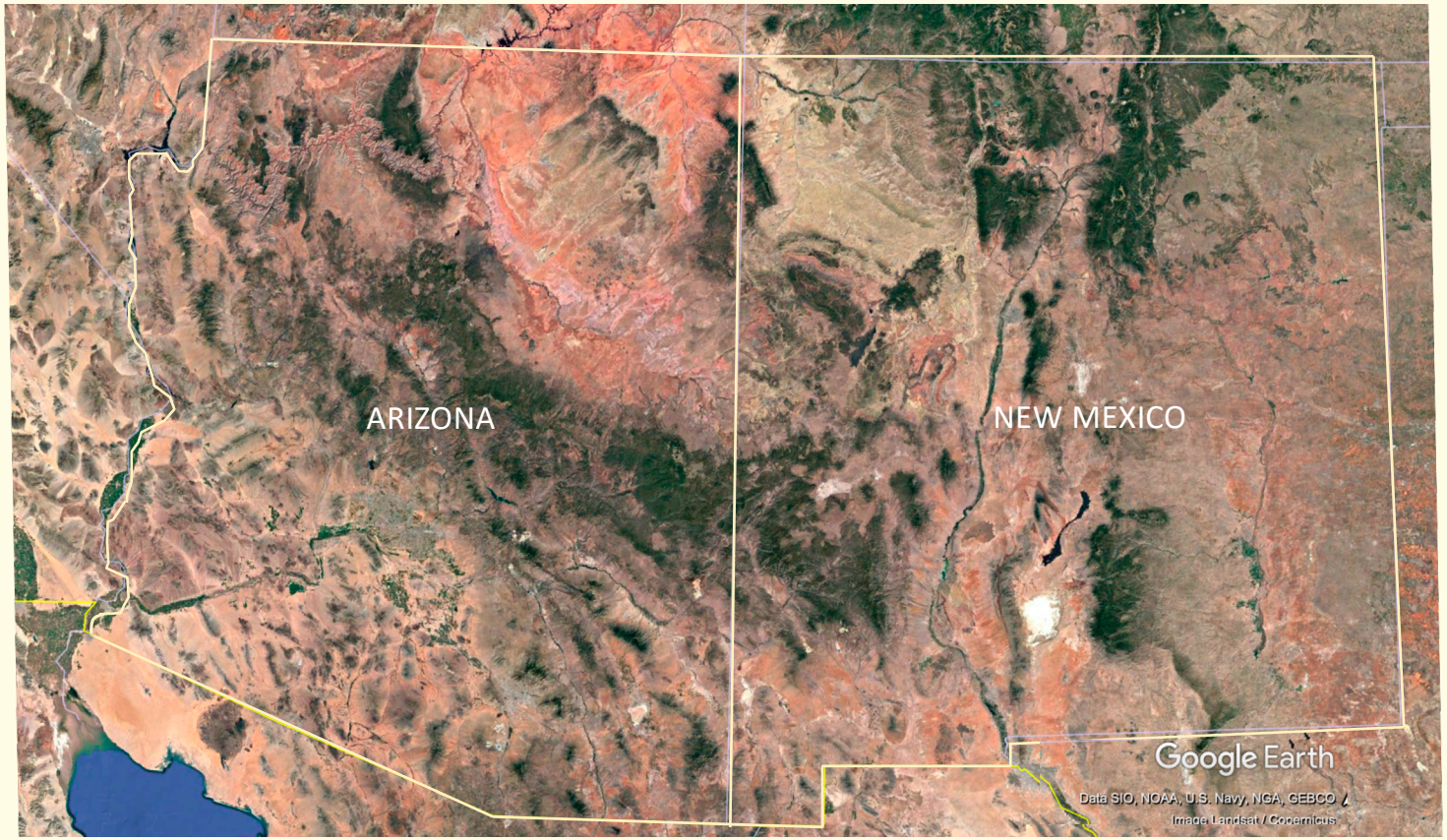


Urban Tree Threat Response Guide

For Insect, Disease and Environmental Threats to Urban Trees

IN ARIZONA AND NEW MEXICO

Major funding provided by the Arizona Department of Forestry and Fire Management's Urban and Community Forestry Program and USDA Forest Service. These institutions are equal opportunity providers.

TABLE OF CONTENTS

Overview

Trees in urban and community forests are subject to a wide range of insect and disease threats. This Guide focuses on high priority threats—including both native and nonnative invasive species—that can damage or kill urban trees. Many are present in Arizona and/or New Mexico now. Some have not yet been detected, but could move here from other US states where they are currently impacting urban trees and forests.

Detrimental environmental conditions and poor cultural practices can also result in tree damage or death and are addressed in this Guide as well.

Arizona and New Mexico urban and community forests

Urban and community forests are the combined trees growing throughout cities, towns and the urban/rural fringe. These forests include trees in parks, backyards, gardens, school yards, commercial properties, public sites, urban preserves, public rights of way, greenways and more.

Urban forests in Arizona and New Mexico provide a multitude of social, environmental and economic benefits including cooling and shading people, buildings and streets; improving human health; sequestrating carbon; filtering air and water; cleansing stormwater; conserving energy; creating habitat for urban wildlife and beautifying the landscape.

A portion of the trees impacted by insect, disease and environmental threats are medium and high water-use trees. The species composition of urban forests could evolve in coming decades as the combined impacts of rising temperatures, ongoing drought and increased competition for water supplies further stress existing urban trees, making them more vulnerable to insect, disease and environmental threats.

Transitioning to more heat- and drought-tolerant trees with low and medium water-use needs—including planting more native southwest species—could increase urban canopy coverage and improve climate resilience in urban and community forests going into the future.

Ganoderma tsugae conk
Photo credit: Joseph O'Brien, USDA Forest Service, Bugwood.org

Emerald Ash borer
Photo credit: David Cappaert, Michigan State University, Bugwood.org

Trees in Arizona and New Mexico urban areas providing multiple environmental, economic and aesthetic benefits
Photo credit: Ann Audrey

Overview of the Integrated Pest Management (IPM) framework

The Integrated Pest Management framework is used throughout this Guide to address management of specific insect, disease and environmental threats to urban trees in Arizona and New Mexico. While the definition below focuses on insect pests, general IPM management steps and controls are equally applicable to fungal diseases and environmental conditions.

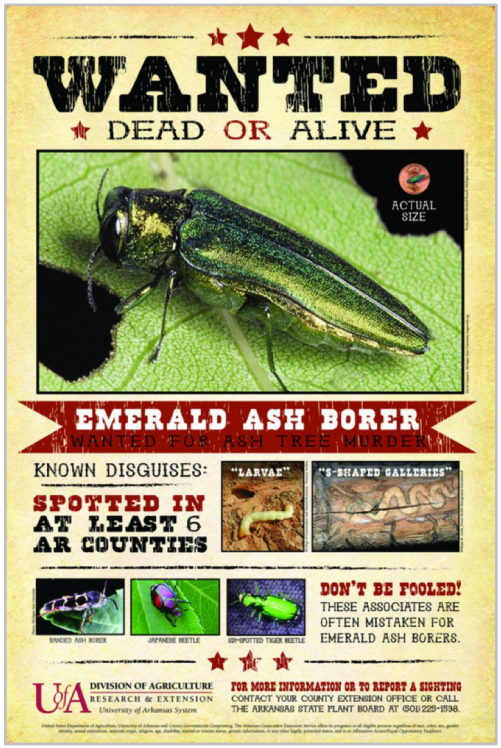
> *"Integrated pest management (IPM) is a sustainable approach to pest management that combines cultural, mechanical/physical, biological, and chemical control strategies in a way that minimizes economic, health, and environmental risks (USDA–ARS, 2018).*
>
> *When managing urban trees for insect pests, the following steps are key to a successful IPM program.*
> ***Prevention** – Avoid insect pests through proper plant selection, planting techniques, tree maintenance, irrigation, and fertilization.*
> ***Monitoring** – Regularly inspect your trees and shrubs for insect pests or signs of damage.*
> ***Identification** – Be sure to correctly identify both the tree species and insect pests that are present.*
> ***Management** – Select the appropriate IPM strategies for the pest, including cultural, mechanical, biological, and chemical pest suppression tactics."*
>
> Source: Integrated Pest Management (IPM) Strategies for Common Insect Pests of Trees in New Mexico Guide H-174

Cultural, mechanical, biological and chemical control strategies are described on the following pages, along with examples of these controls.

Cultural control strategies make trees less vulnerable to insects, diseases and environmental threats by meeting plant needs, addressing signs of plant stress and informing the community of tree threats to increase awareness and tree protection.

Examples of cultural controls include:

- Supporting plant health and vigor by adjusting watering practices and schedules to fit seasonal tree needs, fertilizing trees if needed, creating habitats for beneficial insects and correctly planting new trees
- Addressing negative environmental/cultural conditions that stress trees by moving sprinklers that spray trees, removing nearby plant debris to reduce habitat for pest species and painting tree trunks damaged by sun scorch or sunburn
- Engaging the public in tree care and protection by providing flyers about emerging insect threats, providing resources on pest management and providing guidance on correct tree planting and care



Poster alerting people to emerald ash borer appearance and symptoms
Source: https://www.dontmovefirewood.org/emerald-ash-borer-awareness-week-toolkit/ar-eab-wanted-poster/

Mechanical control strategies modify trees using equipment or hands-on actions to address damaged or diseased plant material and pests without using chemicals or biological agents.

Examples of mechanical controls include:

- Cutting down and removing trees that repeatedly host high populations of pests or cannot be saved from fungal infections
- Using correct pruning practices to remove diseased or infested twigs and branches
- Correctly treating or destroying cut trees and pruned diseased/infested plant materials to prevent spread
- Using correct pruning practices to increase air circulation, light and heat in tree interiors to treat fungal infections
- Pruning trees strategically to reduce the potential of wind-throw damage
- Removing and dislodging pests by hosing off trees with high pressure water streams or applying sticky barriers to trunks to intercept insects
- Trenching between healthy and diseased trees to cut root grafts between trees through which fungal infections spread

Asian longhorned beetle infestation in Chicago. The only means of control available is to identify which trees are infested, cut them down and chip them into tiny pieces.
Photo credit: Michael T. Smith, Bugwood.org

Lycorma delicatula (spotted lanternfly) nymphs on brown sticky band
Photo credit: Lawrence Barringer, Pennsylvania Department of Agriculture, Bugwood.org

Branch pruning, using correct pruning practices
Photo credit: Joseph OBrien, USDA Forest Service, Bugwood.org

Biological control strategies use living organisms such as predators, parasites, parasitoids or pathogens to suppress pest populations, and to support the survival of these beneficial organisms. Major strategies used in biological controls include conserving existing natural enemies and maintaining landscape ecosystems in ways that support natural enemies and their activities, introducing and/or encouraging native enemies of tree pests if they are not already present, and introducing new natural enemies with the goal of establishing a permanent population if native enemies are not available. When using any of these methods, it is important to not disrupt beneficial enemies of tree pests with insecticides.

Examples of biological controls include:

- Purchasing and releasing beneficial insect predators in order to increase their presence on a tree so they can enhance natural pest suppression
- Adding plants that provide nectar, pollen and nesting sites to support natural enemies of tree-threatening insects
- Releasing large numbers of pest predators to quickly overwhelm a pest population, knowing the released predators may not propagate and provide on-going pest control
- Introducing a fungal pathogen that causes a disease in an insect pest

Adult mealybug destroyer feeding on a mealybug
Photo credit: Palex66, Dreamstime.com

Release of 500 adult scale picnic beetles *(Cybocephalus nipponicus)* onto a juniper infested with juniper scale
Photo credit: Joseph LaForest, University of Georgia, Bugwood.org

Oobius agrili parasitizing an emerald ash borer egg on an ash tree
Photo credit: Houping Liu, Michigan State University, Bugwood.org

Caterpillar in the center is infected with *Entomophaga*, a fungal pathogen
Photo credit: Steven Katovich, Bugwood.org

Chemical control strategies focus on using pesticides with the goal of killing or repelling insect pests or regulating or interrupting their growth. Pesticides include insecticides, miticides, fungicides, bactericides, herbicides, repellants and other chemical agents. Chemical controls may be needed if cultural, mechanical or biological control methods are not able to meet pest control goals. It is important to correctly identify the pest in order to select the most appropriate chemical control. When using chemical controls, use of narrow spectrum pesticides will help in avoiding damage to natural enemies.

NOTE: Follow all cautions and instructions carefully when using pesticides. Get necessary training to apply pesticides and use certified professionals when required.

Examples of chemical controls include:

- Applying pesticides to protect non-infested trees as a preventative strategy before damaging insects emerge and spread from adjacent trees
- Injecting pesticides directly into a tree trunk in order to concentrate systemic pesticides in a tree's vascular system so it can move more quickly through tree tissues
- Drenching a pesticide mixture onto the soil that surrounds the tree base so roots can take it up systemically into the tree
- Spraying horticultural oil at the right time of year and at the right time of day to suffocate insect pests

Cutting infested wood and hand spraying to kill Southern pine beetles
Photo credit: Robert L. Anderson, USDA Forest Service, Bugwood.org

Basal drench insecticide application in hemlock
Photo credit: Elizabeth McCarty, University of Georgia, Bugwood.org

URBAN TREE THREAT

MEDITERRANEAN PINE ENGRAVER [MPE] *(Orthotomicus erosus)*

INVERTEBRATE: INSECT, BEETLE

LIFE STAGES, SIGNS & SYMPTOMS

Yellowing needles on dying eldarica pine in Phoenix

Adult 1/10 inch long

Reddish brown boring dust

Adult top view

Exit holes, 1/20 inch

Larvae in gallery

Gallery pattern

AESTHETIC DAMAGE DEATH

Severity: Can be fatal within 1 year of first sign

MPE is an invasive, nonnative beetle that has been detected in California, Nevada and Arizona. Standing trees are killed by a single MPE generation

OVERVIEW

- Adults generally behave as secondary pests
- Most likely to infest stressed or injured pines
- Trees typically die within a year of showing symptoms
- Phoenix area has increasing concentrations of MPE, and MPE has been detected in Tucson
- Proper care and watering of pine trees will help them resist attack
- Removal of infested trees and woody material is critical to reducing spread of MPE

POTENTIALLY AFFECTED TREES IN AZ & NM:

Pinus spp.:

- *P. eldarica* (Afghan pine, eldarica pine)
- *P. halepensis* (Aleppo pine)
- *P. canariensis* (Canary Island pine)
- *P. coulteri* (Coulter pine)
- *P. pinea* (Italian stone pine)
- *P. radiata* (Monterey pine)
- *P. brutia* (Turkish pine)

Note: Non-*Pinus* hosts may be used mainly for maturation feeding or overwintering sites for adults, including:

- *Pseudotsuga menziesii* (Douglas-fir), *Picea* spp. (spruce), *Abies* spp. (fir), *Cupressus* spp. (cypress), *Cedrus* spp. (cedar)

Top Photo: Photo credit: Steve McKelvey, Arizona Department of Forestry and Fire Management

Photo sources left, top to bottom:

Photo 1: Photo credit: Steven Valley, Oregon Department of Agriculture, Bugwood.org.

Photo 2: Photo credit: Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org. Photo 3: Source: https://naldc.nal.usda.gov/download/7504444/PDF

Photo sources right, top to bottom:

Photo 1: Photo credit: Bob Celaya, Department of Forestry and Fire Management. Photo 2: Source: Arizona Department of Forestry and Fire Management. Photo 3: Photo credit: William Ciesla, Forest Health Management International, Bugwood.org

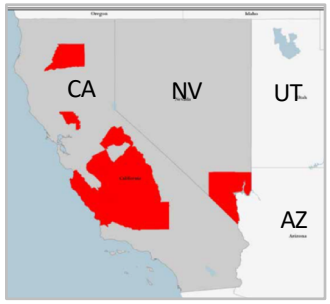
Arizona Forest Health Alert: Mediterranean Pine engraver (MPE) *(Orthotomicus erosus)*
Found in Metro Phoenix, 2018, and in Tucson, 2021

If you suspect a pine is unhealthy or may be infested with MPE, contact a certified arborist for an assessment. To find tree care professionals use Find An Arborist tool at: www.treesaregood.org.
Contact Arizona Department of Forestry and Fire Management with tree location details to help monitor MPE spread: Email info/questions to: UCF@dffm.az.gov or FH@dffm.az.gov

GEOGRAPHIC DISTRIBUTION

- MPE native to Europe, Middle East, Africa, China
- Likely arrived in US in wood packing material
- Found in CA 2004; found in AZ in 2018; present in NV
- Not currently detected in NM

Mediterranean pine engraver monitoring sites and detections in Arizona. Yellow area has most detections.
Source:https://www.arcgis.com/apps/dashboards/5c8c20c109e64906b3f1387463fb4ac4



Mediterranean pine engraver detections in US (not updated to include AZ)
Source: USDA Forest Service, Northern Research Station and Forest Health Protection. "Alien Forest Pest Explorer – species map." Database last updated 25 March 2019.
https://www.fs.usda.gov/nrs/tools/afpe/maps/png/MPEB.png

Control measures: Cultural, Mechanical, Chemical

See next page for additional information

MEDITERRANEAN PINE ENGRAVER [MPE] *(Orthotomicus erosus)* INVERTEBRATE: INSECT, BEETLE

LIFE STAGES AND DISEASE PROCESSES

- Adult MPE are reddish-brown, approx. 1/10 inch long and are distinguished from other small bark beetles by moderately concave declivity on end of abdomen with four pairs of spines on each side, 2nd spine the broadest
- Beetles generally attack distressed trees by boring holes in bark and chewing on the layer just under the bark
- Males bore through the bark to cambium layer to construct nuptial chamber
- Females mate then construct egg gallery from the nuptial chamber, parallel to wood grain
- Females oviposit up to 75 eggs. Eggs are white, translucent, approximately 1/25 inch long and laid separately in niches along the egg gallery
- Larvae mine at right angles to parent gallery and have three instars; white to cream-colored, C-shaped, legless grubs, up to 1/10 inch long
- Galleries often have two branches, sometimes three. Egg galleries comprise the central tunnel; each is approx. ½ to 5 inches long with numerous larval tunnels extending outwards
- Pupae are white and mummy-like. New adults must feed before reaching sexual maturation: if inner bark of brood tree is still moist, they feed there; if inner bark is too dry, they may feed on a different host tree
- MPE may have multiple generations per year, depending on temperature
- Tunnels created by beetles block tree's ability to transport water and nutrients, which kills the tree

TREE SIGNS AND SYMPTOMS

- *Tree precondition: Stressed or wounded.*
- *Presence of frass.* Reddish-brown boring dust on the bark surface
- *Presence of weeping/oozing sap*. If relatively vigorous trees are attacked, may see pitch tubes in bark crevasses
- *Needles: Color change.* Most conspicuous symptom is foliage of infested tree fading from green to yellow to reddish-brown, especially at top of tree
- *Bark: Exit holes, pinhead sized.* Circular holes, spread randomly over the bark, 1/20 inch diameter
- *Beneath bark: Larval galleries, tunneling.* Cambial gallery pattern may consist of nuptial chamber and one to five longitudinal egg galleries
- *Beneath bark: Insects, eggs, larvae, pupae.*
- *Beneath bark: Discolored sapwood.* Blue stain in woody tissue accompanies breeding attacks
- *Full tree: death.* Standing trees are killed by a single generation of MPE

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- MPE adults generally behave as secondary pests, infesting recently fallen trees, stressed standing trees (such as by drought, other insects and diseases, etc.), logging debris and ≥ two-inch diameter broken branches with rough bark

SIMILAR INSECTS OR CONDITIONS

- To ensure positive identification have professional examine the suspect beetle
- MPE holes are perfectly round and spread randomly over bark
- Non-MPE beetle holes are often bigger and may be flat on one side
- Woodpecker/other sapsucker holes are fairly large; usually in rows or columns
- MPE adults and gallery patterns are similar to bark beetles of genus *Ips*

TREATMENT AND MANAGEMENT OVERVIEW

- Arizona Department of Forestry and Fire Management monitoring/mapping MPE: https://www.arcgis.com/apps/dashboards/5c8c20c109e64906b3f1387463fb4ac4
- Stressed/injured pine trees are vulnerable to MPE
- To date, eldarica pines (*P. eldarica)* are documented as being impacted in Arizona

CULTURAL CONTROLS

- Early detection of MPE enables people to be more cautious with materials
- Proper care and watering of pine trees will help pine trees resist attack, see: https://dffm.az.gov/sites/default/files/media/APB%20Pest%20Alert%20June%202021%20FINAL.pdf for watering guidance
- Limit movement of pine firewood and recently cut pine branches and stems because beetle populations can spread quickly in transported materials
- Avoid piling any pine material next to live trees
- Avoid planting pines on unsuitable sites

MECHANICAL CONTROLS

- Remove infected trees to remove beetles from area before they spread
- Rapidly remove wind-thrown trees that could serve as breeding sites
- Remove all infested green material from the site: chip, bury or burn
- To prevent populations building up on freshly cut, broken, or dead logs/branches, chip, burn or debark freshly cut pine material or, if quantities are small, cover completely with thick, clear plastic sheeting in a sunny location

CHEMICAL CONTROLS

- Registered insecticides (e.g. carbamates, pyrethroids) can provide preventative treatments; should be applied before high value trees are attacked
- (+)-Ipsdienol can be used to interrupt MPE flight to otherwise attractive materials
- Semiochemicals are used as lures in monitoring traps: combining R-(-)- Ipsdienol and 2-methyl-3-butan-2-ol and alpha-pinene attract synergistically
- Funnel traps baited with α-pinene, methylbutenol, ipsdienol, and ethanol are effective at catching flying adults

REFERENCE AND RESOURCE WEBSITES

- https://dffm.az.gov/sites/default/files/media/MPE%20Alert_8-19-19.pdf
- https://dffm.az.gov/arizona-forest-health-alert-mediterranean-pine-engraver-found-urban-pines
- https://www.fs.fed.us/psw/publications/seybold/psw_2005_seybold001_lee.pdf
- https://www.dontmovefirewood.org/pest_pathogen/mediterranean-pine-engraver-beetle-html/
- http://dnrc.mt.gov/divisions/forestry/docs/assistance/pests/fidls/176.pdf
- https://www.cabi.org/isc/datasheet/37954

LIFE STAGES

Adult females scales 0.1 - 0.15 inch long

Dead adult scales lifted to reveal eggs

Crawlers and dead female adult

Heavily infested branch

SIGNS & SYMPTOMS

Cracked bark associated with infestation

Comparison of infested and non-infested trunks

Damage due to infestation

Removing scales from trunk

Photo sources, left top to bottom:
Photo 1: Photo credit: Darren Blackford, USDA Forest Service, Bugwood.org
Photos 2, 3, 4: Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org
Photo sources, right top to bottom:
Photos 1, 4: Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org
Photo 2: Photo credit: USDA Forest Service
Photo 3: Photo credit: USDA Forest Service - Forest Health Protection Intermountain Region - Ogden, UT , USDA Forest Service, Bugwood.org

URBAN TREE THREAT

OYSTERSHELL SCALE (OSS) *(Lepidosaphes ulmi)*

INVERTEBRATE: INSECT, ARMORED SCALE

AESTHETIC STRUCTURAL DAMAGE DEATH

Severity: Drain due to sap sucking may kill branch or entire tree

OVERVIEW

- Oystershell scale is an invasive sap-sucking insect that infests a wide range of broadleaf trees
- Found in Arizona and New Mexico at higher elevations; aspen trees are major targets
- OSS continues to infest the same hosts and potentially nearby hosts year after year
- Dense populations may kill branches, whole trees, or even forest stands

POTENTIALLY AFFECTED TREES:

- Aspen appears to be the preferred host in Arizona, but OSS will infest other thin-barked trees
- Attacks broadleaf tree species, including *Acer* spp. (maple), *Betula* spp. (birch), *Fagus* spp. (beech), *Fraxinus* spp. (ash), *Malus* spp. (apple), *Populus* spp. (aspen, poplar), *Prunus* spp. (stone fruits), *Salix* spp. (willow), *Ulmus* spp. (elm) plus many additional plants

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Trees with areas of thin bark offer good feeding sites, while trees that form a thick corky bark are not good hosts

SIMILAR INSECTS OR CONDITIONS

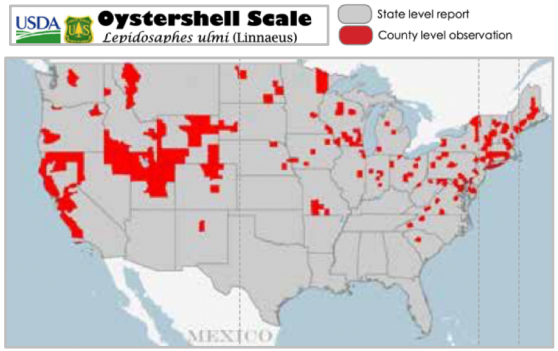
- Other scale insects that might be confused with OSS are *Quadraspidiotus gigas, Lepidosaphes beckii* and *Lepidosaphes conchiformis*
- From a distance, fungal-caused cankers may appear as darkened patches similar to OSS infestations including Cytospora canker (*Cytospora* spp.) and hypoxylon *(Entoleuca mammatum)*

LET US KNOW!

This USDA Forest Service Oystershell Scale Survey helps track the spread of OSS in the West. If you have spotted OSS, particularly in an urban environment, please fill out this survey to let us know. To submit a report, visit the app store to download the Survey123 app, then scan this QR Code through the app.

GEOGRAPHIC DISTRIBUTION

- OSS is common in higher elevations of northern Arizona, and has been detected in northern New Mexico
- OSS is of uncertain geographic origin, but is now found in almost every temperate area in the world and is distributed throughout the US



Oystershell scale distribution in US. Source: USDA Forest Service, Northern Research Station and Forest Health Protection. "Alien Forest Pest Explorer – species map." Database last updated 25 March 2019. https://www.nrs.fs.usda.gov/tools/afpe/maps/ Accessed 9-25-22

Control measures:
Cultural, Mechanical, Chemical

See next page for additional information

OYSTERSHELL SCALE (OSS) *(Lepidosaphes ulmi)* INVERTEBRATE: INSECT, ARMORED SCALE

LIFE STAGES AND DISEASE PROCESSES

- Oystershell scale insects suck sap from cells underlying thin bark, often killing the cells at the feeding sites of thin-barked regions of host plants
- Mature females are most commonly observed form, 0.1 to 0.15 inch long, narrow at one end, resemble miniature mussel shells, no eyes or legs, short antennae, mandibles adapted to suck sap, coloration varies with host: mottled, brown or gray
- Female lays about one hundred oval white eggs in late summer and early fall retaining them under her body, then female dies. Scale darkens and stays in place, protecting eggs through winter from temperatures well below 0°F
- Eggs hatch in spring as crawlers. In northern and central Arizona, most crawlers emerge over a 2- to 3-week period from late May to early June, but may continue to emerge throughout summer and into fall
- Tiny crawlers are pale yellow to yellow-orange, <0.04 inch long, and are the only mobile stage of the insect. They actively disperse to find protected sites with thin bark where they can sink stylet into vascular tissues
- Some crawlers may be carried by wind or on animal bodies from tree-to-tree
- If crawlers do not find suitable feeding sites, they die a few days after hatching
- Once settled, crawlers permanently remain in place and develop a waxy coating forming shell-like coverings protecting them from predators, parasites, insecticides
- Crawlers molt twice before becoming adult females and continue to feed and reach maturity in late summer or early fall
- Some crawlers may develop into males, but not all colonies produce males and regional oystershell scale populations appear to reproduce asexually
- OSS continues to infest the same hosts and potentially nearby hosts year after year
- Dense populations may kill branches, whole trees, or even forest stands

TREE SIGNS AND SYMPTOMS

- *Presence of insects.* Adult female scales can densely cover infested branches or trunks—adults may appear as darker patches against white trunk of aspens; crawlers look like tiny yellow-orange specks on tree trunk and branch surfaces
- *Twig/branch: dieback.*
- *Bark: Cracking.* Bark cracking often occurs on areas of bark damaged by OSS
- *Whole tree: Decline.* Severe prolonged infestation can stunt growth; cause decline
- *Whole tree: Death.* Severe prolonged infestation can kill trees
- *Other:* Infestation weakens host plants, making them more susceptible to other insects or pathogens, including Cytospora fungi-induced cankers on aspen

REFERENCE AND RESOURCE WEBSITES

- https://cals.arizona.edu/extension/ornamentalhort/plantprotect/oystershell.pdf
- https://www.dontmovefirewood.org/pest_pathogen/oystershell-scale/
- https://www.fs.usda.gov/foresthealth/technology/pdfs/Forest_Pest_Insects_Photo_Guide_508.pdf
- https://en.wikipedia.org/wiki/Lepidosaphes_ulmi
- https://extension.colostate.edu/topic-areas/insects/oystershell-scale-5-513/
- http://ipm.ucanr.edu/PMG/GARDEN/PLANTS/INVERT/oysterscale.html
- https://extension.psu.edu/oystershell-scale
- https://pubs.nmsu.edu/_h/H174/index.html
- https://dffm.az.gov/sites/default/files/media/AZ%20OSS%20Alert%20-%20Final%202022_UPDATED%20July2022.pdf
- https://extension.colostate.edu/topic-areas/insects/oystershell-scale-5-513/

TREATMENT AND MANAGEMENT OVERVIEW

Oystershell scale continues to infest current hosts and potential new hosts yearly. Crawlers are the life stage most vulnerable to management controls that could reduce populations. For more information, see https://extension.colostate.edu/topic-areas/insects/oystershell-scale-5-513/

CULTURAL CONTROLS

- Maintain tree health and vigor, use proper pruning techniques, prune in dormant season and provide adequate watering to reduce stress and minimize OSS impacts

MECHANICAL CONTROLS

- Prune and destroy heavily infested twigs and branches
- Physically scrub infested areas with soft plastic pad or nylon brush to remove scale coverings and eggs. Using mild soap solution while scrubbing helps destroy insects
- Spray with a strong stream of water from a hose or power washer to remove scales, being careful not to damage leaves and bark
- After treatment, remove all or a portion of old scales from trees to monitor for crawler emergence the following year to determine if more treatment is needed

CHEMICAL CONTROLS

- **Crawler sprays.** Most insecticides will kill crawlers on bark. But eggs hatch over an extended period, so insecticides that remain active on bark throughout egg hatching are useful. Pyrethroid insecticides can be used on trees, formulations may include those containing bifenthrin, cyfluthrin, cyhalothrin, or permethrin. Other useful crawler spray insecticides contain acetamiprid, carbaryl, malathion.
- **Horticultural oil sprays.** Correctly timed oil spray can cover and smother insects on trunks and branches and can be combined with crawler treatments. For more information on horticultural oils, see https://extension.colostate.edu/topic-areas/insects/insect-control-horticultural-oils-5-569/
- **Summer season oil sprays**. Begin to apply summer season horticultural oils when crawlers are active. In northern and central AZ, most crawlers emerge over a 2- to 3- week period from late May to early June, but may continue to emerge throughout summer and into fall. Crawler emergence can vary with spring weather. To time applications, carefully examine trees, shake scale-infested limbs onto paper or trap crawlers with sticky tape attached to infested limbs. Young nymph stages with minimally developed wax covers can be smothered with oil sprays as well.
- **Winter season oil sprays**. Apply 'dormant season' horticultural oils to kill over-wintering eggs. Other controls may be needed in addition to this treatment.
- **Insect growth regulators**. Pyriproxifen is an insect growth regulator that can be applied during the crawler period and post-crawler period. Pyriproxifen is effective against scale insects while not adversely affecting many other insects. Currently sold only for use by commercial applicators, with trade name Distance.
- **Systemic insecticides.** Dinotefuran is effective against armored scales and can be applied as a soil drench for root uptake, or as a trunk spray where it is absorbed then translocated within the plant. Dinotefuran remains active for one to two years. Currently dinotefuran formulations for tree/shrub use are only available to commercial applicator, with trade names Safari, Zylam.

Adult *Dendroctonus* species, Size relative to grain of rice, Larval gallery, Range map

Image 1. Mexican pine beetle (XPB) *(Dendroctonus mexicanus)*
Affected *Pinus* species: Apache, Chihuahua and ponderosa

Image 2. Mountain pine beetle (MPB) *(Dendroctonus ponderosae)*
Affected *Pinus* species: Ponderosa, whitebark, lodgepole, Scots, jack, limber and others

Image 3. Roundheaded pine beetle (RPB) *(Dendroctonus adjunctus)*
Affected *Pinus* species: Ponderosa and limber, plus additional species in Mexico

Image 4. Southern pine beetle (SPB) *(Dendroctonus frontalis)*
Affected *Pinus* species: Apache, Chihuahua and ponderosa, plus additional species in eastern US

Image 5. Southwestern pine beetle (SWPB) *(Dendroctonus barberi)* (formerly known as *D. brevicomis*)
Affected *Pinus* species: Coulter and ponderosa

URBAN TREE THREAT

PINE BEETLES (*Dendroctonus* species)

INVERTEBRATE: INSECT, BEETLE

AESTHETIC DAMAGE DEATH

Severity: Successful pine beetle attack is always fatal to a tree due to damage from insect galleries and beetle-introduced blue stain fungus

OVERVIEW

- Five *Dendroctonus* pine beetles are described here
- Their native ranges include parts of AZ and NM
- Pine beetles are attracted to stressed *Pinus* species, which they colonize
- Attacked trees die as a result of beetle galleries and introduced blue stain fungus preventing transport of nutrients and water
- Trees removed from the population make more resources available to nearby trees
- In healthy forests, localized pine beetle attacks are normal, but forest imbalances due to drought, high tree density and other stressors have led to more extensive attacks and heavy tree die off
- Pine beetles also attack stressed pine trees in urban areas

Control measures:
Cultural, Mechanical, Biological, Chemical

Image Sources

Image 1. Mexican pine beetle
- Adult photo credit: Steven Valley, Oregon Department of Agriculture, Bugwood.org
- Gallery photo source: https://formato7.com/2019/12/03/alarmante-infestacion-de-escarabajos-en-bosques-mexicanos-ek-del-val/
- Map:https://www.researchgate.net/publication/288982849_The_Mexican_pine_beetle_Dendroctonus_mexicanus_First_record_in_the_United_States_and_co-occurrence_with_the_southern_pine_beetle_-_Dendromnus_frontalis_Coleoptera_Scolytidae_or_Curculionidae_Scolytina

Image 2. Mountain pine beetle
- Adult photo credit: Region 2 - Rocky Mountain Region , USDA Forest Service, Bugwood.org
- Gallery photo credit: Leslie Chong, Simon Fraser University, Bugwood.org
- Map: https://www.eddmaps.org/distribution/uscounty.cfm?sub=27

Image 3. Roundheaded pine beetle
- Adult photo credit: TH Atkinson, Biodiversity Center, University of Texas at Austin. This image is the property of the National Museum of Natural History, Smithsonian Institution, Washington, D.C.
- Gallery photo credit: USDA Forest Service, Bugwood.org
- Map: https-//gd.eppo.int/taxon/DENCAD/distribution

Image 4. Southern pine beetle
- Adult photo credit: USDA Forest Service, Bugwood.org
- Gallery photo source: Tim Tigner, Virginia Department of Forestry, Bugwood.org
- Map: https://www.eddmaps.org/distribution/uscounty.cfm?sub=24

Image 5. Southwestern pine beetle
- Adult photo credit: Pest and Diseases Image Library, Bugwood.org
- Gallery photo source: Ladd Livingston, Idaho Department of Lands, Bugwood.org
- Map: Ross Gerrard, USDA Forest Service

PINE BEETLES (*Dendroctonus* species) INVERTEBRATE: INSECT, BEETLE

LIFE STAGES AND DISEASE PROCESSES

Life history and disease process varies somewhat with each species, the following description is generalized for the five species addressed

- Adult beetles range from ≈ 3mm to 6.5 mm (≈ 0.1 to 0.3 inch)—smaller than a grain of rice (Images 1 - 5)
- Emerging adults bore holes out of the bark of infested trees leaving exit holes
- Adult beetles can become active with warming spring temperatures and continue attacks until cold weather begins; specific timing of adult activity varies with different species
- While beetles can disperse by flying up to 2 miles—and also potentially via wind currents—they appear to prefer nearby hosts
- There is potential for year-round beetle flights in hotter desert climates
- Can be multiple beetle flights/year; depends on local temperature/conditions
- Adults often seek out stressed trees of preferred species, but will attack healthy trees of other species when a large number of beetles are present
- Females initiate tree attack, producing aggregation pheromones that draw large numbers of beetles to the tree (Image 6)
- Resin within healthy tree can "pitch out" a small number of beetles (Image 7)
- Mass beetle attacks deplete resin production capabilities, resulting in reduced or ceased resin flow, so tree can no longer protect itself
- Attacking adults chew through outer bark then tunnel and lay eggs in inner bark (phloem)
- Beetles mate and construct egg galleries where females lay eggs (Image 8)
- Eggs are pearly white, oval ≈ 1 to 1.5 mm (≈ 0.04 to 0.06 inch) diameter
- Galleries may be partially packed with boring dust
- Females produce one or more broods a year; eggs hatch in around a week
- Hatched larvae tunnel away from egg galleries, feeding on inner bark, producing characteristic gallery patterns that vary with species (Images 1 - 5)
- Larva develop through four instars over a period of six to eight weeks
- Larvae sizes vary with development stage, ranging from slightly larger than an egg to slightly smaller than an adult (image 9)
- In later instars, larvae of some species bore into outer bark to pupate
- Pupal stages last ≈ two weeks or more depending on species (Image 10)
- Galleries created by both adult beetles and larvae in phloem can effectively girdle a tree, causing tree death by preventing distribution of nutrients from leaves to other parts of the tree
- As beetles attack trees, they introduce spores of a blue stain fungus that colonizes the tree's xylem tissues preventing upward water transport, making it impossible for tree to survive regardless of control measures
- Beetles have one to four generations a year depending on species
- Overlapping generations during the summer may produce continuous attacks

LIFE STAGES

Image 6. Mass attack. Photo credit: Leslie Chong, Simon Fraser University, Bugwood.org

Image 8. Female in gallery with eggs. Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org

Image 9. White to cream-colored larvae of *Dendroctonus ponderosae* (average length 6 mm) feeding at right angles to the egg gallery. Photo credit: G.D. Amman, USDA Forest Service, Bugwood.org

Image 7. Adult killed in "pitch-out" of ponderosa pine. Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org

Image 10. Mountain pine beetle pupa. Photo credit: USDA Forest Service - Region 2 - Rocky Mountain Region , USDA Forest Service, Bugwood.org

PINE BEETLES (*Dendroctonus* species) INVERTEBRATE: INSECT, BEETLE

TREE SIGNS AND SYMPTOMS

- *Presence of frass.* Fine reddish-brown boring dust catches in bark flakes and crevices around and under the tree, created by beetles chewing through bark to enter tree (Image 11)
- *Presence of pitch tubes.* On relatively healthy trees, resin mixed with boring dust may exude from entrance holes when tree is first attacked looking like crystallized honey with brown, pink or yellow tint (Image 12). The fewer the attacks, the larger the pitch tubes—heavily attacked trees have very small or no pitch tubes
- *Presence of unusual woodpecker activity.* Evidence of woodpeckers feeding on trunk such as patches of removed bark and bark flakes on ground/snow under tree (Image 13)
- *Needles: Color change.* Following previous year's attack, needles start to fade in late spring to light green, yellow, red, then brown, usually dropping around a year after attack (Image 14)
- *Beneath bark: Larval galleries, tunneling.* Adult egg laying and larval feeding on phloem/inner bark creates mazelike galleries (Images 1 - 5)
- *Beneath bark: Discolored sapwood.* Blue stain fungus introduced by adults colors sapwood blue-gray (Image 15)
- *Full tree: Death.* Successfully attacked trees always die

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Multiple species of *Dendroctonus* pine beetles are native in the southwest
- Trees that are stressed attract beetle attacks. Stress can be caused by drought, dense forest stands, shallow/rocky soils, nearby excavation, raising of soil grade, lightning, disease, attacks by other insects, over maturity and other factors
- Fire suppression—past forest management, grazing and urbanization contributed to this

TREATMENT AND MANAGEMENT OVERVIEW

Cultural and mechanical controls to improve and maintain tree health and vigor can help trees maintain their normal defense mechanism against beetles. Biological controls can provide monitoring. Chemical control can protect selected trees from infestation. When beetle populations are high, no tree is completely safe from infestation. Combinations of control measures could increase chance tree will survive an outbreak.

CULTURAL CONTROLS

- Cultural controls support tree health and vigor to help keep individual trees safe from attack
- Pay particular attention to old trees, crowded groups of trees and newly planted trees
- Increase watering: Support trees with supplemental watering during extended dry periods, this applies to all seasons. Supplemental fall/winter watering is extremely important during La Nina winters, and supplemental summer watering during extreme drought/heat events.
- Check soil moisture monthly by probing to a depth of 6 to 8 inches just outside tree's dripline. If soil is dry, especially during extended dry periods, water at least two feet deep in a circle at the dripline
- Tree spacing: Maintain minimum 25-foot distance between mature pines in urban settings
- Increase tree diversity: Increase the diversity of both tree species and tree sizes
- Minimize injury: Avoid all forms of injury to roots and trunks including soil compaction, impacts by equipment, increasing grade around trees and other abiotic impacts
- Move infested firewood and slash: Move pine beetle infested firewood and slash to an area where pines do not grow to help reduce spread

SIGNS AND SYMPTOMS

Image 11. *Presence of frass.* Boring dust on pine. Photo credit: Terry S. Price, Georgia Forestry Commission, Bugwood.org

Image 12. *Presence of pitch tubes.* Photo credit: Ronald F. Billings, Texas A&M Forest Service, Bugwood.org

Image 13. *Presence of unusual woodpecker activity.* Photo credit: Jerald E. Dewey, USDA Forest Service, Bugwood.org

Image 15. *Beneath bark: Discolored sapwood.* Cross section of log showing blue stain. Photo credit: USDA Forest Service - Region 2 - Rocky Mountain Region , USDA Forest Service, Bugwood.org

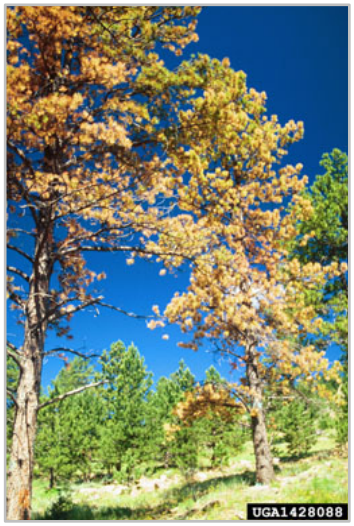


Image 14. *Needles: Color change.* Fresh fading ponderosa pine due to previous year's mountain pine beetle attack. Photo credit: William M. Ciesla, Forest Health Management International, Bugwood.org

PINE BEETLES (*Dendroctonus* species) INVERTEBRATE: INSECT, BEETLE

MECHANICAL CONTROLS

- Thinning closely growing trees provides more water to remaining trees; however, avoid thinning and pruning during active beetle flight periods because fresh tree wounds may attract beetles and stress remaining trees, predisposing them to beetle colonization
- Heavily attacked trees will die as soon as symptoms of attack are observed, quickly fell and remove infested trees before beetles can emerge and disperse
- Take felled infested trees off the site to a location that has no susceptible host trees
- Chipping and leaving materials on site is not recommended because debris puts out a chemical signal that will attract active pine beetles
- Freshly cut pine slash and firewood are also subject to attack by pine beetles
- For guidance on managing slash to prevent infestation, see: https://www.fs.usda.gov/psw/publications/fettig/psw_2008_fettig(degomez)002.pdf
- For information on treating firewood to prevent beetles, see: https://docslib.org/doc/9974267/firewood-bark-beetles

BIOLOGIC CONTROLS

- Traps baited with beetle-attracting pheromones are used to monitor beetle populations, but baited traps are not a practical, tested method of population control
- Natural pine beetle enemies include woodpeckers and insects such as clerid beetles, bark-gnawing beetles, long-legged flies and braconid wasps:
  - While these attack pine beetles, they rarely control them
  - Release of predators and/or parasites into sites infested with beetles has not effectively suppressed beetle populations, however, natural enemies might help reduce bark beetle population size, reducing the number of nearby trees that are attacked by beetles and killed
- Verbenone is an anti-aggregation pheromone produced by mountain pine beetles to disperse adult beetles away from a fully colonized tree:
  - This compound has now been artificially synthesized and packaged in slow-release pouches
  - These pouches can be used on individual non-infested trees or stands to deflect adult beetles as a short-term strategy
  - Verbenone is not as effective as pesticides, does not protect all treated trees and does not deter all bark beetles, but does provide an alternative to pesticide use
  - For more information, see: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5373188.pdf

CHEMICAL CONTROLS

- Once a tree is colonized by pine beetles, no insecticide treatment will save the tree
- Non-colonized high-value trees can be protected using preventive insecticide treatments:
  - The following pesticides are labeled and recommended for preventing colonization by *Dendroctonus* beetle species (also *Ips* species):
    - Trade names Sevin SL (containing carbaryl)
    - Astro and Dragnettrade (containing permethrin)
  - Treatments are sprayed on tree bark; when beetles attempt to bore into the bark for egg laying, the pesticide kills them
  - Pesticides that are not specifically formulated or registered for use on pine bark beetles should not be used
  - Treatment must be applied before beetle's first flight in spring or before tree is attacked
  - Determine whether a tree is infested by inspecting the trunk/limbs for fresh pitch tubes or frass, peel a small portion of outer bark from trunk to look for signs of beetle adults or larvae, and inspect foliage for light green or yellowing needles—a professional may be needed to conduct this inspection
  - Chemically treating trees that have already been attacked won't save the tree and might kill beneficial insects
  - For more information about chemical control see: bark-beetle-faqs20181107.pdf
- Systemic products are being investigated but are not currently recommended for pine bark beetle control
- Preventive tree sprays should be used in conjunction with cultural and mechanical control strategies to support tree health

REFERENCE AND RESOURCE WEBSITES

Multiple	https://www.fs.usda.gov/r3/resources/health/field-guide/pages/BarkBeetle.shtml
Multiple	https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1300-2015.pdf
Multiple	https://www.coniferousforest.com/pine-beetle.htm
Multiple	https://docslib.org/doc/9974267/firewood-bark-beetles
Multiple	http://ipm.ucanr.edu/PMG/PESTNOTES/pn7421.html
XPB	https://www.srs.fs.usda.gov/pubs/ja/ja_moser005.pdf
MPB	https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5373188.pdf
MPB	https://www.cabi.org/isc/datasheet/18354
MPB	https://apps.fs.usda.gov/r6_decaid/views/mountain_pine_beetle.html
MPB	https://tidcf.nrcan.gc.ca/en/insects/factsheet/2816
RPB	https://www.fs.fed.us/r3/resources/health/field-guide/bb/roundhead.shtml
RPB	https://en.wikipedia.org/wiki/Dendroctonus_adjunctus
SPB	http://entnemdept.ufl.edu/creatures/trees/southern_pine_beetle.htm
SPB	https://texasinsects.tamu.edu/southern-pine-bark-beetle/
SPB	https://en.wikipedia.org/wiki/Dendroctonus_frontalis
SWPB	https://www.researchgate.net/figure/Distribution-of-western-pine-beetle-Dendroctonus-brevicomis-with-a-dashed-line_fig1_358629631
SWPB	https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5188577.pdf
SWPB	https://www.cabi.org/isc/datasheet/18348

URBAN TREE THREAT

PINYON IPS BEETLE *(Ips confusus)*

INVERTEBRATE: INSECT, BEETLE

LIFE STAGES, SIGNS AND SYMPTOMS


Adult ≈ 0.17 to 0.25 inch


Adult in gallery, finger for scale


One pupa, two larvae in gallery


Adults in gallery

Frass on bark


Pitch tubes


Galleries under bark


Large irregular shaped hole made by woodpecker; small, round pinhead-sized exit holes made by adult beetles


Damage to singleleaf pinyons


Damage to of two-needle pinyons

AESTHETIC DAMAGE DEATH

Severity: Attacks by *ips confusus* beetles are typically fatal, especially in stressed or weakened pinyon trees

OVERVIEW

- *Ips confusus* are bark beetles that target stressed and weakened pinyon pine trees
- Adults attack trees in large numbers, boring into tree bark to create galleries where they lay eggs
- Larvae feed under the bark in the phloem layer, extending galleries
- Adult and larval galleries damage phloem, cutting off water and nutrient transport, resulting in tree death
- Beetle populations increase as more trees are infested
- *Ips confusus* attacks have killed millions of drought-stressed pinyon trees in the Southwest

POTENTIALLY AFFECTED TREES:

Pinus species including *Pinus edulis* (two-needle pinyon), *Pinus monophyla* (singleleaf pinyon) and other pinyon pines

Photo sources, left top to bottom:
Photo 1: Photo credit: Darren Blackford, USDA Forest Service, Bugwood.org
Photo 2: Photo credit: Dennis Brock for CSFS
Photo 3: Photo credit: ©Anthony I. Cognato
Photo 4: Photo credit: William M. Ciesla, Forest Health Management International, Bugwood.org
Photo 5: Source: Photo credit: USDA Forest Service - Forest Health Protection Intermountain Region - Ogden, UT, USDA Forest Service, Bugwood.org
Photo sources, right top to bottom:
Photo 1: Photo credit: ©Anthony I. Cognato
Photo 2: Photo credit: Jerald E. Dewey, USDA Forest Service, Bugwood.org
Photo 3: Photo credit: Kamie Long, CSFS
Photo 4: Photo credit: Tia Smith, Bugwood.org
Photo 5: Photo credit: William M. Ciesla, Forest Health Management International, Bugwood.org

GEOGRAPHIC DISTRIBUTION

Pinyon ips beetle is found in North America and Central America. It is native to Arizona, New Mexico and throughout US Southwest

Pinyon Ips Beetle distribution in the US
Source: https://www.cabi.org/isc/datasheet/28821

SIMILAR INSECTS OR CONDITIONS

Dendroctonus spp. pine bark beetles are also found in the US Southwest, but have different egg gallery characteristics, distinguishing adult characteristics and different frass patterns. For details on differences, see: https://www.fs.usda.gov/r3/resources/health/field-guide/bb/engravers.shtml

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

Pinyon ips beetles are attracted to pinyon trees that are experiencing stress and weakened defenses that could be due to mechanical injury, fire injury, pruning, compacted soils, recent transplanting, attack by other beetles, damaging agents (especially black stain root disease), presence of heavy dwarf mistletoe infections, underwatering, overwatering or high heat and drought.

Control measures: Cultural, Mechanical, Chemical

See next page for additional information

PINYON IPS BEETLE *(Ips confusus)* INVERTEBRATE: INSECT, BEETLE

LIFE STAGES AND DISEASE PROCESSES

- Adult beetles are cylindrical, ≈ 0.17 to 0.25 inch long, shiny black to dark brown, five spines at back end of abdomen
- Larvae grow to ≈ 0.25 inch when mature, white to dirty gray, legless, with dark heads; then go on to pupate
- Insects live around eight weeks and have from two to four generations—more generations in years with higher temperatures and drought
- Egg galleries have an enlarged central chamber and radiating galleries
- Hatched larvae create galleries in phloem; galleries are Y or H shaped
- Frass is pushed out of galleries through tree entry holes
- Beetles overwinter under the bark and adult emerge in the spring
- Emerging adults chew their way out of bark through small, round exist holes the size of pinheads
- Adult flight begins in early spring; emergence times vary by location, elevation and latitude—generally earlier in warmer areas
- Dispersing beetles are attracted to the odor of fresh sap emitted by stressed, weakened or damaged trees and by freshly cut green logs, firewood or branches that emit odor
- Emerging adults bore into other parts of same trees, new trees or cut pinyon wood creating galleries under bark where they mate and lay eggs
- Attacked trees attempt to "pitch" out boring beetles, but mass attacks driven by pheromone releases attract so many attacking beetles a tree's defenses become exhausted, especially in periods of low moisture
- Extensive gallery construction in phloem of a living tree cuts off nutrients and water flow, starving the tree, leading to death

TREE SIGNS AND SYMPTOMS

- *Presence of pitch tubes.* Small clumps of red-tinted sap (due to frass in sap) appear on bark as trees attempt to "pitch" beetles out of their entry holes; pitch tubes might not be present if moisture is low
- *Presence of frass.* Frass may be present on trunk, in bark crevices or at the base of tree, pushed out of galleries through entry holes
- *Presence of unusual woodpecker activity.* Woodpeckers may peck irregular-shaped holes to feed on the larvae living under the bark
- *Needles: Color change.* Needles fade quickly from green to straw to rust/red and finally to brown; in dry years fading may start within weeks of infestation, in normal rainfall years needles may fade over several months; larger trees may first show fading of upper crowns, young tree crowns may fade throughout
- *Bark: Exit holes, pinhead sized.* Exit holes are round, pinhead sized, and indicate adults have emerged and moved to other trees
- *Beneath bark: Larval galleries, tunneling.* Galleries are formed by adults and larvae; usually are Y or H shaped; frass is typically absent
- *Full tree: Death.* Mass attacks followed by gallery construction in phloem cuts off nutrients and water flow, starving the tree, leading to death

TREATMENT AND MANAGEMENT OVERVIEW

Beetles are attracted by the sap odor emitted by weakened or stressed trees and by fresh cut tree material. Management strategies should include maintaining pinyon trees in healthy condition and removing beetle-attracting cut wood material from the area. High value trees can be treated chemically to help protect them from beetle attacks.

CULTURAL CONTROLS

- In areas where pinyons are dying or have died and/or if beetles are present, inspect green pinyon trees to see if they have been attacked and respond accordingly (see below)
- Water high value pinyon trees at and around the canopy drip zone during hot/dry periods; water in fall, winter and spring as needed to reduce tree stress and maintain tree health and vigor—but do not overwater
- Prevent injury and stress to trees caused by construction, road building, soil compaction, over pruning and other stressors
- Avoid planting vegetation that requires excessive watering under pinyon trees

MECHANICAL CONTROLS

- Promptly remove trees that are infested as soon as trees are identified; ensure all material is dry (no green wood remaining) or, if material is green, quickly remove cut wood from the area containing pinyon trees to prevent attracting adult beetles
- If at all possible, do not cut fresh wood between the time beetles emerge in spring and when they enter dormancy in fall
- Thin trees during winter to provide remaining trees with more water, nutrients, sun
- When cutting fresh wood during beetle dormancy period:
  - Do the cutting in late fall, early in the dormancy period
  - Remove green cut wood from the pinyon area if possible
  - For any remaining material, cut slash in short pieces, split material > 4 inches in diameter, and place material in sunny areas to promote rapid drying

CHEMICAL CONTROLS

- DO NOT SPRAY PINYON TREES if pinyon nuts will be collected for human consumption
- Once a tree is infested, preventive insecticide treatments are not effective—remove the infested tree as described above
- Remaining high value pinyon trees whose nuts will not be harvested and that have not been attacked can be sprayed with pesticides to kill attacking, chewing insects
  - Active ingredients such as carbaryl, permethrin or bifenthrin can be used
  - Apply spray to main trunk and all large branches in early spring, as high up as possible
  - Protect new transplants for first year or more with preventative sprays
  - More than one treatment may be needed, depending on the product used
  - Always apply pesticides according to the directions provided, and follow all cautions

REFERENCE AND RESOURCE WEBSITES

https://csfs.colostate.edu/wp-content/uploads/2020/06/2020_Pinon_Ips_CSFS_Quick_Guide_Web.pdf
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187536.pdf
https://www.fs.usda.gov/r3/resources/health/field-guide/bb/engravers.shtml
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5306142.pdf
https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1394.pdf
https://forestry.nv.gov/pinyon-ips-beetle

LIFE STAGES


Adult 0.8 - 1.4 inches


Adult in hand for scale


Larva 1.5 to 2 inches

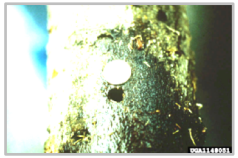

Pupa 1.2 - 1.3 inches


Life stages side by side

SIGNS & SYMPTOMS


Yellowing leaves


Egg laying sites 0.5 inch


Round exit hole 0.4 inch


Galleries and frass


Galleries deep in tree heartwood

URBAN TREE THREAT

ASIAN LONGHORNED BEETLE [ALB] *(Anoplophora glabripennis)*

INVERTEBRATE: INSECT, BEETLE

AESTHETIC STRUCTURAL DAMAGE DEATH

Severity: Extensive infestation can cause structural damage and lead to death

OVERVIEW

- Asian Longhorned Beetle (ALB) *(Anoplophora glabripennis)* is a threat to America's hardwood trees
- Roughly 30 percent of US trees are hosts
- Early identification and eradication are critical

POTENTIALLY AFFECTED TREES

Roughly 30 percent of US trees are hosts. These 13 genera hosts are susceptible to ALB:

- *Acer* spp. (maple and box elder)
- *Aesculus* spp. (horse chestnut and buckeye)
- *Albizia* spp. (mimosa)
- *Betula* spp. (birch)
- *Celtis* spp. (hackberry)
- *Cercidiphyllum* spp. (katsura tree)
- *Fraxinus* spp. (ash)
- *Koelreuteria* spp. (golden rain tree)
- *Platanus* spp. (sycamore and London planetree)
- *Populus* spp. (poplar)
- *Salix* spp. (willow)
- *Sorbus* spp. (mountain ash)
- *Ulmus* spp. (elm)

Acer is the most commonly infested tree genus in US, followed by *Ulmus* and *Salix*

Photo sources, left, top to bottom:
Photo 1: Photo credit: Karen Snover-Clift, Cornell University, Bugwood.org. Photo 2: Photo credit: Kenneth R. Law, USDA APHIS PPQ, Bugwood.org. Photo 3: Photo credit: Kenneth R. Law, USDA APHIS PPQ, Bugwood.org. Photo 4: Source: www.aphis.usda.gov/ppq/ep/alb/gallery/36.html (archived).

Photo sources, right, top to bottom:
Photo 1: Photo credit: Pennsylvania Department of Conservation and Natural Resources - Forestry , Bugwood.org. Photo 2: Photo credit: Michael Bohne, USDA Forest Service, Bugwood.org. Photo 3: Photo credit: USDA APHIS PPQ - Oxford, North Carolina , USDA APHIS PPQ, Bugwood.org. Photo 4: Photo credit: Michael Bohne, USDA Forest Service, Bugwood.org. Photo 5: Source: US gov, Public domain, via Wikimedia Commons.

ALERT: ASIAN LONGHORNED BEETLE

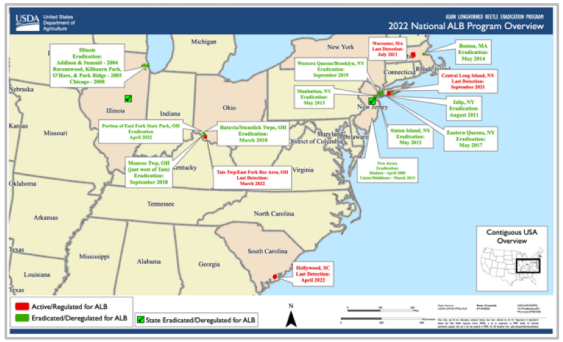
This insect species has not yet been detected in Arizona or New Mexico

If you think you have detected it: Record location, photograph insect and damage, and contact state forestry department:

- In Arizona, email: foresthealth@dffm.az.gov
- In New Mexico, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- ALB is not yet recorded in Arizona and New Mexico
- Native to several Asian countries
- Introduced to US in infested wood packaging
- Detected in New York, 1996; Illinois, 1998; New Jersey, 2002; Massachusetts, 2008; Ohio, 2011; and South Carolina, 2020



CONFIRMED ALB LOCATIONS IN US AS OF 2022

Map source: 2022 National ALB Program Overview showing affected states along with monitoring and control status. Source: https://www.aphis.usda.gov/plant_health/plant_pest_info/asian_lhb/downloads/albmaps/alb-program-progress-map.pdf

Control measures: Cultural, Mechanical, Chemical

See next page for additional information

ASIAN LONGHORNED BEETLE [ALB] *(Anoplophora glabripennis)* INVERTEBRATE: INSECT, BEETLE

LIFE STAGES AND DISEASE PROCESSES

- Females lay eggs, and larvae thrive, on healthy or stressed host trees of all ages as well as on recently cut logs
- Individual eggs are deposited under bark in pits chewed by adult females
- First three larval instars, or development phases, typically feed at the interface of the phloem (nutrient conducting outer tissue) and xylem (water conducting deep tissue)
- Older larva instars tend to tunnel more deeply into the xylem forming tunnels (galleries) in the trunk and branches
- Larvae mature into pupae in the galleries
- Adult beetles emerge and chew out of tree, forming round exit holes around 0.4 inch diameter (pencil sized)
- In warmer areas, development cycle is completed in a year
- ALB damage interferes with nutrient flow and weakens structural integrity
- Infested trees are prone to secondary attack by other insects, fungi, diseases
- Tree will eventually die if infestation is severe enough
- Adults survive several weeks
- Females often lay eggs on same tree year after year, but may also move to adjacent or distant trees
- Tendency to disperse appears to increase with crowding
- ALB can overwinter in tree or cut wood product as egg, larva or pupa
- Wood materials can spread infestation even if no beetles are visible, including firewood, solid wood packing material, wood debris and trimmings, branches, logs, stumps and lumber

TREE SIGNS AND SYMPTOMS

- *Presence of insects.* Adult ALB has black body with white markings 0.8 - 1.4 inches long
- *Presence of frass.* Larvae tunnel and feed, often pushing frass out onto the ground or onto tree branches
- *Presence of weeping/oozing sap.* Heavy sap flow may occur from trunk and branch wounds
- *Bark: Exit holes, round shaped.* Adult beetles chew their way out of trees leaving perfectly round exit holes approximately 0.4 inch or larger
- *Bark: Depressions (egg sites).* Adult females chew up to 90 round/oval depressions about 0.5 inch wide, laying 1 egg in each. Wound edges sometimes have chew marks
- *Beneath bark: Larval galleries, tunneling.* Larvae tunnel into tree growing layers (phloem and cambium) and eventually into woody tree tissue (xylem); fallen branches or cut wood may reveal tunneling
- *Leaves: Color change, unseasonable.* May observe unseasonable yellowed or drooping leaves
- *Twigs/Branches: Dieback.* Branches dying or dropping
- *Other:* Initially low populations of ALB in tree can easily be overlooked

TREATMENT AND MANAGEMENT OVERVIEW

An integrated approach to ALB control includes: imposing quarantines, inspecting trees, removing infested trees, sometimes removing at-risk host trees and using insecticide.

CULTURAL CONTROLS

- Be careful in moving wood materials that can spread infestation even if no beetles are visible, including: firewood, solid wood packing material, wood debris and trimmings, branches, logs, stumps and lumber
- Plant trees that are well adapted to site conditions and not attacked by ALB
- Provide proper cultural care of susceptible trees and protect them from injuries
- Do not store freshly cut wood near trees

MECHANICAL CONTROLS

- Completely remove and chip or burn all infested trees and grind stumps
- Prune off dead limbs during season when adult borers are not active
- Debark or solarize logs beneath clear plastic in the sun to prevent beetles from emerging from cut wood and attacking nearby hosts

CHEMICAL CONTROLS

- USDA Animal and Plant Health Inspection Service (APHIS) and state partners use insecticide treatments to reduce spread of ALB from currently infested areas by treating trees where ALB adults are present, but tree is not yet infested
- Insecticide is not used to treat already infested trees because later larval stages are in tree heartwood where treatment will not reach. Already infested trees must be removed and destroyed
- For treatment of trees where ALB are present but tree is not yet infested, use imidacloprid (generic), a systemic insecticide:
  - Insecticide is pulled upward into stems, twigs & foliage where it kills beetles as they eat leaves and lay eggs; also effective against early larval stages
  - Can apply through tree trunk by direct injection, or soil injection at base of tree
  - Once treatment area is identified, treating all area host trees is the most effective
  - If treated trees are later found to be infested, remove and destroy them
  - For more info on imidacloprid, go to: pubchem.ncbi.nlm.nih.gov/compound/imidacloprid

REFERENCES AND RESOURCES

- https://www.aphis.usda.gov/plant_health/plant_pest_info/asian_lhb/downloads/response-guidelines.pdf
- https://www.aphis.usda.gov/pests-diseases/alb
  https://academic.oup.com/jipm/article/6/1/4/788453
- https://www2.ipm.ucanr.edu/Invasive-and-Exotic-Pests/Asian-longhorned-beetle/
- http://ipm.ucanr.edu/PMG/GARDEN/PLANTS/INVERT/asianlong.html
- https://www.invasivespeciescentre.ca/invasive-species/meet-the-species/invasive-insects/asian-long-horned-beetle/
- https://www.nrs.fs.fed.us/disturbance/invasive_species/alb/control_management/systemic_insecticides/
- https://www.aphis.usda.gov/publications/plant_health/fs-alb-insecticide-treatments.pdf

URBAN TREE THREAT

COCONUT RHINOCEROS BEETLE [CRB] *(Oryctes rhinoceros)*

INVERTEBRATE: INSECT, BEETLE

AESTHETIC STRUCTURAL DAMAGE DEATH

Severity: Extensive infestation can cause structural damage and lead to death

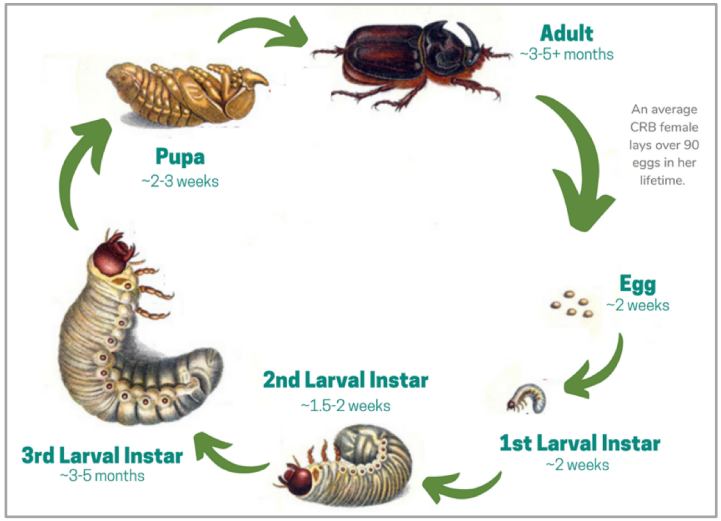
CRB impacts to palms include: slower growth, lower yield, frond damage and fatality if CRB populations are high

OVERVIEW

- Coconut Rhinoceros Beetle (CRB) has not been reported in the mainland US but is a serious invasive pest in Hawaii
- No single treatment is available to completely rid an area of CRB
- Several treatments and practices can reduce impacts and are most effective when combined

POTENTIALLY AFFECTED TREES:

- CRB prefers species of the palm genera: *Cocos*, *Phoenix*, *Roystonea* and fan palms including *Pritchardia*
- CRB is a minor pest on other palm genera



Graphic above, Source: https://www.crbhawaii.org/coconut-rhinoceros-beetle

Photo sources left top to bottom:
Photo 1: Source: https://www.crbhawaii.org/coconut-rhinoceros-beetle. Photos 2 & 4: Source: https://beetleidentifications.com/coconut-rhinoceros-beetle/. Photo 3: Source: https://www.crbhawaii.org/coconut-rhinoceros-beetle.

Photo sources right top to bottom:
Photos 1, 2 & 3: Source: https://www.crbhawaii.org/coconut-rhinoceros-beetle. Photo 4: Source: CRB FACTSHEET https/hdoa.hawaii.gov/pi/files/2013/01/npa-CRB-5-1-14

ALERT:
COCONUT RHINOCEROS BEETLE

This insect species has not yet been detected in Arizona or New Mexico

If you think you have detected it: Record location, photograph insect and damage, and contact state forestry department:

- In Arizona, email: foresthealth@dffm.az.gov
- In New Mexico, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- As of 2022, CRB has not been reported in the mainland US, including Arizona and New Mexico
- CRB is native to Asia
- CRB is a serious invasive pest in Hawaii, detected in 2013
- Recently introduced into Guam, Hawaii, mainland Papua New Guinea, and Solomon Islands
- Widespread in South and Southeast Asia, Oceania and other island locations

Control measures: Cultural, Mechanical, Biological, Chemical

See next page for additional information

LIFE STAGES

Adult 1.25 to 2.5 inches long, 0.75 to 1 inch wide

Egg 0.1 to 0.15 inch

Larvae largest instar up to 4 inches long

Pupa around 2 inches long

SIGNS & SYMPTOMS

Cut palm fronds

Scalloped leaf edges

Bore holes

Severe damage to palm tree

COCONUT RHINOCEROS BEETLE [CRB] *(Oryctes rhinoceros)* INVERTEBRATE: INSECT, BEETLE

LIFE STAGES AND DISEASE PROCESSES

- Length of CRB life cycle from egg to adult varies depending on food source and environmental conditions
- CRB uses legs and horn to dig into the crown of palm trees, then feeds on juices in inner spear using sucking mouthparts
- When palm leaves grow out, damage appears as V-shaped cuts or holes through base of fronds
- Females deposit eggs (50 to 100 eggs over lifetime) inside dead palms, decaying plant material, rich soil and occasionally wood structures
- Larvae go through 3 instars, feeding on surrounding organic material, then turn into pupae
- Emerging adults fly to new sites to feed and mate
- Beetles are active at night; hide in feeding or breeding sites by day
- Impacts to palms include slower growth, lower yield, frond damage and fatality if CRB populations are high

TREE SIGNS AND SYMPTOMS

- CRB damage can significantly reduce coconut production and kill palm trees
- *Palm fronds: V-shaped cuts.* CRB damage creates 45 degree v-cuts on palm fronds and scalloped leaf edges
- *Palm fronds: Boreholes at base of fronds.* CRB create large bore holes at the base of the palm fronds
- *Full tree: Loss of vigor, weakened.* Palm trees can be visibly sick or dying

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Younger palms are more vulnerable than mature palms to CRB
- Direct transmission of disease by CRB has not been reported, but beetle damage increases risk of secondary infections and infestations of palms

SIMILAR INSECTS OR CONDITIONS

- Western Hercules beetle *(Dynastes grantii)* is found in Arizona and New Mexico, but the adult is grayish-white rather than dark brown or black like CRB

TREATMENT AND MANAGEMENT OVERVIEW

- No single treatment is currently available to completely rid an area of CRB
- Several treatments and practices that can reduce impacts are most effective when combined
- It is advisable to allow authorized agricultural specialists access to properties to look for beetles and possibly hang traps
- The attractant ethyl 4-methyloctanoate can be used in traps to monitor populations

CULTURAL CONTROLS

- Remove all potential breeding material (mulch, compost, rich soil, stumps, dead trees, plant waste piles); treatment is needed before removal if material is infested
- Avoid accumulation or bringing in new potential breeding material
- Inspect mulch and compost piles for beetle larvae
- Infested material can be treated to kill CRB by incineration, heat treatment that brings all the material to >131 degrees F (55 C), fumigation with sulfuryl fluoride (e.g. Profume or Vikane), and chipping branches, palm fronds or logs

MECHANICAL CONTROLS

- Remove dead palms, but in general do not remove living palms since reducing palm numbers could concentrate damage on existing palms or drive CRB to new areas
- Netting can entangle and exclude CRB from accessing the crown of a tree

BIOLOGIC CONTROLS

- Viruses in the genus *Nudivirus* may play a role in controlling CRB where it is invasive
- Infection by *Oryctes rhinoceros nudivirus* may kill larvae and hinder oviposition by females, but *nudivirus* may harm other scarabs

CHEMICAL CONTROLS

- Injection of palm trees can be done with Imidacloprid (e.g. ImaJet) and Acephate (e.g. AceJet)
- Soil drench can be done with Imidacloprid (e.g. Imidacloprid 75 WSP)
- For more information, see https://www.crbhawaii.org/post/how-to-treat-coconut-rhinoceros-beetle-infestation

REFERENCE AND RESOURCE WEBSITES

- https://www.ctahr.hawaii.edu/haraa/CPS%20CRB%205_2014%20for%20email.pdf
- https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/coconut-rhinoceros-beetle/hp-crp
- https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/coconut-rhinoceros-beetle
- https://www.cabi.org/isc/datasheet/37974#tosummaryOfInvasiveness
- https://www.crbhawaii.org/coconut-rhinoceros-beetle
- https://www.crbhawaii.org/resourcelibrary
- https://www.crbhawaii.org/post/how-to-treat-coconut-rhinoceros-beetle-infestation
- http://entnemdept.ufl.edu/creatures/orn/palms/Oryctes_rhinoceros.htm
- https://www.pestnet.org/fact_sheets/coconut_rhinoceros_beetle__oryctes_108.htm
- https://beetleidentifications.com/coconut-rhinoceros-beetle/
- https://www.mdpi.com/2075-4450/13/5/487/htm

URBAN TREE THREAT

EMERALD ASH BORER [EAB] *(Agrilus planipennis)*

INVERTEBRATE: INSECT, BORER

LIFE STAGES

Adult, typically 0.5 inch

Adult, wings extended

Eggs, 0.02 - 0.04 inch

Larvae, 1 – 1.25 inch

Pupa

SIGNS & SYMPTOMS

Thinning crown

Adults feed on leaves

D-shaped exit holes, 0.13 inch diameter

Vertical split in bark

S-shaped galleries

Epicormic sprouting

AESTHETIC DAMAGE DEATH

Severity: Can be fatal within 1 year of first sign

Emerald ash borer (EAB) is an invasive, nonnative beetle that has killed tens of millions of ash trees in the US and Canada since it was found here in 2002

OVERVIEW

- Emerald ash borer attacks a wide range of *Fraxinus* species (ash)
- The closest confirmed siting to Arizona and New Mexico is in Colorado
- Has killed ash trees in both forests and urban areas
- New infestations are difficult to detect
- Usually by the time symptoms are detected, a tree is heavily infested and could be near death
- If heavily infested trees are detected, lightly infested trees in the area could be protected
- Treatment must start early to save infested trees

POTENTIALLY AFFECTED TREES:

Fraxinus species (ash)

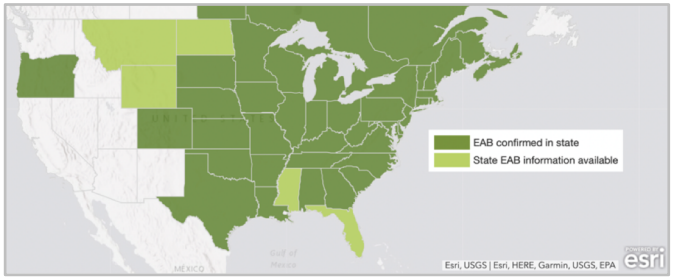
Photo sources, left top to bottom:
Photo 1: Source: https://www.arborday.org/trees/health/pests/emerald-ash-borer.cfm. Photo 2: Photo credit: David Cappaert, Michigan State University, Bugwood.org.
Photo 3: Source: The Life Stages of EAB - CTPA (Connecticut Tree Protective Association)
Photo 4:Source: https://csfs.colostate.edu/wp-content/uploads/2020/02/Colorado_EAB_Diagnostic_Field_Guide.pdf. Photo credit: David Cappaert, Michigan State University, Bugwood.org.
Photo 5: Source: https://csfs.colostate.edu/wp-content/uploads/2020/02/Colorado_EAB_Diagnostic_Field_Guide.pdf.
Photo sources, right top to bottom:
Photos 1, 4, 5: Source: https://csfs.colostate.edu/wp-content/uploads/2020/02/Colorado_EAB_Diagnostic_Field_Guide.pdf.
Photo 2: Source: The Life Stages of EAB - CTPA (Connecticut Tree Protective Association). Photo 3, 6: Source: https://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/eab-manual.pdf.

SERIOUS THREAT ALERT: Emerald ash borer (EAB)
DO NOT TRANSPORT ASH FIREWOOD

- EAB has been detected in 36 states. EAB is not yet documented in Arizona or New Mexico, but is in neighboring Colorado
- For more information about EAB, see: https://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/What-is-the-EmeraldAshBorer.pdf
- If you think you have found EAB: Record location, and photograph insect and damage if possible
  - Report EAB in Arizona to: foresthealth@dffm.az.gov
  - Report EAB in New Mexico to: (505) 690-8531
- To verify the beetle as EAB:
  - Get ID assistance in Arizona at https://azpdn.cals.arizona.edu
  - Get ID assistance in New Mexico at https://aces.nmsu.edu/ces/plantclinic/
- For information on EAB identification, see: http://www.emeraldashborer.info/documents/eab_id_guide.pdf

GEOGRAPHIC DISTRIBUTION

- EAB is not yet documented in Arizona or New Mexico
- EAB is native to Asia. It was discovered in US in 2002 in Michigan and is now present in 36 states



Emerald Ash Borer distribution in the US
Source: Emerald Ash Borer Information Network

Control measures: Cultural, Biological, Chemical

See next page for additional information

EMERALD ASH BORER [EAB] *(Agrilus planipennis)* INVERTEBRATE, INSECT, BORER

LIFE STAGES AND DISEASE PROCESSES

- Elytra (hardened forewings) of adult EAB are a bright, emerald green color, giving the species its common name
- After mating, female EAB lay eggs on the bark
- Larvae enter trunk to feed and grow, making s-shaped tunnels under bark, progressively destroying phloem/cambium/outer sapwood
- Damage caused by feeding larvae decreases transport of nutrients/water
- The more extensive the infestation, the more injury to the tree
- When full grown, larvae tunnel into sapwood to pupate
- Adults emerge in May/early June cutting small, D-shaped exit holes around 0.13 inch wide, and feed on ash foliage
- EAB has one-year life cycle with one generation/year the norm
- Adults can fly at least half a mile from ash tree where they emerge. In favorable conditions, a few may fly several miles, spreading infestation
- Many infestations begin when people move infested ash firewood, green lumber, branches, logs, chips, and nursery stock

TREE SIGNS AND SYMPTOMS

- *Presence of unusual woodpecker activity.*
- *Canopy: Thinning, defoliated.* Generalized, progressive crown thinning
  Canopy: Top kill. Branch dieback in the upper crown
- *Leaves: Wilted.*
- *Leaves. Color change, unseasonable.* Leaves on all or part of tree appear smaller and lighter colored compared to normal leaves
- *Leaves: Cut or notched.* Leaf notches are created by feeding adults
- *Twigs/Branches: Dieback.* Branch dieback occurs in the upper crown
- *Bark: Exit holes, D-shaped.* Adults exit holes, D-shaped, 0.13-inch diam.
- *Bark: Cracking/splitting.* Vertical bark splits
- *Beneath bark: Larval galleries, tunneling.* S-shaped galleries are created by boring, feeding larvae
- *Trunk: Excessive epicormic sprouting.* Sprouting from roots or tree trunk
- *Full tree: Death.* In areas of the US where EAB has been present since early 2000s, it has been fatal to nearly 100% of ash trees it has infested
- *Other:* Damage might not be apparent on trees for up to three years

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Drought, mechanical damage, insult by other pests and other stressors

SIMILAR INSECTS OR CONDITIONS

- Ash stressed by drought or diseases may have EAB-like symptoms
- Some insects with similar appearances or symptoms include: redheaded ash borer *(Neoclytus acuminatus)*, six-spotted green tiger beetle *(Cicindela sexguttata)*, lilac/ash borer *(Podosesia syringae)*, honey locust borer *(Agrilus difficilus)*. See: http://www.emeraldashborer.info/documents/eab_id_guide.pdf

TREATMENT AND MANAGEMENT OVERVIEW

- EAB eradication is not considered feasible
- National focus is to slow EAB spread and reduce densities of existing populations
- Cultural, biological and chemical controls help slow the spread and reduce densities
- Traps baited with chemical lures suspended in ash trees help detect EAB

CULTURAL CONTROLS

- Do not move infested ash firewood, green lumber, branches, logs, chips or nursery stock; inspect trees for signs or symptoms of EAB infestation, contact authorities if found
- When receiving ash nursery stock or firewood, know its point of origin because larvae could be hiding under the bark
- Learn about local, state and federal regulations and quarantines, and follow them
- US federal quarantines regulate movement of any ash material that may be infested, including trees, limbs, cut firewood, logs, and bark chips, and limit nursery sales of ash trees in some locations. Once products are cleared from quarantine they can be moved

BIOLOGIC CONTROLS

- Woodpeckers feed on late instar EAB larvae
- Areas with low population densities of EAB are more likely to be successfully managed with biological control by either native or introduced parasitoid wasp species
- EAB was parasitized by native wasp, *Atanycolus cappaerti,* in heavily infested Michigan area
- Currently nonnative tiny stingless wasps (parasitoids) are being released to help manage infestations: *Spathius agrili, Spathius galinae, Tetrastichus planipennisi* and *Oobius agrili*
- For more information about biological control of EAB, see: https://www.aphis.usda.gov/publications/plant_health/faq_eab_biocontrol.pdf

CHEMICAL CONTROLS

- Insecticidal control of EAB is most likely to be effective if tree is still relatively healthy
- Insecticides used to treat EAB move systemically in plants and are typically applied as either soil drenches, trunk sprays or direct injections into trunk
- Four pesticides used to control emerald ash borer are: imidacloprid, dinotefuran, emamectin benzoate, and azadirachtin
- Insecticides can prevent new injuries by EAB and if EAB damage is not too advanced, trees can recover when insecticides are used
- If EAB causes canopy to thin 30-50%, it is probably too late to save the tree since systemic insecticides might not be transported within the tree to branches and canopy
- For more information about chemical control of EAB, see: https://extension.colostate.edu/topic-areas/insects/insecticides-used-to-control-emerald-ash-borer-on-residential-shade-trees-5-626/

REFERENCE AND RESOURCE WEBSITES

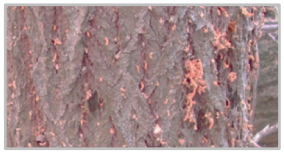
- https://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/eab-manual.pdf
- https://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/downloads/What-is-the-EmeraldAshBorer.pdf
- https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/emerald-ash-borer/emerald-ash-borer-beetle
- https://www.fs.fed.us/foresthealth/technology/pdfs/FHTET-2014-09_Biology_Control_EAB.pdf
- https://www.aphis.usda.gov/publications/plant_health/faq_eab_biocontrol.pdf
- https://extension.colostate.edu/topic-areas/insects/insecticides-used-to-control-emerald-ash-borer-on-residential-shade-trees-5-626/
- http://entnemdept.ufl.edu/creatures/TREES/BEETLES/emerald_ash_borer.htm

LIFE STAGES

Adult PSHB

Female PSHB, from left: young larva, older larva, pupa, immature adult, mature adult

Heavily attacked trunk



Frass from entry/exit holes

Exuding sap/gum

Dark stain

White powdery exudate

SIGNS & SYMPTOMS

Adult KSHB

Entry/exit hole

Galleries and stain

Branch dieback

Thinning canopy

URBAN TREE THREAT

POLYPHAGOUS SHOTHOLE BORER (PSHB) (*Euwallacea fornicates)* KUROSHIO SHOTHOLE BORER (KSHB) (*Euwallacea kuroshio*)

INVERTEBRATE: INSECT, BORER

AESTHETIC STRUCTURAL DAMAGE DEATH

Severity: Infestation of trees where beetles complete their development generally results in gradual death of the tree

OVERVIEW

- Polyphagous shothole borer (PSHB) (*Euwallacea fornicates)* and Kuroshio shothole borer (KSHB) (*Euwallacea kuroshio*) are native to Southwest Asia
- PSHB was detected in Southern California in 2003; KSHB was detected in 2012
- These borers are a dangerous threat to native and nonnative trees; in California, they are called invasive shothole borers (ISHB)
- PSHB and KSHB have not yet been detected in AZ and NM
- These species colonize healthy trees where they introduce spores of a symbiotic fusarium fungus; the fungus grows inside tree tissue where it serves as the sole food supply for the beetles and larvae
- The fungal growth induces a disease called Fusarium Dieback (FD)
- The combined impact of beetle infestation and fungal growth is known as ISHB-FD, and has attacked >260 species in California

POTENTIALLY AFFECTED TREES: ISHB-FD may cause tree death in the following reproductive host trees: *Acer* spp.: *A. buergerianum* (trident maple), A *macrophyllum* (bigleaf maple), *A. negundo* (boxelder); *Parkinsonia aculeata* (palo verde); *Platanus* spp.: *P. racemosa* (California sycamore), *P. x hispanica* (London plane); *Populus* spp.: *P. fremontii* (Fremont cottonwood), *P. nigra* (black poplar), *P. trichocarpa* (black cottonwood); *Quercus* spp.: *Q. lobate* (valley oak), *Q. robur* (English oak); *Ricinus communis* (castorbean); *Salix* spp.: *S. gooddingii* (black willow), *S. laevigata* (red willow), *S. lasiolepis* (arroyo willow). An additional 50 species in 40 genera of reproductive host broadleaf trees are somewhat less susceptible
For a complete tree list see: https://ucanr.edu/sites/pshb/pest-overview/ishb-reproductive-hosts/

Photo sources, left top to bottom:
Photo 1: Photo credit: Gevork Arakelian, Los Angeles County Agricultural Commissioner
Photo 2: Photo credit: Mike Lewis, University of California, Riverside
Photo 3: Photo credit: Beatriz Nobua-Behrmann, UC Cooperative Extension
Photo 4: Photo credit: John Boland
Photos 5, 6, 7: Photo source: https://ucanr.edu/sites/pshb/diagnosis/#ishb-detection-assessment
Photo sources, right top to bottom:
Photo 1: Photo credit: Sue Smith
Photo 2: Photo credit: Monica Dimson
Photo 3, 4: Photo credit: Beatriz Nobua-Behrmann, UC Cooperative Extension
Photo 5: Photo source: https://ucanr.edu/sites/pshb/diagnosis/

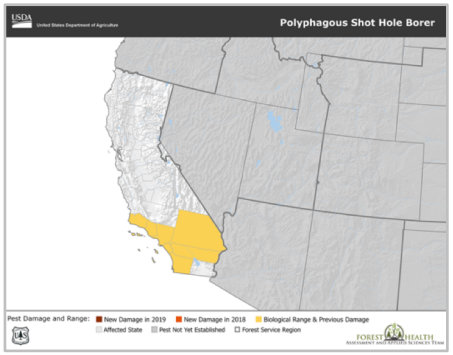
ALERT: INVASIVE POLYPHAGOUS AND KUROSHIO SHOTHOLE BORERS

These species have not yet been detected in Arizona or New Mexico
If you think you have detected them: Record location, photograph insect and damage, contact forestry departments:

- In AZ, email: foresthealth@dffm.az.gov
- In NM, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- PSHB and KSHB have not yet been detected in AZ and NM
- PSHB and KSHB are native to southeastern Asia
- PSHB first documented in Los Angeles County in 2003, and KSHB first observed in San Diego County in 2012



Location of biological range and previous damage for polyphagous shothole borer in California. Source: https://www.fs.usda.gov/foresthealth/docs/Range_Maps/FDAR-PolyphagousShotHoleBorer.pdf

Control measures: Cultural, Mechanical, Chemical

See next page for additional information

POLYPHAGOUS SHOTHOLE BORER (PSHB) (*Euwallacea fornicates),* KUROSHIO SHOTHOLE BORER (KSHB) (*Euwallacea kuroshio*)

LIFE STAGES AND DISEASE PROCESSES

- PSHB and KSHB are genetically different but appear identical
- Females ≈ 0.08-inch long, brown to black, with wings to disperse by flying
- Males are round 0.06-inch long, light brown to black, with no wings
- Females bore galleries into trunk & branches of host trees, expelling boring dust
- Females inoculate gallery walls with a Fusarium fungus and lay eggs
- Larvae typically have three instars and pupate in the galleries
- Adults and larvae feed entirely on symbiotic fungi cultivated within the xylem
- Substantially more adult female sisters than adult male brothers emerge
- Newly emerged sisters mate with the brothers
- Within a few weeks new females emerge and start another gallery in either the natal tree, or they leave the gallery through original entrance holes to a new tree
- Borers can complete multiple generations in the galleries before dispersing
- Dispersing females carry the symbiotic Fusarium fungal spores to new trees
- Females disperse during daytime, generally attacking host trees within hundreds of feet— though they can travel a quarter of a mile
- Brother-sister mating increases the chances of colonization of new regions since very small numbers can establish a new population
- Extensive tunneling activities can undermine the structure of tree trunks
- The fungi colonize wood beyond gallery walls, blocking water movement through tree's vascular system, causing stress and Fusarium Dieback (FD) disease

TREE SIGNS AND SYMPTOMS

- *Presence of frass.* Fine white- to tan- colored boring dust emerges from entry/exit holes and is found in bark cracks and at tree base
- *Leaves: Color change, unseasonable.* Pale, wilted, discolored
- *Bark: Entry/exit holes, pinhead sized.* Perfectly round <0.04 inch diameter (like tip of ballpoint pen); female beetle abdomen may protrude from entry hole
- *Bark: Staining.* Bark staining found near entry/exit holes varies for different tree species and ranges from dark and wet to dry, light and powdery
- *Beneath bark: Larval galleries, tunneling.* Branching galleries ≈ 3 inches deep into wood, perpendicular to trunk, stained brown to blackish by symbiotic fungi
- *Trunk: Weeping/oozing sap.* Thick resin may be observed at entry holes, pushing beetles out, sometimes dripping down trees
- *Trunk: Excessive epicormic sprouting.* Sprouting common in high-density attacks
- *Full tree: Loss of vigor, weakened.* Advanced infestations lead to tree decline and weakened structural integrity
- *Full tree: Dieback.* Crown and branch dieback common with high density attacks
- *Full tree: Death.* Mortality and stem failure may occur when injury is extensive
- *Other:* Attacks are common along main stem and larger branches. Attacks that are concentrated on branches/branch collars can lead to limb failure
- *Other:* Affected trees have increased susceptibility to other pests and diseases
- *Other:* Symptoms vary by species. To search for symptoms based on host trees see: https://ucanr.edu/sites/pshb/diagnosis/#identifying-signs-and-symptoms

SIMILAR INSECTS OR CONDITIONS

Foamy bark canker *Geosmithia* spp.; Fruit tree shot-hole borer, *Scolytus rugulosus*; Western sycamore borer, *Synanthedon resplendens*; Lesser ambrosia beetle, *Xyleborinus saxeseni*; Oak ambrosia beetles, *Monarthrum dentiger, M. scutellare*; Avocado trunk canker caused by *Phytophthora mengei;* Avocado branch canker and dieback caused by *Botryosphaeria* spp. and *Phomopsis* spp.; Bacterial canker caused by *Xanthomona campestris;* Black streak disease caused by *Botryosphaeria* spp.

TREATMENT AND MANAGEMENT OVERVIEW

Management strategies for ISHB-FD in urban trees can vary depending on whether tree species is a reproductive host, the level of infestation, tree location and potential hazards due to infested limbs and trunks. Information on management: https://ucanr.co1.qualtrics.com/jfe/form/SV_bIuyTZY7hkqiqod

CULTURAL CONTROLS

- Use cultural practices to support tree health and vigor including: appropriate irrigation, mulching, pruning and fertilization
- Do not move firewood since borers can be spread through transport of infested wood; buy firewood where you intend to burn it
- Disinfect all tools for pruning and sampling, and equipment including chainsaws and wood chippers that contact infected wood before using them on uninfected trees
- Inspect trees for signs and symptoms of infestation for early detection

MECHANICAL CONTROLS

- For low to moderately infested trees, remove actively infested branches in combination with using chemical treatments
- For heavily infested trees (> 150 entry/exit holes and signs of branch dieback), remove trees and properly dispose of infested wood to eliminate any sources of new beetles and prevent hazards resulting from structural damage
- Wood from ISHB-infested trunks and branches is full of live beetles: do not use untreated infested logs or chips for firewood or mulch; treat infested materials by solarizing, composting, kiln-drying and/or use them in biogeneration; see: https://ucanr.edu/sites/pshb/management/#infested-material-disposal

CHEMICAL CONTROLS

- Can protect tree before infestation using systemic insecticides such as emamectin benzoate alone (systemic insecticide) or combined with propiconazole (systemic fungicide); injection into infested trees typically not effective
- Preventative insecticide sprays applied on bark surfaces last 4 to 8 weeks so they need to be reapplied periodically; bark penetrant helps assure extended effect

REFERENCE AND RESOURCE WEBSITES

- https://anrcatalog.ucanr.edu/pdf/8590.pdf
- https://edis.ifas.ufl.edu/publication/FR422
- https://ucanr.edu/sites/pshb/
- KSHB-TRValley2020.pdf
- https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5441594.pdf
- https://cisr.ucr.edu/invasive-species/polyphagous-shot-hole-borer
- https://ucanr.edu/sites/eskalenlab/files/292754.pdf
- https://www.cdfa.ca.gov/State_Board/pdfs/CDFAIssueBrief_SHB082016.pdf

URBAN TREE THREAT

SIREX WOODWASP [SWW] *(Sirex noctilio)*

INVERTEBRATE: INSECT, WASP

LIFE STAGES

Adult 1 to 1.5 inches long

Male (left), female (right)

Larva, final instar
1 inch long

Pupa

SIGNS & SYMPTOMS

Wilt, yellowing browning needles, needle drop

Pitch/resin flow from egg laying sites

Larval galleries range from 2 to 8 inches long

Round exit holes range from 0.1 to 0.3-inch diameter

AESTHETIC DAMAGE DEATH

Severity: Can be fatal within 1 year of first sign

Attacks by Sirex woodwasps stress and weaken trees that are frequently already in distress, which can result in tree death within a year

OVERVIEW

- Nonnative, invasive Sirex woodwasp has spread to nine states in the eastern US since 2004
- There is concern about impacts when it reaches the southeastern and western US where forests have pine species that have been killed by SWW in Southern Hemisphere pine plantations
- Overstocking and drought stress—conditions common in these areas—are closely tied to SWW outbreaks in the Southern Hemisphere
- Control treatments that succeed in the Southern Hemisphere may not be as effective in the US

POTENTIALLY AFFECTED TREES:

- SWW only attacks conifers, primarily *Pinus* spp.
- Stressed, suppressed and crowded pines are favored for egg laying
- At high population densities, SWW will also attack and kill healthy pines
- In North America attacked or confirmed infested species include *P. sylvestris* (Scots), *P. radiata* (Monterey), *P. taeda* (loblolly), *P. elliottii* (slash), *P. echinate* (shortleaf), *P. ponderosa* (ponderosa), *P. contorta* (lodgepole), *P. banksiana* (jack)
- SWW do not infest dry or dead timber

Photo sources left top to bottom:
Photo 1: Photo credit ©Gyorgy Csoka, Hungary Forest Research Institute/via Bugwood.org - CC BY 3.0. Source: https://www.cabi.org/isc/datasheet/50192. Photo 2: Photo credit: Demian Gomez, University of Florida. Source: https://entnemdept.ufl.edu/creatures/misc/wasps/Sirex_noctilio.htm. Photo 3: Source: https://sref.info/resources/publications/the-sirex-woodwasp-sirex-noctilio-ecology-potential-impact-and-management-in-the-southeastern-u.s. Photo 4: ©William M. Ciesla, Forest Health Management International/via Bugwood.org - CC BY-NC 3.0.
Photo sources right top to bottom:
Photo 1: Photo credit ©Vicky Klasmer, Instituto Nacional de Tecnologia Agropecuaria/via Bugwood.org - CC BY-NC 3.0. Source: https://www.cabi.org/isc/datasheet/50192. Photo 2: Photo credit ©Carrie Crook/via Bugwood.org - CC BY-NC 3.0. Source: https://www.cabi.org/isc/datasheet/50192. Photo 3: Photo credit ©Vicky Klasmer, Instituto Nacional de Tecnologia Agropecuaria/via Bugwood.org - CC BY-NC 3.0. Source: https://www.cabi.org/isc/datasheet/50192. Photo 4: Photo credit ©Dennis Haugen/via Bugwood.org - CC BY-NC 3.0. Source: https://www.cabi.org/isc/datasheet/50192

ALERT: SIREX WOODWASP

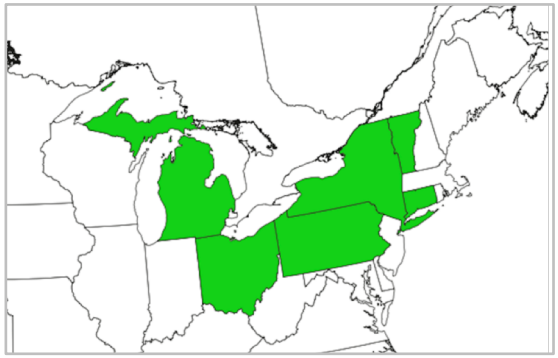
This insect species has not yet been detected in Arizona or New Mexico

If you think you have detected it: Record location, photograph insect and damage, and contact state forestry department:

- In Arizona, email: foresthealth@dffm.az.gov
- In New Mexico, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- SWW not yet detected in Arizona, New Mexico
- Native to Asia, Europe, and North Africa
- In native range, it is kept in check by natural enemies and limited pine tree hosts
- First detected in New York in 2004, arrived in wood packaging
- Currently present in New York, Pennsylvania, Vermont, Connecticut, Ohio, Michigan, New Jersey, Massachusetts and New Hampshire



US Distribution of Sirex woodwasp

Source: EDDMapS. 2022. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed August 16, 2022

Control measures: Cultural and Biological

See next page for additional information

SIREX WOODWASP [SWW] *(Sirex noctilio)* INVERTEBRATE: INSECT, WASP

LIFE STAGES AND DISEASE PROCESSES

- SWW life cycle generally takes about 1 year. In cooler climates life cycle can take 2 to 3 years
- Females are attracted to suppressed, stressed or injured trees for egg laying
- At high population densities, they can also attack and kill healthy pines
- Females drill ovipositors into outer sapwood to inject a symbiotic fungus *(Amylostereum areolatum)*, toxic mucus, and eggs
- These injections dry up wood and make it rot, creating nutrients for pest larvae
- Combined attack can lead to tree death; especially for weakened trees
- Females lay 25 to 500 eggs, depending upon female's size
- Eggs are white, sausage-shaped and up to 0.04 to 0.06 inch long
- Unfertilized eggs develop into males, fertilized eggs produce females
- Eggs incubate in 2 to 4 weeks
- Larvae feed on the growing symbiotic fungus as they tunnel through wood
- For one-year life cycles, larvae average 6 to 7 instars
- Life cycles are slower in colder regions, taking two+ years, with 8 to 12 instars
- Larvae construct large galleries 2 to 10 inches long
- Trees might try to ward off infestation by flooding boreholes with resin, or halting the fungus by producing a wall of polyphenol, leading to larval death
- Mature larvae pupate, with pupae located close under the bark surface
- Adults emerge about 3 weeks later in July - September; peaking in August
- Adults bore 0.1 to 0.3-inch diameter exit holes through the bark
- Adults only live one to two weeks and do not feed
- Dispersal is in several short, powerful flights
- Natural spread rate is about 10 to 30 miles per year
- Can spread farther by transport of infested wood

TREE SIGNS AND SYMPTOMS

- *Canopy: Thinning, defoliated.* Tip dieback, tree flagging
- *Needles: Color change.* Progressing change from green to yellow-red, to brown over three to six months
- *Needles: Excessive dropping.* Sudden foliage wilting, heavy needle fall
- *Bark: Exit holes, round shaped.* Adults bore circular 0.1 to 0.3-inch diameter exit holes through bark. In newly infested areas, holes are generally found 10-30 feet above ground; in heavily infested areas, holes found along whole trunk
- *Beneath bark: Larval galleries, tunneling.* Larvae tunnel towards heartwood then loop back towards bark in frass-packed galleries. Tunnels vary in length from 2 to 8 inches depending on size of larvae
- *Trunk: weeping/oozing sap.* Pitch/resin drops/flows originate from egg sites
- *Full tree: Loss of vigor, weakened*
- *Full tree: Death.* Attacks can result in tree death within a year
- *Other:* Narrow bands of brownish fungal stain in outer sapwood
- *Other:* Symptoms may be present on suppressed, stressed or injured trees, or on healthy trees if SWW populations densities are high

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Stressed, suppressed and crowded pines are favored for egg laying
- At high population densities, SWW can also attack healthy pines
- Dry or dead timber is not infested
- Trees free of injury, vigorously growing in favorable conditions, are more resistant

SIMILAR INSECTS OR CONDITIONS

- *Sirex nigricornis,* a native woodwasp in eastern North America also uses pine as host

TREATMENT AND MANAGEMENT OVERVIEW

- Early detection and rapid suppression of small populations is an important control strategy; cultural and biological controls can provide further suppression

CULTURAL CONTROLS

- Do not transport logs or green untreated saw timber from attacked areas—adults, pupae, larvae and eggs may be carried on solid wood packing material, logs, and saw timber
- Thin dense trees and remove damaged and unhealthy trees
- A trap-tree system can provide early detection; trapping involves stressing a tree using herbicide injection to attract SWW, and setting a trap to capture SWW

BIOLOGIC CONTROLS

- In Southern Hemisphere, SWW has been managed using biological control agents
- The nematode, *Deladenus siricidicola* is inoculated into infested trees
- *D. siricidicola* feeds on the symbiotic fungus that SWW associates with and has a parasitic life cycle inside the larvae, pupae and adults of SWW; ultimately it sterilizes females
- Infected females lay infertile eggs filled with nematodes, spreading nematodes to other trees, keeping SWW population below damaging levels
- Issues with doing this in the US include impacts on native woodwasps and the nematodes having less impacts on SWW here
- Hymenopteran parasitoids are wasps that lay eggs on the larvae of other species.
- These have been introduced into SWW populations in the Southern Hemisphere
- Most are native to North America, including *Megarhyssa nortoni, Rhyssa persuasoria, Rhyssa hoferi, Schlettererius cinctipes*, and *Ibalia leucospoides*
- Native wasp parasitoids might be a safe form of control on SWW in North America

REFERENCE AND RESOURCE WEBSITES

- https://www.cabi.org/isc/datasheet/50192
- https://www.invasivespeciesinfo.gov/terrestrial/invertebrates/sirex-woodwasp
- https://www.dontmovefirewood.org/pest_pathogen/woodwasp-html/
- https://www.dec.ny.gov/animals/7248.html
- https://www.crowley.com/wp-content/uploads/sites/4/2018/10/Sirex_Woodwasp.pdf
- https://entnemdept.ufl.edu/creatures/misc/wasps/Sirex_noctilio.htm
- https://www.newsweek.com/superwasp-threatens-americas-forests-females-capable-producing-1000-offspring-1718649
- https://en.wikipedia.org/wiki/Sirex_woodwasp
- https://nyis.info/invasive_species/sirex-woodwasp/
- http://www.tsusinvasives.org/home/database/sirex-noctilio
- https://animaldiversity.org/accounts/Sirex_noctilio/

LIFE STAGES

Adult male side view

European, female top, 2.5 - 3.5 inch wing span; male bottom, 1.5 inch wing span

Egg mass, 500 – 1000 eggs, 1.5 x 0.75 inch

5th instar caterpillar, grow to 2 to 3.5 inches long

Pupae

SIGNS & SYMPTOMS

Females laying egg masses on tree trunk

Egg masses laid on lawn mower

1st instar larvae emerging from egg mass

Defoliated oak branch

Defoliated tree

URBAN TREE THREAT

SPONGY MOTHS, EUROPEAN AND ASIATIC

(Lymantria dispar dispar, Lymantria dispar asiatica)

INVERTEBRATE: INSECT, MOTH

AESTHETIC STRUCTURAL DAMAGE DEATH

Severity: Repeated defoliation stresses trees and can lead to mortality, especially in urban or drought-stricken areas

OVERVIEW

- Spongy moth (formerly known as gypsy moth) is a nonnative invasive moth
- Both European *(Lymantria dispar dispar)* and Asiatic *(Lymantria dispar asiatica)* subspecies have been detected in the US
- Only European spongy moths are well established in the US, and are found in eastern states
- Spongy moths prefer oak but will attack a variety of tree species, both hardwood and conifers
- Defoliation by spongy moths can be fatal in repeatedly attacked trees, especially in urban or drought-stricken areas

POTENTIALLY AFFECTED TREES IN AZ & NM:

- Prefers *Quercus* (oak)
- Also will feed on *Acer* (boxelder, maple), *Alnus* (alder), *Betula* (white birch), *Carya* (hickory), *Castanea* (chestnut), *Celtis* (hackberry), *Fagus* (beech), *Juglans* (walnut), *Larix* (tamarack, larch), *Liquidambar* (sweetgum), *Malus* (apple, crabapple), *Picea* (spruce), *Pinus* (pine), *Populus* (aspen), *Prunus* (cherry), *Salix* (willow), *Sorbus* (mountain ash), *Tilia* (basswood, linden), *Tsuga* (hemlock), *Ulmus* (elm)

Photo sources left top to bottom:
Photo 1: Photo credit: Susan Ellis, Bugwood.org. Photo 2: Photo credit: USDA APHIS PPQ , USDA APHIS PPQ, Bugwood.org. Photo 3: Photo credit: Milan Zubrik, Forest Research Institute - Slovakia, Bugwood.org. Photo 4: Photo credit: Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org. Photo 5: Photo source: PA Department of Conservation and Natural Resources-Forestry Archive, Bugwood.org.

Photo sources right top to bottom:
Photo 1: Photo credit: Milan Pernek, Forestry Research Institute Bugwood.org. Photo 2: Photo credit: USDA/APHIS, Susan Lane. Photo 3: Photo credit: USDA FS Archive. Photo 4: Photo credit: Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org. Photo 5: Photo credit: Kirby Stafford. Source: https://portal.ct.gov/-/media/CAES/DOCUMENTS/Spongy-Moth/Spongy-Moth-Fact-Sheet.pdf

ALERT: SPONGY MOTH

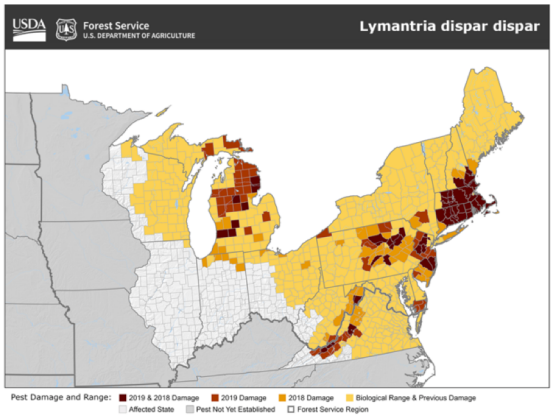
This insect species has not yet been detected in Arizona or New Mexico

If you think you have detected it: Record location, photograph insect and damage, and contact state forestry department:

- In Arizona, email: foresthealth@dffm.az.gov
- In New Mexico, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- Not yet detected in Arizona or New Mexico
- European subspecies is native to Europe; currently found in eastern US (see map)
- Asian subspecies is native to Asia
  - Recently detected in Washington, Oregon, Georgia, Oklahoma, South Carolina
  - Was detected in Utah but was eradicated



***Lymantria dispar dispar* Forest Damage Agent Range Maps, USDA, USFS.** Photo source: https://www.fs.usda.gov/foresthealth/docs/Range_Maps/FDAR-Lymantria-dispar-dispar-2019.png

Control measures: Cultural, Mechanical, Biological, Chemical

See next page for additional information

SPONGY MOTHS, EUROPEAN AND ASIATIC *(Lymantria dispar dispar, Lymantria dispar asiatica)* INVERTEBRATE: INSECT, MOTH

LIFE STAGES AND DISEASE PROCESSES

- Egg masses laid July - September on outdoor surfaces—tree trunks, branches, rocks, firewood, houses, patio furniture, vehicles, etc.
- Eggs hatch in spring. Small larvae can put out silk and be carried by wind
- Emerging larvae (caterpillars) climb up trees and feed on leaves or many hardwoods and conifers—though they prefer oak
- Larval stage lasts for 6 to 8 weeks from late spring to early summer
- First 3 instars feed during the day
- Fourth instars and later feed at night; hide under bark, in crevices, etc.
- Fully grown caterpillars seek shelter to pupate in early summer, with metamorphosis lasting 10 to 14 days
- Pupae are found under bark, in crevices, under branches, on ground and other larval resting places. Dense populations may pupate in exposed areas
- Adults do not feed, they mate, reproduce and die in several weeks. European female moths cannot fly. Asiatic females can fly up to 25 miles, spreading risk
- Moth populations can exist for multiple years at low densities, rapidly expand their numbers several orders of magnitude, then fall back to low numbers within a few generations

TREE SIGNS AND SYMPTOMS

- *Presence of eggs.* Buff/yellowish egg masses covered with hair from female's abdomen that causes serious skin rashes if touched. Masses are laid on tree bark and outdoor objects, about 1.5 inches long, 0.75 inch wide
- *Presence of larvae.* Newly hatched black, hairy caterpillars are 0.1-inch long, reaching 2 to 3.5 inches long at maturity. Later instars are mottled yellow to gray, with hair tufts; 5 pairs of blue dots, 6 pairs of red dots run down backs
- *Presence of adult insects.* Males are brown with dark-brown wavy lines, large feathery antennae, around 1.5-inch wing-span. Females are cream/white with dark saw-toothed patterns on wings, thin antennae ranging from 2.5 to 3.5 or larger. European females cannot fly. Asiatic female moths can fly
- *Canopy: Thinning, defoliated.* Caterpillars can chew small holes in leaves or completely strip a canopy, depending on age and population levels
- *Leaves: Cut or notched.*
- *Twigs/branches: Dieback.*
- *Full tree: Death.* Healthy trees may tolerate intensive attack for 1 to 2 years, but repeated infestations weaken tree, making recovery unlikely. Repeated defoliation stresses trees and can lead to mortality, especially in urban or drought-stricken areas
- *Other:* Defoliation and dieback make trees susceptible to disease, other pests
- *Other:* Infestations can weaken tree regeneration due to impacted seed production and root sprouting

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Trees in urban or drought-stricken areas are more susceptible to mortality

SIMILAR INSECTS OR CONDITIONS

- Western tent caterpillar *(Malacosoma californicum)* and fall webworm *(Hyphantria cunea)* might be confused with spongy moths

TREATMENT AND MANAGEMENT OVERVIEW

Spongy moth management strategies include immediately controlling outbreak populations to minimize impact, and preventing introduction and spread to new locations using cultural, mechanical, biological and chemical controls.

CULTURAL CONTROLS

- Keep trees healthy to help ward off attacks, including proper watering and care
- Teach public how to identify gypsy moth life stages to assist in detection and control
- Look for egg masses in late autumn to early spring to avoid inadvertent transportation of eggs on vehicles, firewood, outdoor furniture, etc.
- Do not move firewood or other materials that may harbor egg masses
- Establish quarantines to help slow the spread

MECHANICAL CONTROLS

- Keep small scale gypsy moth populations suppressed and at a manageable level by destroying eggs and caterpillars
- Contact with caterpillar hairs can cause irritation
- Always wear gloves to dispose of caterpillars
- Control caterpillars by wrapping sticky bands around tree trunks to intercept caterpillars
- If eggs are detected, wear gloves to scrape masses off surfaces and destroy masses by crushing or submerging in soapy or bleach water for at least two days, then discard mixture
- Examine outdoor items regularly during spring and summer—if larvae/caterpillars are found, wear gloves to remove them

BIOLOGIC CONTROLS

- *Entomophaga maimaigi* fungus has been introduced in the US from Japan, and causes mass mortality in established spongy moth populations. Infections spread best in a wet spring season
- *Nucleopolyhedrosis* virus (NPV) only affects gypsy moth and occurs naturally but only in large populations. NPV severely damages internal organs of caterpillars, killing them
- Pheromone traps intercept male moths to determine extent of spread and keep populations suppressed and manageable, including Disrupt II, Luretape Gypsy Moth, and Luretape Plus

CHEMICAL CONTROLS

- Bioinsecticides made from *Bacillus thuringiensis kurstaki* (Btk) can control young larvae
- Btk is short-lived, minimizes nontarget effects and has low environmental impact
- Btk can be used with pheromone mating disruptors in larger areas with high infestations in baited traps or aerial foliar sprays

REFERENCE AND RESOURCE WEBSITES

- https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/gypsy-moth-free/
- https://www.aphis.usda.gov/publications/plant_health/fsc-moving-check-gypsy-moth.pdf
- https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/asian-gypsy-moth/asian-gypsy-moth
- https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/the-threat/hp-egm/hp-egm
- https://portal.ct.gov/DEEP/Forestry/Forest-Protection/The-Spongy-Moth-Information-for-Tree-and-Woodland-Owners
- https://extension.usu.edu/pests/factsheets/spongy-moth.pdf
- https://fyi.extension.wisc.edu/spongymothinwisconsin/pest-management-2/favored-trees-and-shrubs/
- https://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/gypsy_moth.pdf

URBAN TREE THREAT

SPOTTED LANTERNFLY [SLF] *(Lycorma delicatula)*

INVERTEBRATE: INSECT, PLANTHOPPER

LIFE STAGES

Adult 1 to 1.5 inches long

Adult 2-inch wing span

Egg masses

Nymph, early instar

Nymph, 4th instar

Life stages. Instars range from 0.12 to 0.5 inch long; adults 1 to 1.5 inches long

SIGNS & SYMPTOMS

4th instar nymphs, feeding scars, yellowing leaves

Females coating egg masses with putty-like substance

Egg masses laid on tire

Aggregating adults

Mold growing on accumulated sap and honeydew at tree base

AESTHETIC **STRUCTURAL DAMAGE** **DEATH**

Severity: Infestation over multiple years can cause structural damage and can lead to death

OVERVIEW

- Spotted lanternfly feeds on plant sap resulting in stress to host trees
- Weakened trees are more susceptible to drought, secondary pathogens and infections, causing additional stress
- Cumulative damage from multiple years of attacks can weaken and kill trees

POTENTIALLY AFFECTED TREES:

- Prefers *Ailanthus altissima* (tree of heaven) for feeding
- Will also feed on *Acer* spp. (maple), *Betula* spp. (birch), *Juglans* spp. (walnut), *Malus* spp. (apple), *Populus* spp. (poplar), *Prunus* spp. (stone fruit), *Rhus* spp. (sumac) and *Salix* spp. (willow), among others
- Spotted lanternfly will lay eggs on many trees and plants, as well as relatively smooth non-plant surfaces including manmade surfaces

Photo sources left top to bottom:
Photo 1: Photo credit: ©Lawrence Barringer/Pennsylvania Department of Agriculture/Bugwood.org - CC BY 3.0 US. Source: https://www.cabi.org/isc/datasheet/110524. Photo 2: Photo credit: NYSIPM Staff. Source: https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/biology-life-cycle-identification-and-dispersion/. Photo 3: Photo credit: NYSIPM Staff. Source: https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/biology-life-cycle-identification-and-dispersion/. Photo 4: Photo credit: L. Barringer, PA Dept. of Agriculture, Bugwood.org. Source: https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/biology-life-cycle-identification-and-dispersion/. Photo 5: Photo credit: Lawrence Barringer, Pennsylvania Department of Agriculture. Source: https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=26349
Photo sources right top to bottom:
Photos 1: Photo credit: Eric R. Day, Virginia Polytechnic Institute and State University, Bugwood.org. Photo 2: Photo credit: Lawrence Barringer, Pennsylvania Department of Agriculture. Source: https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=26349. Photo 3: Photo credit: Zil Fessler. Source: https://www.aphis.usda.gov/publications/plant_health/fsc-slf-checklist.508.pdf. Photo 4: Photo credit: Lawrence Barringer, Pennsylvania Department of Agriculture. Source: https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=26349. Photo 5: Photo credit: Lawrence Barringer, Pennsylvania Department of Agriculture. Source: https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=26349

ALERT: SPOTTED LANTERNFLY
This species has not yet been detected in Arizona or New Mexico
If you think you have detected it: Record location, photograph insect and damage, and contact state forestry departments:
- In Arizona, email: foresthealth@dffm.az.gov
- In New Mexico, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- Spotted Lanternfly not yet recorded in Arizona or New Mexico
- Native to China, India, and Vietnam
- First discovered in US in Pennsylvania in 2014
- Now present in Pennsylvania, New Jersey, Delaware, Maryland, Virginia, West Virginia, New York, Connecticut and Ohio

CONFIRMED SPOTTED LANTERNFLY LOCATIONS IN US
Source: EDDMapS. 2022. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed August 19, 2022.

Control measures:
Cultural, Mechanical, Chemical

See next page for additional information

SPOTTED LANTERNFLY [SLF] *(Lycorma delicatula)* INVERTEBRATE: INSECT, PLANTHOPPER

LIFE STAGES AND DISEASE PROCESSES

- Spotted lanternfly adults use powerful hind legs to jump; can fly short distances. Can move 3 to 4 miles by walking, jumping and flying
- Nymphs & adults have piercing/sucking mouthparts, feed on sap
- Females start laying eggs around September continuing until winter
- Eggs planted in clusters of 30-50 eggs. Multiple females may lay in same area
- Females cover eggs with white putty-like substance that darkens over time
- Smooth-barked trees are most common egg-laying surfaces, but flat artificial structures, surfaces, vehicles, furniture, equipment, rocks, etc. are also used
- Egg masses overwinter and emerge in April to May
- Nymphs instars range from 0.12 to 0.5 inch. First three instars are black with white spots. Fourth instar is red with white dots and black stripes
- Food preferred by nymphs is *Ailanthus altissima* (tree of heaven)
- Feeding can cause plants to ooze or weep sap, resulting in a fermented odor
- Feeding also produces honeydew and results in feeding scars that drip sap
- Highly mobile adults appear in summer, feeding on woody trees or large vines
- Lanternflies live one year and most adults die by the end of December
- Larger instars and adults consume more fluid posing greatest risk to plants
- Honeydew/sap accumulations on leaves can lower photosynthesis
- These fluids also promote mold growth which can further limit light
- Large white mats of mold may appear under heavily fed-upon trees
- SLF can congregate in large numbers on a single plant, directly causing substantial damage and potentially killing parts of or whole plants
- Direct & indirect effects of SLF attacks can reduce yields of fruit-bearing trees
- Weakened plants susceptible to drought, pathogens, insects, increasing stress
- Plant death typically results from multiyear feeding, especially larger trees
- SLF is transported by movement of materials with eggs/nymphs/adults

TREE SIGNS AND SYMPTOMS

- *Full tree: Loss of vigor, weakened, dieback.*
- *Presence of insects and nymphs.* Adults & nymphs gather in large numbers on host plants; easiest to spot at dusk or nighttime migrating up and down trunks
- *Presence of eggs.* Eggs masses are typically laid on smooth trunks of host plants or other smooth surfaces such as brick, stone, metal surfaces, etc.
- *Presence of weeping/oozing sap.* Wounds by feeding nymphs/adults weep sap
- *Presence of fermented odor.* Weeping sap can result in a fermented odor
- *Presence of honeydew.* Sap-feeding nymphs and adults excrete large volumes of honeydew, attracting other insects
- *Presence of sooty mold.* Sap/honeydew accumulations promote mold growth
- *Leaves: Wilted.* Coated with black fungal growth
- *Twigs/branches/trunk: Feeding wounds, weeping sap.*
- *Base of tree: Mold growth.* Sap and honeydew accumulations dripping from above can promote mold growth at base of tree

SIMILAR INSECTS OR CONDITIONS

- To see photos of insects that might be confused with spotted lanternfly, go to: https://www.aphis.usda.gov/publications/plant_health/fs-slf-lookalikes.508.pdf

TREATMENT AND MANAGEMENT OVERVIEW

- Controls used to reduce spotted lanternfly infestations include cultural, mechanical and chemical strategies used in an Integrated Pest Management framework
- Public engagement is particularly important in identifying and suppressing this insect, and can be achieved by public outreach efforts to alert people to their appearance, behaviors and to simple control methods
- For more information on control measures, see https://extension.psu.edu/spotted-lanternfly-management-guide

CULTURAL CONTROLS

- Develop public awareness campaigns to alert people to SLF (especially highly visible fourth instars and adults) and provide information on reporting
- Check for SLF on bark, stone, wood, metal, plastic and stiff fabrics both exposed and underneath objects, especially at dusk and at night
- Monitor for SLF using tree bands wrapped around trees and posts

MECHANICAL CONTROLS

- Egg scraping requires inspecting plants and other hard surfaces for egg masses, scraping masses off surfaces, then killing the eggs
- Sticky bands can be placed around tree trunk about four feet above the ground to trap moving nymphs and adults and should be installed in a way that does not catch birds, mammals, etc.
- Physical traps using lures can be effective in areas of high density SLF populations
- Removing the preferred host tree, tree-of-heaven *(Ailanthus altissima),* or using it as a trap tree by treating it with pesticides, has been used in some locations to reduce risk of infestation and spread

CHEMICAL CONTROLS

- Start with insecticidal soaps, neem and botanical oils, and pyrethrum, the least-toxic options, which have very little residual activity
- Use contact or systemic applications, including dinotefuran, bifenthrin, zeta-cypermethrin and carbaryl, which may have longer residual efficacy

REFERENCE AND RESOURCE WEBSITES

- https://extension.psu.edu/spotted-lanternfly-management-guide
- https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/sa_insects/slf
- https://www.aphis.usda.gov/publications/plant_health/alert-spotted-lanternfly.pdf
- https://extension.psu.edu/spotted-lanternfly
- https://nysipm.cornell.edu/environment/invasive-species-exotic-pests/spotted-lanternfly/spotted-lanternfly-ipm/biology-life-cycle-identification-and-dispersion/
- https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=26349
- https://www.nj.gov/agriculture/divisions/pi/prog/pests-diseases/spotted-lanternfly/
- https://en.wikipedia.org/wiki/Spotted_lanternfly

LIFE STAGES, SIGNS AND SYMPTOMS

Ganoderma lucidum fruiting body (conk)

Ganoderma lucidum pore surface

Ganoderma applanatum conk

Ganoderma tsugae conk

Standing on a large *ganoderma* conk

Thinning crown of infected tree

Conks at base of tree

Typical failure of live aspen

Spores on top of conks

Trees down due to rotted bases

Photo sources, left top to bottom:
Photo 1: Photo credit: Robert L. Anderson, USDA Forest Service, Bugwood.org. Photo 2: Photo credit: Joseph LaForest, University of Georgia, Bugwood.org. Photo 3: Photo credit: Mary Lou Fairweather, USDA Forest Service. Source: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5320331.pdf. Photo 4: Photo credit: Joseph O'Brien, USDA Forest Service, Bugwood.org
Photo sources, center top to bottom:
Photo 1: Photo credit: Joseph O'Brien, USDA Forest Service, Bugwood.org. Photo 2: Photo credit: Elizabeth Bush, Virginia Polytechnic Institute and State University, Bugwood.org. Photo 3: Photo credit: Edward L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org
Photo sources, right top to bottom:
Photo 1: Photo credit: Edward L. Barnard, Florida Department of Agriculture and Consumer Services, Bugwood.org. Photo 2: Photo credit: Jim Worrall, USDA Forest Service. Source: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5320331.pdf.
Photo 3: Source: https://www.fs.usda.gov/r3/resources/health/field-guide/rd/ganoderma.shtml

URBAN TREE THREAT

GANODERMA ROT DISEASE (*Ganoderma* species)

DISEASE: FUNGUS, ROT

AESTHETIC **DAMAGE** **DEATH**

Severity: Ultimately fatal once tree is infected. Can be fatal within 3 to 5 years or longer.

OVERVIEW

Ganoderma species are a group of wood-decaying fungi found throughout the world on all types of wood. Ganoderma rot disease is fatal. The rate of decay appears to be determined by tree vigor, which is often influenced by environmental stresses.

POTENTIALLY AFFECTED TREES

- Ganoderma rot disease affects all types of wood including conifers, cycads, broadleaf trees and palms
- Potentially affected trees in Arizona and New Mexico include, but are not limited to:
  - *Ganoderma lucidum* causing root rot in native and landscape trees such as olive, African sumac, mulberry, hackberry, oak and others
  - *Ganoderma applanatum* found on aspen trees in Arizona and New Mexico
  - *Ganoderma tsugae* found in the mountains of Arizona and New Mexico on Douglas-fir and other conifers
  - *Ganoderma* species also cause root rot in mesquite and acacia

GEOGRAPHIC DISTRIBUTION

- *Ganoderma* species are widely distributed around the world
- 13 *Ganoderma* species are recognized in the US
- *Ganoderma* species present in Arizona and/or New Mexico include: *Ganoderma lucidum, Ganoderma applanatum* and *Ganoderma tsugae*

Control measures: Cultural, Mechanical

See next page for additional information

GANODERMA ROT DISEASE (*Ganoderma* species) DISEASE: FUNGUS, ROT

LIFE STAGES AND DISEASE PROCESSES

- Ganoderma rot disease may suddenly appear in areas with no history of infection
- Microscopic, airborne *Ganoderma* spores are released from pores on conk undersides, dispersed during humid summer periods, carried by wind, washed into soil by rain or irrigation
- Spores germinate to infect damaged roots and open wounds on root flares and lower trunk areas. Infection travels up and down roots and into lower tree trunk attacking sapwood, heartwood, and/or cambium of major roots and lower tree trunk
- Damage focuses primarily on roots, resulting in root rot and degradation, interfering with water and nutrients uptake. Decayed wood increases yearly resulting in dangerously soft, spongy wood in the part of the tree that serves as its anchor
- In deserts, *Ganoderma* reproduction usually takes place during summer rains
- Once established, *Ganoderma* form shelf-like conks (fruiting bodies) around tree base or low on trunk. New conks may be produced annually
- Fleshy conks harden with maturity; up to 14 inches wide, projecting outward. *G. lucidum* conks: pink-buff to cinnamon-buff to tawny colored, white edge and underside; *G. tsugae* conks: shiny, red-brown, white edge and underside, often with a stem or stalk; *G. applanatum* conks: dark brown to gray, white underside that stains brown when marked
- By the time conks appear, infection cannot be stopped. Not every infected tree has conks, but most advanced infections produce conks before tree falls over or dies
- *Ganoderma* kills host tree and can infect other trees, sometimes through root to root contact
- Disease may kill tree in 3 to 5 years or may proceed slowly taking 20 years to kill a tree
- Infection often results in windthrow. Infested aspens fall over while alive, often with healthy looking crowns, contributing to hazard trees at developed sites
- Sites with rots may have continuing tree problems into the future because diseases remain on the site for long periods and spread slowly among root systems

TREE SIGNS AND SYMPTOMS

- *Tree precondition: Stressed or wounded.* Disease occurs in wounded live, or dead/broken trees
- *Weather precondition:* Conks form in desert environments during rainy seasons
- *Canopy: Thinning, defoliated.* May have more dead lower leaves than normal. Symptoms may appear across entire canopy. Leaves may fail to emerge. Tree may have slow growth
- *Leaves: Undersized, wilted, yellowed, premature drop.*
- *Twigs/Branches: Dieback.*
- *Trunk/base of tree: Fungal growth.* Conks are found at base of tree or low on trunk. Appear shelf-like, up to 14 inches wide, projecting outward. *G. lucidum* conks: pink-buff to cinnamon-buff to tawny colored, white edge and underside. *G. tsugae* conks: shiny, red-brown, white edge and underside, often with a stem or stalk. *G. applanatum* conks: dark brown to gray, white underside; underside stains brown when marked. Heavy spore releases may form powder-like layer on ground. Decay associated with conks is white spongy rot with black flecks.
- *Roots: Fungal threads, mats or fruiting bodies*. Creamy colored mycelium may be seen under bark that is pulled away from the roots. Fungal-induced root rot compromises tree's anchoring, *Full tree: Loss of vigor, weakened.* Symptoms are similar to those of drought or water shortage
- *Full tree: Break or fall before death.* Infected trees often fall, blowing down during rainstorms or windy periods. Advanced decay of larger roots may extend from a few inches to several feet into the lower (butt) portion of the tree, depending on *Ganoderma* species
- *Full tree: Death.* By the time conks appear, infection cannot be stopped. Trees can decline rapidly and die.

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Even small wounds can allow *Ganoderma* to infect roots or lower trunk
- Rate of decay appears to be determined by tree vigor, which is often influenced by environmental stresses.

SIMILAR DISEASES FOR CONDITIONS

- Other prominent root diseases in Arizona and New Mexico include Armillaria root rot, Annosus root rot, Texas root rot *(Phymatotrichopsis omnivora)* and Velvet Top fungus *(Phaeolus schweinitzii)*

TREATMENT AND MANAGEMENT OVERVIEW

There is no control for Ganoderma rot disease once the plant is infected, but good cultural controls could help prevent new infections. Mechanical controls can help prevent damage and injury from hazard trees.

CULTURAL CONTROLS

- Maintain tree health and vigor with appropriate planting, fertilizing, watering, pruning, and others means
- Use good sanitization practices with tools
- Avoid damage to tree trunks and roots caused by excessive pruning, misused yard care equipment, construction and other potential sources of injury
- Select appropriate species and cultivars for a site—it may be advisable to shift away from planting vulnerable aspen trees in developed sites
- Monitor trees and stumps closely: if a tree's leaves wilt for no apparent reason, or conks appear, send root sample to a diagnostic laboratory as soon as possible

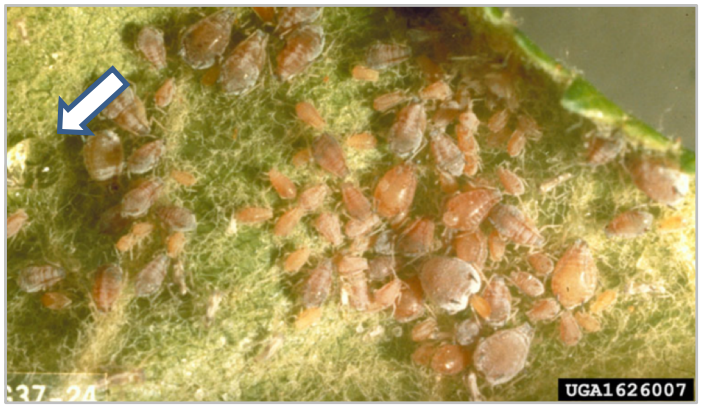
MECHANICAL CONTROLS

- Remove conks before they release spores
- When a conk is observed, have tree inspected by trained professional for structural integrity because large trees with severe internal rot may fall with little warning, injuring people and damaging property
- Remove heavily infected trees as soon as possible, removing as much of the stump and root system as possible and grind up any remaining stump

REFERENCE AND RESOURCE WEBSITES

- https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5320331.pdf
- https://extension.arizona.edu/sites/extension.arizona.edu/files/attachment/august-2018.pdf
- https://www.fs.usda.gov/r3/resources/health/field-guide/rd/ganoderma.shtml
- https://cals.arizona.edu/extension/ornamentalhort/plantprotect/pldiseases_urban.pdf
- https://plantclinic.tamu.edu/calendar2018/ganoderma-rot/
- https://www.missouribotanicalgarden.org/gardens-gardening/your-garden/help-for-the-home-gardener/advice-tips-resources/pests-and-problems/diseases/rot/ganoderma-root
- https://www.pinalcentral.com/trivalley_dispatch/home_and_hearth/gibson-ganoderma-is-serious-fungus-disease-for-trees-shrubs/article_579175b6-4c6d-5d1a-b3b3- 9be7c9744606.html
- https://www.fungimag.com/spring-2019-articles-02/Ganoderma%20.pdf

SIGNS & SYMPTOMS



Aphids feed on sap and excrete a sugary waste product called honeydew. Note the clear drop on the left side of this picture

Sooty mold on fruit

Sooty mold on tree bark/trunk

Spots of sooty mold on leaf

Leaves blackened by sooty mold coverage

Sooty mold growing on honeydew that has accumulated under tree

URBAN TREE THREAT

SOOTY MOLD (Multiple species)

DISEASE: FUNGUS, DECOMPOSER

AESTHETIC **STRUCTURAL DAMAGE**

Severity: Impact is primarily aesthetic. Combined impact of sap-sucking insects and resultant sooty mold growth can result in loss of tree vigor. Years of impacts could result in tree damage.

OVERVIEW

- Sooty molds grow on accumulated honeydew excreted by piercing/sucking insects feeding on plant sap
- Sooty mold coating leaves can indirectly damage plants by reducing sunlight reaching leaf, resulting in reduced photosynthesis
- The combination of sap-sucking insects and reduced photosynthesis can reduce plant vigor

POTENTIALLY AFFECTED TREES

- Any plant where piercing/sucking insects such as aphids, scales, mealybugs, psyllids, leafhoppers, whiteflies feed, and where honeydew is produced, may be affected by sooty mold

GEOGRAPHIC DISTRIBUTION

- Sooty molds occur in all parts of the US including Arizona and New Mexico

Control measures:
Cultural, Mechanical, Chemical

See next page for additional information

Photo sources, left top to bottom: Photo 1: Photo credit: John A. Weidhass, Virginia Polytechnic Institute and State University, Bugwood.org. Source: https://www.insectimages.org/browse/detail.cfm?imgnum=1626007.
Photo 2: Photo credit: Rebecca A. Melanson, Mississippi State University Extension, Bugwood.org. Source: https://www.ipmimages.org/browse/subthumb.cfm?sub=11501
Photo 3: Photo credit: Sarah Vanek, Bugwood.org. Source: https://www.ipmimages.org/browse/subthumb.cfm?sub=11501
Photo sources, right top to bottom:
Photo 1: Photo credit: Elizabeth Asteraki/CABI SEARC. Photo source: https://www.cabi.org/isc/datasheet/11238.
Photo 2: Photo credit: R. Scott Cameron, Advanced Forest Protection, Inc., Bugwood.org. Source: https://www.insectimages.org/browse/detail.cfm?imgnum=1361112.
Photo 3: Photo source: Whitney Cranshaw, Colorado State University, Bugwood.org. Source: https://www.ipmimages.org/browse/subthumb.cfm?sub=11501

SOOTY MOLD (Multiple species) DISEASE: FUNGUS, DECOMPOSER

LIFE STAGES AND DISEASE PROCESSES

- Sooty molds are not parasites and do not directly attack trees
- Sooty mold is a dark-colored fungus that grows on honeydew excreted by piercing/sucking insects feeding on plants
- Sooty mold fungi are decomposers that break down honeydew or naturally exuded plant materials as their source of nutrition
- Multiple fungi can cause sooty mold including *Aethaloderma, Capnodium, Cladosporium, Euantennaria, Fumago, Scorias, Trichomerium* and others
- Piercing/sucking insects include aphids, scales, mealybugs, psyllids, leafhoppers, whiteflies and others
- These insects ingest copious amounts of sap to extract nutrients, much of which is excreted as honeydew
- Soon after heavy infestations, plants may be covered with honeydew. Unless washed off by rain, honeydew clings to plants and objects below
- Sooty mold fungi grow microscopic threads. When abundant, these form visible black spots or may create continuous thin sheets that cover plant surfaces
- When very abundant, sooty molds cause plants to appear dark and sooty or almost uniformly charcoal gray
- Spores or fragments of sooty molds are blown or carried to honeydew locations where new colonies of sooty mold develop
- Sooty mold coating on leaves can indirectly damage a plant by reducing the sunlight reaching the leaf, reducing photosynthesis, which in turn can stunt plant growth
- The combination of feeding by large populations of sap-sucking insects and reduction in photosynthesis due to sooty mold, can reduce plant vigor. Years of impact could result in tree damage

TREE SIGNS AND SYMPTOMS

- *Full tree: Loss of vigor, weakened.*
- *Presence of honeydew.*
- *Presence of piercing/sucking insects.*
- *Leaves: Coated with black fungal growth.*
- *Leaves: Premature leaf drop.*
- *Fruit: Coated with black fungal growth.*
- *Twigs/Branches: Coated with black fungal growth.*
- *Base of tree: Coated with black fungal growth.*

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Wet conditions encourage mold spores to germinate and sooty mold to grow
- Warm dry weather may increase moisture stress in trees, which can result in increased aphid populations and honeydew production
- In dry conditions, there is less rain to remove or dilute honeydew concentrations suitable for sooty mold growth

TREATMENT AND MANAGEMENT OVERVIEW

A combination of cultural, mechanical and chemical controls may be needed to reduce negative impacts to trees resulting from the combined impacts of piercing/sucking insects who excrete honeydew, and resultant sooty mold growth

CULTURAL CONTROLS

- Fertilize and water properly to keep trees healthy, but not growing excessively

MECHANICAL CONTROLS

- Wash off sap sucking insects with a strong stream of water
- Wash sooty mold and honeydew from plants using water or mild soap and water
- Carefully prune to remove infested plant parts
- Apply a sticky compound around tree trunk and trim limbs that touch buildings or other ant access points to reduce access to trees by honeydew-eating ants who protect sap sucking insects from natural predators

CHEMICAL CONTROLS

- If possible, identify the specific piercing/sucking insect that is producing honeydew and apply treatments known to control that specific insect
- In general, apply insecticides that reduce sap-sucking insect populations
- Apply horticultural oils to overwintering aphid eggs and scales in spring prior to bud break
- Horticultural oil formulations can control sap sucking insects and also soften sooty mold so it can be washed off easier by rain or hose
- Apply insecticidal soap or pyrethroid to nymphs, crawlers and adults when present
- Apply systemic insecticide (neonicitinoid) in spring to target insects that produce honeydew

REFERENCE AND RESOURCE WEBSITES

- https://extension.usu.edu/pests/ipm/ornamental-pest-guide/diseases/sooty-mold
- https://plantdiseasehandbook.tamu.edu/problems-treatments/problems-affecting-multiple-crops/sooty-mold/
- https://ag.umass.edu/landscape/fact-sheets/sooty-mold
- http://ipm.ucanr.edu/PMG/PESTNOTES/pn74108.html
- https://content.ces.ncsu.edu/sooty-molds

URBAN TREE THREAT

TEXAS ROOT ROT *(Phymatotrichopsis omnivora)*

DISEASE: FUNGUS, ROT

SIGNS & SYMPTOMS

Overnight tree death and wilting and bronzing of leaves

Fungal strands on infected root

Phymatotrichopsis omnivora fruiting bodies

Spore mat of *Phymatotrichopsis omnivora,* typically two to 16 inches in diameter

Affected areas often appear as circular patterns of dead trees, as shown in this pecan grove

AESTHETIC | STRUCTURAL DAMAGE | DEATH

SEVERITY: Fatal

- Texas root rot is fatal for many broad-leafed plants (dicotyledonous)
- Most woody trees and shrubs show no symptoms during first few years after planting into root rot-infested areas
- Time of death after exposure varies: faster in hot temperatures, slower when cool

OVERVIEW

- Texas root rot is found throughout southern and western Arizona, and southern New Mexico
- It is fatal for susceptible trees—which include over 2,300 species
- The fungus persists as sclerotia and mycelial strands for decades in the soil
- It cannot be eradicated
- Get technical identification of the pathogen on roots to verify presence
- Cultural control is recommended to prevent continued tree death

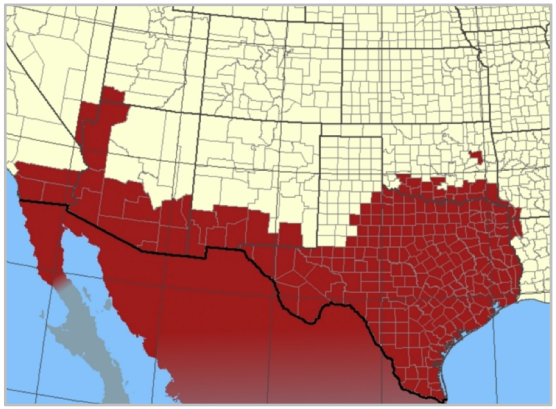
POTENTIALLY AFFECTED TREES:

- Affects over 2,300 species of broadleaved plants
- Often shows a preference for fruit trees and broadleaf deciduous trees and shrubs
- Can survive on the roots of native vegetation without causing disease
- Somewhat tolerant native species include some species of *Cercidium, Prosopis, Parkinsonia, Chilopsis, Celtis* and *Acacia*
- Gymnosperms, such as pine, spruce, cypress, and juniper are also somewhat tolerant
- Monocots are totally resistant to Texas root rot
- Winter annuals escape the disease because *P. omnivora* is not active in cold soils

For assistance with Texas Root Rot, contact the Cooperative Extension office for your county at:
AZ: https://extension.arizona.edu/locations
NM: https://aces.nmsu.edu/county/

GEOGRAPHIC DISTRIBUTION

- Restricted geographically to southwest US and northern Mexico
- Found in calcareous, alkaline soils with a pH range of 7.0 to 8.5 and with low organic matter
- Occurs only at elevations below 5,000 feet
- In New Mexico, it occurs only in southern counties, and is most prevalent in agricultural areas along the Rio Grande and Pecos rivers



US Distribution of *Phymatotrichopsis omnivora*, Texas root rot.
Source: Source:https://aggie-horticulture.tamu.edu/vitwine/files/2017/04/PD-and-Cotton-Root-Rot-Dr-Appel.pdf

Control Strategy: Cultural control

See next page for additional information

Photo sources, from top down: Photos 1, 5: Extension Publication AZ1771-2018 that can be found at https://extension.arizona.edu/pubs/ phymatotrichopsis-root-rot-pecan. Photos 2, 4: Phymatotrichum Root Rot, Guide A-229, Natalie Goldberg and Phillip Lujan, College of Agricultural, Consumer and Environmental Sciences, New Mexico State University. https://pubs.nmsu.edu/_a/A229/. Photo 3: Source: S.D. Lyda, Bugwood.org 1949030-PPT

TEXAS ROOT ROT *(Phymatotrichopsis omnivora)* DISEASE: FUNGUS, ROT

LIFE STAGES AND DISEASE PROCESSES

- *P. omnivora* persists almost indefinitely, primarily in top 2 to 6 feet of soil
- Greatest disease incidence occurs when soil at 1 foot deep is greater than 80°F and air temperature in plant canopy is above 104°F
- When environmental conditions are favorable, fungus invades plants with interwoven masses of fungal hyphae (mycelia) that colonize healthy roots
- Strands grow short distances through the soil to infect healthy roots
- Once strands grow and colonize roots, susceptible plants wilt and die
- Infected roots rot and cannot transport water to the aboveground portion of the plant—symptoms on aboveground plant parts resemble water stress
- The fungus appears in localized circular patterns
- No aerial or soil-borne spores spread the fungus; growth of strands from one host to another is probably the only method for fungus to spread and explains a typical pattern of kill where susceptible trees or shrubs are adjacent
- Symptom development and fungal activity vary by elevation in AZ
  - At <3600 ft, symptoms consist of stress, wilting and death of plant within a few days after initial symptoms (typically late May through September)
  - At >3600 ft, plants may not wilt suddenly, but instead die more slowly

TREE SIGNS AND SYMPTOMS

- *Weather precondition: High air and soil temperatures.* Fungus is only active in summer months when air and soil temperatures are high
- *Leaves: Delayed development.*
- *Leaves: Wilted.* Permanent wilting of the branches can occur very rapidly in as little as two weeks from the first expression of disease
- *Leaves. Color change, unseasonable.* Yellowing/bronzing leaves
- *Leaves: Dying/dead leaves remain attached.*
- *Twigs/Branches: Dieback.* Severe defoliation and twig dieback in the center of canopy, creating sparse or see-through canopy
- *Base of tree: Fungal growth.* Spore mats might be present on soil surface near infected plants
- *Roots: Fungal threads, mats or fruiting bodies.* Wooly strands of the fungus are often visible on decayed root surfaces
- *Roots: Wood rot*. Severely decayed root with bark readily sloughed off
- *Roots: Lesion on root crown.* Reddish lesions might be present on root crown. Mats appear off-white or tan; are level with soil surface
- *Full tree: Death.* Fatal for many broad-leafed plants (dicotyledonous); once strands grow and colonize roots of a susceptible plant, the infection results in wilting and plant death, though many native trees are immune
- *Other:* Affected areas often appear as circular patterns of dead trees
- *Other:* Positive identification of the pathogen on roots is essential for a diagnosis

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Soils low in organic matter
- Alkaline soils (pH 7.0–8.5)
- High temperatures: Fungus is only active in summer months when air and soil temperatures are high
- Mature plants: The fungus only infects roots of mature plants—seedlings are not susceptible to this disease
- Presence of *P. omnivora* in the soil from previous infections

SIMILAR DISEASES OR CONDITIONS

- Verticillium wilt, sudden wilt, root rot due to excessive moisture in waterlogged soil

TREATMENT AND MANAGEMENT OVERVIEW

- Positive identification of root pathogen is essential because plants may die for reasons other than Texas root rot
- For identification assistance:
  - In AZ, go to https://azpdn.cals.arizona.edu
  - In NM, go to https://aces.nmsu.edu/ces/plantclinic/
- If confirmed, use cultural controls to avoid additional plant death

CULTURAL CONTROLS

- Lowering soil alkalinity may help delay or prevent root rot infection: add organic amendments, fertilizers, sulfur
- Avoid planting or replanting in infested locations, if possible
- Once a diagnosis is confirmed, remove infected plants and wait a full growing season before replanting
- In infested areas, plant immune or highly resistant species such as:
  - Monocotyledonous plants including palms
  - Dicotyledonous desert plants that are not immune but are tolerant and usually grow normally in infested areas, including:
    - *Cercidium: C. floridum, C. microphyllum, C. praecox*
    - *Prosopis: P. velutina*, *P. chilensis*
    - *Parkinsonia aculeate, Chilopsis linearus, Celtis* spp. (hackberry), *Acacia greggii*

REFERENCES AND RESOURCE WEBSITES

- https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1814-2020.pdf
- https://pubs.nmsu.edu/_a/A229/
- https://cals.arizona.edu/forageandgrain/sites/cals.arizona.edu.forageandgrain/files/az1150-2015.pdf
- https://cals.arizona.edu/yavapai/anr/hort/byg/archive/texasrootrot2015.html
- https://www.cabi.org/isc/datasheet/40311

URBAN TREE THREAT

THOUSAND CANKERS DISEASE [TCD]

(*Vector: Pityophthorus juglandis.* Causal agent: *Geosmithia morbida*)

INVERTEBRATE: INSECT, BARK BEETLE plus DISEASE: FUNGUS, CANKERS

LIFE STAGES

Adult side view
0.06 to 0.08 inch long

Adult top view

Tiny adults on penny

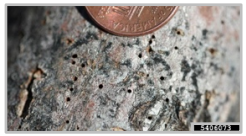
Adults, pupae, fungus

Pupae within galleries

Egg galleries under
bark of large branch

SIGNS & SYMPTOMS

Yellowing leaves,
branch with dieback



Adult exit wounds

Numerous cankers
coalescing

External weeping on
trunk above galleries

External view of beetle
gallery on AZ walnut

Rapid wilting in final
disease stage

AESTHETIC **DAMAGE** **DEATH**

Severity: Usually lethal within 2 to 3 years of appearance of symptoms

OVERVIEW

- Thousand cankers disease (TCD) is a disease complex native to the western United States
- TCD was first documented as a disease in 2001 in NM
- Since 2010 it has spread to some eastern states
- TCD severely affects *Juglans nigra* (black walnut) and less severely affects some other *Juglans* species
- The disease is the result of the combined activity of the walnut twig beetle *Pityophthorus juglandis* and the fungus *Geosmithia morbida*
- Native southwest *Juglans* species have relatively high resistance to the disease
- TCD may have originated in resistant species then passed to less resistant species causing severe problems

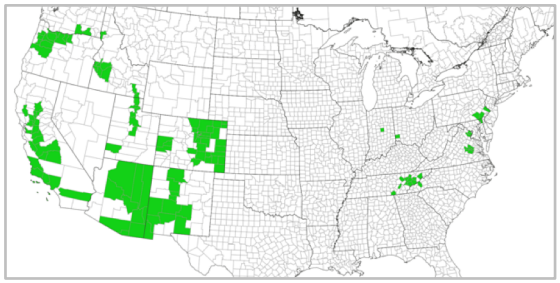
POTENTIALLY AFFECTED TREES:

- TCD impacts *Juglans* spp. (walnut); susceptibility varies:
  - High susceptibility: *Juglans nigra* (black walnut)
  - Intermediate susceptibility: *Juglans hindsii* (northern California walnut), *Juglans regia* (English walnut)
  - Fairly high resistance: *Juglans californica* (southern California walnut), *Juglans microcarpa* (little walnut)
  - Resistant: *Juglans major* (Arizona walnut); tree defenses quickly seal off tissue damaged by the beetle-introduced fungus and there is very little branch injury
- Also occurs in closely related *Pterocarya* spp. (wingnut)

Photo sources, left top to bottom:
Photos 1 & 2: Photo credit: Jim LaBonte, Oregon Department of Agriculture
Photo 3: Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org
Photo 4: Source: https://extension.colostate.edu/docs/pubs/insect/1008_alert.pdf
Photo 5: Photo credit: Curtis Utley, CSUE, Bugwood.org
Photo 6: Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org
Photo sources, right top to bottom:
Photos 1 & 2: Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org
Photo 3: Photo credit: Elizabeth Bush, Virginia Polytechnic Institute and State University, Bugwood.org
Photo 4: Photo credit: Ned Tisserat, Colorado State University, Bugwood.org
Photo 5: Photo credit: Curtis Utley, CSUE, Bugwood.org
Photo 6: Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org

GEOGRAPHIC DISTRIBUTION

- Walnut twig beetle first described in 1928 on Arizona walnut trees (note: beetles alone do not cause TCD without the presence of the *G. morbida* fungus)
- Beetle's native range: AZ, NM, CA, Chihuahua, Mexico
- TCD documented causing walnut die-off in NM, 2001
- May have caused other die-offs in 1980s/1990s
- TCD is currently present in both AZ and NM
- TCD was confined to western US until 2010



Thousand Cankers Disease Distribution in US

Source: EDDMapS. 2022. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed October 6, 2022.

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Water availability may impact the severity of TCD symptoms, with greater damage occurring in dryer conditions with drought stress

SIMILAR INSECTS OR CONDITIONS

- Fruit tree pinhole borer (*Xyleborinus saxeseni)* resembles walnut twig beetle in size and shape, but can be distinguished using microscope or hand lens
- Symptoms such as leaf yellowing, crown thinning and limb flagging may be due to factors other than TCD

Control measures
Cultural, Mechanical, Biological, Chemical

See next page for additional information

THOUSAND CANKERS DISEASE [TCD] (*Vector: Pityophthorus juglandis.* Causal agent: *Geosmithia morbida*) INVERTEBRATE: INSECT, BARK BEETLE plus DISEASE: FUNGUS, CANKERS

LIFE STAGES AND DISEASE PROCESSES

- Females tunnel egg galleries; lay eggs under bark, typically on branches >0.8 inch diam.
- Beetles introduce *G. morbida* into trees when tunneling—each attack yields a canker
  - Fungal mycelium initially grows around galleries in phloem. Over the next month, black, oval-shaped, inky cankers extend beyond galleries and may grow into cambium
  - Expanding cankers grow together, girdling branches, restricting nutrient movement
  - Bark remains attached to canker rather than sloughing off, impacted areas hard to see
  - Fungus does not appear to provide value to beetles; no fungal sexual stage found yet
- White C-shaped larvae feed 4 to 6 weeks on phloem in vertical meandering tunnels
- Pupation occurs at the end of larval tunnels
- Adults are 0.06 to 0.08-inch long, reddish brown, ≈3 times as long as wide
- Adults emerge through tiny round entry/exit holes and fly to branches to mate
- Beetles potentially have 2 to 3 overlapping generations/year
- Adults may fly nearly year-round, peaking in summer, declining in fall, overwinter in galleries in cold winters. In warmer areas, larval development may continue in winter
- TCD develops slowly; external symptoms may not be visible for up to 20 years
- As tree declines, enormous numbers of beetles are attracted, resulting in many more cankers, hence the name thousand cankers disease
- During advanced disease large branches and trunk may be colonized, bark may have dark amber to black staining, dieback accelerates and tree rapidly declines
- Tree death appears to result from progressive depletion of tree's energy reserves, restricted nutrient flow storage, and possibly, reduced photosynthesis efficiency

TREE SIGNS AND SYMPTOMS

- *Canopy: Thinning, defoliated.* Upper crown thinning progresses to general thinning
- *Leaves: Color change, unseasonable.* Yellowing on exterior of crown, initially on a single branch, then spreading more broadly as disease progresses
- *Leaves: Wilted.* Sudden leaf wilting indicates end stage of disease
- *Twigs/Branches: Dieback.* Localized dieback progresses to more generalized dieback
- *Twigs/Branches: Flagging.* Flagging of smaller branches and limbs
- *Twigs/Branches: Lesions/cankers/wounds.* Cankers in underlying phloem—can gently peel back bark to reveal insects, galleries and cankers
- *Twigs/Branches: Internal discoloration.* Dark discoloration caused by cankers
- *Bark: Exit holes, pinhead sized.* Numerous tiny adult entry/exit holes
- *Bark: Cracking/splitting.* Bark may crack over cankers, but doesn't typically slough off
- *Bark: Staining.* Dark amber to black stain may appear near cankers
- *Beneath bark: Larval galleries, tunneling.* Insects typically attack branches >0.8 inch diam., galleries are 1 to 2 inches long and run parallel or perpendicular to wood grain within cankers; galleries may contain insects, larvae, pupae, frass and/or fungal mycelium
- *Beneath bark: Canker.* Circular to oblong shaped, inky cankers in phloem under bark
- *Trunk: Excessive epicormic sprouting.* Branches may sprout near tree base
- *Trunk: Lesions/cankers/wounds.* Main tree stem attacked/cankered in final stages
- *Full tree: Loss of vigor, weakened.* As girdling from insect attacks and canker growth progresses, larger tree areas are affected
- *Full tree: Death.* Susceptible host trees typically die within 2 to 3 years after leaf yellowing

TREATMENT AND MANAGEMENT OVERVIEW

TCD is difficult to control; focus on early detection and reducing TCD spread

CULTURAL CONTROLS

- Don't transport firewood or dead/dying walnut wood, branches off-site
- Water availability may impact the severity of TCD symptoms, with greater damage occurring in dryer conditions. Keep trees well-watered, well maintained and free of mechanical injury to support tree health and vigor
- Conduct vigorous monitoring program to detect early-stage symptoms; guidelines for using pheromone-baited traps to detect and monitor for walnut twig beetle are available at http://ipm.ucanr.edu/PDF/PESTNOTES/WTB_trapping.pdf
- Some eastern states have quarantines to limit unprocessed wood movement

MECHANICAL CONTROLS

- Remove wood from TCD-infected trees as soon as possible
- Since infested walnut wood is extremely infectious for at least 2–3 years after trees are cut, handle all wood in a way that prevents further spread Treatment methods include:
  - Heat treating wood to ≥ 60°C for ≥ 30 minutes to kill walnut twig beetle
  - Chipping wood is 90% effective at controlling walnut twig beetle
  - Bury wood or store wood in locations where TCD cannot spread
- Inspect walnut tree intended for shipment for any signs of dieback, cankers and galleries after harvest. Remove bark, phloem and cambium to reduce the risk of spreading TCD with shipments

BIOLOGIC CONTROLS

- Entomopathogenic fungi *Metarhizium brunneum* and *Beauveria bassiana* reduced brood production when adult beetles were exposed to both pathogens during testing of biocontrol agents

CHEMICAL CONTROLS

- Systemic insecticide TREE-äge G4 can reduce canopy decline from TCD in walnut crop trees, but impact may be limited to two years after treatment
- Reducing walnut twig beetle populations using traps in combination with applying emamectin benzoate could reduce walnut twig beetle populations and protect valuable crop trees in black walnut stands threatened by TCD

REFERENCE AND RESOURCE WEBSITES

- https://www2.ipm.ucanr.edu/agriculture/walnut/Walnut-twig-beetle/
- http://ipm.ucanr.edu/PDF/MISC/thousand_cankers_field_guide.pdf
- http://ipm.ucanr.edu/PDF/PESTNOTES/WTB_trapping.pdf
- https://thousandcankers.com/wp-content/uploads/2018/08/CSU_TCD_FAQ_7_2012.pdf
- https://agriculture.mo.gov/plants/pests/tcd-pest-alert-from-us-forest-service.pdf
- https://extension.colostate.edu/docs/pubs/insect/1008_alert.pdf
- https://agriculture.ks.gov/docs/default-source/pp---thousand-cankers/detecting-and-identifying-the-walnut-twig-beetle.pdf?sfvrsn=c0a3dca6_0
- https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/thousand-cankers-disease/thousand-cankers-disease

URBAN TREE THREAT

OAK WILT *(Ceratocystis fagacearum)*

DISEASE: FUNGUS, VASCULAR WILT

SIGNS & SYMPTOMS


Leaf discoloration on bur oak (a red oak spp.)


Root grafts formed between oak trees


Leaf discoloration on Texas live oak


Fungal mat under bark of red oak tree


Early oak wilt symptoms on foliage


Fungal mat visible under bark of red oak


Vascular streak due to fungal growth


Bark cracking from underlying fungal matt (pressure cushion)


Northern pin oak (red oak spp.) killed by oak wilt, retaining dead leaves


Aerial view of root graft-caused mortality pattern in live oak

AESTHETIC DAMAGE DEATH

Severity: Can be fatal within 1 year of first sign

OVERVIEW

- Oak wilt is a fungal disease that moves through the xylem (water conducting tissue) of the tree
- All *Quercus* species are susceptible to oak wilt, but symptoms and fatality rates vary. All species of red oak die from the disease, along with most live oaks
- Oak wilt has not yet been detected in Arizona or New Mexico but is a major problem in Texas and other states east of the Rocky Mountains

POTENTIALLY AFFECTED TREES:

- All *Quercus* species are susceptible to oak wilt, but symptoms and fatality rates vary
- Red oaks have severe symptoms and frequently die quickly. Susceptible species include *Q. buckeyli (*Texas red oak/Spanish oak), *Q. coccinea* (scarlet oak), *Q. ellipsoidalis* (pin oak), *Q. marilandica (*blackjack oak), *Q. rubra* (northern red oak), *Q. shumardii* (Shumard's oak) and *Q. velutina* (black oak)
- Live oaks, including *Q. fusiformis* (Texas live oak) and *Q. virginiana* (southern live oak), have intermediate symptoms. Most live oaks die within 60 days to 2 years after symptoms appear, though some survive several years
- White oak symptoms develop more slowly; trees can recover with limited damage, but some trees die. *Q. laceyi* (Lacey oak), *Q. muehlenbergii* (chinquapin oak) and *Q. sinuata var. breviloba* (white shin oak) sometimes form root grafts that spread infection to adjacent trees, which leads to higher infection and mortality rates. Other affected white oaks are *Q. alba* (white oak), *Q. macrocarpa* (bur oak), *Q. polymorpha* (netleaf white oak), *Q. stellate* (post oak) and *Q. vaseyana* (sandpaper oak/ Vasey oak)

Photo sources, left top to bottom:
Photo 1: Photo credit: Fred Baker, Utah State University, Bugwood.org
Photo 2: Photo credit: Joseph O/Brien, USDA Forest Service, Bugwood.org
Photo 3: Photo credit: Ronald F. Billings, Texas A&M Forest Service, Bugwood.org
Photo 4: Photo credit: Robert F. Bassett, USDA Forest Service, Bugwood.org
Photo 5: Photo credit: John N. Gibbs, Forestry Commission, Bugwood.org

Photo sources, right top to bottom:
Photo 1: Photo credit: James Solomon, USDA Forest Service, Bugwood.org
Photo 2: Illustration by: Robert O'Brien
Photo 3: Source: https://texasoakwilt.org/photos/identification
Photo 4: Photo credit: North Carolina Forest Service, Bugwood.org
Photo 5: Source: https://texasoakwilt.org/photos/identification

ALERT: OAK WILT

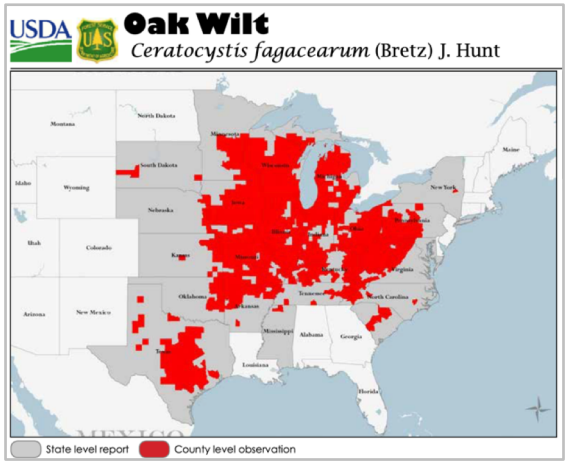
This fungal species has not yet been detected in Arizona or New Mexico

If you think you have detected it: Record location, photograph signs and symptoms, and contact state forestry department:

- In Arizona, email: foresthealth@dffm.az.gov
- In New Mexico, call: (505) 690-8531

GEOGRAPHIC DISTRIBUTION

- Oak wilt not yet been detected in Arizona or New Mexico
- Disease origin is unknown, but likely emerged from Mexico, Central America or South America
- Oak wilt was first identified in Wisconsin in the 1940s, but may have been present decades earlier
- Oak wilt was a major disease in the Upper Mississippi Valley by 1951 and in Texas by the 1960s
- Now found in multiple states east of Rocky Mountains
- Oak wilt has not yet been detected west of the Rocky Mountains or outside the US



Oak Wilt US Distribution Map. Source: USDA Forest Service, Northern Research Station and Forest Health Protection. "Alien Forest Pest Explorer – species map." Database last updated 25 March 2019. https://www.nrs.fs.usda.gov/tools/afpe/maps/ accessed 9/25/22

Control measures: Cultural, Mechanical, Chemical

See next page for additional information

OAK WILT *(Ceratocystis fagacearum)* DISEASE: FUNGUS, VASCULAR WILT

LIFE STAGES AND DISEASE PROCESSES

- Oak wilt grows within tree xylem, reducing water flow. The tree's vascular tissue responds by compartmentalizing fungus in xylem, further restricting water flow
- The disease progresses inward and downward from the tree top, with symptoms appearing as discolored leaves, wilting, dieback, and in many cases death
- In some oak species, root grafts form naturally underground between roots of the same species; spores in infected tree's xylem moves through grafts to infect nearby trees resulting in dying and dead trees surrounding a dead central tree
- Diseased trees can harbor and transmit the disease for several years through the root network
- Following defoliation, fungal mycelial mats (pressure pads) can form under bark of infected red oak trees, typically in spring or fall; mats grow until they split overlying bark
- Mats release fruity odor that attracts sap-feeding beetles. Sticky fungal spores get attached to insects, who fly or are carried on wind to new locations where insects feed on sap of fresh tree wounds, spreading oak wilt infection
- Wind can also spread fungal spores a long distance

TREE SIGNS AND SYMPTOMS VARY FOR DIFFERENT TYPES OF OAKS

Red oak symptoms. *Leaves: Color change, unseasonable.* Young leaves turn pale green then brown; mature leaves turn dark green, pale green or bronze starting at leaf margins and progressing inward. Color change begins on one branch; quickly engulfs entire tree

- *Leaves: Dying/dead leaves remain attached.* This typically occurs on red oaks
- *Canopy: Thinning, defoliated*. Heavy defoliation accompanies wilting
- *Bark: Cracking/splitting.* Inconspicuous narrow cracks form in bark of dying red oaks— remove loose bark to reveal underlying fungal mat
- *Beneath bark: Fungal mat.* Fungal mats appear only on red oak species and grow to 4 to 8 inches, elliptical in shape, colored gray with white margins that darken with age; typically form in spring; have sweet odor that attracts sap-feeding insects
- *Presence of insects.* Sap-feeding beetles may be present on fungal mats, where the insects pick up spores and carry them to uninfected trees that are freshly wounded
- *Beneath bark: Discolored sapwood.* Outermost ring of sapwood may turn dark brown or black due to fungal growth; discoloration appears as streaks when bark is peeled away
- *Trunk: Excessive epicormic sprouting.* Sucker sprouts often form on dying trunks
- *Full tree: Dieback.* Trees dieback quickly
- *Full tree: death.* Red oaks always die, frequently 4 to 6 weeks following symptom appearance

Live oak symptoms. *Leaves: Color change, unseasonable.* Leaf veins turn yellow and eventually brown; or veins may turn darker green than the rest of the leaf; leaf margins turn brown

- *Canopy: Thinning, defoliated.* Defoliation occurs quickly after symptoms appear
- *Trunk: Fungal fruiting bodies.* Weakened trees may be colonized by *Hypoxylon* spp., *Acremonium* spp. (formerly *Cephalosporium* spp.) or other fungi
- *Full tree: death.* Most trees die 60 days to 2 years after symptoms; some may survive longer

White oak symptoms. *Leaves: Color change, unseasonable.* Leaves turn pale green and brown, from leaf margins inward

- *Twigs/Branches: Dieback.* Trees infected ≥two years have isolated branch dieback in crown
- *Twigs/Branches: Internal discoloration.* Brown streaks often are found in the sapwood of infected branches, and appear as a dark ring in branch cross-sections
- *Full tree: death.* White oaks are moderately resistant, but can die over one to several years. Species that form root grafts have higher infection and mortality rates (see Affected trees)

SIMILAR INSECTS OR CONDITIONS

- Oak tree stress due to many causes has similar symptoms
- Anthracnose has similar symptoms

TREATMENT AND MANAGEMENT OVERVIEW

Oak wilt disease cannot be eradicated so stopping spread to new trees is a key management objective. Cultural, mechanical and chemical control methods can assist in stopping disease spread, but all depend on timely detection and confirmation of the disease.

CULTURAL CONTROLS

- Do not store oak wood cut from oak wilt infection areas around healthy oaks
- Protect trees from wounding; treat injured wood right away
- Alert public to the oak wilt threat and inform them of steps to take to identify and address the disease
- Confirm oak wilt disease by sending tree sample to diagnostic laboratory; see https://plantclinic.tamu.edu/files/2010/10/Plant-Disease-Diagnosis-Form-D-1178.pdf for example sample submission form used in Texas

MECHANICAL CONTROLS

- Sap from wounded oaks can attract sap-feeding insects that carry fungal spores, so confine tree pruning and cutting to tree's dormant season
- If trees must be pruned or are mechanically injured when fungal mats are forming (spring) and/or sap is running, quickly paint cuts with wound paint
- For infected species that form root grafts, limit fungal spread by severing root connections between infected and uninfected trees; trench deeply enough to sever all existing roots; after trenching, remove all trees on the diseased side of trench; see: https://www.fs.usda.gov/treesearch/pubs/33446
- Treat infected materials carefully to prevent further spread of oak wilt
- Selective pruning of diseased branches of white oak may prolong the survival of high-value trees; treat the wounds promptly

CHEMICAL CONTROLS

- Soil fumigation can kill grafted roots if trenching is not possible; sodium-n-methyl dithiocarbamate (sold as Vapam®) is commonly used; place fumigant in soil between adjacent diseased and healthy trees; caution: fumigants are highly toxic; consult tree care professional regarding this strategy
- The fungicide propiconazole (sold as Alamo®) can be injected into trees to prevent or suppress oak wilt; injection should be conducted by a tree care professional and is most effective in trees that are symptom-free

REFERENCE AND RESOURCE WEBSITES

- https://texasoakwilt.org/oakwilt
- https://texasoakwilt.org/oakwilt/oak-wilt-management
- https://texasoakwilt.org/resources/materials
- https://palopinto.agrilife.org/files/2015/07/Oak-Tree-Diseases-and-Their-Control.pdf
- https://www.canr.msu.edu/news/oak_wilt_diagnosing_and_preventing
- https://store.extension.iastate.edu/Product/Oak-Wilt-Identification-and-Management-Sustainable-Urban-Landscapes
- https://en.wikipedia.org/wiki/Oak_wilt
- https://usfs.maps.arcgis.com/apps/MapSeries/index.html?appid=9aec8460770d46aa9d073ae7ec2c783e

SIGNS & SYMPTOMS

Canopy: Aleppo pine blight


Discolored needles


Different degrees of blight in group of Aleppo pines


New growth on browning Aleppo pine branch


Dead Aleppo pine

URBAN TREE THREAT

ALEPPO PINE BLIGHT

ABIOTIC THREAT TO URBAN TREES

AESTHETIC **STRUCTURAL DAMAGE** **D**

Severity: Typically aesthetic or structural; occasionally fatal

Aleppo pine blight can result in needles browning. Twigs and branches may die. In most cases tree regrows needles once stressors are reversed. If appropriate tree care is not provided and stress continues, tree condition can deteriorate and occasionally result in death.

OVERVIEW

- A range of environmental factors including drought, heat, wind, poor soil conditions and others can cause sufficient stress to induce Aleppo pine blight
- The result is needles browning, and twigs and branches potentially dying back
- Care consists of using Cultural Controls including increased deep watering to reduce tree stress
- Aleppo pine blight can often be reversed, though trees may have subsequent episodes of blight
- Severely impacted trees can suffer limb death
- If care is not provided to reverse blight, and stressors continue, tree may continue to deteriorate, occasionally leading to tree death

POTENTIALLY AFFECTED TREES:

- *Pinus halepensis* (Aleppo pine)

GEOGRAPHIC DISTRIBUTION

- Aleppo pine blight is common in Southern Arizona
- Has been reported in other Southwest US environments where Aleppo pines grow, including Nevada

Photo sources, top to bottom:
Photos 1, 2 & 3, top two rows: Photo credit Arizona Department of Forestry and Fire Management. Photo 4: Source: Bob Morris Gardening, https://www.reviewjournal.com/local/local-columns/bob-morris/aleppo-pine-blight-damages-trees-grown-in-desert/. Photo 5: Photo credit Ann Audrey

Arizona Forest Health Alert, June 2021
Aleppo pine blight

Excessive summer heat is creating stressful conditions for mature Aleppo pines.

Deep-watering through the hot summer months may help these high-value trees. Irrigating your Aleppo pine during the summer may protect it from disease.

For more information, see: https://dffm.az.gov/sites/default/files/media/APB%20Pest%20Alert%20June%202021%20FINAL.pdf

Contact Aly McAlexander: AZDFFM Forest Health Specialist, amcalexander@dffm.az.gov

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

- Aleppo pines planted in shallow or poorly draining soils are particularly subject to drought stress
- Poor soil drainage caused by underlying hard-pan contributes to blight by hampering root development
- Increasing summer heat and decreasing precipitation intensify symptoms of stress from Aleppo Pine blight disease

SIMILAR INSECTS, DISEASES OR CONDITIONS

- Root rot in Aleppo pines might result in similar symptoms, but this is rare

Control measures: Cultural

See next page for additional information

ALEPPO PINE BLIGHT, ABIOTIC THREAT TO URBAN TREES

IDENTIFICATION AND DISEASE PROCESSES

- It is still unclear exactly what causes Aleppo blight, some factors may be:
  - Water shortage, drought stress, shortage of nutrients during the summer
  - Sun exposure and/or drying winds (chilly or hot)—symptoms usually show up on sun-exposed, windward tops and sides of trees
  - High temperatures causing excessive transpiration coupled with low soil moisture making tree work harder to pull water from the soil—without enough water, tree dries out
  - Drying winds and low relative humidity during fall and spring are associated with onset of symptoms
  - Sudden changes between warm and cold weather in fall/winter can result in insufficient time for tree to enter true winter dormancy
  - Changes from cold to warm temperatures induce needle growth—if tree has insufficient resources to sustain rapid needle growth, it may have excess needle die back
  - Poor root system development due to hard pan, coupled with other stress
- In most cases, Aleppo blight is reversible if tree gets good care as weather warms
- Most affected branches survive and replace brown needles in late spring/early summer as trees begin new growing season
- If some branches have died, new growth can appear below dead parts
- If the tree is severely weakened, tree may be subject to attacks by insects, fungi and bacteria
- Injury tends to reoccur on severely damaged trees. Permanent damage is possible, including occasional death
- Though rare, browning needles and twig death could be related to a more serious disorder such as root rot

REFERENCE AND RESOURCE WEBSITES

- https://dffm.az.gov/sites/default/files/media/APB%20Pest%20Alert%20June%202021%20FINAL.pdf
- https://cals.arizona.edu/maricopa/garden/html/t-tips/cultural/aleppo.htm
- https://ricksgardenspot.blogspot.com/2013/12/aleppo-pine-blight.html
- https://www.reviewjournal.com/local/local-columns/bob-morris/aleppo-pine-blight-damages-trees-grown-in-desert/
- https://mvprogress.com/2014/03/12/garden-spot-aleppo-pine-blight/
- https://cals.arizona.edu/extension/ornamentalhort/plantprotect/pldiseases_urban.pdf

TREE SIGNS AND SYMPTOMS

- *Tree precondition: Stressed or wounded.* Tree stress could be due to prior drought, heat, wind, poor soil conditions or other factors
- *Needles: Color change.* Blighted needles take on a gray-green color that later turns reddish-brown; sun and wind-exposed sides of trees are the most affected
- *Needles: Excessive dropping.* Dead needles can stay on the tree for months
- *Twigs/Branches: Dieback.* If needles and twigs are brittle and snap easily, tree might be experiencing dehydration and death in some parts
- *Twigs/Branches:* Lesions/cankers/wounds. Water-soaked cankers can appear on branches
- *Twigs/Branches: Splitting.*
- *Twigs/branches: Weeping/oozing sap.* Tree sap may sometimes seep from the blighted twigs
- *Full tree: Death.* Injury tends to reoccur on severely damaged trees; permanent damage is possible, with occasional death
- *Other:* Symptoms usually occur in upper tree branches starting in November through February or March
- *Other:* If the tree is severely weakened by blight, other problems may follow including attacks by insects, fungi, and bacteria

TREATMENT AND MANAGEMENT – OVERVIEW

Because Aleppo pine blight is not caused by insects or diseases, but instead by abiotic stressors, trees condition may be improved using cultural controls

CULTURAL CONTROLS

- Aleppo pines are large trees and need strong anchorage in the soil, so water to a depth of at least 3 feet. Deep water at the dripline (outer edge of tree branches) during hot and dry spring and summer months, but do not overwater; for more information, see: https://dffm.az.gov/sites/default/files/media/APB%20Pest%20Alert%20June%202021%20FINAL.pdf
- To retain soil moisture, mulch 2-4 inches deep out to the dripline (outer edge of tree branches); keep mulch pulled away from trunk and root flare
- Nitrogen fertilization may help prevent Aleppo Pine Blight but do NOT over fertilize since that weakens these trees and only fertilize when there's enough water—otherwise fertilizing stresses trees even more
- Watch trees carefully for signs that the problem is getting worse because if the tree is severely weakened by blight, other problems may follow including attacks by insects, fungi, and bacteria

URBAN TREE THREAT

ASH DECLINE (Phytoplasma), Abiotic stress in ash

DISEASE: PHYTOPLASMA, ABIOTIC STRESS

AESTHETIC STRUCTURAL DAMAGE DEATH

Severity: Ash decline caused by phytoplasma infection can lead to tree fatality. Decline due to abiotic stress has the potential to be reversed.

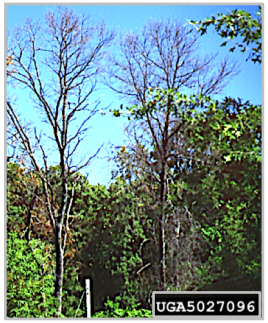
SIGNS AND SYMPTOMS

Verified phytoplasma

Witches broom on Green ash

Abnormal branching

Canopy thinning on White ash



Dead white ash trees

Cause not determined

Witches broom symptoms, Modesto ash, Prescott Valley, AZ

Thinning canopy, cracked bark, Modesto ash, Prescott Valley, AZ

Light green leaves, branch dieback, Tucson

Dead ash tree, Tucson

Cause not determined

Necrotic brown leaves retained on dead branch

Pealing, cracking bark

Epicormic sprouting from trunk

OVERVIEW

Progressive decline of ash trees can have multiple causes:

- Ash Decline refers to a decline-inducing disease caused by phytoplasmas (bacteria-like organisms)
  - Infected trees may live for years or die more quickly, depending on tree health and stress level
  - Drought amplifies the disease
- Progressive decline of ash can also occur due to abiotic stress—stress due to non-living factors
  - This may be caused by unfavorable environmental and/or cultural conditions that reduce tree health and damage trees
  - Determining causes of stress and improving tree care can help address this type of decline in ash trees
- Symptoms observed on ash trees due to phytoplasma infections and due to abiotic stress are sometimes similar, making diagnosis difficult
- Improving tree care to reduce abiotic stress in combination with testing for phytoplasma could be a prudent strategy to address declining ash trees

POTENTIALLY AFFECTED TREES:

- *Fraxinus* species (ash) of all ages subject to Ash Decline caused by phytoplasmas
- In the US, *F. americana* (white ash) and *F. pennsylvanica* (green ash) are often affected; *Syringa* species (lilac) are also affected
- In Arizona, phytoplasma-induced disease has been detected on *F. velutina* (Arizona ash) and *F. velutina* 'Modesto' (Modesto ash)
- *F. oxycarpa (*Raywood ash) may also be affected in Arizona
- Abiotic stress can affect all *Fraxinus* species

GEOGRAPHIC DISTRIBUTION

- Ash decline caused by phytoplasma groups called *Candidatus* Phytoplasma fraxini occurs in US northeast, midwest, Great Plains and Rocky Mountain region and in Canada. It has also been detected in southern Utah
- Ash decline caused by undetermined phytoplasmas is present in Phoenix

Photo sources, left top to bottom:
Photo 1: Photo credit: William Jacobi, Colorado State University, Bugwood.org; Photo 2: Photo credit: USDA Forest Service - Forest Health Protection Eastern Region - St. Paul, MN , USDA Forest Service, Bugwood.org; Photo 3: Photo credit: William Jacobi, Colorado State, University, Bugwood.org; Photo 4: Photo credit: Joseph O'Brien, USDA Forest Service, Bugwood.org
Photo sources, center top to bottom
Photo 1, 2: Photo credit: Jeff Schalau, Photos 3, 4: Photo credit: Ann Audrey
Photo sources, right top to bottom:
Photo 1, 2, 3: Photo credit: Ann Audrey

Control measures: Cultural, Mechanical

See next page for additional information

ASH DECLINE (Phytoplasma), Abiotic stress in ash DISEASE: PHYTOPLASMA, ABIOTIC STRESS

PHYTOPLASMA DISEASE PROCESSES

- Phytoplasmas are a specialized group of bacteria that have no cell wall or nucleus
- Not much is known about this relatively newly recognized disease
- Phytoplasma organisms attack phloem
- It is unknown exactly how Phytoplasma enters a tree and how it spreads
- Phloem-feeding insect vectors are suspected because Phytoplasmas are often spread in the salivary secretions of insects during feeding
- The group of phytoplasmas causing a form of ash decline called Ash Yellows, have been identified as *Candidatus* Phytoplasma fraxini. Different strains of this group vary in aggressiveness and tree impacts
- Symptoms of phytoplasma infection can occur within two or three years of infection
- Symptoms vary depending upon ash species and environment conditions, with some symptoms similar to those caused by abiotic stress
- Both phytoplasma infection and environmental factors can combine to cause premature ash tree death from 2 to 10 years after symptoms appear

TREE SIGNS AND SYMPTOMS FOR PYTOPLASMA INFECTIONS

NOTE: Many signs and symptoms below also occur when ash trees suffer abiotic stress

- *Canopy: Thinning, defoliated.* Defoliation can give trees a sparse look
- *Leaves: Color change, unseasonable.* Leaves turn light green, yellow, chlorotic
- *Leaves: Tip and/or edge necrosis*. Tip/edge necrosis followed by leaves dying, turning brown
- *Leaves: Dying/dead leaves remain attached.* Necrotic brown leaves stay on dead branches
- *Leaves: Undersized.* Leaves are often smaller and thinner than normal
- *Twigs/Branches: Dieback.* Progressive dieback on stems and branches
- *Twigs/branches: Witches broom, tufted foliage.* Undersized foliage grows from buds lower on branches
- *Trunk: Witches broom, tufted foliage.* Tufted foliage may grow on main trunk
- *Bark: Cracking/splitting.* Vertical cracks may form on lower trunk; bark may peel and crack on main trunk and branches
- *Full tree: reduced growth rate.* Infected trees typically grow at much slower rate than non-infected trees (as much as one half the rate); reduced radial and branch growth
- *Full tree: Loss of vigor, weakened.* Trees undergo progressive decline
- *Full tree: Dieback.* Branches in crown begin to die; die-back can continue until crown dies
- *Full tree: Death.*

REFERENCE AND RESOURCE WEBSITES

- https://cals.arizona.edu/yavapai/anr/hort/byg/archive/ashdecline2018.html
- https://en.wikipedia.org/wiki/Candidatus_Phytoplasma_fraxini
- https://www.public.asu.edu/~camartin/plants/Plant%20html%20files/Bricker%20and%20Stutz%20Ash%20Decline.pdf
- http://joa.isa-arbor.com/request.asp?JournalID=1&ArticleID=202&Type=2
- https://hort.extension.wisc.edu/articles/ash-yellows/
- https://www.missouribotanicalgarden.org/gardens-gardening/your-garden/help-for-the-home-gardener/advice-tips-resources/pests-and-problems/diseases/viruses/ash-yellows.aspx
- https://hortnews.extension.iastate.edu/ash-decline
- http://ipm.ucanr.edu/PMG/GARDEN/PLANTS/DISEASES/yellows.html
- https://inaturalist.ca/taxa/900701-Phytoplasma-fraxini

CONDITIONS MAKING TREES MORE SUSCEPTIBLE

Once infected with phytoplasma, environmental conditions and tree health affect how long trees survive—trees experiencing abiotic stress can die quickly; drought is known to amplify the disease.

SIMILAR INSECTS OR CONDITIONS

- Emerald Ash Borer symptoms mimic Ash Decline, so proper identification of cause of decline is important
- Fungi including *Verticillium dahliae* and *Phymatotrichopsis omnivora* cause symptoms with similarities to Ash Decline

TREATMENT AND MANAGEMENT OVERVIEW

There is no known cure for Phytoplasma infection, so focus management on avoiding spread of the disease. If infection is suspected, tree sampling and laboratory analysis are needed to confirm the disease. Diagnosis is done using molecular analysis since the organisms do not survive outside the plant. If disease is confirmed, improving tree care could reduce the severity of symptoms in phytoplasma-infected trees. Improving tree care can also address declining ash conditions due to abiotic stress.

CULTURAL CONTROLS

- Test ash trees for phytoplasma infection if it is suspected
- Do not plant ash trees in areas where ash decline is prevalent
- If ash must be replanted in infected areas, use resistant cultivars
- Increase tree species diversity in the landscape
- Address misplaced or malfunctioning irrigation emitters, fertilize if needed, inspect trees for signs of girdling roots, address sunscald and correct other environmental stresses and cultural practices that negatively impact tree health
- Increase watering during extreme heat and drought using a soaker hose or basin flooding, extending the application of water from the trunk to canopy drip line
- Ensure new ash or other trees are planted at correct depth, roots are uncoiled before planting, irrigation amounts are adjusted seasonally and irrigation locations are adjusted as trees grow

MECHANICAL CONTROLS

- Immediately remove trees testing positive for phytoplasma to prevent disease spread to other trees via insects
- Remove trees that have severe dieback whether caused by phytoplasma or abiotic stress, since they are not likely to recover
- Prune dead limbs using proper pruning techniques
- Practice good sanitation by cleaning cutting and pruning equipment to prevent transmission of disease or pests

IMPACTED TREES

Mechanical mower damage to exposed Roots. Photo credit: David Stephens, Bugwood.org

Tree injured during regrading. Photo credit: Joseph OBrien, USDA Forest Service, Bugwood.org

Sunscald on one side of tree Photo credit: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Sunburned palo verde trunk

MANAGEMENT STRATEGIES

Fencing protecting tree during construction. Photo credit: Peter Bedker, Bugwood.org

Fencing marks access around trees during construction, and woodchips reduce compaction over roots. Photo credit: Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org

Tree protected by wooden structure. Photo credit: Joseph OBrien, USDA Forest Service, Bugwood.org

Protect trunks with mulch circle. Keep mulch 3 to 6 inches from trunk Photo credit: Kansas State

White or light colored tree trunk wraps reflect sunlight and prevent sunscald. Photo credit: Utah State University

Tree guard barrier. Photo source: https://www.plantra.com/Plantra-Trunk-Saver-Mower-Trimmer-Tree-Guard-Brown-12in-Ht-6-Pack-_p_227.html

Sheet protecting fruit tree from freeze

URBAN TREE THREAT

Tree injuries, multiple causes

ISSUES

- Mechanical damage above and/or below ground from yard equipment, vehicles, trimmers, construction activities
- Sunscald and sunburn of sensitive trunks, typically on the side of the tree most exposed to afternoon sun in hot dry climates
- Frost and freeze damage to cold-sensitive trees
- Tree damage from misuse of herbicides, fungicides, insecticides, plant growth regulators (called phytotoxicity)

MANAGEMENT STRATEGIES FOR EXISTING TREES

- Strategies to protect tree trunks from equipment/mechanical damage:
  - Install temporary fencing between trees and construction areas to prevent injury and soil compaction
  - Construct permanent curb-type barriers around trunks to deflect vehicles and yard equipment
  - Remove grass around base of trees and replace with a bed of organic mulch 1 to 2 feet from trunk, keeping mulch 3 to 6 inches from trunk
  - Place plastic or metal trunk guard around trunk to deflect equipment contact and damage—allow for growth of trunk diameter
- Strategies to protect trees from sunscald and sunburn include:
  - Where natural tree canopy structure shades tender bark, keep the natural shade as long as possible, and especially during early tree life.
  - Install white or light-colored trunk guard/sleeve to protect trees from extreme sun exposure. Guards should be 8+ inches tall, large enough to allow trunk growth, and pressed 2 inches into soil to deflect burrowing rodents
  - Paint tree trunk with specially formatted white wash or tree trunk paint products to deflect intense sunlight.
- Help protect cold-sensitive trees from frost and freezing by covering, supplemental heating and/or irrigating; avoid pruning cold-damaged tree until spring
- Use moderation when applying herbicides, fungicides, insecticides, plant growth regulators; follow directions closely; do not apply in high winds or high temperatures; select correct chemicals to meet goals, do not mix products into “chemical cocktails”

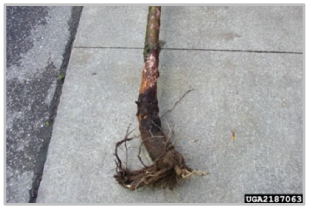
REFERENCE AND RESOURCE WEBSITES – MANAGING TREE INJURIES

- https://extension.psu.edu/prevent-moweritis-from-killing-your-young-trees-and-shrubs
- https://pubs.nmsu.edu/_h/H505/index.html
- https://cals.arizona.edu/yavapai/anr/hort/byg/archive/sunscald2021.html
- forestry.usu.edu/files/utah-forest-facts/sunscald-injury-or-southwest-winter-injury-on-deciduous-trees.pdf
- https://extension.colostate.edu/docs/pubs/garden/02932.pdf
- http://pubs.cahnrs.wsu.edu/publications/wp-content/uploads/sites/2/publications/fs197e.pdf
- https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1222.pdf
- https://extension.umd.edu/resource/phytotoxicity-damage-trees
- https://extension.psu.edu/phytotoxicity

IMPACTED TREES

Girdling or circling roots

Tree planted too deeply; and drainage is poor. Photo credit: William Fountain, University of Kentucky, Bugwood.org



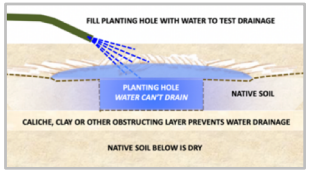
Scots pine planted too deep. Bark in contact with soil rotted and tree failed. Photo credit: Joseph LaForest, University of Georgia, Bugwood.org

Staking wire constricting nutrient flow in phloem under bark. Tree could snap off at constriction. Photo credit: Andrew Koeser, International Society of Arboriculture, Bugwood.org

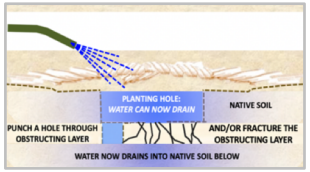
TREE PLANTING TECHNIQUES

Inspect roots before planting

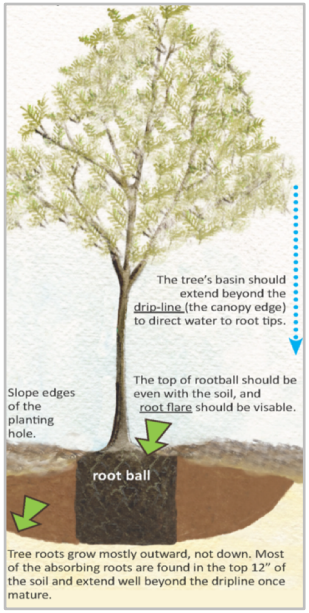
Loosen circling, matted roots



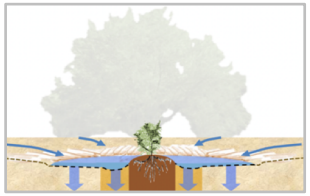
Check planting hole to see if it drains within several hours or if drainage is too slow



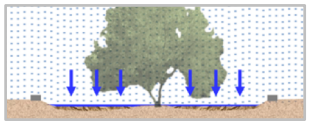
If drainage is slow, fracture or dig through impeding layer to improve drainage



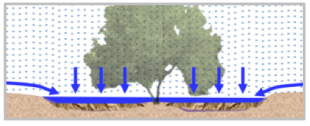
Planting diagram showing width and depth of planting hole and position of root crown relative to top of soil level. Source: http://tucsoncleanandbeautiful.org/wp-content/uploads/2019/06/tree-care-guide-how-to-plant.jpg.png



Place tree on slightly raised planting area if inside a water harvesting basin to protect trunk from frequent inundation



One inch of organic mulch in basin receiving direct rainfall allows rain to penetrate mulch to soil below, and helps reduce evaporation



Two inches of organic mulch in basin with rainfall + runoff further reduces evaporation. Runoff water can flow under thicker mulch to soil below

URBAN TREE THREAT

Tree planting issues

ISSUES

- Girdling roots can restrict water and nutrient flow, weakening trees
- Planting too deep can cause bark to deteriorate; possibly killing the tree
- Poor drainage in planting hole results in water logged soil
- Damage caused by staking wire can reduce water and nutrient flow

MANAGEMENT OF EXISTING TREE

- If tree is showing stress due to girdling roots, consult certified arborist to determine if girdling roots can be removed to save the tree
- To counteract deep planting, carefully remove excess mulch or soil from around the trunk to expose trunk flare and maintain soil at this level
- To improve existing drainage, create vertical drains around tree, fill with gravel to drain water below root zone
- Check staking to ensure tree is not being damaged. Remove staking when tree is stable on its own

PLANTING NEW TREES

- Set up water harvesting system prior to or during planting. Determine basin size, raise elevation of tree in the basin
- Make sure tree well/water harvesting basin drains well. Break or dig through any obstructing layers such as caliche or dense clay
- Plant trees carefully to correct depth (tendency is to plant too deep), following these guidelines:
  - Dig shallow, wide hole (2 - 3 times root ball width) as deep as the root ball
  - Break up any girdling or matted roots on the root ball
  - Only mineral soil, no organic amendments in back fill
  - Set root ball on undisturbed soil to prevent sinking
  - Stake only if necessary; remove stakes 2 to 3 years after planting
  - Do no unnecessary pruning
  - Plant when temperatures favor plant establishment
- Use organic mulch to reduce evaporation and weed growth, insulate soil surface, recycle nutrients and promote root and trunk growth. Keep mulch 3 to 6 inches away from tree trunk

REFERENCE AND RESOURCE WEBSITES - MANAGEMENT OF EXISTING TREE

- https://tfsweb.tamu.edu/uploadedFiles/TFS_Main/Urban_and_Community_Forestry/About_Urban_and_Community_Forestry/Urban_Forest_Information_Sheets/Technical%20Tree%20Solutions%20-%20Correcting%20girdling%20roots.pdf
- https://extension.umd.edu/resource/trees-planted-too-deeply
- https://landscape-water-conservation.extension.org/practices-to-improve-drainage/
- https://cals.arizona.edu/yavapai/anr/hort/byg/archive/treefailures2020.html

REFERENCE AND RESOURCE WEBSITES - PLANTING NEW TREES

- https://www.isa-arbor.com/store/product/104/
- https://cals.arizona.edu/yavapai/anr/hort/mastergardener/mgcourseresources/az1022.pdf
- http://tucsoncleanandbeautiful.org/wp-content/uploads/2019/06/tree-care-guide-where-to-plant.jpg.png
- https://extension.arizona.edu/sites/extension.arizona.edu/files/attachment/SelectingPlantingStaking-2.pdf
- https://www.ose.state.nm.us/WUC/PDF/TreeBrochure.pdf
- https://treenm.org/education/tree-tips/
- https://www.isa-arbor.com/store/product/104/

IMPACTED TREES

Citrus tree died after irrigation system malfunction

Drought stress on netleaf hackberry with insufficient irrigation

Irrigation emitters left too close to trunk; one not working

Eucalyptus planted on mound with insufficient irrigation died during drought

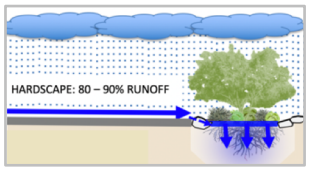
MANAGING WATER SUPPLIES

Checking irrigation systems can prevent malfunctions

Increase irrigation watering in summer, decrease in winter
Source:https://www.youtube.com/watch?v=IjwJFnB6wj4

Irrigation emitters moved out to tree dripline

Soaker hose placed at dripline to support drought stressed tree. Mulch being added to reduce evaporation from soil

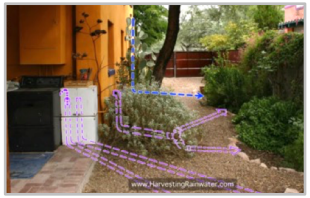


Urban environments yield large volumes of runoff to harvest

Swales retains direct rainfall

Curb cut harvests street runoff

Large-scale green stormwater infrastructure. Photo credit: MRWM Landscape Architects



Combined graywater and roof-top rainwater harvesting. Photo credit: HarvestingRainwater.com

URBAN TREE THREAT

Water supply issues

ISSUES

- Irrigation system issues including malfunctions; wetting trees, need to update timing, volume and emitter locations to meet plant needs
- Ongoing regional drought stressing trees and increasing tree vulnerability to insects, diseases and wildfire
- Increasing pressure to conserve urban potable water use, potentially reducing potable water available to support trees

MANAGEMENT OF EXISTING TREES

- Periodically inspect and repair irrigation system elements
- Adjust sprinklers to ensure they do not wet tree trunks and leaves
- Adjust irrigation timers seasonally to match tree needs; adjust more often if needed during extreme heat and/or drought periods.
- As trees grow, increase the number of emitters and deliver water to tree's drip zone, or extend watering using soaker hose system
- Provide periodic deep watering based on species needs and weather
- Where potable water supplies are limited, increase collection and infiltration of rainwater, stormwater, graywater and condensate water
- Place organic mulch under tree canopies to reduce evaporation loss

STRATEGIES FOR NEW TREES

- Design tree-planting areas to provide reliable long-term water supplies to trees, making maximum use of non-potable supplies including:
  - Retaining and infiltrating (rather than deflecting) direct rainfall
  - Harvesting and infiltrating immediate site rainfall runoff
  - Harvesting and infiltrating stormwater from large roofs, parking lots, streets and other hardscapes (Green Stormwater Infrastructure – GSI)
  - Accessing and delivering graywater from inside buildings to outside planting areas, following prescribed requirements
  - Accessing and delivering condensate water from cold-producing machines (air conditioners, ice machines, etc.) to outside planting areas, following prescribed requirements
- Place a tree carefully relative to water harvesting areas to address the tree's tolerance for temporary inundation
- Design, operate and maintain irrigation systems per list above
- Place organic mulch under tree canopies to reduce evaporation loss

REFERENCE AND RESOURCE WEBSITES - MANAGEMENT OF EXISTING TREES

- https://www.amwua.org/resource_documents/drip_irrigation_guide.pdf
- https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1392-2016_0.pdf
- https://www.ose.state.nm.us/WUC/PDF/IrrigationBasics2004.pdf
- https://pubs.nmsu.edu/_h/H707/index.html

REFERENCE AND RESOURCE WEBSITES - STRATEGIES FOR NEW TREES

- https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1916-2021.pdf
- https://watershedmg.org/learn/resources/GSI
  https://legacy.azdeq.gov/environ/water/permits/download/graybro.pdf
  https://www.ose.state.nm.us/WUC/PDF/NewMexGWGuide.pdf
- https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/Glawe%20UA%20Condensate%20Powerpoint.Nov-12-14.pdf

SELECTION AND PLACEMENT ISSUES

Large tree on small right of way obstructing sidewalk and traffic intersection and growing into power lines

Tall tree had to be heavily pruned due to powerline conflict

Tree on slope has exposed roots due to erosion and needs heavy staking for stability

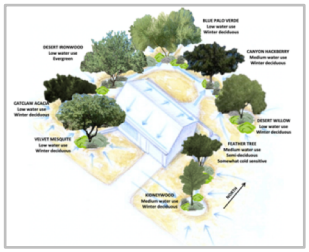
Higher water use tree died during drought. Low water use tree survived

BENEFICIAL TREE SELECTION & PLACEMENT

Tall conifers placed between building and overhead power lines with ample room to grow to full size

Small stature whitethorn acacia appropriate for planting under powerlines

Arizona cypress in public space with ample space to reach maturity without heavy pruning



Example tree placement based on solar angles, heat tolerance, water needs and other factors
Source: https://tucsoncleanandbeautiful.org/native-trees-for-tucson/

Low water use plant lists are available throughout Arizona
Source: https://new.azwater.gov/conservation/landscaping

Map of projected New Mexico climate zones by the year 2100. Climate resilient plants lists are available throughout New Mexico
Source: https://treenm.org/wp-content/uploads/2022/08/Climate-Ready-Trees-Zone-Lists-6.23.22.pdf

URBAN TREE THREAT

Tree selection and placement issues

ISSUES

- Tree canopies growing into overhead utility lines
- Trees obstructing sidewalks, streets, intersections or other access
- Trees planted on mounds resulting in exposed roots and other issues
- Higher water use trees

MANAGEMENT OF EXISTING TREES

- Use certified utility tree trimmers to prune trees that have reached or may reach powerlines
- Prune trees as needed to provide necessary access
- Stabilize eroding slopes or mounds where trees are planted to prevent further soil erosion and provide more solid footing for trees
- Assess tree condition during extreme weather/climate conditions and provide additional water or other assistance to keep trees healthy

STRATEGIES FOR SELECTING AND PLACING NEW TREES

- Learn tree characteristics and their suitability to basic site conditions including sun/shade patterns, prevailing wind and storm patterns, heat and cold extremes, soil type, drainage, taking into account user needs for evergreen and/or deciduous species, solar panel access, etc.
- Anticipate future changes in climate including average and extreme high/low temperatures, rainfall and other key climate conditions
- Learn about heat- and drought-tolerant species for placement in hot, harsh urban environments, including native southwest US tree species
- Take into account insect and disease infestations that are present or potentially coming to an area, and choose species that are resistant, especially in locations where infested trees have been removed
- Learn tree water needs and determine how to consistently meet these needs. If water supply may be scarce due to drought and/or limitations on potable water use, select drought tolerant, low water-use species, including native southwest trees
- Place trees in locations that provide sufficient space for their mature canopy size, taking into account:
  - Presence of underground and overhead utility lines
  - Access that will be needed for sidewalks and streets
  - Safe view lines that will be needed for pedestrian and drivers
  - Presence of buildings and walls, distance to nearby trees

REFERENCE AND RESOURCE WEBSITES - TREE SELECTION AND PLACEMENT

- https://wwv.isa-arbor.com/store/product/104/
- https://new.azwater.gov/conservation/landscaping
- https://dffm.az.gov/sites/default/files/media/APS%20Right%20Tree%20Right%20Place%20Brochure-EN.pdf
- https://www.aztrees.org/Resources/Documents/Planting_Guides/RightTreeRightPlace_guide.pdf
- https://treenm.org/wp-content/uploads/2022/08/Climate-Ready-Trees-Zone-Lists-6.23.22.pdf
- https://www.nature.org/content/dam/tnc/nature/en/documents/Climate-Ready-Trees-Report-Nov2020.pdf
- https://www.youtube.com/watch?v=EI5HbSKm-CQ

IMPACTED TREES

Extreme pruning stresses tree and drastically reduces shade

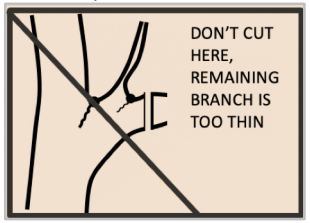
Dead wood needing pruning

Angular cut too close to branch collar weeping sap, stressing tree

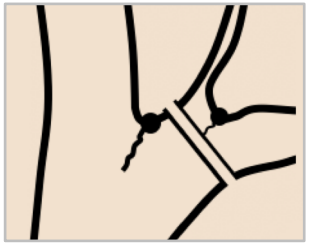
Trees at urban-rural fringe exposed to wildfire danger

GOOD PRUNING PRACTICES

Native multitrunk tree pruned to maintain natural structure casts deep shade



Do not prune lower branch since upper branch is too small to reroute the water and energy



Instead, prune off both right-side branches. Reroute water and energy through the main trunk

Large tree was vulnerable to wildfire due to shrub/understory

Wait several years before pruning young trees to allow hormones made in branch tips to assist in root growth

Perpendicular circular cut outside branch collar with out stub promotes wound sealing

Firewise trimming protected tree and house from wildfire

URBAN TREE THREAT

Tree pruning issues

ISSUES

- Incorrect and extreme pruning can distort, damage and stress trees, making them vulnerable to pests and drastically reducing shade
- Lack of Firewise trimming can leave trees at urban-rural fringe more vulnerable to wildfire

PRUNING MANAGEMENT TO SUPPORT TREE HEALTH

- Prune only the parts of tree that are dead, damaged, in the way of needed access, having conflicts with utility lines, having potential windthrow problems and other issues
- Do not force multitrunk trees into single trunk forms
- Use proper pruning practices including:
  - Use sharp pruning tools to make clean cuts
  - Prune at junctions where branches divide, where remaining branch is growing up and out and at least 1/3rd the diameter of the cut branch
  - Make perpendicular cuts just outside branch collar to create small circular wounds that tree can efficiently seal
  - Prune trees at appropriate times of year for the health of trees
  - Allow 2 - 3 years of growth before a tree's first pruning because hormones made in a tree's branch tips assist in root growth
  - Do not prune more than 20 – 25% of a tree at any one time
  - Do not top trees unless absolutely necessary
  - Clean pruning equipment; destroy cut diseased/infested plant material
- After removing what must be pruned to meet site goals, leave the rest of the tree in its natural form so abundant leaves can fuel growth, thicker canopies can provide deeper shade, broad canopies can deflect winds

FIREWISE PRACTICES TO PROTECT TREES FROM WILDFIRE

- Conduct Firewise trimming to reduce the potential for a site to carry wildfire that damages trees and structures
- Avoid vertical continuity of ladder fuel within 100 feet of structures by removing shrubs and grasses that are under or close to trees
- Avoid horizontal continuity of fuel within 100 feet of structures by creating gaps between neighboring trees and shrubs to slow fire
- Mow or trim grasses to a low height within defensible space
- Keep plants that are near buildings well watered during wildfire season

REFERENCE AND RESOURCE WEBSITES - PRUNING MANAGEMENT TO SUPPORT TREE HEALTH

- https://extension.arizona.edu/sites/extension.arizona.edu/files/attachment/PruningTreesandShrubs-2.pdf
- https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1139-2015.pdf
- https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1455.pdf
- https://pubs.nmsu.edu/_h/H156/index.html
- https://pubs.nmsu.edu/_h/H327/index.html
- https://www.isa-arbor.com/store

REFERENCE AND RESOURCE WEBSITES - FIREWISE PRACTICES TO PROTECT TREES FROM WILDFIRE

- https://dffm.az.gov/sites/default/files/media/LivingWithWildfire_HomeownersFirewiseGuideForArizona_June2016.pdf
- https://www.emnrd.nm.gov/sfd/wp-content/uploads/sites/4/LivingwithFire_2018_NMStateForestry_FINAL.pdf

Urban Tree Threat Response Guide for Arizona and New Mexico

The Guide is available to download at: http://www.urbantreethreatsaznm.org, along with a searchable threat Directory

Organizations listed below provide on-going information about existing and emerging insect and disease threats of relevance to tree health in urban and community forests in Arizona and New Mexico

Arizona Department of Forestry and Fire Management, Forest Health
https://dffm.az.gov/forestry-community-forestry/forest-health

Arizona Department of Forestry and Fire Management, Urban and Community Forestry
https://dffm.az.gov/forestry-community-forestry/urban-community-forestry

Arizona Cooperative Extension
https://extension.arizona.edu/forest-health

New Mexico, Energy, Minerals, and Natural Resources Department, Forest Health
https://www.emnrd.nm.gov/sfd/forest-health/

New Mexico, Energy, Minerals, and Natural Resources Department, Urban and Community Forestry
https://www.emnrd.nm.gov/sfd/urban-and-community-forestry/

New Mexico Cooperative Extension
https://extension.nmsu.edu

California Statewide Integrated Pest Management Program
http://ipm.ucanr.edu/index.html

Colorado Integrated Pest Management
https://agsci.colostate.edu/agbio/ipm/

Texas Integrated Pest Management Program
https://ipm.tamu.edu

Utah Integrated Pest Management
https://extension.usu.edu/pests/ipm

USDA Animal and Plant Health Inspection Service
https://www.aphis.usda.gov/aphis/resources/pests-diseases

Don’t Move Firewood Organization
https://www.dontmovefirewood.org