INVASIVE DISEASES & PESTS

Interesting Nuances

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Dr. Roberts retired from Michigan State University in 2018 after committing over four decades to advancing MSU's Land Grant Mission, originally signed into law by President Abraham Lincoln during the midst of the American Civil War. He received his B.S. (1975) and M.S (1977) from The Ohio State University and his Ph.D. from Michigan State University. Over the decades, Dr. Roberts has published hundreds of articles and has taught hundreds of lectures and workshops. He has re-searched many issues in Michigan's plant industry including Dutch Elm Disease, *Diplodia* Tip Blight of Pines, along with variety of cultural problems such as plant nutrition and herbicide toxicity. Dr. Roberts has worked on Oak Wilt for 40 years, inventing several new and innovative remediation techniques. During his career, he has discovered a variety of new diseases and pests such as *Phomopsis* Canker of Spruce and the first bacterial wilt disease of turfgrasses in North America. His discovery of a bacterial biological herbicide for weed grasses resulted in several patents with MSU. His research on greenhouse and nursery crops disclosed the first fungicide-resistant strains of the *Pythium*, a root rot fungus, altering management methods for crop preservation. In the early 2000s, his research on Ash Decline in Southeast Michigan led to the discovery of the invasive Emerald Ash Borer in North America. In his retirement, Dr. Roberts intends to remain active with the Arboriculture/Landscape/Nursery Industries while hoping to have more time for his hobbies. Dr. Roberts is President, CEO and CBW (Chief Bottle Washer) of The Plant Doctor, LLC… aka The Tree Doctor. Contact information: **Phone 248/320-7124; Email treedoctordave@gmail.com**

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INTRODUCTION

Invasive Diseases and Pests have unfortunately become more commonplace in North America as decades have rolled by and world trade became more common. "Invasives" can be more destructive and challenging to manage than their native counterparts. For example, while the Dutch Elm Disease (DED) fungus (*Ophiostoma ulm=Ceratocyctis ulmii*) is present in Asia and North America, it is highly destructive on native Elm trees (*Ulmus* sp.) in the United States/North America but far less aggressive on Elm trees in Asia. The most plausible explanation for this differential activity in geographic locations is due to the evolution (natural selection) of the fungus and its host plant in Asia, where Elm species and the fungus have evolved over millennia to adapt to one another, a phenomenon in Science often referred to as "Balanced Coexistence". For a fungus or insect to survive long term, it is of no benefit to completely eliminate its host plant. When the causal DED fungus was introduced into North America in the early 1900s, our native Elm populations had no natural defense; many/most have succumbed to the destructive nature of the fungus. Over long periods of time, we might expect American Elms to develop resistance. However, there is not a strong selection pressure for this to happen because Elms often germinate and reach seed bearing age (20-30 feet in height) before succumbing to the disease. It is a common observation that various disease microbes and pests are often inconspicuous or of minor importance in their native habitat but reach destruction of the highest order when introduced into new geographic areas.

I wanted to review some of the major diseases and pests that have been introduced and that are forever changing the urban and natural forest ecosystems in North America. Knowing some of the important nuances or attributes might help us understand how to prevent and better manage them better.


P1A


P1B

White Pine Blister Rust:

It is widely believed that *Cronartium ribicola,* the cause of White Pine Blister Rust (WPBR, Photos 1A & 1B), was probably introduced into New England from Europe on White Pine nursery stock in the late 1800s. By 1910, the disease had spread to Minnesota and south to North Carolina. Also, the disease was introduced on nursery stock at about the same time into British Columbia from France. Like some other "macrocyclic" rust diseases, WPBR requires two different host plants to complete its disease/life cycle. Some cultivated and wild *Ribes* sp. (currant) serve as the necessary alternate host plant to White Pine. Although many Americans through the decades have commonly criticized our U.S. Government for its bureaucracy, one of the more successful programs for WPBR management began during the Great Depression when President Franklin D. Roosevelt created the Civilian Conservation Corps (CCC) and sent hordes of (unemployed) people trampling throughout the North American Forests to try to eradicate or decrease the population of *Ribes* in these forests to save the valuable White Pine timber resource. Although the disease has caused millions if not billions of dollars in lost timber value, the losses would have been far more astronomical without the efforts by the CCC.

P1A&B White Pine is not only Michigan's state tree, this species is a valuable component of our landscapes and woodlands (Photo 1A). White Pines in forests offer great value in timber. It's hard to believe that a tiny, introduced fungus that causes White Pine Blister Rust can destroy such a large, handsome tree. In Photo 1B, note the "Rust" blisters on the trunk of the White Pine; those blisters will eventually girdle and kill the tree. Also, note the tiny yellow lesions on the small adjacent alternate Ribes host plant, which is needed to complete the disease cycle.

P2A B&C American Chestnut was not only prized for its timber value but also for its seeds, which were a source of nourishment for people and animals (wild and domesticated). The tree was also valued for lumber. American Chestnut could reach great size as this old photo from Appalachia shows (Photo 2A, source: Donnie Laws East Tennessee Outdoors). Chestnut Blight (CB), spread by windborne spores, was so efficient at eliminating American Chestnut trees from American forests and landscapes that virtually none remain (except for a few escapees). Stumps of old Chestnut trees will sprout new stems, which contract the canker-causing fungus in an endless cycle of life and death (Photo 2B); note CB canker on the trunk of a new tree (Photo 2B Inset). Furniture and other items made from American Chestnut are highly sought after by certain aficionados; this old plant stand, to the right of the 'Forest Parlor Stove', was made from American Chestnut wood and found by the author many years ago in an antique store (Photo 2C).

Chestnut Blight:

Caused by the fungus, *Chryphonectria parasitica* (=*Endothia parasitica*), Chestnut Blight (CB) was initially discovered in New York in 1904. The fungus is disseminated as spores on air currents and by animals


P2A

P2B


P3A

P2C

P3 A&B This is not winter! The time is the summer of 2013, and the foliage on these trees in a park near Ann Arbor, Michigan has been decimated by the Gypsy Moth (now called Spongy Moth). Typically, trees such as these will tolerate at least one or maybe two defoliations before being seriously harmed. Despite the aggressive attack by Gypsy Moth (3A), the larvae of the insect in Photo 3B are already starting to die in great numbers as the "natural" (actually, introduced) parasites and pathogens are killing larvae by the millions.

such as birds and is capable of attacking healthy chestnut trees by simply infecting and causing cankers on branches. No wounds are needed. Prior to the introduction of CB, chestnut trees comprised a significant proportion of North American forests (Photo 2A). Old stumps of the killed trees can still be found; many send up shoots, which are usually attacked again by the lethal fungus in a continuous cycle of life and death (Photo 2B). Most chestnut trees are long gone but some "escapees" are occasionally found. There are a number of active groups that are trying to revitalize this species of tree as a once again prominent member of our natural forest. Interestingly, because of the speed of spread and thoroughness of devastation, many people in current generations have never heard of the American Chestnut Blight. Lumber and products made from America Chestnut wood are rare today and highly sought after (Photo 2C).

Gypsy Moth (aka Spongy Moth):

The Gypsy Moth (*Lymantria dispar*) is considered one of the most destructive forest pests in North America. The insect had evolved in Europe and Asia for many thousands of years before being introduced into Boston around 1868 by Leopold Trouvelot. How would you like your name associated with the introduction of a pest that would cause billions of dollars in forest damage? Not


P3B

me!!! Repeated defoliation of trees by the insect accompanied by environmental and human-induced stresses have resulted in significant tree mortality. The Gypsy Moth occasionally flares up in Michigan communities but because of introduced natural predators, parasites and pathogens (e.g. *Entomaphaga* fungus from Japan), the insect is not nearly as devastating as it used to be (Photos 3A & 3B). Populations often crash soon after they begin to explode. However, in some areas there are some mysterious oak deaths commonly associated with symptoms that may be mistaken for Oak Wilt. The Two-Lined Chestnut Borer and drought, among other stresses, are likely responsible.

Hemlock Woolly Adelgid:

The Hemlock Woolly Adelgid (HWA= *Adelges tsugae*) is native to Asia. Although known on the U.S. West Coast since the 1920s, it was first found on the East Coast in the 1950s near Richmond, Virginia. By 2005, the insect had spread to more than 16 states ranging from Maine to Georgia. Hemlocks in the Appalachian and Smoky Mountain ranges have been decimated. Although the invasive insect has been introduced into Michigan several times in past decades, it has usually been successfully eradicated with aggressive "slash and burn" methods. Unfortunately, in 2016, a large outbreak was noted on the western coast of Michigan and, hence, the pest is here to stay. The insect kills by literally sucking the life out of the trees (Photo 4). It spreads as immature nymphs on air currents and by transportation on animals (as well as nursery trees and tree products). The pest is relatively easy to manage with insecticides on Hemlocks in the landscape; however, it is another of those problems that requires pesticides when many of us are trying to minimize pesticide usage. Regrettably, trees of lower value such as those in woodlands and forests will succumb to this destructive invasive.

Emerald Ash Borer:

Discovered by the author in 2002 in Southeast Michigan, the Emerald Ash Borer (*Agrilus planipennis*=EAB) has spread far and wide in the past 22 years (Photos 5A & 5B). Compared to many disease agents which are passively carried by air currents or by other means such as insects or animals, the EAB flies throughout our landscape, countryside, state and regions to seek out Ash trees to infest… and ultimately to destroy. Of course, the EAB can be transported long distances in nursery stock or wood products such as firewood. The EAB is a prime example of the native vs. introduced phenomenon; the insect is largely inconspicuous in Asia from whence it came, but highly destructive and lethal in North America where Ash trees had not developed defenses to the insect over the millennia.

Beech Bark Disease:

Beech Bark Disease (BBD) is a collaborative venture between several species of introduced Beech Bark Scale (BBS) insects and several introduced and native species of the fungal pathogen in the genus *Nectria* sp. The scale insects colonize the Beech trees in great numbers (Photo 6); that colonization results in numerous tiny wounds created by the piercing/sucking mouth parts of the scale. With such extensive wounding, *Nectria* fungi, which are usually considered wound pathogens, invade the branches and trunk of the tree, causing cankers and eventually resulting in "Beech snap" (structural failure). The author has found astonishing long-term control of the BBS with high rates of Talus. Compared to other invasives discussed in this article, it turns out that a small percentage of native Beech trees appear to be less affected or unaffected by BBD. These unaffected trees may help eventual recovery of Michigan and U.S. forests.

Dutch Elm Disease:

The disease, caused by two species of *Ophiostoma ulmi* (formerly *Ceratocystis ulmi*), attains its name because it was first reported in the Netherlands, even though the lethal fungus is native to Asia. Asian species of trees such as Siberian Elm and Chinese Elm are largely resistant. The disease was first found in Europe in 1920, causing severe damage on native Elms there, especially in Holland. The disease was first found in the U.S. in Ohio in 1930. In the subsequent three years, the disease was also found in New York, New Jersey and Connecticut. An American quarantine had been in place for almost two decades before the disease was

P4 The Hemlock Woolly Adelgid has decimated eastern forests. Recently, the insect has been found in western Michigan in an expanding area making eradication from the state virtually impossible. (Photo Credit: Connecticut Agricultural Experiment Station, Bugwood.org)

P5 A&B The Emerald Ash Borer (EAB) kills young and old Ash trees alike by feeding on the rich nutritional sources of cambium tissues. In Photo 5A, one Ash tree has been killed (center), one has been severely debilitated (right), and one appears virtually healthy (left), even though it is also being attacked. Adult EABs have no impact on the health of Ash trees; larvae kill trees by feeding in the cambium. Note a canker has formed on this older Ash tree where a larva had fed in a serpentine pattern before emergence as an adult (Photo 5B).

P6 This American Beech tree is heavily colonized by the Beech Bark Scale and is ripe for invasion by the deadly *Nectria* fungus.

introduced, yet it was still introduced from a foreign country! It was discovered that Elm logs had been imported from Europe for veneer several years prior to the discovery of the disease in the U.S. Ports of entry include the Atlantic Ocean and the Gulf of Mexico, from where Elm logs were shipped overland on open railroad cars, sometimes several hundred miles to their destination. Imagine the disease "leaping off" the logs as they were being transported around the U.S to veneer mills. Overland spread of the disease depends on transmission by feeding injury from native and introduced Elm Bark Beetles. As with Oak Wilt, the disease may also disseminate "underground" through root grafts between nearby trees. We still have some large Elms left in Michigan that escaped the epidemics of the 1950s-1970s and up to the present time (Photos 7A & 7B).

Oak Wilt:

Oak Wilt (OW), caused by the fungus *Bretziella fagacearum* (formerly known as *Ceratocystis fagaceraum*), was first discovered in Wisconsin in 1944. There were scientific descriptions of Oak tree death mimicking OW dating back to the late 1800s; hence, it was likely spreading in the U.S. long before it was discovered. DNA technology has recently disclosed that OW is an introduced, exotic, "invasive" disease. Like DED, OW is transmitted overland by insects and underground through root grafts to nearby trees. Oak Wilt is gradually expanding in Michigan in large part to human activity. If we humans would stop wounding trees and stop transporting firewood, we could slow its rate of progress dramatically (Photo 8). In specific cases, irresponsible human remediation efforts are causing more Oak deaths than Oak Wilt does!

Trellis Rust:

Also known as European Pear Rust, Trellis Rust (TR) was imported from Europe. Requiring an alternate host plant (*Juniperus* sp.) to complete its disease cycle, it is similar to some of our native macrocyclic rust diseases such as cedar-apple, cedar-quince and cedar-hawthorn rust. However, because it is an introduced disease, we have experienced more devastation to our native *Pyrus* trees (ornamental or fruit) than similar native rust diseases (Photo 9). In recent years, the disease has spread from Southeast

P7 A&B This large American Elm, likely in excess of 100 years of age and residing near Ann Arbor, Michigan, has escaped the deadly Dutch Elm Disease (DED) all of these years (Photo 7A). The major wave of DED passed through Michigan in the 1950s through 1970s, but occasionally kills American Elm "escapees" to this day. Note that the trunk of this tree is over 4 feet dbh in this self-portrait by the author (Photo 7B).

Michigan across the state and is expected to become more serious in many parts of Michigan. The severity of the disease largely depends on the proximity of its two host plants; the more closely located they are, the more devastating. The disease can be suppressed with some well-timed fungicide sprays.

Nuances of Interest:

In their native ecosystem, plants, pests and diseases evolve 'in harmony' over many thousands (millions) of years. In fact, one can almost be assured of the origin of a pest or disease by its effect on trees in various countries on various continents. For example, the EAB is almost harmless to Ash trees in Asia and is often considered a background insect pest there, attacking severely stressed or declining *Fraxinus* sp. DED is not very aggressive on Siberian and Chinese Elm, indicating the likely origin as Asia. It is of particular interest to note that ***invasives*** tend to affect ***whole genera*** of plants whereas ***native*** pests and diseases attack species within plant genera. For example, the EAB attacks all native species of *Fraxinus* in North America. Native pests and diseases tend to be less broad ranging (ex. Tar Spot affects Norway Maple but not Sugar Maple). We may also experience "native invasives"; one example is Thousand Cankers Disease that is native to the southwestern U.S. and Mexico but has been introduced to the eastern U.S., causing severe damage on *Juglans* sp.

Another area of interest is the manner of spread and transmission of invasive pests and diseases. Most are spreading through the landscape, countryside, state and nation by flying, in the case of insects, or by spore dispersal, in the case of (fungal) diseases. Obviously, invasives can be spread much more quickly and far greater distances by human activity such as transportation of infested/infected plants or parts of plants. Although each invasive pest and disease has its own particular nuances, Oak Wilt stands out as different in a significant manner from the rest. In order for Overland transmission to occur, Oaks must be injured. The EAB, DED, TR, WPBR, etc. do not need wounding of their host plants to infect/infest them. DED does require wounding, except it's by the bark beetles that feed on the trees. The primary Overland transmission of OW is via sap beetles, which cannot wound Oak trees, per se. Sap beetles require the injury of Oak trees by some mechanical means: pruning, storm injury, etc. Therein lies the secret to OW management. Prevent injury to Oaks during the risky transmission period from activities such as pruning, disc golf, lawn mowers, weed trimmers, etc.!!! And in the case of storm injury, implement prompt storm repair damage techniques. If an Oak Bark Beetle were introduced into North America, analogous to Elm Bark Beetles' relationship in the DED cycle, Oak Wilt could reach the devastation of, for example, DED or EAB.

If we were to visit North America thousands of years into the future, we may very well see native plant/tree species that exhibit resistance to their invasive attackers of yesteryear.

P8 Oak Wilt occurs throughout Michigan in residential communities and in natural woodlands and forests. In this photo, Oak Wilt-infected trees can be seen over the roof of this house in a residential area near Traverse City, Michigan. The introduced (invasive) disease has some similarities to Dutch Elm Disease: vascular wilt, lethality to its host plant, dissemination by insects and through root grafts. The difference between the two diseases is that Oak Wilt requires wounding for Overland Spread while DED does not, the reason why so many more Elms have been killed compared to Oak trees by their respective pathogens.

P9 Trellis Rust (aka European Pear Rust) is an introduced disease affecting Pear (*Pyrus* sp.), requiring Juniper as its alternate host to complete its life cycle. The disease causes lesions on leaves and twigs that usually result in eventual decline of trees (Inset). The severity of the disease is dependent on the proximity (closeness) of the two host plants.