The whitespotted sawyer can vector pine wilt nematode. Joseph Berger, Bugwood.org

WHITE PINE BLISTER RUST

Not known to currently occur in Utah

Background

White pine blister rust (WPBR) is a disease that threatens five-needled (white) pine stands and ecosystems. WPBR is caused by the fungus *Cronartium ribicola*, which is native to central Siberia and east into Asia. It was introduced into North America in the late 1800s via imported nursery stock, and is now found in most regions where five-needled pines grow in the U.S. In Utah, the disease has only been found on an alternate host in the central part of the state (whitestem gooseberry, *Ribes inerme*). The closest infected pines occur in southeast Idaho on limber pine (*Pinus flexilis*) in Bear Lake County.

Plant Hosts

The primary hosts of WPBR are five-needled (white) pines, including western white pine (*Pinus monticola*), limber pine (*P. flexilis*), Great Basin bristlecone pine (*P. longaeva*), whitebark pine (*P. albicaulis*), Rocky Mountain bristlecone pine (*P. aristata*), and southwestern white pine (*P. strobiformis*). Like most rust fungi, *Cronartium* requires an alternate host to complete its life cycle, and these include currant and gooseberry (*Ribes* spp.), indian paint brush (*Castillija* spp.), and lousewort (*Pedicularis bracteosa* and *P. racemosa*).

Description & Life Cycle

The fungus that causes WPBR, *Cronartium ribicola*, has a complex life cycle that includes five spore types and an alternate host (most commonly currant or gooseberry). During late summer or fall, spores (basidiospores) produced from alternate hosts are carried short distances on cool, moist air currents to infect pines through stomates on needles. The fungus then slowly grows through the host tissue to cause a canker on twigs, branches, or the main trunk, moving about three inches a year. The following spring, small honey-colored droplets (pycnia) form on the surface of the bark at the margins of branch cankers, filled with short-lived spores (pyniospores). During the second spring after infection, white blisters (aecia) form in place of the pycnia and crack open to release pustules of yellow-orange spores (aeciospores), which are then carried long distances on wind currents to infect alternate hosts. On the alternate host, the fungus forms masses of orange spores (urediniospores) on the underside of leaves that cause infections on other *Ribes* hosts throughout the season. In late summer or fall (when temperatures drop, day length shortens, and alternate hosts naturally shed their leaves), hair-shaped structures (telia) form to produce wind-dispersed spores (basiodiospores) that then infect pine hosts, repeating the life cycle.

Injury Symptoms

Signs and symptoms on alternate hosts include yellow to orange leaf spots with visible fruiting bodies on the underside of the spots, and leaf drop. On pines, symptoms may appear slightly different depending on the host. Initial symptoms appear as inconspicuous yellow or red spots on needles, followed by a slight swelling of the branch or twig. A few years after the initial infection, sunken or swollen cankers form on branches, often with yellow or orange-colored margins and resin flow. As cankers mature, they may girdle the phloem and kill the branch. Distinctive blisters of orange spores are visible during the spring and summer. Other symptoms include top-kill and branch flagging (dead branches with reddish-orange or brown needles), reduced cone and seed production and tree vigor, rodent-feeding at canker margins, and increased susceptibility to other pests. Five-needled pines of all ages are susceptible to WPBR; however, seedlings and young trees have higher mortality rates due to the shorter distance for the disease to travel from the infected needles to the main stem.

Management

Current control efforts focus on preventive management strategies. Note that some of these options are labor intensive, costly, may require specialized knowledge, judgement, and/or skill, and may need to be performed yearly. Some strategies may only be suitable for high-value trees.

Remove alternate hosts. Early control efforts focused on eradication of *Ribes* from the vicinity of pine hosts because the basiodiospores, which are short-lived, are thought to infect mostly nearby pines. This strategy was relatively successful on cultivated *Ribes*, but the abundance of wild *Ribes* in difficult terrain and remote locations prevent this from becoming a realistic and widespread solution. Regardless, removal of alternate hosts (especially within a 200 feet radius) can help to reduce the incidence of WPBR. Alternate hosts can be uprooted or removed using a herbicide application in accordance with label directions.

Plant resistant varieties. Increasing the frequency of host resistance across the landscape is seen as the most sustainable strategy for managing WPB. ‘Paton’s Silver Splendor’ is a variety of eastern white pine that exhibits resistance to WPBR. Further, many cultivars of currant and gooseberry are known to be resistant, including ‘Red Lake’ (*Ribes rubrum*), ‘Consort’ (*R. nigrum*), ‘Imperial’ (*R. sativum*), and ‘Pixwell’ (*R. hirtellum*).

Reduce moisture on needles. Fungal spores need moisture to germinate and infect the host. Minimize overhead irrigation and promote good air circulation by controlling surrounding weeds, spacing new trees appropriately, and avoiding the planting of new trees in chronically wet areas.

Use disease-free plants. Examine nursery stock for signs of infestation. Incoming stock should be temporarily separated from existing stock to prevent contamination.

Remove and destroy diseased and cankered branches. Pruning is used to prolong the life of host trees. Infections are more common on needles of low branches. Remove cankered branches at least four inches beyond the visible canker margin and before infections reach the main stem; otherwise, it may be too late to save the tree. Infected branches do not require special disposal because the disease does not spread from pine to pine and cannot survive in dead wood.

Fungal spores (urediniospores) on the underside of an alternate host (*Ribes*) leaf. Robert Anderson, USDA Forest Service, Bugwood.org

Promote diverse plantings. Consider planting conifers other than white pines, especially where alternate hosts are abundant in the landscape and moisture conditions favor infection.

Small flagged branches may indicate white pine blister rust infection. Joseph OBrien, USDA Forest Service, Bugwood.org

Fungicides. Protectant fungicides may be an option in nursery settings, but are not practical in forest stands. Active ingredients (and example trade names) that are labeled for ornamental use in Utah and are known to be effective against rust fungi include triadimefon (Bayleton), triadimefon + trifloxystrobin (Trigo), and mancozeb (Protect).

Flagged branch and resin flow from the bark. Andrej Kunca, National Forest Centre - Slovakia, Bugwood.org

Currant leaf showing signs of white pine blister rust. Mike Schomaker, Colorado State Forest Service, Bugwood.org

Top kill and flagged branch. Joseph OBrien, USDA Forest Service, Bugwood.org

White blisters (aecia) release pustules of orange spores. H.J. Larsen, Bugwood.org

Pycniospores appear as gummy, orange droplets. USDA Forest Service - Ogden, Bugwood.org

White pine blister rust infection, canker, and branch swelling. Danielle Malesky, USDA Forest Service

Close-up view of the aecia. H.J. Larsen, Bugwood.org

Canker chewed by animals. Minnesota Department of Natural Resources, Bugwood.org

ASIAN LONGHORNED BEETLE

Not known to occur in Utah

Background

Asian longhorned beetle (ALB) (*Anoplophora glabripennis*) is an invasive wood-boring pest that is a major threat to many hardwood tree species and to maple syrup production. It was first detected in the U.S. in New York during the 1980s, and probably arrived via infested wood packing material from China. An outbreak was detected in Brooklyn in 1996, followed by several others in eastern locations, including Chicago and New England. ALB is currently found in Massachusetts, New York, Ohio, and South Carolina, and is considered to have been successfully eradicated from New Jersey and Illinois.

Plant Hosts & Susceptibility

ALB infests more than 100 different tree species, making it especially threatening to forests and difficult to detect and eradicate. Maple (*Acer*) is the preferred host, and others include ash (*Fraxinus*), birch (*Betula*), elm (*Ulmus*), poplar (*Populus*), willow (*Salix*), and sycamore (*Platanus*). Some trees appear to not be at risk of ALB infestation, including oak (*Quercus*) and honeylocust (*Gleditsia*). It is unknown if ALB infests conifers, such as pine (*Pinus*), fir (*Abies*), and juniper (*Juniperus*).

Description & Life Cycle

Adults are large beetles that are bullet-shaped, ¾ – 1 ½ inches in length (excluding the long black and white antennae), and have a glossy, smooth black body with irregular white spots. Although rare, some adults have yellow spots and newly emerged adults may have a blue-colored feet and antennae. The scutellum, or the triangular segment between the top of the wing covers, is black. Note that a similar looking native insect (whitespotted sawyer, *Monochamus scutellatus*) has a white scutellum and is often mistaken as ALB. Eggs are ¼ inch in length, roughly the size of a grain of rice, flat, and creamy-white in color. Larvae are typical of roundheaded beetle larvae. They are cylindrical, ribbed, light yellow or white, and can reach up to two inches in length. Young larvae create galleries just under the bark, but tunnel into the heartwood of the tree as they mature. Pupae are about 1½ inches in length and the same color as larvae, but have traits that resemble the adult. Pupae darken in color as they mature.

ALB has one generation per year. Adults emerge from host trees in late spring and can be found throughout the summer, until about the first frost. Adults feed on leaf veins and bark of young twigs for 10 to 20 days before mating. Each female lays up to 90 eggs. She places them individually in craters (oviposition or egg-laying pits) she has chewed into the bark on the lower trunk, main branches, or lower crown. Eggs hatch within two weeks and the newly emerging larvae feed on the cambium and sapwood, eventually tunneling deeper into the heartwood. ALB typically overwinters as larvae. The following spring, larvae tunnel back toward the cambium, where they pupate. Pupation lasts about 20 days, with adults chewing the rest of the way out of the tree in late spring. Adults may remain on the tree they developed in, or fly short distances to infest new trees.

Injury Symptoms

Both adults and larvae feed on host trees, although the larvae cause the most damage. The most obvious symptom is adult exit holes, which are perfectly round, nearly dime-sized ($^3/_8$ inch in diameter), and may ooze sap. Adults feed on leaf veins, and the females chew ½ inch diameter craters (egg-laying pits) into tree bark, leaving mandibular (mouthpart) marks that can be seen around the edges. Craters vary in shape from circular to oval. Freshly chewed pits are easier to see because the coloration of the inner bark contrasts with the outer bark.

Larvae bore into and feed on the cambium and sapwood, creating large hollow chambers that can be seen in cross-sections of the trunk. Deposits of frass (sawdust-like insect waste) may collect at tree trunks and limb bases. Severe larval infestations lead to dead branches and can make tree limbs more likely to break during storms and cause damage to nearby structures. Larval feeding also disrupts the flow of water and nutrients, causing the tree to slowly die. Infested trees may have drooping leaves and discolored foliage.

Monitoring

ALB is currently monitored by pheromone-baited traps, such as interceptor traps. However, ALB has been detected primarily by the public or through visual surveys. Therefore, there is a big push toward training volunteers to help with the surveying process (in areas where ALB has been detected) or to keep their eyes open for these pests (in areas where ALB has and has not been detected). Since initital infestations typically begin in the upper parts of the tree canopy, trees are scanned with binoculars or inspected with bucket trucks. Initial detections of ALB in Utah, however, should focus on the identification of the adult beetle, as similar damage can be caused by insects that are already present.

Management

ALB has not been detected in Utah, so there is no current need for chemical control of this insect. Once ALB infestations are detected, APHIS and state officials attempt to eradicate the beetles by establishing a quarantine to restrict the movement of ALB and ALB host materials (known as regulated articles). This decreases the chance of ALB spreading to new locations. Currently, the most practical approach for controlling ALB is to detect and eradicate it before it spreads to other areas. Please report any suspected ALB infestations to USU, UDAF, or APHIS.

Don't move firewood. ALB can travel short distances on its own, but larvae and adults can survive within firewood and other wood materials.

Maintain healthy trees. In general, healthy trees are less susceptible to insect borers. Trees should be properly watered and pruned, and fertilized when necessary. Keep at least a four-foot diameter area around trees free of weeds and grass to reduce competition for water or nutrients and so trunks are not damaged by lawnmowers.

Remove and destroy infested trees. Unfortunately, control options beyond removing and chipping or burning infested trees are limited.

Biological control. Several of the known natural enemies (parasitoids and predators) in the native range of ALB negatively affect insects that are native to the U.S., and therefore not likely to be effective or approved for release in controlling ALB in North America.

Avoid using insecticides. Some systemic insecticides have been used in the U.S. to control ALB, but they are known to harm pollinators and should only be used on wind-pollinated trees.

Adult Asian longhorned beetle. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Some Asian longhorned beetle adults have a bluish tinge to the legs and antennae. Arrow points to black scutellum. Dutch government [CC0]

Asian longhorned beetle eggs look like rice grains. Melody Keena, USDA Forest Service, Bugwood.org

A pupa beginning to resemble an adult. Melody Keena, USDA Forest Service, Bugwood.org

Oviposition pits and adult exit holes. Dennis Haugen, USDA Forest Service, Bugwood.org

Various stages of Asian longhorned beetle larvae. Steven Katovich, USDA Forest Service, Bugwood.org

Recent oviposition wound. Note the chew marks around the pit edges. Donald Owen, California Department of Forestry and Fire Protection, Bugwood.org

Adults tend to feed along the veins of leaves. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Tree heavily attacked by Asian longhorned beetle showing fresh and old oviposition pits. Michael Bohne, Bugwood.org

Adult feeding damage (stripped bark). Dean Morewood, Health Canada, Bugwood.org

Adult exit holes are perfectly round and $^3/_8$ inch in diameter. Daniel Herms, The Ohio State University, Bugwood.org

Internal damage to tree trunk caused by Asian longhorned beetle development. Thomas B. Denholm, New Jersey Department of Agriculture, Bugwood.org

Damage caused by larval feeding. Joe Boggs, Ohio State University, Bugwood.org

Larval galleries and exit holes under the bark. Dennis Haugen, USDA Forest Service, Bugwood.org

Frass from larval feeding often collects at tree trunks and branch crotches. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Damage from Asian longhorned beetle typically begins in the upper canopy. Dennis Haugen, USDA Forest Service, Bugwood.org

Asian longhorned beetle can cause unseasonably discolored foliage. Dennis Haugen, USDA Forest Service, Bugwood.org

BALSAM WOOLLY ADELGID

Present in Utah

Background

Balsam woolly adelgid (BWA) (*Adelges piceae*) is a tiny sucking insect that is a serious pest of true firs (*Abies*) in forests, landscapes, and Christmas tree production. In some areas of North America, BWA has completely removed true firs from forest stands. Originally from Europe, BWA was first detected in the U.S. in 1908. Through multiple introductions and subsequent spreading, it now infests true firs over most of the U.S. In Utah, BWA was first observed killing subalpine fir in 2017. It is now confirmed in Box Elder, Cache, Davis, Morgan, Rich, Salt Lake, Summit, Utah, and Weber counties.

Plant Hosts & Susceptibility

BWA attacks all true fir species (*Abies* spp.). In Utah, subalpine fir (*A. lasiocarpa*) is highly susceptible and white fir (*A. concolor*) is moderately susceptible. Subalpine fir typically grows at elevations above 7,500 feet, and until now, has been one of the few forest tree species that has resisted large-scale pest infestations.

Description & Life Cycle

Adults are very small (less than 1/20 of an inch) and barely visible. They are dark purple to black, oblong, and wingless. Female adults produce a waxy protective covering called "wool." The wool covers both the female body and her eggs. Wool patches can be seen on host tree trunks and branches. Immature life stages (eggs, crawlers, nymphs) are also very small and only barely visible to a trained eye using a hand lens or microscope.

In its native range, BWA alternates between spruce (*Picea*) and fir; however, in North America, BWA remains on fir as its European spruce host is not present. BWA populations in North America are composed of females reproducing without mating (parthenogenesis); sexual reproduction requires the European spruce host.

Two generations are most common in the mountainous regions of western North America. In cold locations, a resting (immature) nymph, known as neosistens, is the only stage that can survive winter temperatures. The overwintering neosistens begin movement in spring. By early summer, most overwintering BWA have reached the adult stage. Each female produces 100-250 amber colored eggs (first generation). Eggs hatch into reddish-brown crawlers in early summer; this is the only mobile life stage. Crawlers then move to new feeding sites on the same tree, or are dispersed longer distances by wind, animals, or humans (via firewood). Upon finding a new feeding site, the crawler inserts its feeding tube and begins sucking. Once the crawler begins feeding, it remains stationary and then transforms into a resting nymph. By late summer or early fall, wool-covered adults and eggs are present. By late fall, the second-generation eggs have developed into crawlers that disperse to new feeding sites. By winter, crawlers have developed into overwintering neosistens.

Injury Symptoms

Vigorous, mature host trees four inches or more in diameter are most susceptible to BWA attack, but saplings and seedlings may also be affected. Common symptoms include:

- yellowing or bronzing of needles
- reddening and thinning of foliage from inside out
- white, waxy "wool" covering may be evident on the trunk, near the tree base and on branches
- abnormal swelling of branch nodes and buds called "gouting" in response to adelgid feeding
- lower crown dieback leaving a green top and/or "top curl"
- reduced cone production and poor stand regeneration
- reduced growth, poor form, and stunted trees and branches
- dead leaders

Stem or trunk infestations tend to be more serious than crown infestations, and can result in wide, irregular growth rings and reddish, brittle wood ("rotholz"). BWA feeding eventually results in decreased water flow to the crown, leading to tree death. Tree mortality typically occurs within two to 10 years of infestation; heavy infestations can kill trees in two to three years.

Monitoring

BWA presence is difficult to detect until a tree is heavily infested and displays advanced symptoms (canopy decline, branch and node swelling). In forests, common monitoring methods include aerial surveys to detect tree stand decline, followed by groundtruthing to identify specific BWA symptoms. In older stands:

- Examine the upper third portion of tree crowns. Look for thinning of foliage, twig gouting, stunted branch and leader growth, and dead leaders.
- Examine recently windblown branches or slash for symptoms.
- Examine the main stem for white wool up to about 30 feet.
- Collect samples of all signs and symptoms for verification.
- In young stands, sample and examine branch nodes from two, 2-to-11-year-old branches per tree, from two trees per site.

Management

Completely removing BWA from western ecosystems is not likely, as they are widespread and wind dispersed. Therefore, management focus primarily on prevention.

Don't move firewood. The crawler stage is the only life stage that is capable of dispersal. Long distance spread is aided by winds, but BWA can also spread by movement of firewood and contact with birds and other animals.

Remove and destroy infested trees. Selectively remove heavily infested trees. It is recommended to cut and remove infested trees in winter when crawlers are inactive, and consider prevailing winds when establishing cutting boundaries.

Promote diverse plantings. Favor non-host tree species and genetically resistant strains or hybrids through selective harvest and planting.

Chemical control. Due to the adelgid's small size, protected feeding sites, and the presence of wax around second and third stage immatures and adults, aerial insecticide applications do not provide coverage adequate for control. High-value trees in areas such as ski resorts, campgrounds, tree farms, and urban settings can be protected by high-pressure insecticide application from the ground. In North Carolina, successful management of all life stages in Frasier fir (*Abies fraseri*) Christmas tree farms was achieved using a single application of the pyrethroids fenvalerate (which has been replaced by esfenvalerate) or permethrin, or insecticidal soap targeting the crawler stages. In Utah, target crawlers with a pyrethroid insecticide, horticultural oil, or soap in summer and/or fall.

Ventral view of adult balsam woolly adelgid. Gilles San Martin from Namur, Belgium [CC BY-SA 2.0 (https://creativecommons.org/licenses/bysa/2.0)]

White woolly masses of balsam woolly adelgid on a fir trunk collar. Diane Alston, Utah State University

Balsam woolly adelgid eggs. Ronald S. Kelley, Vermont Department of Forests, Parks and Recreation, Bugwood.org

Needle mortality due to balsam woolly adelgid. Great Smoky Mountains National Park Resource Management , USDI National Park Service, Bugwood.org

Branch swelling. Ronald S. Kelley, Vermont Department of Forests, Parks and Recreation, Bugwood.org

Abnormal swelling, or gouting, of fir branches caused by feeding injury from balsam woolly adelgid. Diane Alston, Utah State University

A subalpine fir stand infested with balsam woolly adelgid. Diane Alston, Utah State University

Young subalpine fir infested with balsam woolly adelgid; note severely stunted growth. Diane Alston, Utah State University

CAMPHOR SHOT BORER

Not known to currently occur in Utah

Background

Camphor shot borer (CSB) (*Cnestus mutilatus*), also known as camphor shoot beetle, is an invasive wood-boring beetle with a broad host range that includes many woody ornamental nursery crops. Attacks occur on small-diameter trunks and branches on stressed and weakened trees. CSB can also mistakenly bore into plastic gas containers and hoses when attracted to ethanol volatiles. CSB is native to parts of Asia and likely entered the U.S. in wood packing materials, crates, or pallets. It was first recorded in the U.S. in 1999 in Mississippi. Although it is not currently considered a major pest in the U.S., it is a poorly-known species, and recent range expansion indicates that it is highly adaptive to new environments. CSB currently occurs throughout most of the eastern and central U.S., from Pennsylvania to Florida westward to Missouri and Texas. A single beetle was found in Utah in Logan Canyon (Cache County) in 2019; however, it is not known to be established in the state.

Plant Hosts

In its native Asian range, the preferred host is Chinese chestnut (*Castanea mollissima*). In the U.S., CSB has a wide host range that includes more than 22 plant families and 200 plant species, including apple (*Malus domestica*), plum (*Prunus*), redbud (*Cercis canadensis*), black walnut (*Juglans nigra*), muscadine grape (*Vitis rotundifolia*), flowering dogwood (*Cornus florida*), and Japanese maple (*Acer palmatum*). Small-diameter trunks and branches less than two inches in diameter are attacked on stressed, weakened, or recently dead trees, including trees grown in nurseries.

Description & Life Cycle

Adults are small, cylindrically-shaped beetles that are about 1/8 inch in length, and dark brown to black in color with reddish-colored legs and antennae. The abdomen is shorter than the head and thorax, and the posterior end has a sharp slope that gives the beetle a compressed, or "squished" appearance. Adult males are smaller and flightless. Eggs are ellipsoid-shaped, white, and shiny. Larvae are C-shaped and legless with an amber-colored head.

In early spring before beetles emerge from trees, males mate with multiple females (sisters) inside the gallery, and then die. Mated females leave the host tree and fly up to three miles to locate new hosts, using ethanol volatiles naturally released by stressed, weakened, and dying trees. Each female bores a hole into the host plant and creates a gallery system that is a short horizontal entrance that branches into vertical tunnels up to 1 ½ inches in length. She lays up to 38 eggs (10 on average) within the gallery, and inoculates its walls with ophiostomatoid fungi that become the food source for both her and her offspring. She protects the gallery entrance from predators and other enemies by plugging the entrance hole with her body. Eggs hatch in about one week, and the developing larvae feed on the fungal mycelia for two to three weeks, pupate, and then emerge as adults in the gallery in about one week. Males emerge first, and there are one to three males per gallery. Depending on the time of year, females may emerge from the host to attack new plants, or overwinter within the galleries. In Japan, CSB produces one generation per year, but multiple generations are possible in the southern parts of the U.S. Like other ambrosia beetles, CSB feed on fungal spores from the introduced fungi. The introduced fungi are not currently known to contribute to tree death.

Injury Symptoms

Symptoms are similar to other bark and ambrosia beetles and include wilting foliage or twig dieback, and plant growth may be negatively affected. Boring dust (sawdust) may be seen on branches, at the tree base, and in bark crevices. Removing the bark often reveals a dark brown or black fungal stain. Small entrance and exit holes about $^{1}/_{12}$ inch in diameter are visible and can be measured by inserting a $^{5}/_{64}$-inch drill bit.

Monitoring

CSB can be monitored with traps or visual surveys. Effective homemade traps can be made from 2-liter soda bottles baited with hand sanitizer containing from 63% to 95% ethanol, but commercially available ethanol-baited traps can also be used. Black-colored traps are more attractive to CSB than other colors, especially yellow and white. Traps placed along field borders may attract beetles into the desired host plants (nursery fields). To avoid spillover, place traps about 200 feet into the bordering landscape away from desired host plants. During visual surveys, pay close attention to small branches from 1½ feet above ground to about chest height for beetle entrance/exit holes. Clip the branches near the holes and examine them for distinctive t- or cross-shaped galleries with long hollowed-out arms that run parallel to the stems. If a beetle "plug" is visible, use a knife to cut it from the hole for identification purposes. Boring holes may also be visible on plastic gasoline containers, boat fuel lines, and other ethanol-laced items, as these can attract CSB.

Management

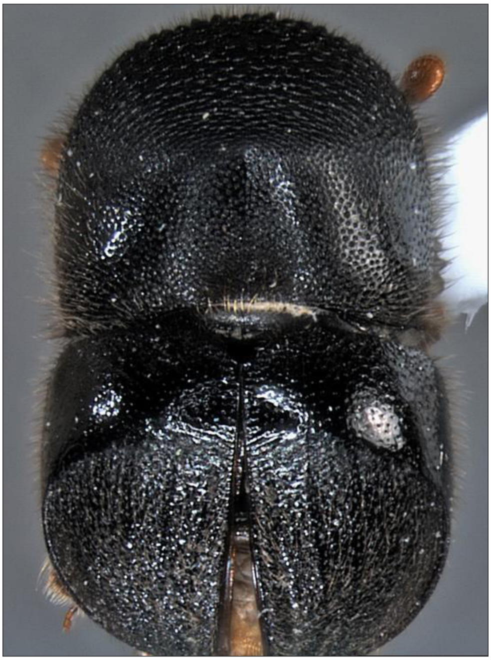
Don't move firewood. CSB and other pests can be transported to new areas when infested material is moved, including firewood and plants; severely limit the movement of these items.

Maintain healthy trees. Ensure tree health and vigor to minimize the risk of attack by beetles. Choose plants that are healthy and adapted to the given site location. Keep potted nursery trees in appropriately sized containers to avoid plant stress.

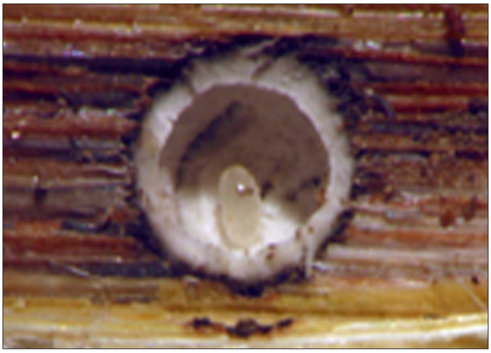
Remove and destroy infested trees. Remove trees and limbs that are stressed, weakened, and recently dead or dying, and promptly chip, compost, or bury the wood to eliminate host material.

Use chemicals when necessary. Insecticides are not effective once beetles are inside trees, so the focus is on preventing adult beetles from entering trees. Applying kaolin clay to tree trunks has been suggested as a possible method to decrease attacks, as its stark white color is unattractive to CSB. Insecticides specifically for the control of CSB have not been tested. However, pyrethroid-based insecticides (e.g., bifenthrin) and systemic neonicotinoids (e.g., imidacloprid) have been effective in controlling some ambrosia beetle species when used during the seasonal flight period, but care should be taken during application to protect pollinators and other beneficial insects as flowering coincides with peak beetle flight. Netting treated with the insecticide deltamethrin can provide some protection from ambrosia beetle attacks; wrap the net upward from the base of the stem to the branch junction.

Lateral view of adult camphor shot borer. Javier E. Mercado, Bark Beetle Genera of the U.S., USDA APHIS PPQ, Bugwood.org



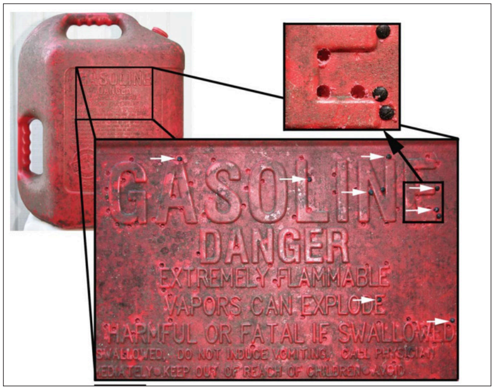
Dorsal view of adult. Javier E. Mercado, Bark Beetle Genera of the U.S., USDA APHIS PPQ, Bugwood.org



Eggs are ellipsoid-shaped, white, and shiny. Note the thick fungi lining the gallery wall. Doug Stone, Mississippi State University, Bugwood.org

Larva feeding on ambrosia fungi. Doug Stone, Mississippi State University, Bugwood.org

Camphor shot borer gallery showing black stain from the fungi. Doug Stone, Mississippi State University, Bugwood.org



Camphor shot borer can damage plastic fuel storage containers when attracted to the ethanol volatiles. Carlton and Bayless 2011.

EASTERN FIVE-SPINED BARK BEETLE

Not known to currently occur in Utah

Background

Eastern five-spined bark beetle (*Ips grandicollis*), also known as southern pine engraver, eastern 5-spined engraver, and five-spined bark beetle, is a wood-boring pest of several pine trees (*Pinus* spp.). Like other bark beetles, it is a vector of several fungal pathogens, including destructive blue stain fungi (e.g., *Ophiostoma* and *Graphilbum*), which degrades and discolors the outer sapwood and contributes to tree death. This beetle is native to eastern North America, from Canada south to the Gulf, and has recently been found in central and western U.S. states. In 2018, the Utah Department of Agriculture and Food detected five beetles in Weber and Utah counties, but it is not known to be established in these areas. This insect has also recently been detected in British Columbia, Mexico, the Caribbean islands, and Central America. It has become a widespread invasive pest of pine forests in Australia, particularly plantations of Monterey pine (*P. radiata*), which is native to California. This beetle targets newly dead and stressed pine trees but can attack healthy trees when population densities are high, although it is not known for causing large-scale mortality in North America. Attacks increase during drought or when conditions are abnormally warm and dry, particularly when breeding material is available.

Plant Hosts

Hosts include most pine (*Pinus*) species found in its geographical range, including ponderosa pine (*P. ponderosa*), Scots pine (*P. sylvestris*), eastern white pine (*P. strobus*), red pine (*P. resinosa*), and pitch pine (*P. rigida*). Secondary hosts may include spruce (*Picea*), fir (*Abies*), and hemlock (*Tsuga*).

Description & Life Cycle

Adults are about the size of a rice grain, $^1/_8$ to $^3/_{16}$ inch long, cylindrical, hard-bodied, and light brown when first emerged, turning dark red-brown to almost black in color as they mature. The rear of the abdomen has a scooped-out depression with five spines on each side. Eggs are about $^1/_{30}$ inch long. Larvae are small, legless and whitish in color, with heads up to $^1/_{30}$ inch wide, and are about the size of adults when mature. Pupae are also similar in size to adults and are waxy white in color.

Adults fly beginning in spring, when temperatures exceed 50°F, in search of suitable hosts, preferring trees that are dead, stressed, or weakened. Males bore through the outer bark and into the inner bark to construct nuptial chambers where they release pheromones to attract females for mating. Each male is joined by multiple females, and following mating, the females lay eggs along galleries in the phloem. After the eggs hatch, the developing larvae create characteristic individual feeding tunnels that run perpendicular to the parent galleries (across the tree trunk) as they feed and mine the tree phloem. Larvae pupate at the end of their feeding galleries, emerge as adults, and bore through the outer bark to repeat the life cycle. In the southern U.S., one generation takes about 30 days to complete, depending on environmental conditions, and six or more generations can occur per year.

Trees that are four years or older and injured, stressed, or recently felled are typically targeted for attacks, and often only a few trees in a given area are killed. However, under certain conditions (e.g., drought), populations may become epidemic and result in hundreds of trees dying. Like other bark beetles, this pest can vector blue stain fungi that clog the tree's water transport system and contribute to tree death.

Injury Symptoms

This pest typically occurs in weakened or dying standing pine trees in the mid-to upper main trunk areas and basal parts of large branches, and on recently-felled trees and fresh logging debris. Symptoms of infestation include yellow (dying), red (recently dead) or brown (completely dead) foliage on branches and/or the tree crown, and the presence of boring dust and frass (insect feces) pushed out onto the bark surface. Galleries are typically vertical in an I, H, or Y shape and are clear of debris. Along the main trunk, small, perfectly round emergence holes, about 1/16 inch in diameter, are present once a life cycle is complete. Pitch tubes (globs of resin and boring dust) of less than ½ inch diameter may be found on the flat part of the bark, but may be absent on weak trees. Note, however, that these symptoms are characteristic of ips beetles in general, including native species.

Monitoring

Regularly inspect host trees, especially those that are stressed or weakened, for damage symptoms and signs of beetle infestations, such as discolored leaves in the mid-to-upper part of trees and on larger branches. Beetle infestations can also be monitored during the summer using a Lindgren funnel trap baited with (+/-)-ipsenol or a combination of (+/-)-ipsenol and (+/-)-ipsdienol, but traps may be more feasible for federal and state agencies that monitor insect pests.

Management

Management focuses on creating conditions that favor tree and stand health and limiting host suitability in an area. Note that some of the options listed here are labor intensive and/or costly; may need to be performed regularly and require specialized knowledge, judgement, and/or skill; and may only be suitable for high-value trees. Some strategies may be impractical when large areas are involved.

Maintain healthy trees. Create conditions that favor vigorous tree growth by ensuring that trees are properly watered and fertilized if needed. During drought periods, apply one inch of water (up to two inches on sandy soils) once or twice per week. Control competition from surrounding vegetation, and consider replacing turfgrass with mulch within the drip zone or extent of the crown. Use care around trees during management activities such as mowing, pruning, or burning to avoid inadvertent tree injuries and minimize soil compaction. Thin stands to maintain vigor if necessary, but avoid thinning too late and during drought conditions, as these could lead to bark beetle infestations. Further, identify and address other underlying issues, such as defoliating and sap-sucking insects and damage from weather events, to maintain tree health.

Don't move firewood. Bark beetles can complete development in firewood, especially wood with bark still attached, so debark and limit the movement of firewood to prevent the spread of this insect and other harmful tree pests.

Promote appropriate and diverse plantings. Choose pine species that are best suited to the area and plant mixed stands instead of monocultures, especially in areas prone to drought.

Remove and destroy unhealthy and infested trees. Promptly salvage or destroy pines severely damaged by wind, snow, lightning, fire, disease, insects, or other causes. Debark the wood to eliminate breeding habitat, and promptly destroy the bark by burning, chipping, or burying. If burning, please observe local burn restrictions. If using the wood for firewood, cover piles with a double layer of 6-mil thick clear or black plastic sealed around the edges with soil to solarize the wood and render it unsuitable to bark beetles.

Biological control. The entomopathogenic fungus *Beauveria bassiana* is a naturally occurring pathogen of bark beetles and can be used on fallen trunks and in soil around trees. Apply when temperatures are moderate and remain above freezing, ideally between 50-95°F. This fungus affects the current generation only and is not passed on to the offspring, so reapplication may be necessary.

Apply a preventative insecticide to at-risk trees. Consider spraying high-value trees that are at risk with a preventative insecticide labeled for ips beetles. The most effective active ingredients include permethrin, bifenthrin, or carbaryl (Sevin). Be sure to follow label directions and rotate modes of action with each generation to prevent insecticide resistance. Applications should occur in the spring prior to beetle flight and once temperatures are consistently over 50°F. Note, however, that insecticide applications are not effective once a tree is infested.

Adult eastern five-spined bark beetle. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Larva. Erich G. Vallery, USDA Forest Service - SRS-4552, Bugwood.org

Adult in gallery. Albert (Bud) Mayfield, USDA Forest Service, Bugwood.org

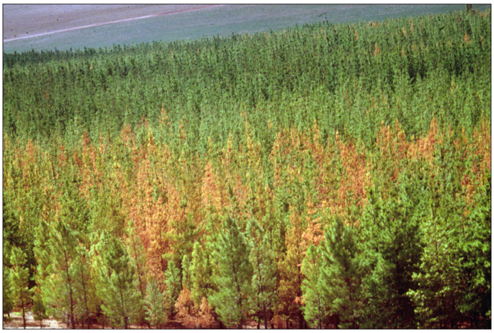
Young callow adult. Erich G. Vallery, USDA Forest Service - SRS-4552, Bugwood.org

Larva, pupa, and young callow adult. Roger Anderson, Duke University, Bugwood.org

Adult and larval galleries. Gerald J. Lenhard, Louisiana State University, Bugwood.org

Galleries constructed by eastern five-spined bark beetles. Jeffrey Eickwort, FL Department of Agriculture and Consumer Services, Bugwood.org

Galleries and adult beetles. Dennis Haugen, Bugwood.org



Damage due to eastern five-spined bark beetle. Dennis Haugen, Bugwood.org

Blue stain in *Ips* killed pine. Ronald F. Billings, Texas A&M Forest Service, Bugwood.org

ELM BARK BEETLES

Present in Utah

Background

Banded elm bark beetle (BEBB) (*Scolytus schevyrewi*) and European elm bark beetle (EEBB) (*Scolytus multistriatus*), also known as smaller European elm bark beetle, are invasive wood-boring pests of native and introduced elm (*Ulmus* spp.) in North America, and are vectors of Dutch elm disease (DED), a fungal pathogen that has devastated native elm populations since its arrival in the 1930s. BEBB is native to parts of Asia and Russia, and likely arrived in North America on infested wood pallets or shipping crates. It was first identified in 2003 from traps placed near wood recycling facilities in northern Utah and Colorado, but may have arrived as early as 1994 as revealed by subsequent museum specimens in Colorado, New Mexico and Texas. In North America, BEBB currently occurs in Canada, Mexico, and 29 U.S. states, and is considered widespread in Utah, Colorado, Kansas, and New Mexico. In parts of the Rocky Mountain region, BEBB has displaced the long-established EEBB. EEBB is native to Europe and is one of the most important species responsible for spreading DED worldwide. In the U.S., EEBB was first recorded in 1909 near Boston, Massachusetts, likely arriving on infested elm shipping crates or imported elm logs sent to veneer mills. In North America, EEBB occurs throughout southern Canada, in isolated temperate regions of Mexico, and in all U.S. states except Alaska and Hawaii, and was first recorded from Utah in 2010.

Plant Hosts & Susceptibility

Primary hosts include species of elm (*Ulmus*), including American elm (*U. americana*), Siberian elm (*U. pumila*), English elm (*U. procera*), and rock elm (*U. thomasii*). Alternate hosts for BEBB in its native range include Russian olive (*Elaeagnus angustifolia*), weeping willow (*Salix babylonica*) and other willow (*Salix*) species, woody species in the pea family (*Caragana* spp.), and fruit trees including pear (*Pyrus*), apple (*Malus*), and *Prunus* species such as apricot, almond, cherry, and peach. Alternate hosts for EEBB include Japanese zelkova (*Zelkova serrata*) and poplar (*Populus* spp.). BEBB has shown preference for Siberian elm (*U. pumila*) over American elm (*U. americana*), and young and healthy elm trees are typically less susceptible to attack.

Description & Life Cycle

Adults are small, shiny beetles, about the size of a rice grain, $^1/_8$ inch in length, cylindrically shaped, and dark brown, dark reddish-brown, or black in color. When viewed from the side, the end of the abdomen has a “fingernail-like” appearance and a projecting center spine, and the wing tips extend past the end of the abdomen. BEBB has a dark transverse band across the wings (elytra) that varies in pattern and darkness. Eggs are small, shiny, and pearly-white in color. Eggs are laid singly in a vertical gallery with egg niches along each side. Larvae are small, white, legless, C-shaped grubs, $^1/_5$ to $^1/_3$ of an inch in length, with heads that are creamy yellow (BEBB) or brown (EEBB). They can be found under bark where they create feeding tunnels in the gallery. Pupae are about $^1/_8$ inch in length and initially white in color, darkening with age, and have wings folded under the abdomen.

Sexually immature (callow) adult beetles bore exit holes through the bark and fly from host trees from April to July (EEBB) or from March through October, peaking in July and August in the western U.S. (BEBB). They may fly to a nearby healthy elm or to a healthy part of the same tree and feed on the phloem in tender twig crotches for up to a week to complete their "maturation feeding", after which time they are sexually mature. The beetles carry DED fungal spores (conidia) on their bodies and/or in their gut from the infected host tree, and can transfer the DED pathogen as they feed on healthy material. Once maturation feeding is complete, beetles fly to stressed or weakened elms where females usually excavate a single-branched egg gallery (tunnel) in the phloem before mating. Egg galleries are about 1½ to 2½ inches in length and generally scored to the wood surface. Mating occurs on the bark surface, and females lay an average of 60 eggs in closely-arranged egg niches along the gallery wall. Eggs hatch throughout the summer, and the emerging larvae mine tunnels that are perpendicular to the main gallery as they feed. Each larva develops through four or five growth stages (instars) before forming a pupal chamber at the tip of the feeding gallery. There are typically two overlapping generations per year in most locations, with each generation taking up to 60 days to complete. Because generations overlap, all life stages may be present in the galleries towards the end of the summer. Overwintering takes place by the mature larvae or pupae inside the pupal chamber, or by adults under the bark. EEBB targets both healthy and weakened elms of all ages by using both plant volatiles and beetle-generated aggregating pheromones, whereas BEBB locates hosts primarily by plant volatiles.

Injury Symptoms

The first signs of beetle infestation are the presence of boring dust on trunks or at the base of trees, and numerous round, shot-sized holes on the bark that are about $^1/_{16}$ to $^1/_{12}$ inch in diameter. In healthier trees, sap may flow near the holes. Bark may easily peel and slough off to expose larval galleries which radiate outward perpendicularly from the main tunnel. Extensive feeding or repeated attacks can eventually girdle and kill trees, but the main impact of EEBB is its vectoring the primary fungus responsible for DED, *Ophiostoma novo-ulmi.* By midsummer, healthy elms that were a food source for newly emerged beetles may develop symptoms of DED, which typically start in the upper crown and include wilting, drying, yellowing, and browning foliage, and brown rings or streaking in the sapwood. Some trees die within several weeks of becoming infected, whereas others will struggle for years before usually succumbing (see chapter on DED for more information about this pathogen). Symptoms of BEBB are similar to those of EEBB, although BEBB appears to be no more efficient, and perhaps even less efficient, at vectoring DED.

Monitoring

Beetle infestations can be monitored by visually inspecting elm trees for boring holes, sawdust on the trunk and base of trees, and larval galleries on loose and fallen bark, but be on the lookout for symptoms of DED as well (see chapter on DED for more information). Beetle infestations can also be monitored using Lindgren funnel traps baited with a commercial lure (for *Scolytus multistriatus* or *Ips*), but this may be more conducive for federal and state agencies that monitor insect pests.

Management

Current control efforts largely focus on the preventive management strategies listed below. Note that some of these options are labor intensive and/or costly, may need to be performed regularly and require specialized knowledge, judgement, and/or skill, and may only be suitable for high-value trees.

Don't move firewood. Beetles can complete development in firewood, especially wood with bark still attached, so debark and limit the movement of firewood to prevent the spread of this insect and other harmful tree pests.

Maintain healthy trees. Healthy trees are less susceptible to insect and disease outbreaks, and drought stress predisposes exotic elm species to infestation by both BEBB and EEBB. Ensure tree health and vigor by properly watering, fertilizing when necessary, and practicing good tree husbandry.

Remove and destroy infested trees. To prevent continued beetle attack, infested trees should be removed at ground level and disposed of properly, either by burning, burying, chipping, or debarking cut wood. If the infestation is caught early, diseased branches can be pruned out (see chapter on DED for more information). Prune branches or remove entire trees during the non-flight months of November through March to decrease the likelihood of new beetle infestations. Alternatively, during the months of April through October, cut trees during the early morning or late afternoon to limit the release of elm volatiles during the middle of the day when the beetles are most active. Never pile infested material adjacent to a living tree or shrub.

Plant tolerant varieties. No American elms are resistant to DED; however, cultivars of American elm rated 'resistant/least susceptible' include 'Princeton' and 'New Harmony'; Asian preferred cultivars include The Morton Arboretum introductions and 'New Horizon.'

Apply chemicals when necessary. Insecticides can be applied either in early spring (prior to bud swell) or late fall (after leaf drop) to kill emerging overwintered adults or the last brood of adults that would be entering trees and laying eggs for overwintering, respectively. Another application can be applied in mid-May to early June if necessary. All bark surfaces should be covered with spray, especially small branches and twigs in the crown. Active ingredients labeled for foliar application for "bark beetles" in Utah include azadirachtin, bifenthrin, carbaryl, cypermethrin, and permethrin. Be sure to rotate modes of action with each generation to prevent insecticide resistance. A systemic injectable fungicide can also be applied on high value or historical trees where DED is a concern. Note, however, that injectable fungicides are an expensive option and require application by a licensed pest control professional. See chapter on DED for more information.

Adult banded elm bark beetle. Joseph Benzel, Screening Aids, USDA APHIS PPQ, Bugwood.org

Adult European elm bark beetle. Gerald J. Lenhard, Louisiana State University, Bugwood.org

Banded elm bark beetle adults and associated twig feeding. Whitney Cranshaw, Colorado State University, Bugwood.org

Last instar larvae and pupae exposed from under bark. Whitney Cranshaw, Colorado State University, Bugwood.org

Recently constructed exit hole with small amount of weeping at wound site. Whitney Cranshaw, Colorado State University, Bugwood.org

Feeding injury on twigs caused by European elm bark beetle. The Dutch elm disease pathogen can be introduced into the tree through such wounds. Joseph OBrien, USDA Forest Service, Bugwood.org

Freshly made European elm bark beetle gallery with staining from Dutch elm disease visible around it. Joseph LaForest, University of Georgia, Bugwood.org

Exit holes left by European elm bark beetle. Joseph LaForest, University of Georgia, Bugwood.org

European elm bark beetle galleries. William M. Ciesla, Forest Health Management International, Bugwood.org

Damage caused by banded elm bark beetle. Dennis Haugen, Bugwood.org

European elm bark beetle galleries. Ferenc Lakatos, University of Sopron, Bugwood.org

EMERALD ASH BORER

Not known to occur in Utah

Background

Emerald ash borer (EAB) (*Agrilus planipennis*) is an invasive wood-boring beetle that has caused the decline and mortality of tens of millions of ash trees (*Fraxinus*) in the U.S. It is considered the most destructive forest pest to ever invade North America. Originally from Asia and parts of Russia, EAB was first discovered in the U.S. in 2002 in southeastern Michigan. This insect most likely arrived to the U.S. as larvae or pupae embedded in ash pallets, crates, or packing material. EAB now occurs in more than 30 eastern and midwestern states, and is rapidly expanding its range. As of July 2020, it has not been found in Utah, but isolated infestations occur in parts of Colorado. Information on its most current distribution can be found at emeraldashborer.info.

Plant Hosts

EAB attacks all North American ash (*Fraxinus*) species, including small, large, stressed, and even healthy trees. Utah has two native ash species that are susceptible to EAB: the small, shrubby singleleaf ash, *F. anomala*, that occurs sporadically in southern Utah, and velvet ash, *F. velutina*, that occurs in SW canyons. Yet, various ash species comprise up to 30% of the urban canopy in many Utah communities, and all are susceptible to EAB attack.

EAB was thought to specialize on ash, but has been found infesting white fringe trees (*Chionanthus virginicus*) in Ohio and Illinois. This may indicate that EAB has a wider host range than originally thought, or that it is adapting to utilize new hosts. Both ash and fringe trees are members of the olive family (Oleaceae).

Description & Life Cycle

EAB adults are metallic green beetles with bronze heads, short saw-toothed antennae, flattened backs, rounded bellies, and iridescent purple-red abdominal segments beneath their wing covers. They are bullet-shaped, lack a defined waist, and are about ½ inch long and 1/8 inch wide. Eggs are oval to round, 1/16 inch in diameter, cream-colored when first deposited, and reddish-brown as they develop. Due to their small size, eggs are not easily observed. Larvae are cream-colored with 10 body segments and a flattened abdomen. They can reach a length of one inch when mature, are tapeworm-like, and have a pair of brown, pincer-like appendages on the last abdominal segment. Their brown head is mostly retracted, but the mouthparts are visible externally. The last instar larva (pre-pupa) will excavate a tiny chamber and curve back on itself (J-shaped). Pupae have the characteristic shape of the adult, with short saw-toothed antennae and a blunt spine at the tip of the last abdominal segment. Newly developed pupae are white, but take on the adult coloration as they develop.

EAB has a one-year life cycle. Adults

emerge from ash trees in spring when degree-day (DD) accumulations reach 450 to 550 DD (using a base temperature of 50°F), which in Utah can occur from mid-April in southern Utah to mid-May in northern Utah. Peak emergence is at 900 to 1,100 DDs (mid-to late July). For more information on DDs in Utah, visit climate.usu.edu/traps/. Adults feed on ash leaves for one to two weeks before searching for mates. Mated females lay 60 to 90 eggs, individually or grouped, on bark or in bark crevices. Eggs hatch after two to three weeks, and the newly developed larvae bore into the tree, feed on the phloem and cambium layers, and pass through four larval stages. EAB overwinters as a mature larva or pre-pupa in a tiny chamber excavated in the sapwood. They pupate in the spring and repeat the life cycle.

Injury Symptoms

Adults feed on ash foliage, but cause little damage overall to the tree. Larvae are the primary damaging life stage and are responsible for killing trees. They chew through bark into the phloem and sapwood, creating serpentine-shaped and excrement-filled galleries, which disrupt the flow of nutrients and water, and starve the tree. Larval galleries curve at near right angles so that the tunnel length, as measured in a straight line from start to end, is less than half of the actual total tunnel distance (note: any serpentine gallery in an ash tree should be suspect). Galleries increase in size as larvae feed and grow, and are more common in the upper canopy in newly infested trees, but can be found lower on the trunk as the infestation progresses. Larval infestations lead to bark splits, canopy dieback, epicormic branching (suckers) at the base of large, dead branches or the base of the tree, and increased woodpecker activity. Adults leave D-shaped exit holes ($^1/_8$ inch wide) on tree branches and trunks when they emerge from trees. In Colorado, researchers have found that ash trees infested with EAB have leaves that are smaller and lighter in color compared to normal ash leaves. When EAB densities are high, small trees can die within one to two years of becoming infested, whereas large trees can be killed within three to four years. Unfortunately, EAB infestations are difficult to detect, especially during the early stages of invasion, and are nearly always fatal to the tree unless insecticides are used to protect trees.

Monitoring

There are a number of monitoring techniques that state and federal survey personnel use for detecting EAB, including traps, branch sampling, and girdled (trap) trees. Some of these may be suitable for homeowners.

Purple prism traps or green Lindgren funnel traps are used during statewide detection trapping programs, but are not readily available to the public. Traps are baited with a lure made of oils that mimic chemicals released by stressed ash to attract EAB. Traps are placed in trees during the spring and summer, and then taken down in August. Traps are for detection or monitoring purposes, and are not used to control EAB.

Branch sampling is recommended for both homeowners and survey personnel, and is most valuable in urban and other high-risk areas. Collect branches in the fall when larvae are more easily detected. Use the following steps to inspect branches:

1. Choose an ash tree that is 20 to 60 feet tall with a large, open canopy.
2. Collect two branches (one to four inches in diameter) from the middle canopy. Remove branches using proper pruning safety procedures and precautions.
3. Remove lateral branches.
4. Use a drawknife to peel back the bark in thin strips.
5. Carefully examine the branches for EAB galleries and/or larvae.

Girdled (trap) trees are considered effective EAB detection tools. Trees are girdled by removing the outer layer of bark and cambium layer around the entire circumference of the trunk. The tree is then forced into a state of stress and, therefore, highly attractive to EAB. In areas known to be infested with EAB, girdled trees are removed within a few weeks and destroyed, and a large number of EAB larvae are destroyed with it. This is known as a "population sink." In areas where EAB has not been detected, the tree is removed at the end of the season and remaining bark is stripped to check for EAB galleries and larvae.

Management

Don't move firewood. EAB can travel short distances on its own, but it is introduced to new, distant locations via infested firewood or other wood material containing living EAB. The Utah Firewood Quarantine, which is enforced by the Utah Department of Agriculture and Food, restricts the movement of firewood from quarantined areas of the U.S. and Canada into the state without appropriate heat treatment and labeling. Firewood that has been heat-treated to 160°F at the core for 75 minutes and has a USDA APHIS or state of origin compliance sticker may be moved across state lines. Note that some firewood bundles are labeled as kiln-dried and pest-free, but kiln-drying firewood is not considered to be as effective at killing pests as heat-treating firewood.

Maintain tree health. Healthy trees are less likely to become infested with EAB and other pests. Trees should be properly watered and pruned, and fertilized when necessary. Your local Extension office can provide information on tree maintenance.

Do not include ash in new plantings. Remove any ash that are in sub-optimal health or located in poor sites. The website Treebrowser.org can be used to select a variety of ash alternatives.

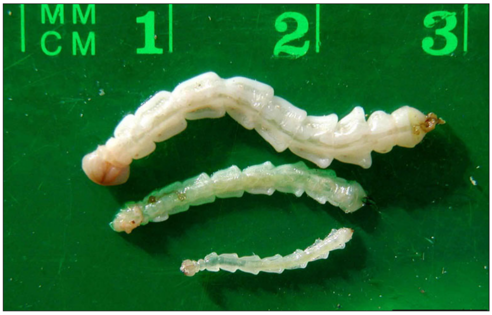
Biological control. USDA has been working to develop biological control agents to help slow the spread of EAB. Utah has already received the permits needed to release *Oobius agrili*, a tiny solitary egg parasitoid of EAB, when EAB arrives in the state.

Apply insecticides when necessary. EAB has not been detected in Utah, so there is no current need for chemical control of this insect. Insecticides (preventative or curative) should only be considered when EAB has been detected within 10 to 15 miles of your residence. Insecticide treatment options include cover sprays, systemic soil drenches, trunk injections, and basal bark applications. Treatments may need to be repeated annually or biannually to protect trees during EAB invasions. Insecticides are not 100% effective due to the difficulty of managing insects under tree bark. Some chemicals can kill larvae underneath the bark; however, 30-50% canopy decline is the "cutoff" for this to be effective. For more information, refer to the Multistate EAB Insecticide Fact Sheet.

Adult emerald ash borer. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Adults have purple-red abdomens hidden underneath the emerald green wing covers. David Cappaert, Bugwood.org

Eggs are cream-colored (left) when first laid, but turn reddish-brown near maturity. Debbie Miller, USDA Forest Service, Bugwood.org



When mature, larvae can reach a length of one inch. David Cappaert, Bugwood.org

Canopy dieback is a common with emerald ash borer. Joseph OBrien, USDA Forest Service, Bugwood.org

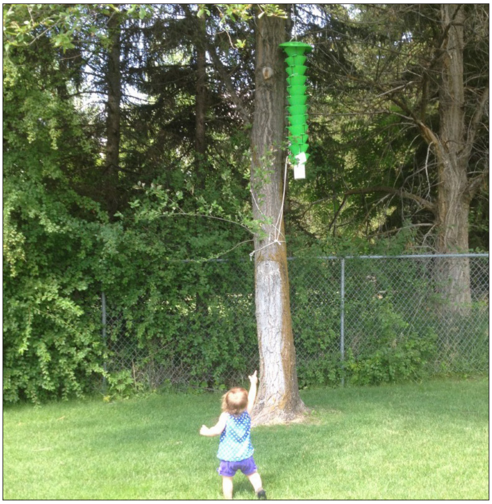
Gradual maturation of pupae to the adult stage (from left to right). Debbie Miller, USDA Forest Service, Bugwood.org

Bark splits may indicate an emerald ash borer infestatin. Michigan Department of Agriculture, Bugwood.org

Adults feed on ash foliage. Debbie Miller, USDA Forest Service, Bugwood.org

Damage from woodpeckers on trunk and epicormic sprouts on ground. Steven Katovich, USDA Forest Service, Bugwood.org

Adults emerge from D-shaped exit holes. Debbie Miller, USDA Forest Service, Bugwood.org



A budding entomologist pointing to a Lindgren funnel trap. Ryan Davis, Utah State University

Larval galleries are serpentine-shaped and curve at near right angles. Kelly Oten, North Carolina Forest Service, Bugwood.org

Girdled tree. Pennsylvania Department of Conservation and Natural Resources - Forestry Bugwood.org

Purple prism trap. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org

Bark peeling with drawknife to look for larval galleries. Kenneth R. Law, USDA APHIS PPQ, Bugwood.org

EUROPEAN SPRUCE BARK BEETLE

Not known to occur in Utah

Background

European spruce bark beetle (ESBB) (*Ips typographus*), also known as eight-toothed bark beetle, is a wood-boring insect that is a major pest of Norway spruce (*Picea abies*), and is among the most significant agents of tree mortality in Europe and Asia. This insect can kill trees directly from extensive feeding or indirectly by vectoring several fungal pathogens, including destructive blue stain fungi (e.g., *Endoconidiophora*, *Leptographium*, *Ophiostoma*, *Grosmannia*). Its native range includes Europe, eastern Siberia, and parts of Asia (China, Japan, and Korea) and coincides with the natural distribution of Norway spruce. It was first detected in the U.S. in the 1990s in pheromone-baited traps in Pennsylvania and Indiana. Although recent infestations have not been confirmed, prior detections and regular port interceptions flag it as a potential threat to North American coniferous forests.

Plant Hosts & Susceptibility

The main host for ESBB is Norway spruce (*Picea abies*), but most spruce (*Picea* spp.) are susceptible, including Englemann spruce (*P. Englemanii*). Firs (*Abies*), Scots pine (*Pinus sylvestris*), larches (*Larix*), and Douglas-fir (*Pseudotsuga menziesii*) are less preferred hosts.

Description & Life Cycle

Adults are small (about $^{3}/_{16}$ inch in length), cylindrically-shaped, reddish or dark brown to black in color, shiny, and have long yellowish hairs. There are a total of eight “teeth” or spines on the rear of the insect, four on each side. It is important to know, however, that there are at least 14 other *Ips* species in the U.S. that have eight spines. A few are commonly encountered in Utah’s urban environment, including *I. pini* (on pines, *Pinus* spp.), and *I. hunteri* and *I. pillifrons* (both on spruce, *Picea* spp.). This emphasizes the need to submit suspect ESBB samples to a qualified entomologist for identification. Eggs are whitish-gray, ovate, and about $^{1}/_{16}$ inch in length. Larvae are about $^{3}/_{16}$ inch in length, C-shaped, legless, and have brown to amber-colored heads and mandibles. Pupae are white, about $^{3}/_{16}$ inch in length, and have projecting appendages not encased by the protective pupal shell.

Adults start to fly in the spring and can travel 10 miles or more in search of suitable hosts, preferring trees that are stressed or recently dead. Males bore through the bark into the trunk and construct nuptial chambers where they are joined by one to four females. Following mating, the females deposit eggs in galleries (tunnels) in the inner bark. A few weeks later, adults may fly to a second host tree for additional mating and egg-laying. The developing larvae create feeding galleries under the bark, and when mature, they construct pupal chambers at the end of their galleries. All life stages can overwinter in the galleries, and adults can also overwinter in stumps, litter, or soil. They typically produce one or two generations per year, depending on climate, but up to three generations may occur under extended warm conditions. Development from egg to adult takes about eight to ten weeks.

Injury Symptoms

This insect is mostly attracted to weakened, damaged, dying, or dead trees, with attacked trees typically occurring in groups. After beetles emerge from trees, they usually attack the nearest trees, typically on the sunny side of stand edges. Infestation frequently begins in the crown, then advances to the lower levels of the tree. Outbreaks can occur during droughts and intensify with warm temperatures. During outbreaks, healthy trees can be targeted and this may lead to extensive tree death. Injury symptoms include red-topped or discolored crowns, and light-colored needles that form mats; the needles may fall to the ground while still green and become noticeable. Light-brown to reddish-brown sawdust-like insect frass (feces) may be found at the base of stems and beetle entrance holes. The underside of the bark may show vertically extending maternal galleries, as well as wavy larval feeding galleries that radiate outward. Bark of infested stems fall to the ground, removed by woodpeckers searching for beetle larvae. Wilted foliage and blue or gray streaked wood may signify the presence of blue stain fungi (e.g., *Ophiostoma polonicum*), which is spread by some bark beetles (including ESBB) and can cause tree death by restricting water movement. This is not a diagnostic feature, however, because staining can result from other factors.

Monitoring

Regularly inspect host trees, including those that are stressed, weakened, or recently fallen, for damage symptoms and signs of beetle infestations, such as red-topped trees with entrance holes and galleries that indicate an advanced level of attack. These are general symptoms displayed by trees attacked by any *Ips* species; collect bark beetle samples from symptomatic trees and send to a qualified entomologist for identification. Pay close attention to trees along stand edges especially those on the sunny side of plantings. Wood products should also be inspected, including unprocessed logs, lumber, crates, and pallets containing bark, since the immature stages in particular can be unintentionally moved by human activity. Trap trees have long been used to suppress ESBB, and their effectiveness can be increased by using commercially available lures.

Management

Current control efforts focus on minimizing attacks on living trees. Note that some of these options are labor intensive, costly, may require specialized knowledge, judgement, and/or skill, and may need to be performed yearly. Some strategies may be impractical when large areas are involved.

Don't move firewood. Limit the movement of firewood to prevent spreading harmful pests, and do not stack recently cut green or unseasoned firewood near living trees.

Maintain tree health. Healthy trees are better able to sustain damage, so properly water trees, add nutrients as needed, and practice good tree husbandry to maintain healthy trees and decrease potential for infestation.

Plant diverse hosts. Plant mixed stands, especially in drought-stricken or prone areas, to reduce the risk of beetle attacks. Dense plantings comprised mostly of older Norway spruce are more likely to become infested.

Remove and destroy infested trees. Before adult beetles emerge in spring, remove or destroy downed trees. In areas with extensive storm damage, salvage logging should be a priority in the first year, followed by sanitation felling. If storing the wood, debark the logs and destroy the bark by burning, chipping, or composting, or completely seal firewood with a double layer of 6-mil clear plastic and age in full sun for at least seven months to reduce available breeding material and render the wood unattractive. Alternatively, immerse the logs in water to kill beetles.

Apply a preventive insecticide to at-risk trees. ESBB has not been detected in Utah, so there is no current need for chemical control of this insect. Insecticide applications do not effectively protect a tree once it is infested; however, at-risk trees can be sprayed with a preventative insecticide labeled for Ips beetles when ESBB has been detected nearby. The most effective active ingredients include permethrin (most likely to be used by homeowners), bifenthrin (Onyx), or carbaryl (Sevin; only certain formulations of Sevin are labeled for bark application to prevent bark beetle damage). Be sure to follow label directions. Applications should occur in the spring prior to beetle flight and once temperatures are consistently over 50°F. To avoid possible needle burning, try limiting applications to the bark. Naturally occuring entomopathogenic fungi have not been shown to be an effective ESBB control.

Adult European spruce bark beetle. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

Adult European spruce bark beetle. Lars Sandved Dalen, Norwegian Institute of Bioeconomy Research, Bugwood.org

Adult posterior. Lindsey Seastone, USDA APHIS PPQ, Bugwood.org

Adults in galleries. Milan Zubrik, Forest Research Institute - Slovakia, Bugwood.org

Egg. Daniel Adam, Office National des Forêts, Bugwood.org

Larva. Milan Zubrik, Forest Research Institute - Slovakia, Bugwood.org

Pupa. Maja Jurc, University of Ljubljana, Bugwood.org

Exit holes. William M. Ciesla, Forest Health Management International, Bugwood.org

Gallery. Milan Zubrik, Forest Research Institute - Slovakia, Bugwood.org

Damage and galleries. William M. Ciesla, Forest Health Management International, Bugwood.org

Galleries. William M. Ciesla, Forest Health Management International, Bugwood.org

Damage. Milan Zubrik, Forest Research Institute - Slovakia, Bugwood.org

GOLDSPOTTED OAK BORER

Not known to occur in Utah

Background

Goldspotted oak borer (GSOB) (*Agrilus auroguttatus*) is a flatheaded borer that infests many species of oak trees. It is native to southeastern Arizona and northern Mexico. It was first discovered outside its native range in San Diego County, CA in the early 2000s and has since spread to parts of Riverside, Orange, Los Angeles, and San Bernardino counties. In some areas, from San Diego to Los Angeles counties, up to 90% of oaks have died. GSOB is likely spread by humans transporting infested firewood outside of the beetle's natural range. The Mexican GSOB, *Agrilus coxalis*, looks similar and has a comparable distribution (southwestern U.S. and Central America). Neither species are considered significant threats to oak trees in their native range, where populations are low likely due to the presence of natural enemies. GSOB prefers thick-barked trees, which are characteristic of many oak trees in CA, but oak trees in their native range tend to be thin-barked.

Plant Hosts & Susceptibility

GSOB attacks oak trees (*Quercus*). Known hosts include coast or California live oak (*Q. agrifolia*), California black oak (*Q. kelloggii*), canyon live oak (*Q. chrysolepis*), Emory oak (*Q. emoryi*), Torrey oak (*Q. acutidens*), and silverleaf oak (*Q. hypoleucoides*). GSOB prefers drought stressed trees and oaks that belong to the red oak section (*Quercus* section *Lobatae*), such as coast live oak, emory oak, silverleaf oak, and California black oak. It is unknown whether GSOB attacks oak species that are native to Utah.

Description & Life Cycle

GSOB undergoes complete metamorphosis, which includes four distinct stages: adult, egg, larva, and pupa. The immature stage (larva) does not resemble the adult. Adults are bullet-shaped, dark green to black in color with three dorsal pairs of gold-colored pubescent spots on the elytra (hard wing coverings) and have short antennae. Adults are about 1/3 to ½ inch long, with females being generally larger than males. Eggs are brown, oval, and are usually laid on the bark surface or in bark fissures. Eggs are very small and difficult to locate. Larvae are legless, white, have a tapeworm appearance, and two pincer-like spines at the tip of the abdomen. They are less than 1/10 inch long when they first hatch, but grow to nearly one inch in length before pupating. Pupae have the characteristic shape of the adults and are initially white in color, but darken as they transform into the adult.

GSOB usually completes one generation per year; however, populations may require more than one year to complete development. In Southern California, adults fly from mid-May to early October with peak flight occurring in late-June to early July. Adults feed on oak foliage for about 10 days before becoming sexually mature. After mating, females deposit between 200-500 eggs, singly or in small clusters in bark crevices on the main tree stem or large branches. Eggs hatch after about 12 days. The first instar larvae bore through the bark and feed within the phloem and outer xylem from July to December. The larvae undergo four immature stages. As they mature, they migrate to the outer phloem just beneath the bark where they create pupal cells, in which they transform to the pupa and then to the adult stage in the spring. Adults survive several months in lab settings, but survival in the field is likely to be shorter in duration.

Injury Symptoms

Adults feed on oak foliage, but do not cause major damage. Damage is caused primarily by larval feeding, which results in reduced water and nutrient uptake by the host tree and subsequently affects the health of the entire tree. Signs of infestation include crown thinning and dieback, formation of callus tissue in damaged areas of the tree, and bark stains that appear as dark wet spots or oozing red sap. Staining is most noticeable when the soil is saturated during the spring and early summer months. Infested trees can also be diagnosed by meandering larval galleries under the bark that are packed with sawdust and frass (insect excrement), the presence of tiny, D-shaped emergence holes, which are often clustered or randomly spaced from the root collar up to about 10 feet, and increased woodpecker feeding and damage.

Monitoring

Although time-consuming, ground surveys are the most effective method for detecting GSOB. Red oaks that are larger than 18 inches in diameter are preferred by GSOB and should be the main focus of ground surveys. Further, oak trees on the edge of a stand should be examined first since GSOB is an edge-driven pest. Ground surveys are best conducted during the cooler months, November to May, because mature larvae (prepupae) can be more easily observed in the outer phloem during this time. Examine trees for injury symptoms as described herein, but note that symptoms are not obvious during the early stages of infestation. If an infestation is suspected, remove the bark to expose larval galleries, but be careful not to cause unnecessary damage to live trees. D-shaped emergence holes on oak are a good indicator that GSOB is present in the tree. Some symptoms, such as crown thinning and bark staining, do not always indicate GSOB infestation. High value oak trees, such as those found in parks, landscapes, and recreation areas, should be inspected at least once a year.

Purple prism and clear sticky panel traps have been used to monitor for GSOB. Traps are usually hung at 10 feet on the south side of host trees from May-September when adults are most active. An effective lure is currently being researched. Other detection methods include trap trees and girdled trees. None of these detection methods, however, are considered to be effective enough to prevent or suppress infestations.

Management

Don't move firewood. GSOB can survive in firewood for up to two years, making them adept hitchhikers. Buy and burn locally cut firewood to decrease the chance of transporting harmful pests, including GSOB.

Plant resistant and diverse hosts. Plant resistant oak varieties, such as Engelmann oak (*Q. engelmannii*) and white oaks, or opt for native non-oak trees and/or a variety of tree species to provide a more resilient landscape for future pest invasions.

Remove and destroy infested trees. GSOB can complete development in felled trees, so infested materials remain ongoing hazards. Research has shown that burning, grinding, and debarking cut wood pieces can prevent/reduce GSOB emergence.

Biological control. Three parasitoid wasps are known to attack GSOB in Arizona and California: *Atanycolus simplex*, *Calosota elongata*, and *Trichogramma* sp. The two former species are generalist and specialist larval parasitoids, respectively, whereas *Trichogramma* sp. is a generalist egg parasitoid, but has only been associated with GSOB eggs in low numbers. Other natural enemies include a generalist predatory mite (*Pyemotes tritici*), snakeflies (Raphidioptera), bark-gnawing beetles (Trogossitidae), and woodpeckers.

Apply insecticides when necessary. GSOB has not been detected in Utah, so there is no current need for chemical control of this disease. Note, however, that preventive insecticides are considered effective at preventing GSOB injury to high-value trees, but they should only be applied when GSOB has been detected within ½ mile. Bark sprays of pyrethroids (e.g., permethrin, cyfluthrin, and bifenthrin), carbaryl EC formulations (carbamate), or dinotefuran (neonicotinoid) may provide some control of GSOB. These should be done in the spring prior to adult flight and applied to the main trunk or large branches (> five inches in diameter), rather than to the entire crown to reduce spray drift and non-target effects. Further, injections of emamectin benzoate (trunk) or imidacloprid (soil) may also be effective and should be applied in fall or winter. Note that insecticides are not recommended on highly infested trees (i.e., trees with more than 25 emergence holes) due to damage to the xylem tissues by larval tunneling. Some insecticides may need to be applied annually and should be applied by a commercial pesticide applicator.

Adult goldspotted oak borer. Mike Lewis, Center for Invasive Species Research, Bugwood.org

Feeding galleries underneath the bark. Tom Coleman, USDA Forest Service, Bugwood.org

Larvae extracted from pupal chambers. Mark S. Hoddle, University of California - Riverside, Bugwood.org

Tree mortality due to goldspotted oak borer. Mike Lewis, Center for Invasive Species Research, Bugwood.org

Adult exit holes. Mark S. Hoddle, University of California - Riverside, Bugwood.org

Staining on the bark surface resulting from larval feeding. Tom Coleman, USDA Forest Service, Bugwood.org

GYPSY MOTH

Not known to currently occur in Utah

Background

Gypsy moth (GM) is a defoliating pest that is a serious threat to U.S. forests. There are two related subspecies of concern to the U.S., the European GM (*Lymantria dispar dispar*) and the Asian GM (*L. dispar asiatica*). The two subspecies can only be distinguished from each other by DNA tests. Both subspecies pose a threat to U.S. forests; however, the Asian GM poses a greater threat because it has a broader host range than the European GM, and the females can fly 20 to 25 miles per day (European GM females are flightless).

The European GM was first brought to the U.S. in 1869 to start a silkworm industry. It is now well-established in the eastern U.S. and has been detected in many other parts of the country, including Utah. The first detection of European GM in Utah occurred in 1988, and small populations have been detected periodically since then, but then eradicated. The most recent Utah detections occurred in 2007 (two moths) and 2016 (one moth). GM is not considered to be established in the state.

The Asian GM was first detected in the U.S. in 1991, likely arriving on ships infested with egg masses traveling from Russia. In recent years, there have been several introductions of Asian GM to the U.S., including Washington and Oregon. The Asian GM has not been detected in Utah.

Plant Hosts

Larvae feed on the foliage of hundreds of tree species. The most preferred hosts include oak, aspen, apple, birch, and poplar, but they will also infest walnut, cherry, elm, hickory, honeylocust, maple, and several western conifers. Asian GM larvae will feed on evergreen and deciduous trees, whereas European GM larvae feed primarily on deciduous trees. Least preferred hosts include ash, dogwood, and lilac, but some research suggests that GM can eventually adapt to unsuitable host plants.

Description & Life Cycle

Male moths are grayish-brown with feathery antennae and have a wingspan of about 1½ inch. Females have creamy white wings with black wavy markings, thread-like antennae, and a wingspan of about 2½ inches. Both males and females have an inverted V-shape that points to a dot on the wings. Eggs occur in conspicuous, velvety masses that are one to two inches long, tan in color, and firm to the touch. The egg masses contain 100 to 1,000 black, pellet-like eggs, and can be found on various outdoor surfaces, including trees, houses, patio furniture, and vehicles. Larvae develop through five to six growth stages. Young larvae are small (1/8 inch long), black caterpillars with long, black hairs and may have irregularly shaped yellow marks on the upper body surface. Older larvae are more easily identifiable; they have long and tan bristles, five pairs of blue spots followed by six pairs of red spots lining the back, and yellow spots along the sides of the body. Mature larvae can reach 2½ inches in length. GM larvae do not produce silken tents or create extensive webbing. Pupae are teardrop shaped, dark brown, about two inches in length, and have hardened shells covered in small bristles. Pupae can be found in bark crevices or other cryptic locations.

GM has one generation per year. They overwinter as eggs, which hatch in spring (April). Young larvae climb to the tops of trees, where they feed during the day and dangle from silk strands until they are dispersed by wind. Mature larvae hide during the day at the base of trees or bark crevices, and then feed at night. Pupation takes place from July to August in sheltered sites, such as bark crevices or leaf litter, and adults emerge from pupal cases in 10 to 14 days. Newly emerged females remain on the tree and release pheromones to attract mates. Egg masses are laid from late July through August. GM populations go through cycles in which the populations increase for several years, then decline, and then increase again.

Injury Symptoms

Larvae are the damaging life stage. Healthy trees can usually tolerate one to two years of GM attack. They defoliate trees, leaving trees weakened, more susceptible to drought, diseases and other pests, and repeated defoliation can eventually kill trees and entire forests. Damage from GM larvae lowers property values in infested urban areas, and the excrement, egg masses, and pupal casings can be a nuisance to homeowners.

Monitoring

There are a number of monitoring techniques state and federal survey personnel use for GM, including larval and adult trapping. These techniques, however, are more suitable for federal and state agencies that are involved in detection and delimiting surveys than for homeowners.

Management

Don't move firewood. Like other forest pests, GM can spread to new areas on infested firewood and other wood materials. As a rule, do not transport firewood outside county boundaries.

Maintain tree health. In general, healthy trees are less susceptible to pests. Trees should be properly watered and pruned, and fertilized when necessary. Keep at least a four foot diameter area around trees free of weeds and grass so that there is no competition for water or nutrients and so trunks are less likely to be damaged by lawnmowers. Your local USU Extension office can help with tree maintenance and planting information.

Biological control. Because GM is not established in Utah, there is no need for control of this insect. Note, however, that management efforts usually target the egg and larval stages, as early life stages are more susceptible to treatments. One of the most common methods for controlling GM is aerial spraying of a bacteria-based pesticide called Btk, named after the bacterium, *Bacillus thuringiensis kurstaki*. Btk is harmful to moths and butterflies only during their caterpillar stage of development. Caterpillars eat vegetation sprayed with Btk, and then spores become activated in their stomachs, causing the caterpillars to die in about 10 days. GM is susceptible to attack by other natural enemies, such as predators, pathogens (fungi and viruses), and parasitic wasps (parasitoids), such as *Aleiodes indiscretus*.

Use non-chemical control options. Other management options include mating disruption (pheromone that prevents male moths from finding mates), destroying egg masses with soapy or oily water, and placing sticky barrier bands on tree trunks. Barrier bands prevent caterpillars from crawling up trunks and into tree canopies. Note, however, that GM larvae can be dispersed by wind.

Adult male (left) and female (right) gypsy moths. John H. Ghent, USDA Forest Service, Bugwood.org

Adult gypsy moth female with egg mass. Steven Katovich, USDA Forest Service, Bugwood.org

Mature gypsy moth larva. Jon Yuschock, Bugwood.org

Gypsy moth larva feeding on oak leaf. USDA APHIS PPQ, Bugwood.org

Larvae defoliate host plants. Haruta Ovidiu, University of Oradea, Bugwood.org

Aerial view of gypsy moth damage. Pennsylvania Department of Conservation and Natural Resources - Forestry, Bugwood.org

Defoliation due to gypsy moth. Haruta Ovidiu, University of Oradea, Bugwood.org

Gypsy moth egg masses can be found on many outdoor surfaces, including trees and outdoor furniture. Daniela Lupastean, University of Suceava, Bugwood.org

Gypsy moth larvae (on clay pot) can be a nuisance to homeowners. Bill McNee, Wisconsin Dept of Natural Resources, Bugwood.org

Delta paper trap used by survey personnel for detecting adult gypsy moth. The traps are baited with the female pheremone which attracts the male moth. The sticky surfaces inside the trap catches moths. USDA APHIS PPQ , USDA APHIS PPQ, Bugwood.org

Frass (insect poop) and leaf litter on picnic table. John Ghent, John Ghent, Bugwood.org

Milk carton trap used by survey personnel for detecting adult gypsy moth. Daniel Herms, The Ohio State University, Bugwood.org

Barrier bands prevent gypsy moth larvae from crawling up tree trunks. William A. Carothers, USDA Forest Service, Bugwood.org

LARGER PINE SHOOT BEETLE

Not known to occur in Utah

Background

Larger pine shoot beetle (PSB) (*Tomicus piniperda*), also known as common pine shoot beetle, is a pest of pine trees [*Pinus* spp., especially Scotch (Scots) pine (*P. sylvestris*)], that primarily affects weakened and low-vigor trees. It may also attack healthy trees when beetle populations are high. PSB is native to Europe, Asia, and northern Africa, and established populations were first recorded in the U.S. in 1992 in Ohio, likely having arrived on wood packing material from foreign cargo transport. PSB currently occurs in 20 northeastern and north central states and the Canadian provinces of Ontario, Québec, and New Brunswick. This beetle is not currently known to occur in Utah, and a state quarantine exists to prevent its introduction and spread from known infested areas.

Plant Hosts

Scotch (Scots) pine (*P. sylvestris*) is the preferred host in both its native range and in North America, but PSB can feed and reproduce on most, if not all, pine (*Pinus*) species including Austrian pine (*P. nigra*), ponderosa pine (*P. ponderosa*), lodgepole pine (*P. contorta*), eastern white pine (*P. strobus*), red pine (*P. resinosa*), and jack pine (*P. banksiana*). Alternate hosts include spruce (*Picea* spp.), fir (*Abies* spp.), Douglas-fir (*Pseudotsuga menzezii*), and larch (*Larix* spp.).

Description & Life Cycle

Adults are small, shiny, cylindrical beetles, up to 1/5 inch in length, and dark brown or black in color. The rear end of the beetle is rounded. Eggs are tiny, oval and smooth, about 1/25 inch long, and shiny white in color. Larvae are legless grubs up to ¼ inch in length with brown heads and a creamy white body.

Adults emerge beginning in March and April when temperatures reach a minimum of 54°F and fly up to two miles using host-tree volatile chemicals to locate stressed or dying pine trees, or freshly cut pine trees, logs, slash, and stumps, where they will mate and lay eggs. Females excavate egg galleries that are four to 10 inches in length between the inner bark and outer sapwood and lay eggs in niches along the gallery wall. During gallery construction, males remove the frass and block the entrance from other beetles. Eggs hatch in two to three weeks, and the developing larvae feed from April to June, mining separate galleries 1½ to 3½ inches in length. Mature larvae pupate at the end of their galleries in May or June and emerge as adults by boring an exit hole through the bark beginning in July. Adults move to healthy pines and feed on terminal shoots during the summer and into the fall by tunneling inside the shoot. Each adult can mine and kill up to six shoots, and shoots up to one year old on living pine trees of all ages can be attacked. After a few hard freezes, PSB moves to the lower trunk of the same tree, or to the soil, to create a short gallery for overwintering. Typically a single generation occurs per year in the northern U.S. PSB can vector wood-damaging fungi, including *Ophiostoma minus* and *Leptographium wingfieldii*, but these associations occur at very low frequency.

Injury Symptoms

In spring, boring dust may be found on cut trees or stumps, and egg and larval galleries that are cleared of sawdust and frass (insect feces) may be found beneath the bark of cut trees or stumps. Beginning in July, branch tips located mainly in the upper third of the tree canopy are hollowed out and begin to droop and turn yellow or red, and may drop during summer and fall. Small ($^1/_{10}$ inch), round exit holes surrounded by pitch may be seen at the base of dead shoots. Tree height and growth can be reduced when shoot feeding is severe.

Monitoring

Conduct visual surveys primarily in summer and fall when adult beetles are feeding in pine shoots. Look at branch tips on the upper half of pines for dead, bent, yellow or red shoots. Clip off suspected shoots and examine for small, round beetle entrance/exit holes. Inspect loose and fallen bark for galleries and the presence of PSB life stages, and closely examine sides warmed by the sun, as galleries are more numerous on these sides. PSB can also be monitored with Lindgren funnel traps baited with α-pinene and trans-verbenol in summer when adults are active and searching for new host material.

Management

Although PSB can reduce the general health of trees and predispose them to attack by other pests, it is unlikely to become problematic on backyard trees. It has caused minimal damage to native pines, maintained Christmas tree farms, and the nursery trade in North America. As such, current control efforts largely focus on sanitation and other preventive management strategies listed below.

Don't move firewood. Limit the movement of firewood to prevent the spread of this insect and other harmful tree pests. PSB may be able to complete development in firewood with intact bark, so consider debarking firewood or cover firewood completely with a heavy-duty clear or black plastic to render it unsuitable for beetle development. Never stack barked firewood under healthy trees.

Select trees suitable for the planting site, and ensure their health and vigor. Choose native trees over exotics, and plant trees in well-suited sites. Healthy trees are better able to defend against insect and disease outbreaks, so practice good tree husbandry by properly watering and fertilizing when needed.

Purchase pest-free trees and wood products from reputable sources. Closely inspect trees for beetle infestations prior to purchase. In addition, buy pine bark mulch and barked wood, including Christmas trees and nursery stock, from local or non-quarantined areas, or from sources whose products are accompanied by certificates or permits.

Remove and destroy infested trees. Remove and destroy dead and dying trees before beetle emergence in spring to eliminate breeding material and decrease the likelihood of PSB infestation. Completely remove and destroy the stump, or leave a maximum stump height of four inches.

Use insecticides when necessary. PSB has not been detected in Utah, so there is no current need for chemical control of this insect. Biological control options are currently not available, and chemical control is typically not necessary. A labeled insecticide with permethrin as the active ingredient may be used for control. Apply to stumps in late April to early May to prevent larval development, or to foliage in June to July right before new adult emergence. Use insecticides with caution and always follow label directions.

Adult larger pine shoot beetle. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

Adult beetle in gallery in pine terminal. E. Richard Hoebeke, Cornell University, Bugwood.org

Galleries. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

Round entrance/exit holes surrounded by pitch (resin) may indicate larger pine shoot beetle infestation. Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org

Boring dust created by larger pine shoot beetle. Stanislaw Kinelski, Bugwood.org

Damage. E. Richard Hoebeke, Cornell University, Bugwood.org

Pine terminals fallen from tree and infested by larger pine shoot beetle. E. Richard Hoebeke, Cornell University, Bugwood.org

SHOT HOLE BORERS

Not known to occur in Utah

Background

Ambrosia beetles bore into the xylem of trees and cultivate and feed on ambrosia fungi. Three members of the genus *Euwallacea* have recently been introduced into the U.S., and are collectively referred to as invasive shot hole borers (ISHB). They attack agricultural (e.g., peach and citrus) and common landscape trees, and spread a fungal disease known as fusarium dieback (FD). ISHB include the polyphagous shot hole borer (PSHB, *E. fornicatus*), Kuroshio shot hole borer (KSHB, *E. kuroshio*), and tea shot hole borer (TSHB, *E. perbrevis*). ISHB are native to parts of Asia and Oceania, but have recently invaded other countries, including the U.S., likely having arrived on infested plants or wood packing materials. PSHB and KSHB have been known from California since 2003 and 2013, respectively; TSHB has been known from Hawaii since 1975 and Florida since 2002. A fourth species, *E. fornicatior*, also commonly referred to as tea shot hole borer (like *E. perbrevis*), is part of the ISHB complex, but is not known to occur in the U.S.

Plant Hosts

ISHBs are generalist feeders that attack over 260 plant species. Known landscape hosts include maple (*Acer* spp.), oak (*Quercus* spp.), sycamore (*Platanus* spp.), beech (*Fagus* spp.), ash, (*Fraxinus* spp.), elm (*Ulmus* spp.), poplars (including cottonwood and aspen) (*Populus* spp.), black locust (*Robinia pseudoacacia*) and willow (*Salix* spp.). They are also known to attack some agricultural hosts, such as avocado (*Persea americana*), cacao (*Theobroma cacao*), citrus (*Citrus* spp.), tea (*Camellia sinensis*), and peach (*Prunus persica*). Some hosts are referred to as reproductive hosts because they are necessary for beetle reproduction (i.e., the beetles must complete their life cycle in these hosts). These hosts are also used for growing the fungi that causes FD. Other hosts are non-reproductive hosts and are used primarily for fungal inoculation (i.e., the beetle leaves or dies after depositing fungal spores on the inside of the tree). ISHB usually attack stressed trees that are already declining in health.

Description & Life Cycle

ISHB have a similar appearance and are difficult to distinguish from each other without DNA analyses. Adult females are black or dark brown in color, whereas adult males are lighter brown and have tiny eyes. Adults are typically smaller than a sesame seed; females are about $^{1}/_{10}$ inch in length; males are slightly smaller and have fused elytra and non-functional wings. Immature life stages (eggs, larvae, and pupae) are also very small and resemble those of other members of the weevil family. Like adults, immature life stages are indistinguishable without DNA technology.

Distinguishing between any bark or ambrosia beetle (over 500 species in the U.S.) is difficult, and requires the assistance of qualified professional. Submit suspect ISHB to the Utah Plant Pest Diagnostic Lab or the Utah Department of Agriculture and Food. These entities can also provide assistance with determining ambrosia beetles from other bark beetles.

Ambrosia beetles likely undergo multiple generations per year, with most of their life cycle spent inside the tree. Adult females create galleries as they bore into trees, introducing ambrosia fungi which they carry in special organs in their mouthparts. The fungi colonize the gallery walls and serve as the food source for the beetles. Adults mate (often with their siblings) inside the galleries and the mated females will either re-attack the same tree or leave the tree and fly to a new host. Females lay eggs either singly or in small clusters in the gallery. After the larvae hatch, they feed on the fungus, becoming carriers of FD, and pass through three instars before pupating and emerging as the adult beetle. Developmental time from egg to adult takes about 40 days and the temperature most favorable for development stretches between about 55-91°F. Males do not fly and usually live their entire life inside the natal gallery; however, they may emerge and crawl on the bark surface before entering a different gallery. Ambrosia beetles have a haplodiploid sex-determination system, in which unfertilized eggs develop into males and fertilized eggs develop into females; they do not have sex chromosomes. More females are produced than males, but males develop more rapidly.

Injury Symptoms

ISHB can spread fusarium dieback (FD), which is caused by various fungi (*Fusarium euwallaceae*, *F. kuroshium*, *F. rekanum* sp. nov., *Graphium euwallaceae*, *G. kuroshium*, or *Paracremonium pembeum*) introduced to the tree by boring female beetles. The fungus disrupts water and nutrient flow within susceptible hosts, eventually killing individual branches or entire trees. Depending on the host, signs of FD include leaf discoloration and chlorosis; branch dieback; epicormic growth at the base of trees or along stems; discolored, wet, thick-gumming, or oily-looking spots surrounding entry/exit holes; and eventual tree death. In some hosts, a white powdery or crusty ring (sugar volcano) may surround the entry/exit hole. Brown necrotic tissue may also be visible by removing the bark under the entry/exit hole. Signs of beetle infestation include frass (sawdust-like excrement) and small entry/exit holes that are about the size of a ball-point pen tip and typically located on the main stem and larger branches. Under the bark, the galleries may start out with a straight entrance, but then terminate, eventually running parallel to the branch surface.

Monitoring

Early detection is key to preventing damage from these pests. Regular monitoring of trees ensures that infestations are found before populations build up and become established, and that infested trees are treated in a timely manner before damage becomes extensive. Previously, there were no known sex or aggregation pheromones, so detection had been limited to visual inspections; however, recent research has found that Lindgren funnel traps baited with commercial lures are effective at capturing PSHB and KSHB. Elm bark beetle traps (12 x 25 inch white sticky panel) and homemade liter bottle traps can also be used.

Management

Don't move firewood. Buy and burn locally cut firewood to decrease the chance of transporting harmful pests.

Sanitation. Remove/prune infested wood and then chip it to a size of one inch or less. Sterilize pruning tools with either a 10% bleach or 70% ethanol solution between each cut. You may also solarize infested wood under a clear trap for several months, kiln-dry at a temperature of 140°F for at least 60 minutes, or take infested wood to a biogeneration facility that will burn the green waste and convert it to energy. Note for the latter that wood should be covered in-transit to prevent beetles from escaping.

Maintain tree health. Healthy trees are generally less susceptible to pests. Promote tree health by using good cultural practices, such as proper fertilization and adequate watering.

Biological control. Options for biological control are being explored and include the use of endophytic bacteria and natural enemies, such as parasitoid wasps.

Use insecticides when necessary. ISHB have not been detected in Utah, so there is no current need for chemical control of these insects. Note, however, that the fungicides tebuconazole and metconazole can reduce effects of FD. In addition, soil drench applications of imidacloprid, trunk sprays of bifenthrin, or trunk injections of emamectin benzoate alone, or in combination with propiconazole or tebuconazole, can reduce new beetle attacks on trees with low to moderate levels of infestation. Note, however, that heavily infested trees have a low chance of surviving.

Adult polyphagous shot hole borer. Rachel Osborn, Southeast Asian Ambrosia Beetle ID, USDA APHIS PPQ, Bugwood.org

Adult kuroshio shot hole borer. Sarah Smith, Southeast Asian Ambrosia Beetle ID, USDA APHIS PPQ, Bugwood.org

Adult tea shot hole borer. Sarah Smith, Southeast Asian Ambrosia Beetle ID, USDA APHIS PPQ, Bugwood.org

Shot hole borer galleries. Mendel et al. 2012.

Exudation of white powder lesions can form around beetle extrance holes. Mendel et al. 2012.

Sugary exudate may indicate an ISHB infestation.
https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=27204

SIREX WOODWASP

Not known to occur in Utah

Background

Sirex woodwasp (SWW) (*Sirex noctilio*) is an invasive non-stinging wasp that is considered one of the top 10 most serious forest pests worldwide. It serves as a vector for a wood-decaying fungus (*Amylostereum areolatum*) and toxic mucus that work together to weaken host trees. SWW was discovered in North America for the first time in 2004 in New York, likely arriving on imported wood products. It has since been found in Connecticut, Michigan, New Jersey, New York, Ohio, Pennsylvania, Vermont, and southern portions of Ontario and Quebec. Pine forests in southern and western U.S. are at risk if SWW continues to spread throughout the country. It has been estimated that SWW could cost the sawtimber and pulpwood industries between $2.8 and $17 billion dollars per year. SWW is native to Europe, Asia, and North Africa, where it is considered a minor secondary pest.

Plant Hosts

SWW can attack a wide variety of conifer trees, but pines (*Pinus* spp.) are at most risk, particularly stressed Scots pine (*Pinus sylvestris*), red pine (also known as Norway pine) (*Pinus resinosa*), and eastern white pine (*Pinus strobus*). Besides pines, other trees found in Utah that are likely to be susceptible to SWW include Douglas-fir (P*sedudotsuga menziesii*), fir (*Abies* spp.), and spruce (*Picea* spp.).

Description & Life Cycle

Adults are large insects that are about one to 1½ inch long, with females being larger than males. They have black antennae, clear yellow-orange membranous wings, and lack the narrow waist that is common in most wasps. Females have orange or red legs and a dark metallic blue or black abdomen, whereas males have orange or red front legs, black hind legs, and a black abdomen with an orange mid-section. SWW are commonly called horntails because of the upturned ovipositor (egg-laying device) which projects from the tip of the abdomen. Note that there are native Siricids in Utah, including the common pigeon tremex (*Tremex columba*), which is generally a brown color marked with yellow. SWW eggs are less than 1/10 inch long, creamy white in color, and sausage shaped. Larvae vary in length from 1/11 inch to one inch, depending on age, and are creamy white in color, legless, and have a spine at their posterior end.

SWW completes one generation per year; however, in cooler climates, a single generation may take two years to develop. They overwinter as eggs or larvae inside the tree, and adult emergence occurs from July to September, with peak emergence in August. Adults mate and then the female uses her ovipositor to deposit eggs into the tree. SWW are haplodiploid, meaning that unfertilized eggs develop into males and fertilized eggs develop into females. As the female deposits eggs, she inadvertently also injects the toxic mucus and wood-decaying fungus, which together weaken the tree and create a favorable environment for the developing eggs and larvae. Females lay anywhere from 25 to 400 eggs, depending on the size of the female, with an average of around 200. The eggs hatch after about eight days, depending on environmental conditions. The larvae then feed on the fungus as they tunnel through the wood, developing through six to twelve instars over 10 to 11 months. They eventually pupate near the bark surface, and the adults emerge from the tree about three weeks later. When the adult females emerge from the trees, they carry the fungal spores in specialized abdominal glands called mycangia. Adults live for only a few weeks and do not feed.

Injury Symptoms

SWW infestations result in wilted leaves that range in color from yellow to red/brown, frass-filled larval galleries underneath the bark, round exit holes that are $^1/_8$ to $^3/_8$ inch in diameter, and resin beads that leak from egg laying sites which are usually located mid-trunk and on the sunny side of the tree. The associated fungus also causes a brown-colored stain in the outer sapwood. Trees that are heavily infested usually die within one year.

Monitoring

SWW can be monitored by visually inspecting host trees during aerial (drone or aircraft) or ground surveys. Ground survey approaches include bark stripping to check for larvae, larval galleries, and fungal staining. Trap trees, preferably stressed pine trees, have also been used for monitoring purposes. It is recommended that trap trees be chemically girdled in June using herbicides registered for such use. Mechanical girdling, which is typically done even earlier in the year, is another option, but is not as effective as chemical girdling. Finally, the Lindgren funnel, Panel Intercept, and Cross vane traps, in combination with a commercially available lure, can also be used for monitoring, but are not considered to be very effective at detecting this pest.

Management

Don't move firewood. SWW can move to new areas on infested wood material. Buy and burn locally cut firewood to decrease the chance of transporting SWW and other harmful pests. Some states have even restricted the movement of firewood as a precautionary measure to slow the spread of invasive species.

Maintain tree health. Silvicultural management can help to prevent or alleviate the impacts of SWW infestations. This management practice involves the targeted removal of weakened, dying, or infested trees, essentially minimizing overcrowding and spread of tree pests and diseases.

Biological control. *Deladenus siricidicola* is a parasitic nematode that has been successful at managing SWW infestations in Australia, New Zealand, and South America. This nematode infects the wasp larvae and ultimately sterilizes the adult females. Parasitized female wasps then lay infertile eggs filled with nematodes that then infect other wasp larvae, keeping SWW populations below damaging levels. The nematode is easy to rear in the lab and can be inoculated into infested trees. In the U.S., however, the nematodes are unable to penetrate the egg and thus sterilize the females, likely due to the nematode strain, the biology of SWW, or both. Wasp parasitoids of SWW larvae have also been used to control SWW populations, including the species *Megarhyssa nortoni*, *Rhyssa persuasoria*, *Rhyssa hoferi*, *Schletererius cinctipes*, and *Ibalia leucospoides*. Most of these parasitoids are native to North America.

Avoid insecticides. SWW has not been detected in Utah, so there is no current need for chemical control of this insect. Regardless, there are no known effective chemical control options for SWW. Insecticides may not be feasible due to the adult's short life span, tendency to not feed, and impacts on non-target organisms.

Adult female (left) and male (right) sirex woodwasps. Vicky Klasmer, Instituto Nacional de Tecnologia Agropecuaria, Bugwood.org

Larva in gallery with tightly compacted frass. Dennis Haugen, Bugwood.org

Pupa and gallery. William M. Ciesla, Forest Health Management International, Bugwood.org

Sirex woodwasp larvae in galleries. Vicky Klasmer, Instituto Nacional de Tecnologia Agropecuaria, Bugwood.org

Resin dribbles from oviposition (egg-laying) wounds. Dennis Haugen, Bugwood.org

Round exit holes vary from $^{1}/_{8}$ to $^{3}/_{8}$ inch in diameter. Dennis Haugen, Bugwood.org

Damage caused by sirex woodwasp. Vicky Klasmer, Instituto Nacional de Tecnologia Agropecuaria, Bugwood.org

Sirex resin beads in red pine. Carrie Crook, Bugwood.org

SPOTTED LANTERNFLY

Not known to occur in Utah

Background

Spotted lanternfly (SLF) (*Lycorma delicatula*) is native to China, Vietnam, and India, and has spread to Japan and South Korea where it is causing considerable damage to some fruit crops. SLF was first detected in the U.S. in Pennsylvania in 2014 and is thought to have first arrived to the country on imported landscaping stone. As of May 2019, SLF has also been reported in Delaware, New York, Virginia, New Jersey, Connecticut, and Maryland. It is not known to occur in Utah. SLF is a quarantine pest and can restrict interstate movement of regulated articles (e.g., fruit, lumber, firewood); however, it can easily spread to new areas by the unintentional movement of life stages on infested plant material and manmade objects. SLF is also a nuisance pest and can congregate in large numbers in and around homes and structures.

Plant Hosts

SLF are broad generalists that feed on more than 70 plant species such as grape (*Vitis*), fruit trees including apple (*Malus*) and *Prunus* species such as apricot, cherry, and peach, and various hardwood/ornamental trees including maple (*Acer*), willow (*Salix*), birch (*Betula*), ash (*Fraxinus*), walnut (*Juglans*), poplar and aspen (*Populus*), sycamore (*Platanus*), oak (*Quercus*), linden (*Tilia*), pine (*Pinus*), lilac (*Syringa*), serviceberry (*Amelanchier*), and dogwood (*Cornus*). Adults show a strong preference for tree-of-heaven (*Ailanthus altissima*), an invasive plant from China that is widely established in the U.S.

Description & Life Cycle

Adults are about one inch long. The forewings are gray with black spots, and black blocks outlined in gray are arranged along the wing tip. The upper sides of the hindwings are black and white, and the lower sides are red with black spots. Their legs are black and their abdomen is yellow with broad black bands on the top and bottom surfaces. Females lay one to two egg masses; each mass contains 30 to 50 eggs and is covered by a waxy substance roughly one inch long. Newly laid egg masses are white in color but turn brownish-gray and mud-like as they age. Beneath the waxy cover, the eggs are seed-like and deposited in four to seven parallel rows. Nymphs (immature life stage) are wingless and undergo four instars. The first three instars are black with white spots; the last instar is black and red with white spots. Fully-winged adults develop after the fourth instar.

SLF has one generation per year, and overwinters as eggs. Eggs hatch from late April to early summer. Nymphs then begin crawling and feeding on a wide range of host plants. Adults are present by mid-summer (mid to late July) and prefer to feed on tree-of-heaven, but can also be found on other hosts. Eggs are laid from September to late November or early December. Adults die with a hard frost.

Injury Symptoms

SLF uses a piercing-sucking mouthpart to feed on phloem from stems, leaves, and bark. It does not feed directly on fruit. Branches highly infested with SLF may lose vigor, wilt, and die. Extensive feeding results in weeping wounds that leave trails of sap along the bark. As it feeds, SLF releases sugary excrement (honeydew) that, along with sap from oozing wounds, promotes the growth of fungi such as sooty mold. Sooty mold (a gray and black fungus) develops around the base of trees and branch crotches, and can coat leaf and fruit surfaces, therefore interfering with photosynthesis and ultimately negatively affecting plant growth and crop yield. Further, the honeydew can attract unwanted insects, such as ants and wasps, and coat porches and vehicles with the sticky residue.

Monitoring

SLF can be monitored with visual inspection. Nymphs and adults gather in large numbers on host plants and are easy to find at dusk or night when they move up and down tree trunks. During the day, they tend to congregate in the canopy or at the base of the host plant if there is adequate cover. Begin monitoring for nymphs towards late April or early May, and continue monitoring for adults through the summer and fall. In addition, keep an eye out for the mud-like egg cases from September through April. Eggs are laid on any smooth surface, such as tree bark, landscaping stone, outdoor furniture, vehicles, railway cars, telephone poles, and fence posts. Sticky tree bands are another useful monitoring tool. Sticky bands should be placed about four feet above the base of host trees, with the sticky portion of the band facing outward. Push pins can be used to help secure the band to the tree. Bands should be checked and replaced every two weeks. Brown sticky traps are more attractive to nymphs and adults than blue or yellow sticky traps, and current field trials are assessing the combined efficacy of brown sticky bands and a methyl salicylate lure.

Management

Remove egg masses. Egg masses can be scraped off a substrate with a credit card, putty knife, or similar tool. Scrape the egg mass into a vial containing rubbing alcohol or hand sanitizer and tightly seal.

Remove preferred host plants. If present, consider removing tree-of-heaven from your property. In Pennsylvania, it is recommended to remove female tree-of-heaven, while leaving a few male “trap” trees for targeted insecticide sprays. Male trap trees are preferred over female trees because females produce seeds which can repopulate the property. An herbicide application to the cut stump will prevent new shoots.

Biological control. At this time, the extent to which natural enemies will control SLF is unknown. Researchers in the U.S. are examining the efficacy of multiple parasitoids, including the gypsy moth egg parasitoid (*Ooencyrtus kuvanae*) that was introduced to the U.S. in 1908, and two agents that are found in China, the egg parasitoid *Anastatus orientalis* and the nymphal parasitoid *Dryinus* sp. nr. *browni*. Two fungi, *Beauveria bassiana* and *Batkoa major*, have been found attacking nymphs and adults in Pennsylvania. Depredation of SLF by spiders and various insects has been observed in the wild, but not at high enough levels to provide effective control.

Use insecticides when necessary. SLF has not been detected in Utah, so there is no current need for chemical control of this insect. All life stages of SLF are susceptible to insecticides; however, nearby populations can repopulate treated areas. Insecticides that appear to be effective against adults and nymphs include carbaryl, malathion, zeta-cypermethrin, acetamiprid, dinotefuran, imidacloprid, thiamethoxam, spinosad, azadirachtin (neem oil), and indoxacarb, whereas JMS Stylet-Oil (paraffinic oil) provides some control of eggs.

Spotted lanternfly adult. Emelie Swackhamer, Penn State University, Bugwood.org

Adults have gray forewings with black spots; and red, white, and black hindwings. Pennsylvania Department of Agriculture, Bugwood.org

Female adult with a newly laid egg mass. Emelie Swackhamer, Penn State University, Bugwood.org

Eggs are laid in vertical parallel rows (see arrow). Emelie Swackhamer, Penn State University, Bugwood.org

Nymphs undergo four instars (molts). The first three instars are black with white spots (top image). The fourth instar is black and red with white spots (bottom image). Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org

Apple highly infested with spotted lanternfly. Emelie Swackhamer, Penn State University, Bugwood.org

Place brown sticky bands around known host trees to monitor for spotted lanternfly. Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org

Feeding can result in weeping wounds and sooty mold growth. Emelie Swackhamer, Penn State University, Bugwood.org

Scrape egg masses into a container filled with rubbing alcohol or hand sanitizer and tightly seal. Pennsylvania Department of Agriculture, in https://extension.psu.edu/spottedlanternfly-management-for-homeowners

VELVET LONGHORNED BEETLE

Present in Utah

Background

Velvet longhorned beetle (VLB) (*Trichoferus campestris*) is a wood-boring pest that infests fruit, forest, and landscape trees, as well as green (timber) and dry wood lumber. VLB is native to Asia and Russia. It was first detected in North America in Quebec in 2002, and in the U.S. in Rhode Island in 2006. It has been detected/intercepted in a few states, mostly in midwest and eastern states, but also in Utah (since 2010). In Utah, VLB is currently found in some orchards, ornamental landscapes, and along natural waterways in Box Elder, Davis, Salt Lake, Summit, Tooele, Utah, and Weber counties. VLB spreads to new areas through infested wood packing material used for imported commodities such as machinery, building supplies, glass, tools, and tiles.

Plant Hosts

VLB is known to infest apple, cherry, mulberry, peach, and a number of hardwood, ornamental, and conifer timber tree species. Many tree species may also serve as dry wood hosts for VLB. It is unknown if VLB prefers stressed or healthy trees; however, it does seem to be more attracted to medium to large sized trees. Nursery trees are susceptible hosts and may act as a reservoir for the pest to spread to new areas.

Description & Life Cycle

Adults have an elongated body that is about ½ to ¾ inch long. They have long parallel wing covers (elytra) and vary in color from dark brown to brownish orange, with the legs and antennae usually being lighter in color than the body. Their antennae are segmented and about ¾ the length of their body. The name “velvet” comes from the fine hairs that are irregularly distributed and form light colored “patches” along the body and wing covers. Eggs are white, oval in shape, and approximately 1/16 inch long. Larvae are about ½ to one inch long, and yellow to white in color with a brown head, segmented body, and short poorly developed legs.

From May to August, adults emerge from trees through 3/8 inch round exit holes, which they create by chewing through the wood. Adults fly at night; peak flight and mating occurs from June to early August. Females lay their eggs on the trunks and large branches of healthy, stressed, dying, or cut trees. Larvae hatch and burrow into the tree bark forming galleries (tunnels) in the cambium, sapwood, and heartwood, increasing in size as they mature. Galleries range in size from two to six inches wide. Larvae are the overwintering and damaging life stage; they can take two or more years to complete their development. Pupation occurs in late winter to spring, with a final molt to the adult stage in spring to summer.

Injury Symptoms

Symptoms include round exit holes (about 3/8 inch) on the trunk and main branches; a thinning, wilted, or yellowing canopy; frass (insect excrement) deposits at the base of the tree; peeling bark; tunnels made by large larvae; and epicormic shoots (shoots that grow from dormant buds beneath the bark, trunk, stem, or branch of a plant). Larval tunneling may weaken the trees, so that branches are more likely to break off during high winds. A VLB infestation can impact fruit yield, tree longevity, and wood marketability.

Monitoring

The best time of year to monitor for VLB is during peak flight from late June to early August. In Utah, high numbers of VLB have been detected in riparian habitats near golf courses and near cull piles of discarded plant materials in commercial fruit production areas. Monitoring in Utah has been successful with Lindgren funnel or cross vane panel traps. In addition, Fluon® or Teflon™ should be applied to the surfaces of panel traps to prevent the beetles from escaping the trap. An insecticide vapor strip, or ethylene (toxic to mammals) or propylene (nontoxic) glycol should be used in combination with traps to kill trapped insects. Other monitoring methods include visual inspection for adult exit holes and tree injury symptoms (as described previously), and black ligh traps.

Management

Don't move firewood. VLB is one of many pests that can be transported to new areas on firewood; therefore, collect or buy firewood within 25 to 50 miles of where you will be using it to prevent inadvertently moving VLB to non-infested areas.

Biological control. Natural enemies of longhorned beetles in the U.S. include predators, parasitoids, and pathogens. Predators include flat bark beetles, cylindrical bark beetles, clerid beetles, click beetles, robber flies, assassin and ambush bugs, thrips, carpenter ants, birds, lizards, spiders, scorpions, toads, and small mammals. Parasitoids include braconid, ichneumonid, and chalcid wasps; and tachinid and sarcophagid flies. Nematodes and fungi have been observed as pathogens of longhorned beetle larvae.

Chemical control. There are no insecticides labeled for VLB; however, insecticides labeled for longhorned beetles in general should reduce numbers of larvae in infested trees. Insecticides containing the active ingredient imidacloprid (neonicotinoid class) have been used successfully on high-value trees for the control of Asian longhorned beetle, a closely related invasive wood borer. Another neonicotinoid insecticide option is dinotefuran (e.g. Safari); however, dinotefuran products are only registered for use on ornamental plants and are not allowed on fruit trees.

Adult velvet longhorned beetle. Boris Loboda, http://ukrbin.com/show_image.php?imageid=28517

Pupae are about ¾ inch in length. Utah Department of Agriculture and Food

Adults vary in color from dark brown to brownish orange. Hanna Royals, USDA APHIS PPQ CPHST ITP, Bugwood.org

Adult exit holes are round and about 3/8 inch in diameter. Utah Department of Agriculture and Food

Larvae are about ½ to one inch in length. Utah Department of Agriculture and Food

Heavy damage from velvet longhorned beetle can cause thinning, wilting, or yellowing canopy. Utah Department of Agriculture and Food

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