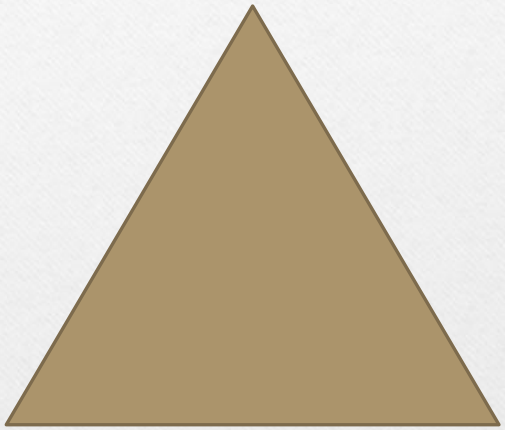
The Forest Health Triangle

Tree resistance



Pest virulence

Environment - microbiota??

- Soil (mostly abiotic)
- Weather (abiotic)
- Climate (abiotic)
- Injury (abiotic?)
- Pollutants and pesticides (abiotic)

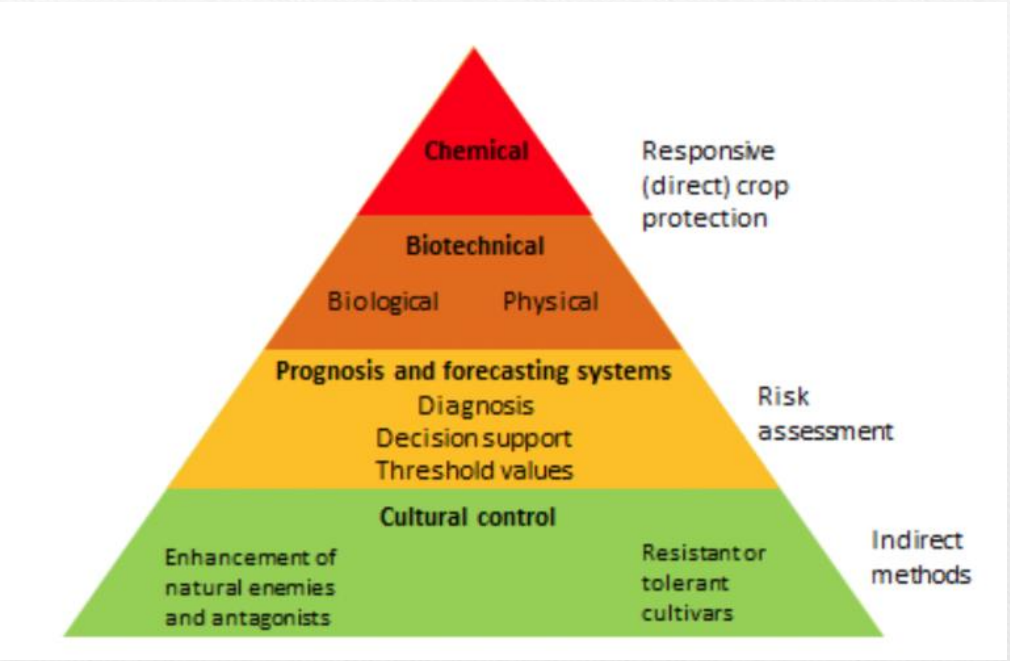
Forest Health Management - Actions to reduce or eliminate the pest or abiotic damage; i.e. biocontrol, pruning, sanitation, pesticides, mulching, irrigation.

Forest Health Monitoring - Methods to detect and quantify presence of pests, amount and type of damage, i.e. surveying, trapping, public awareness.

Resiliency - Forests ability to adjust to, recover, regenerate, withstand, or survive, stress from unpredictable pests (invasive species) or abiotic agents. i.e. species diversity, genetics and provenance (esp. for tree nurseries) geographic (landscape) diversity, age-class diversity, habitat fit, long-term adaptive forest management planning. THIS IS WHERE TREE HARVESTING IS BENEFICIAL – IF DONE WITH THESE GOALS IN MIND.

Adaptive management - Science-based management that tests assumptions, monitors results and adjusts actions. The goal does not change but the method to get there is flexible.

- **Integrated pest management:** IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.



Pest: Organism that damages crops, ecosystems, human enjoyment or health, or any desired trait or product from the environment (SUBJECTIVE (White tail deer, *Odocoileus virginianus*))

Beneficial organisms: Organisms that are typically not directly valuable to humans, however, provide pest control, pollination, nutrient cycling or other ecosystem services; i.e. woodpeckers.

Non-target organisms: Organisms damaged from pest control practices unintentionally.

Biocontrol: Intentional use of organisms that out-compete, prey upon, or parasitize (infest or exploit) the target pest, with the object of reducing or eliminating the damage. Now carefully tested and regulated before release.

Range (not always contiguous): The un-aided by humans, natural geographic occurrence of an organism. Range can naturally expand or shrink.

Native: An organism inside its natural range, usually having survived in a range for long enough to have adapted and evolved in the habitat and is a part of the food web.

Exotic: An organism introduced directly or indirectly by humans.

Naturalized: An exotic organism that has survived in a new range long enough to be well established, unassisted by humans.

Invasive: Exotic organism that is spreading through out-competing native species and is causing damage to the ecosystem or the utility of the forest.

Mid-Atlantic climate change assessment:
https://forestadaptation.org/assess/ecosystem-vulnerability/mid-atlantic
(Comes out of USDA and American Forests funding for Climate Hubs → Climate Change Response Framework)

SUMMARY (365 pages):

- Warmer temperatures all seasons, more variable precipitation; longer dry periods interspersed with more frequent heavy rains.
- Wildfire risk increase.
- More vulnerable tree regeneration (germination and seedling survivability).
- Southern spp up; Northern spp. down.
- Invasive plants, pests, and pathogens likely up.
- Coastal forest and lowland conifer (Atlantic white cedar) more vulnerable.
- Oak & pine forests low vulnerability
- Adaptation resources listed.

Assisted migration: Human-assisted movement of species in response to climate change.

- Natural or human barriers/habitat fragmentation
- Need to adjust to new soils, pests, other climate factors, etc. NOT just warmer temps.

- Projections of High and Low climate change; multiple projections out to 2070 to 2099.

- Large and diverse groups of experts form a consensus.

CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES
MID-ATLANTIC REGION

This region's forests will be affected by a changing climate and other stressors during this century. A team of managers and researchers created an assessment that describes the vulnerability of forests in the region (Butler-Leopold et al. 2018). This report includes information on observed and future climate trends, and also summarizes key vulnerabilities for forested natural communities. The Landscape Change Research Group recently updated the Climate Change Tree Atlas, and this handout summarizes that information. Full Tree Atlas results are available online at www.fs.fed.us/nrs/atlas/. Two climate scenarios are presented to "bracket" a range of possible futures. These future climate projections (2070 to 2099) provide information about how individual tree species may respond to a changing climate. Results for "low" and "high" emissions scenarios can be compared on the reverse side of this handout.

The updated Tree Atlas presents additional information helpful to interpret tree species changes:

- Suitable habitat - calculated based on 39 variables that explain where optimum conditions exist for a species, including soils, landforms, and climate variables.
- Adaptability - based on life-history traits that might increase or decrease tolerance of expected changes, such as the ability to withstand different forms of disturbance.
- Capability - a rating of the species' ability to cope or persist with climate change in this region based on suitable habitat change (statistical modeling), adaptability (literature review and expert opinion), and abundance (FIA data). The capability rating is modified by abundance information; ratings are downgraded for rare species and upgraded for abundant species.
- Migration Potential Model - when combined with habitat suitability, an estimate of a species' colonization likelihood for new habitats. This rating can be helpful for assisted migration or focused management (see the table section: "New Habitat with Migration Potential").

Remember that models are just tools, and they're not perfect. Model projections can't account for all factors that influence future species success. If a species is rare or confined to a small area, model results may be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Planting programs may assist the movement of future-adapted species, but this will depend on management decisions. Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change.

SOURCE: This handout summarizes the full model results for the Mid-Atlantic region, available at www.fs.fed.us/nrs/atlas/combined/resources/summaries. More information on vulnerability and adaptation in the Mid-Atlantic region can be found at www.forestadaptation.org/mid-atlantic. A full description of the models and variables are provided in Iverson et al. 2019 (www.nrs.fs.fed.us/pubs/57857 and www.nrs.fs.fed.us/pubs/59105) and Peters et al. 2019 (www.nrs.fs.fed.us/pubs/58353).

CLIMATE CHANGE CAPABILITY

POOR CAPABILITY	
American holly	Pin oak
Atlantic white-cedar	Pitch pine
Balsam fir	Quaking aspen
Bigtooth aspen	Red pine
Black ash	Red spruce
Black spruce	Shingle oak
Bur oak	Striped maple
Eastern cottonwood	Swamp white oak
Eastern hemlock	Sweet birch
Eastern white pine	Tamarack (native)
Flowering dogwood	Virginia pine
Jack pine	White ash
Northern white-cedar	White spruce
Paper birch	Yellow birch
FAIR CAPABILITY	
American beech	Pond pine
Black cherry	Silver maple
Boxelder	Sweetbay
Overcup oak	
GOOD CAPABILITY	
American basswood	Northern red oak
American elm	Pignut hickory
Bald cypress	Post oak
Bitternut hickory	Red maple
Black locust	Scarlet oak
Black oak	Shagbark hickory
Black walnut	Shortleaf pine
Blackgum	Southern red oak
Blackjack oak	Sugar maple
Chestnut oak	Sweetgum
Chinkapin oak	Sycamore
Eastern redcedar	Water oak
Loblolly pine	White oak
Mockernut hickory	Yellow-poplar
NEW HABITAT WITH MIGRATION POTENTIAL	
Loblolly-bay	Water tupelo
Longleaf pine	Winged elm

NIACS
Northern Institute of Applied Climate Science

www.forestadaptation.org

White Oak: Thomas, Austin M.; Coggeshall, Mark V.; O'Connor, Philip A.; Nelson, C. Dana. 2024. Adaptive Strategies of White Oak (*Quercus alba*) in Response to Climate Change: Insights from a 40-Year Study of Growth and Phenology [Abstract]. In: Martens, C.; Clark, S.; Schweitzer, C. 2024. The International Oak Symposium: Science-based Management for Dynamic Oak Forests. Gen. Tech. Rep. SRS-278. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 79.

- Actual past results.
- Wide ranging species have genetic "provenances" across their range.
- One planting of individuals from across range showed southern provenances outcompeting northerners.

Signs - Direct Evidence

The pest, pest parts (cast skins, cocoons, eggs, mushrooms), frass, holes, feeding marks, leaves missing, parts chewed off and dropped, webs, rolled leafs and "tents".

Vs.

Symptoms - Plant's Reactions

The plant's reaction due to the presence of the pest (death, drying, cankers, leaf drop, spotting, oozing, weeping, wilting, abnormal size, shapes, color, galls, etc.) – often part of the plant's IMMUNE SYSTEM.

Fungi

Anthracnose, rusts, needle casts, wood rot, cankers, wilts.

Armillaria Root Rot

Causal Agent: *Armillaria mellea* and other spp.

Species affected: Many. In Delaware, very common on Virginia pine and bigtooth aspen. Also common on oaks and loblolly pine.

Symptoms/Signs: Rhizomorphs ("shoestrings"), honey mushrooms, white mycelial fans, top dieback. Peel back loose bark to see mycelial fans and rhizomorphs near ground level.

Treatment: No reliable treatments.

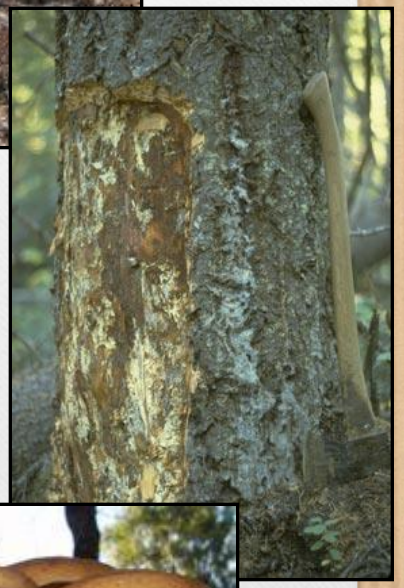
Prevention: Prevent stress.

Prognosis: Decline & mortality.

Recommendations: *Armillaria* is worsened by stress. Prevent stress as much as possible. Infected urban trees should be removed before they fall.

Armillaria is relatively common throughout the USA. It is part of our "background" mortality. Drought stress leads to more Armillaria mortality.

Rhizomorphs (fibrous texture)



Mycelial fans

Hypoxylon Canker

Causal Agent: *Hypoxylon atropunctatum*

Species affected: Mainly oaks (red & white), also beech, sycamore, maple, and elm.

Symptoms/Signs: Flagging, branch and stem dieback. Sloughing bark reveals distinctive stroma, which can be gray, tan, or black. Small black pycnidia (fruiting bodies) sometimes present on stroma.

Treatment: None.

Prevention: Prevent stress. Water trees.

Prognosis: 100% mortality within 1-2 growing seasons.

Recommendations: Infected urban trees should be removed. *Pruning is ineffective and a waste of money*. Will not spread to other trees.

Hypoxylon is very common on oaks due to 2006-2008 drought stress. Do not confuse stroma (smooth texture) with lichens (rough texture, harmless).

Stroma

Verticillium Wilt

Causal Agent: *Verticillium dahliae*

Species affected: Redbud, maples (especially Norway & Japanese), yellow-poplar, elm.

Symptoms/Signs: Wilting & dieback, often on one side of a tree. Splitting bark on trunk on the same side as the branch symptoms. Vascular streaking in symptomatic twigs is diagnostic (cut at an angle and look for blue, green, or brown).

Treatment: Prune symptomatic branches. Sanitize shears between cuts with Lysol. Keep trees well-watered.

Prevention: Avoid stress. Water during drought.

Prognosis: Mortality of symptomatic trees likely within 5 years.

Recommendations: Prune as needed. Remove severely declining trees. Replant with a non-susceptible host since the fungus remains in the soil for many years.

Verticillium wilt moves slowly through soil, infecting stressed & sometimes healthy trees. The disease is common on landscape trees but rare in the woods.

Vascular streaking on redbud

Butt & Heart Rots

Causal Agent: Various fungi

Species affected: All trees.

Symptoms/Signs: Mushrooms or conks, especially below eye leve
Holes & rotted material around root collar. Dieback & crown decline.

Treatment: Depends on pathogen, host, & severity.

Prevention: Prevent stress to reduce incidence & severity.

Prognosis: Refer to ISA-certified arborist if hazard tree.

Recommendations: There are 2 types of rots. Brown rot leaves brown rectangles of brittle wood. White rots cause the entire wood structure to deteriorate into a punky white material. Both are potentially serious and can lead to failure. Important for indentifying HAZARD TREES!

Mushrooms or conks indicate significant rot inside the tree. An arborist can determine the extent of decay and structural integrity. Trees in the woods can sometimes be salvage harvested or left alone.

Bacteria

(Just a few diseases)

Bacterial Leaf Scorch (BLS)

Causal Agent: *Xylella fastidiosa*

Species affected: Red oaks, especially northern red, pin, scarlet, and black. Also elm, ash, mulberry, and Norway maple.

Symptoms: Marginal scorch (August to October only). A yellow "halo" may be visible between scorched and green tissue. Progressive dieback of branches over years.

Treatment: No proven treatments. Professionals can provide an injection containing oxytetracyclen, an **antibiotic** used in treating **leaf scorch**. The **antibiotic** is injected into the root flare at the base of the tree and must be repeated annually to add a few years to the tree.

Prevention: No proven prevention.

Prognosis: Steady decline over a period of years. Eventual mortality likely. Safety issues around targets. BLS-induced stress may lead to *Hypoxylon* mortality or other issues.

Recommendations: Water trees during drought. Prune dead branches as needed. Replace with non-BLS-prone trees after mortality.

BLS is very common statewide on pin and northern red oaks in urban areas. It has also been confirmed in rural forests in all three counties. Disease progression is poorly understood.

Image: Nancy Gregory, University of Delaware

Bacterial Wetwood

Causal Agent: Various bacteria

Species affected: Most hardwoods. Especially common on elm, poplar, ginkgo, apple, dogwood, and maple.

Symptoms/Signs: Liquid oozing from wounds or crotches. Black when fresh, then drying to ash-gray. Sometimes colonized by brightly-colored fungi.

Treatment: None.

Prevention: Avoid wounding trees.

Prognosis: Rarely more than an aesthetic issue.

Recommendations: Do nothing.

This disease is common statewide on selected species. Bacteria reproduce in the heartwood, resulting in excess pressure which is relieved by seepage through weak areas.

Fire Blight

Causal Agent: *Erwinia amylovora*

Species affected: Mainly apple and pear, but also mountain-ash, plum, quince, and hawthorn.

Symptoms/Signs: Blackened terminals in spring/summer with a distinctive "shepherd's crook" appearance. Oozing cankers may be present.

Treatment: Prune branches 12" back from lowest black. Sanitize shears between cuts with Lysol.

Prevention: Apply streptomycin or copper-based solution when leaves have expanded to ¼". Plant resistant varieties (any "Delicious" apple or "Moonglow" pear).

Prognosis: Hard to predict; depends on weather & other factors.

Recommendations: Prune as needed and be aware that the problem will be ongoing. Replace dead trees with resistant varieties or non-host species. Sprays are not a great option because timing is critical.

Fire blight is a bacterial disease spread by insects & sometimes wind, rain, & gardening tools. It is very common on Bradford pear and can kill trees.

Oomycetes

"water molds" (but NOT in the fungal kingdom). Root rots, downy mildew, damping off, Irish potato famine!

Phytophthora Root Rot

Causal Agent: *Phytophthora* spp.

Species affected: All trees.

Symptoms/Signs: Crown dieback. Dark, oozing stem cankers near the ground. Dissecting cankers reveals dark streaking that is continuous from the roots to canker sites. No fruiting bodies.

Treatment: None.

Prevention: None, but preventing stress may help.

Prognosis: Decline & mortality, sometimes within one growing season.

Recommendations: *Phytophthora* root rot is more common than we have realized. It is probably responsible for some mortality that we have not been able to diagnose.

Assume declining and dead trees with oozing cankers near ground level suffer from Phytophthora root rot until proven otherwise. Trees on wet soils are more prone, but it is present everywhere.

Nematodes and Insects

(invertebrates)

Ambrosia Beetles

Causal Agent: *Platypus* spp. (pines) & *Xylosandrus crassiusculus, Xylosandrus germanus* (hardwoods)

Species affected: Pines & hardwoods, especially fruit trees, maple, redbud, persimmon, pecan, Kousa dogwood, and sweetgum.

Symptoms/Signs: Lots of fine frass around base of tree, toothpick-like tubes of fresh frass sticking out from branches and stems, winding galleries under bark. Small beetle holes packed with frass. Wilting foliage. Adults resemble SPB.

Treatment: Trees can be sprayed with Astro or Onyx during the active period (April).

Prevention: Minimize stress by watering and avoiding wounding.

Prognosis: Stress from infestations leads to other problems.

Recommendations: The native *Platypus* generally infests dying pines and is secondary to another problem. The exotic *Xylosandrus* can infest stressed or healthy hardwoods. Reducing stress may be as effective as spraying infested trees.

Ambrosia beetles inoculate their galleries with a fungus to create a garden, their only food source.

Two-Lined Chestnut Borer

Causal Agent: *Agrilus bilineatus*

Species affected: Oaks.

Symptoms/Signs: Crown decline and D-shaped exit holes on stems and branches. Zig-zag galleries under bark. Adults are ½" long, black with 2 white or gold lines down the back.

Treatment: Apply an imidacloprid soil drench (Bayer Advanced Tree & Shrub Insect Control), following label instructions, if at least 2/3 of the crown appears healthy. Apply in April/May or September/October for best results.

Prevention: Reduce stress by watering.

Prognosis: Soil drench is effective unless tree is in severe decline.

Recommendations: Repeat soil drench as needed. Remove trees in severe decline.

This pest mainly affects oaks that are stressed due to drought, BLS, or injury.

Spongy (fka "Gypsy") Moth

Causal Agent: *Lymantria dispar*

Species affected: Many, but especially white oaks and sweetgum.

Symptoms/Signs: Buff-colored egg masses on bark. Larvae grow to 2" long and have five pairs of blue spots and six pairs of red spots.

Treatment: Spray with Bt or other insecticide.

Prevention: None, but wet springs lead to reduced GM populations.

Prognosis: Consecutive years of defoliation can lead to mortality.

Recommendations: Spray only for severe infestations.

DFS receives many calls about gypsy moth, but most are actually ETC. Gypsy moth activity has been minimal since 1996 due to a pathogenic fungus. Some activity in the Great Cypress Swamp was seen from 2006 to 2009 and 2020 SE of Frankford.

Gypsy moth egg mass
Photo: forestryimages.org

Eastern Tent Caterpillar (ETC)

Causal Agent: *Malacosoma americanum*

Species affected: Primarily cherry and other fruit trees.

Symptoms/Signs: Nests in crotches. Larvae are black & hairy, with one white stripe along the length of the body and blue dots on either side of the stripe. Grow to 2.5" long.

Treatment: Not generally required. Tents can be removed manually. Bt or other insecticides can be applied.

Prevention: None.

Prognosis: Rarely kills trees.

Recommendations: Do nothing.

DFS receives many calls in the spring as eggs hatch and tent construction begins.

Fall Webworm

Causal Agent: *Hyphantria cunea*

Species affected: Primarily pecan, hickory, and cherry.

Symptoms/Signs: Webs on terminal branches. Larvae bristly, yellow or gray with yellow spots, up to 1.5" long.

Treatment: Not necessary.

Prevention: None.

Prognosis: No significant damage.

Recommendations: Remove webs by hand if desired.

Fall webworm is very common on selected species and DFS receives many calls from concerned landowners.

Southern Pine Beetle (SPB)

Causal Agent: *Dendroctonus frontalis*

Species affected: Loblolly, Virginia, and other hard pines.

Symptoms/Signs: Discolored needles, decline, small holes on trunk, blue stain fungus, S-shaped galleries under bark, pitch tubes. Adults very small, black. Usually clusters of trees, not single trees.

Treatment: Remove infested trees and trees in a buffer zone around the infestation. Chip, spray, or haul cut trees.

Prevention: None, but early detection helps control efforts.

Prognosis: Infested trees are killed by blue stain fungus and galleries.

Recommendations: Aerial surveys in June should pick up any significant infestations but foresters should be aware of this pest, particularly south of Dover.

SPB has not caused major problems in Delaware in the past few years, (since 2015/16).

“Recent” invasive invertebrates

Emerald Ash Borer (EAB)

Causal Agent: *Agrilus fumipennis*

Species affected: Ash and (somewhat) fringe tree (*Chionanthus virginica).*

Symptoms/Signs: Dieback, epicormics, split bark, winding galleries under bark, D-shaped exit holes, woodpecker activity. Adults are shiny green, ½" long.

Treatment: Soil drench application of imidacloprid for trees with minimal dieback. Certified arborists can inject emamectin benzoate for 2-year to 3-year protection.

Prevention: ***70 percent green canopy needed!*** Soil drench application of imidacloprid or inject emamectin benzoate for 2-year to 3-year protection.

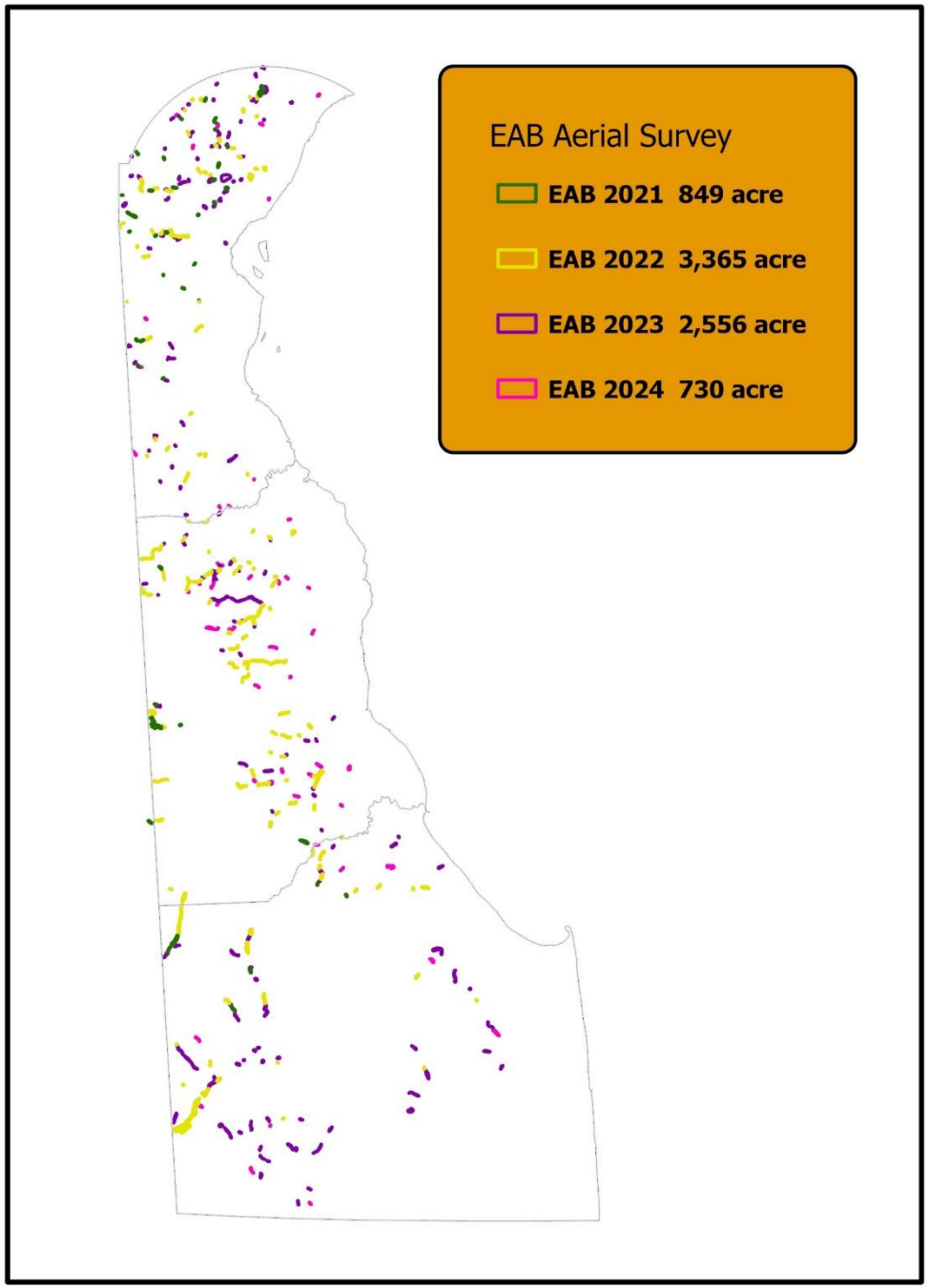
Prognosis: Decline & mortality of untreated trees in 4-7 years.

Recommendations: Treat ash now! Remove hazard trees before they die as they become brittle and more difficult to remove when they die.

EAB has swept through Delaware (2021 to 2024)!

EAB just swept through

- Organize volunteers for lingering ash
- Treesnap app
- Monitor i-Naturalist and other sources



Beech Leaf Disease (BLD)

Causal Agent: *Litylenchus crenatae mccannii*, a microscopic roundworm

Species affected: *Fagus* genus. American beech, European beech, etc.

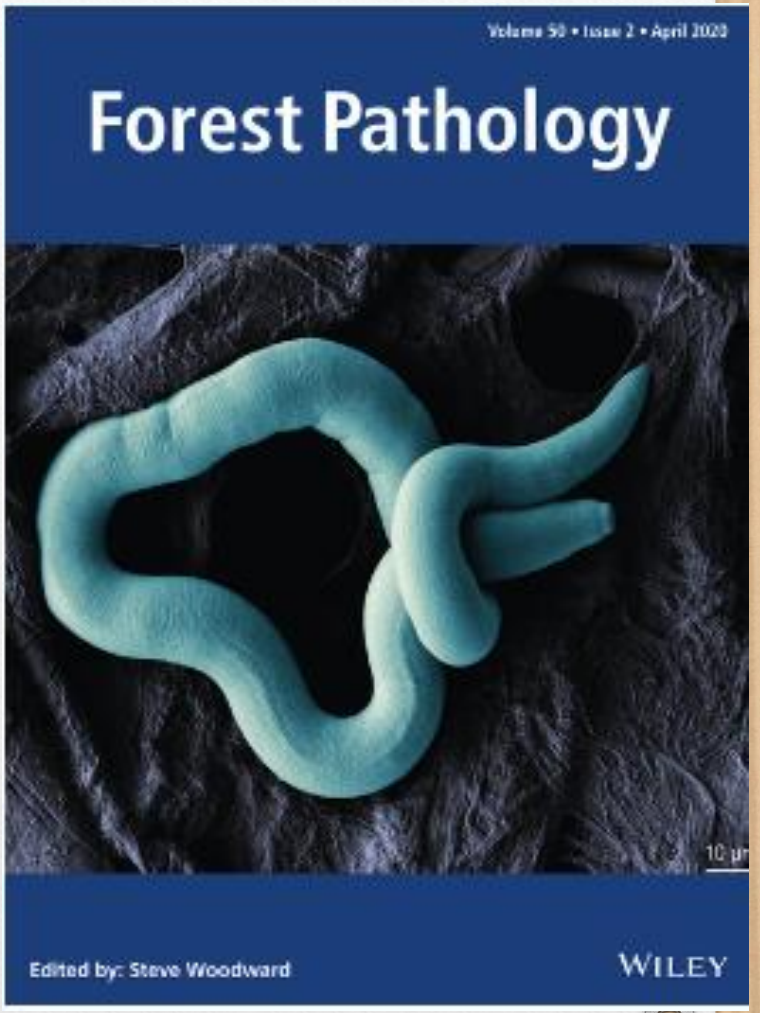
Symptoms/Signs: Initially dark banding parallel to 2ndry leaf veins. Crumpled, necrotic leaves. Aborted buds. Die-back and thinning of canopy with mortality of understory within 5 years and overstory mortality within 6 to 10 years.

Treatment: Fluopyram foliar application in late summer. Experimental results with potassium fertilizers (polyphosphite). Pruning to slow down progression. **https://holdenfg.org/beech-leaf-disease/**

Prevention: None right now (early).

Prognosis: Most of our beech will die unless a new discovery is made in the next 10 to 20 years.

Recommendations: Identify resistant trees (unknown level). MUST BE RESISTANT to BBD as well! Treat valuable trees and a selection of natural areas.



Early Beech Leaf Disease (BLD) - Symptoms

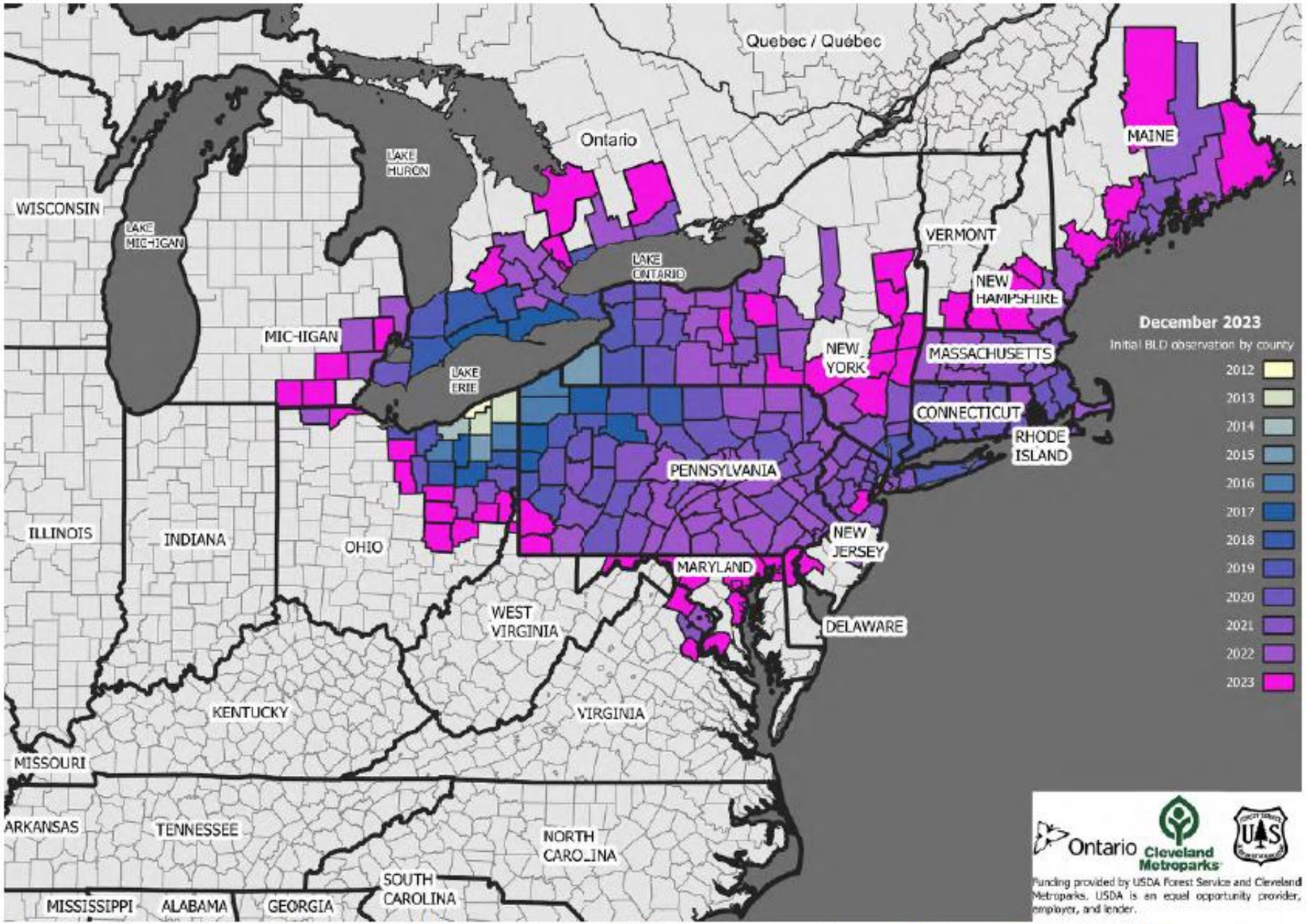


Figure 4.—Known range of BLD, from initial observation in 2012 to its current reach expanded annually by county. Map courtesy of Cleveland Metroparks with USDA Forest Service cooperation.

WTB & Thousand Cankers Disease (TCD)

Causal Agent: Beetle: *Pityophthorus juglandis &* Fungus: *Geosmithia morbida,* vectored by the beetle.

Species affected: Walnuts and butternuts (*Juglans* spp.), esp. black walnut. First found in east (Tennessee) in 2010.

Symptoms/Signs: Early symptoms are wilting and yellowing foliage, then branch mortality, numerous small cankers on branches and the bole, and evidence of tiny bark beetles (small round exit holes).

Treatment: None available at this time. Remove sick walnuts to slow the spread.

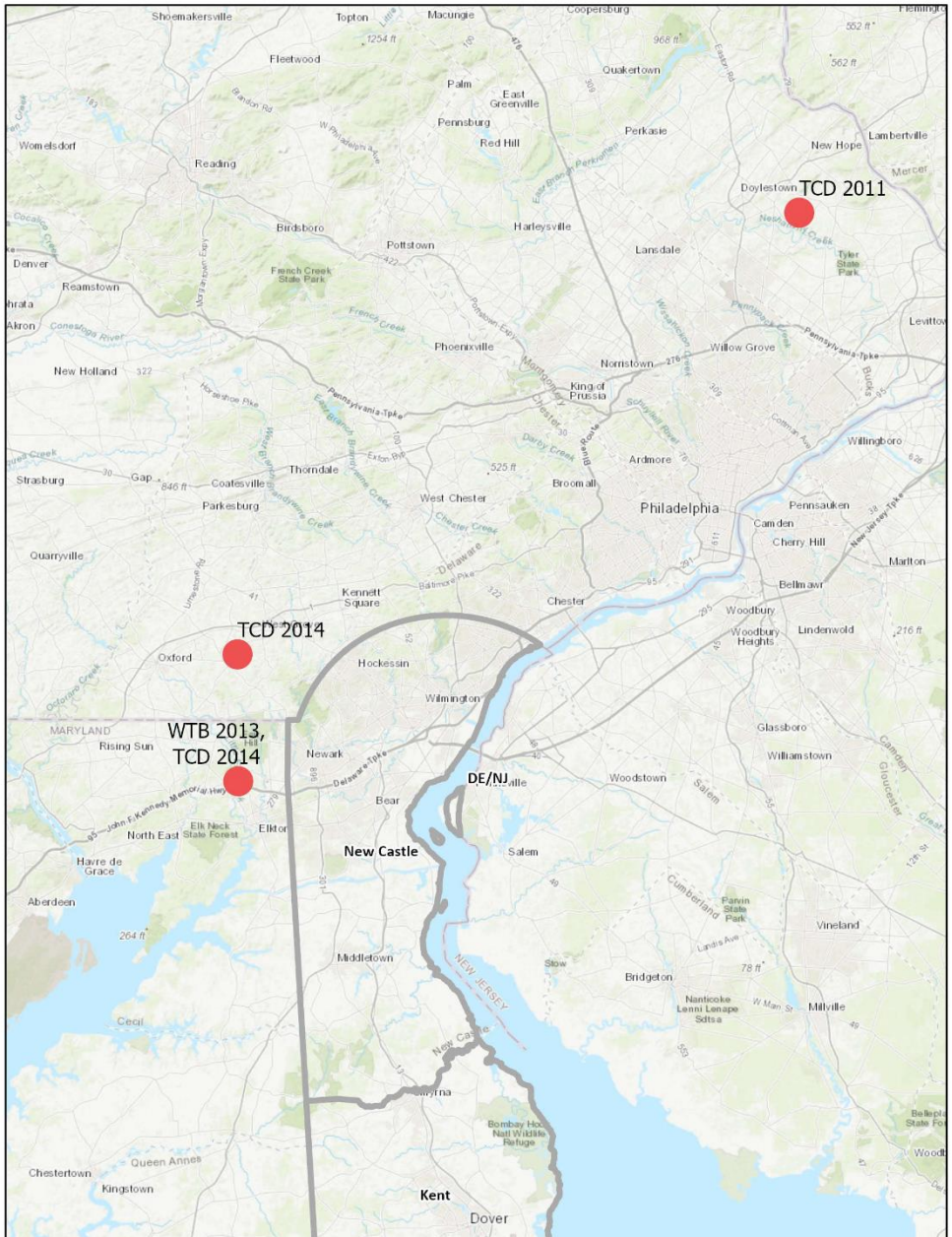
Prevention: Obey quarantines. Avoid moving hardwood firewood more than a few miles. Remove and carefully inspect sick walnuts.

Prognosis: Mortality of infested trees within a few years so far out west.

Recommendations: Continue to survey for this pest and inspect sick walnut trees.

NOT spreading as fast as first feared!

WALNUT TWIG BEETLE (WTB) & THOUSAND CANKERS DISEASE (TCD) FUNGAL POSITIVES.



Eastern US invasive insects (NOT found in DE, Hopefully NEVER)

Asian Longhorned Beetle (ALB)

Causal Agent: *Anoplophora glabripennis*

Species affected: Maples and many other hardwoods (~13 genera).

Symptoms/Signs: Clusters of dead and dying maples. Large round exit holes, frass, oviposition sites. Adults are shiny black, up to 1.5" long, with black & white striped antennae longer than the body. Much slower spreading than EAB, gives us hope of eradication.

Treatment: First detection will trigger a regulatory response from APHIS.

Prevention: Avoid introduction in Delaware.

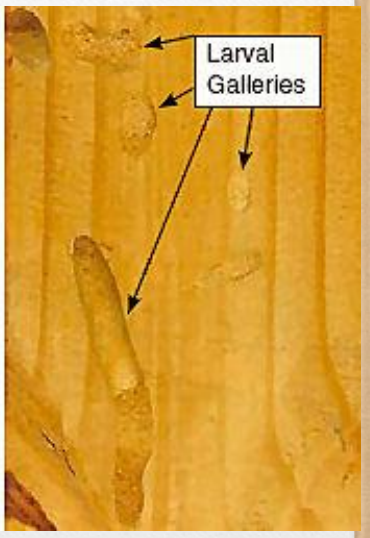
Prognosis: Mortality of infested trees within a few years.

Recommendations: Continue to survey for this pest and inspect sick maple trees.

If you find a maple tree with a round exit hole, can you insert the eraser end of a pencil in past the metal part? If so, you've probably found ALB.

Sirex Wood Wasp

Causal Agent: *Sirex noctilio*



Species affected: Loblolly and other pines, and possibly other conifers.

Symptoms/Signs: Profuse resin flow from many oviposition sites. Discoloration & wilting of foliage. Round exit holes vary in size, mostly around ¼". Galleries under bark packed with sawdust. Adults 1 – 1.5" long, wasplike. Females have a long ovipositor.

Treatment: Unknown.

Prevention: Overcrowded stands are probably more vulnerable. Thin loblolly stands to promote vigor.

Prognosis: Infested trees are killed by a Sirex-borne fungus.

Recommendations: A first find in Delaware could trigger some response by APHIS. DFS surveys for this pest.

Sirex has been found in Pennsylvania & New York state. Its impact in Delaware is hard to forecast because it has never been seen in loblolly stands in the USA.

Elms, maybe Zelkovas?

Quebec, then Virginia – since 2020

Report if found!

USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Eastern Region State, Private, and Tribal Forestry | R9-PR-016-24 | November 2024

Pest Alert

Elm Zigzag Sawfly

Aproceros leucopoda

The elm zigzag sawfly (EZS) is a defoliator of many species in the Ulmaceae (elm) family. Native to East Asia, this pest was discovered in Europe in 2003 where it spread rapidly. In 2020, the insect was first reported in North America by a community science contributor in Québec, Canada. In 2021, it was confirmed in Virginia, U.S.A. EZS impact on native elm populations already imperiled by Dutch elm disease (*Ophiostoma ulmi* or *O. novo-ulmi*) is unknown.

Hosts

EZS feeds on North American trees in the family Ulmaceae, including American elm (*Ulmus americana*), slippery elm (*U. rubra*), and winged elm (*U. alata*), as well as non-native landscape trees such as Chinese elm (*U. parvifolia*) and Siberian elm (*U. pumila*). Susceptibility of other Ulmaceae species, such as zelkova (*Zelkova* spp.), is unknown and requires further investigation.

Description

The adult EZS is small, approximately 7-8 mm long, with a shiny black body; dark, smoky-colored wings; and whitish to pale yellow legs (figure 1). As a member of the Argidae family, they have distinct 3-segmented antennae where the third segment is much longer than the first two. The yellow-green larvae reach 10–11 mm long and can be identified by a brown band on the head and dark T-shaped markings on the two hind pairs of thoracic legs (figure 2).

Figure 3.—Early instars create the characteristic, sinusoidal "zigzag" pattern from the leaf margin to midvein. USDA Forest Service photo by Nathan Siegert.

Figure 1.—Elm zigzag sawfly adult. Courtesy photo by Kelly Oten, North Carolina State University.

Figure 2.—Elm zigzag sawfly larva feeding on an elm leaf. Courtesy photo by Kelly Oten, North Carolina State University.

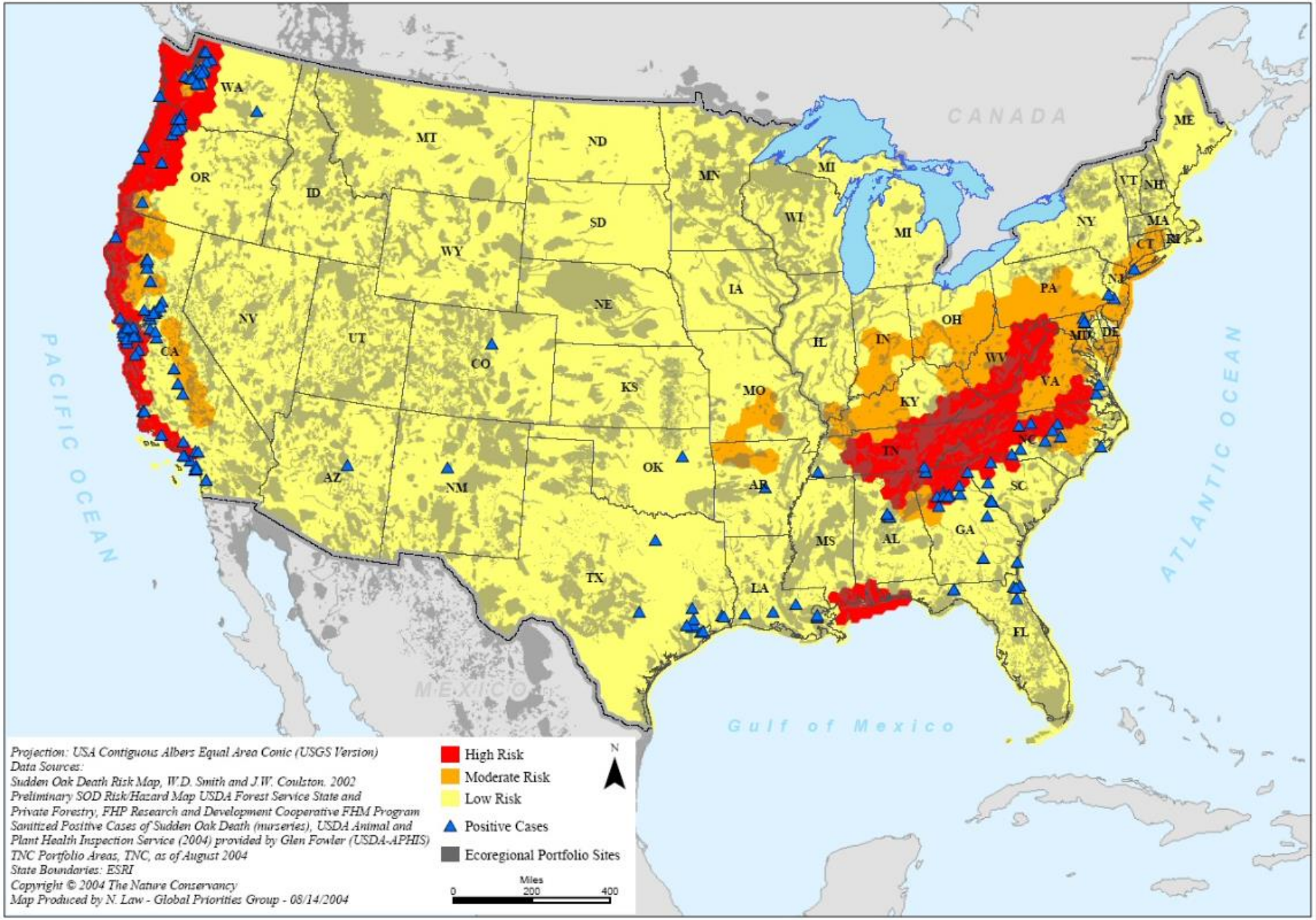
Life History

EZS have 1-6 generations per year determined by environmental conditions and location. The insect is active from April to September. EZS reproduce parthenogenetically; females produce only females without mating (no males). Oviposition begins shortly after emergence, with each female laying 7-60 individual eggs along leaf margins. Eggs hatch in 4-8 days, and larvae begin feeding in a "zigzag" pattern from leaf margin to midvein (figure 3). Older larvae often change feeding pattern to consume larger portions of leaf tissue (figure 4). Larvae feed for approximately 10-18 days before spinning a light "summer" cocoon on the underside of leaves to pupate (figure 5). Pupation takes 4-7 days. In high-density infestations, summer cocoons may be attached to inanimate objects, such as fence posts or vehicles. Overwintering larvae spin a thicker "winter" cocoon within the leaf litter and soil.

Invasion Potential

EZS can spread quickly and are likely more widespread than presently known. Since the 2020 North America discovery,

Sudden Oak Death Risk and Lower U.S. Ecoregional Portfolio Sites



Projection: USA Contiguous Albers Equal Area Conic (USGS Version)
Data Sources:
Sudden Oak Death Risk Map, W.D. Smith and J.W. Coulston. 2002
Preliminary SOD Risk/Hazard Map USDA Forest Service State and Private Forestry, FHP Research and Development Cooperative FHM Program
Sanitized Positive Cases of Sudden Oak Death (nurseries), USDA Animal and Plant Health Inspection Service (2004) provided by Glen Fowler (USDA-APHIS)
TNC Portfolio Areas, TNC, as of August 2004
State Boundaries: ESRI

Map Produced by N. Law - Global Priorities Group - 08/14/2004

Redbay ambrosia beetle *Xyleborus glabratus*

Carries spores of a fungal wilt disease…

"Laurel Wilt" Raffaelea lauricola

Found in 2005; currently in 11 SE states; north to Kentucky, North Carolina. West to Texas.

Threat to sassafras and northern spice bush (*Lindera benzoin*) in DE.

Look for wilting lvs, early leaf drop, vascular streaking and signs of ambrosia beetle entrance holes (<1 mm), frass tubes.

Pest Alert

United States
Department of Agriculture
Forest Service
Southern Region
State and Private Forestry
R8–PR–01–19
October 2019

Laurel Wilt

Laurel wilt is a disease of woody plants in the laurel family (Lauraceae). Hundreds of millions of redbay (*Persea borbonia*) trees have been killed by laurel wilt in the southeastern Atlantic Coastal Plain region of the United States (US). The disease has also killed large numbers of sassafras (*Sassafras albidum*) trees in forests and landscapes, and avocado (*Persea americana*) trees in commercial production. As of October 2019, laurel wilt was known to occur from Texas to North Carolina, south through Florida and north to Kentucky. Laurel wilt is expected to continue spreading through sassafras in the eastern US, and is a potential threat to California bay laurel (*Umbellularia californica*) in the western US and to lauraceous species elsewhere in the world.

Laurel wilt is caused by a fungus (*Raffaelea lauricola*) that is carried by an insect, the redbay ambrosia beetle (*Xyleborus glabratus*). These organisms are native to Asia, are invasive pests in North America, and can be easily transported to new areas by movement of infested wood products and firewood.

Symptoms

In early stages of laurel wilt, trees exhibit drooping, discolored leaves (**Fig. 1A**). In deciduous hosts like sassafras, leaves soon fall from the tree leaving branches bare (**Fig. 1B**). In contrast, evergreen hosts like redbay will retain reddish or brownish leaves for many months. Diseased trees typically exhibit a dark discoloration in the outer sapwood that runs with the direction of the grain (**Fig. 1C**). In sassafras, some trees may produce sparse, stunted leaves in the spring following the initial year of infection (**Fig. 2**).

Redbay ambrosia beetles (**Fig. 3**) are extremely small (~2 mm long), spend most of their life cycle inside the tree, and are not easily seen in the field. Entrance holes (<1 mm diameter) may be seen on smooth bark or on the wood surface when bark is removed. Many ambrosia beetle species produce fine, light-colored sawdust that may be seen at the bark surface, but neither sawdust nor beetle holes are signs specific to laurel wilt.

Disease Process

Spores of the laurel wilt fungus are carried in the mouthparts of the redbay ambrosia beetle. Host trees typically become infected when a female beetle lands on a stem or branch and bores into the wood. The fungal spores enter the water-conducting cells and spread through trees, causing a reaction that restricts water flow. Trees can die within a few weeks or months after infection. The redbay ambrosia beetle will attack

Fig. 1. Laurel wilt symptoms in sassafras. A) Drooping leaves in the early stages of the disease. B) Diseased trees that have recently dropped their leaves. C) Bark removed to show dark discoloration on the surface of the sapwood.

Thank You!

Questions?

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