

Illinois Trees

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Fun Events Designed for Professional Arborists

by Paul Filary



Collaborating and finding time to gather together is one of the best ways to learn and advance any skill. Our new tree climber social events are intended to do just that in a more informal and fun environment. On January 21st, we hosted one of these events at Vertical Endeavors in Glendale Heights with multi-time Illinois Tree Climbing Champion, Alex Julius, presenting on what to look for when buying climbing gear. After gaining some knowledge from Alex, attendees had the opportunity to enjoy the climbing wall and the fun to be had at Vertical Endeavors. A huge thanks to Norm and Kathy Hall, along with Kramer Tree Specialists for sponsoring this awesome event!

Alex gave an excellent presentation on what to be looking for when purchasing climbing

gear to ensure its safety and quality. There are a number of places out there online or in brick-and-mortar stores to purchase climbing gear, and what comes with that is a spectrum of quality and safety of the gear we are purchasing. Alex's extensive knowledge in this



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Don't forget to visit the IAA Website for updates on events, certification classes, and important issues impacting our industry.

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Illinois Arborist Association

Mission Statement

"Foster interest, establish standards, exchange professional ideas and pursue scientific research in Arboriculture"

President's Message

Happy New Year IAA members,

The IAA Board of Directors has gotten down to business right out of the gate in 2023. The Board recently held its annual strategic plan. Over the course of two days, Board members had lengthy discussions about advanced training, core funding, grants, conferences, and many other ways to bring the membership together. The membership survey was discussed and your calls for even more opportunities for training and CEUs are in the works. In many discussions I've had with members from other chapters, I can say that the IAA is at the forefront of training. No matter how membership views the chapter, there is always room to improve and bring you the very best. I look forward to seeing you all and working hand-in-hand with you throughout 2023. The IAA has already begun discussing the summer conference, fall conference, Day of Service, Tree Biz Socials, rec climbs, golf outings, NEMFs, and much more. We look forward to hearing from you if you have ideas for topics or recommendations for speakers. The IAA is always in need of volunteers and has plenty of opportunities to do so. I encourage each and every one of you that reads this to get involved. Your ideas, unique personalities, and different ways of thinking expand our field of vision and allow our organization to grow. I look forward to seeing everyone at all the great events this year.

Illinois Arborist Association President,

Tony Dati



Fun Events Designed for Professional Arborists (cont.)

area was beneficial to both professional climbers as well as purchasers of gear at local practicing arboriculture firms and municipalities. Attendees had great questions and input resulting in an engaging and enlightening discussion. Thanks to All Gear for providing a number of prizes that were handed out throughout the event, the climbing rope dog leashes were especially a big hit amongst attendees!

Keep an eye out for more climber social events put on by IAA throughout the year. The intent of these events is to engage field production arborists and those either experienced or not experienced in the skill and profession of professional tree climbing. We try and keep the events chill and informal, but engaging and interactive. If you have an interest in being a part of, have ideas, or know of a topic or speaker of interest, please contact IAA Commercial Director, Paul Filary, and it might just be at one of our upcoming meetings. Collaborate, engage with your peers, and exchange ideas to help raise the bar in the profession of professional tree climbing and the arboriculture industry!



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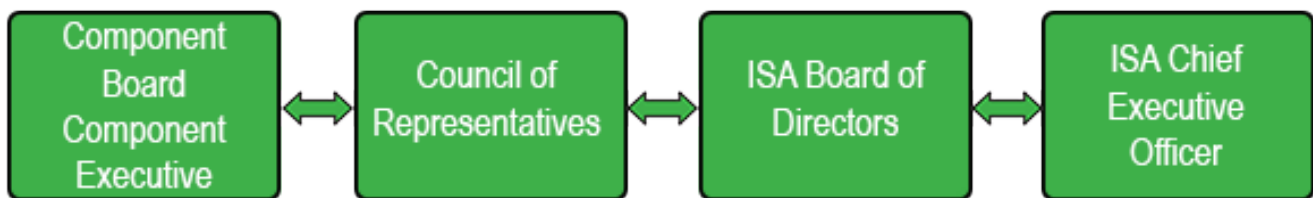


2023 ISA Update *by Steve Lane*

Hello IAA membership! First off, I want to thank you for voting to have me in this role for the chapter, I appreciate your support and intend to fulfill this role as best I can in order to make your experiences with both IAA and ISA as productive and professionally useful as possible. Secondly, I suppose I want to explain a bit about what the Council of Representatives (CoR) actually is, and does for you. The purpose of CoR is, per the new manual which ISA just provided to all of us:

“The ISA CoR supports ISA by acting as an advisory group to the ISA Board of Directors. CoR members are responsible for communicating information to and from their component through the CoR Executive Committee (EC).”

Essentially, if you have concerns or ideas that you believe if heard could benefit the chapter (which ISA calls a “component”) or the industry, let the IAA board or your CoR representative know about it, and we can bring it to the ISA through this chain of communication, which is represented graphically below:



So what does ISA have in store for the coming years? First things first, the ISA International Conference locations have been determined for the next 3 years! They are as follows:

2023 – Albuquerque, New Mexico
2024 – Atlanta, Georgia
2025 – Christchurch, New Zealand

All great locations! And if you ever needed an excuse to run for a spot on the IAA Board of Directors, going out to New Zealand as part of the executive committee might be one of many great reasons to get involved! Additionally, there were some other topics discussed at the most recent CoR meeting:

TCC Going Paperless: Though there are no specifics available yet, it would appear that most of you have had it with paper forms, especially when things were like last year and there was soggy ink everywhere. To this end, ISA is doing exploratory work into how the Tree Climbing Competition scoring system might go paperless for scoring in the future. Don't expect anything immediately, but if you have ideas, please send them along!

Increasing International Scope

ISA is already an international organization, with 25,500+ members in over 70 countries, and that effort is increasing. A new chapter in Africa is being looked at presently, and ISA continues to translate its study materials and tests into many languages around the globe. Do you have language skills you could use to help in this effort? ISA is always looking for translators for material and would like to speak to those who could help with this effort.

ISA Annual Business Meeting

Every year, the ISA holds this virtual meeting to give every member of the organization a glimpse into its inner workings. If you want to get more engaged with ISA, learn more about what else is on their long-term and near-term road maps, etc. this would be a great opportunity to do so. Please contact April at IAA for registration information on this event.

Thank you very much for your time, and if you have concerns or thoughts on how we can make this industry a better place, let's find some time to talk.

IAA Certification Liaison Update *by Aaron Schulz*

Some of you may know me as IAA's Past President but I am also your ISA Certification Liaison for the next 3 years. As Certification Liaison I am the bridge between IAA members and ISA for all credentialing matters, questions, or concerns. In addition, I am responsible for approving and assigning all tree-related ISA Continuing Education Units (CEUs) for events within Illinois.

If you, or your organization, are hosting training events that qualify for ISA CEUs then you may submit your program for approval. Some examples of training events include, but are not limited to, tailgate safety meetings, classroom/lecture training, or hands-on training. As a rule of thumb, 1 hour of training is equal to 1 CEU. We understand that CEUs are valuable to IAA membership so in order to make the CEU submission/approval as easy as possible for members, the IAA has created an online submission form as well as an editable document that can be emailed to me. Both forms can be found here: <https://illinoisarborist.org/ceu-request-form-2/>. Any CEU pre-approval requests MUST be submitted at least 5 business days prior to the training event. I will review CEU requests every Friday evening and email you the CEU sign-in sheet once completed.

The process for submitting for CEU pre-approval is outlined below. The items you will need to fill out are:

- Event Contact Name
- Email
- Phone Number
- Address of Submitter
- Date
- Signature

- Type of event (safety meeting/training, conference/workshop/symposia, other)
- Title of Event (for conferences, you will need to submit a form for each educational session)
- Date of Event (if the event lasts multiple days, you will need to submit a separate form for each day and educational session)
- Location of Event
- Address of Event
- Speaker(s) Name
- Total Seat Time of Event (do not include breaks, only actual training time)
- Brief description of the educational sessions (this helps me break down BCMA CEU allocation)
- Checkbox where you believe your educational session(s) best fits in Science, Practice, and/or Management for BCMA

If you filled out the editable document, you may email it to me at aaron@oakbrostrees.com. If you filled out the online submission form, it will be forwarded to me and there is nothing more you need to do. I will email your CEU sign-in sheets once I have processed them. If you submitted for a virtual session, I will also email you a spreadsheet document with specific instructions on how to fill out and submit to ISA. Once your event has been completed and all attendees have recorded their names and Certification ID #s on the CEU sign-in sheet, you will need to submit your sheet to ISA at ISA@ISA-Arbor.com.

Much like our Board of Directors, the ISA Certification Liaison is a volunteer position and, as a working professional myself, I will strive to review/approve your CEU requests in a timely manner so that you may receive CEU credit for the ongoing training you, or your organization,

~ Calendar of Events ~

February Events

February 16th, NEMF - SMA (Leslie Brooks) - Virtual Only

[Click here to register](#)

February 18th - March 4th Arborist Certification Classes (Exam on March 4th)
Bloomington, Illinois

February 18th, TreeWorker Training Climbing, Rigging, Felling, & Aerial Rescue (Spanish)
Deerfield, Illinois

[Click here to register](#)

March Events

March 11th, 18th, and 25th, Arborist Certification Classes (Exam on March 25th)
Bloomington, Illinois

[Click here to register](#)

March 16th, (10:00 - 11:30) NEMF - Panel Discussion - Lead Water Service Line Replacements
Lombard, Illinois

[Click here to register](#)

March 25th, TreeWorker Training Climbing, Rigging, Felling, & Aerial Rescue (Spanish)
Deerfield, Illinois

[Click here to register](#)

March 28th, Arborist Certification Exam
Crystal Lake, Illinois

[Click here to register](#)

April Events

April 11th, Arborist Certification Exam
Homewood, Illinois

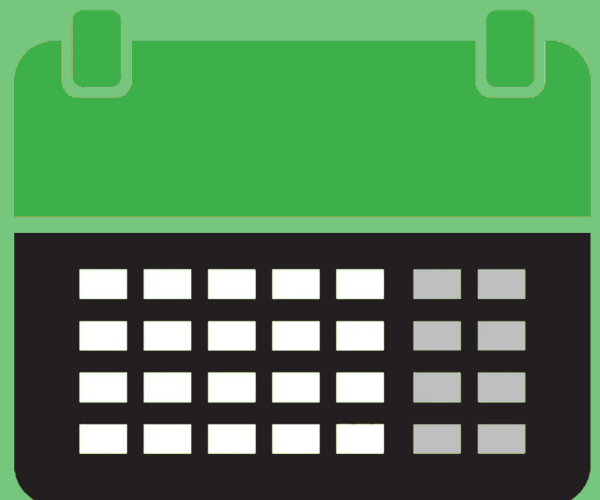
[Click here to register](#)

April 24th, TRAQ Renewal
Zion, Illinois

[Click here to register](#)

April 25 - 27, Full TRAQ Course
Zion, Illinois

[Click here to register](#)



What is the TREE Fund? *by Mike Priller*

We all have been asked whether at the IAA Annual Conference or other IAA functions to buy raffle tickets to support the TREE Fund and win great prizes. Sure, everyone wants to win the chainsaw or some other great gadget; but do you know what the money from the raffle ticket is really going towards? Let me fill you in....

The TREE Fund, [Tree Research and Education Endowment Fund \(TREE Fund\)](#), was established via a merger of the Research Trust of the International Society of Arboriculture (ISA) and the National Arborist Foundation of the National Arborist Association, now the Tree Care Industry Association (TCIA). Organized as a charitable trust in the state of Illinois on July 20, 2002, the roots of TREE Fund go deep into the arboriculture profession and industry. TREE Fund's mission is to identify and fund programs that support the discovery and dissemination of new knowledge in arboriculture and urban forestry.

In addition to funding scientific research related to tree care and urban forestry, TREE Fund also supports student scholarship in this area and environmental education programs for children and adults.

The TREE Fund offers six scholarships each year to students looking to enter or continue their education in Arboriculture or urban forestry whether it be fieldwork or research work. This past year the IAA started the Larry R Hall scholarship, a \$5000 award is available yearly. For a complete list of available scholarships,

and grants and how to apply please visit [TREE Fund Scholarships – TREE Fund](#). Since its inception in 2002, TREE Fund has issued more than 260



awards, totaling nearly \$5.1 million.

Did you know that the TREE Fund also offers FREE CEU's? For those that need CEUs, they offer webinars for you to watch. They average six (6) per year and are worth one (1) CEU. It's ok if you cannot catch the live version, they are recorded and are able to be watched later, for their archive visit: [Webinar Archive – TREE Fund](#)

TREE Fund webinars bring you the latest in tree research, directly from the scientists themselves.

TREE Fund's one-hour webinars are free and offer 1.0 CEU (only for live broadcast) from the International Society of Arboriculture (ISA), the Society of American Foresters (SAF), the National Association of Landscape Professionals (NALP) and sometimes the Landscape Architecture Continuing Education System (LACES). See webinar descriptions for specifics. Space is limited and pre-registration is highly recommended, in doing so, you will receive a reminder email the day before the broadcast.

The Tour des Trees is an annual long-distance cycling adventure, which serves as the primary public outreach and community engagement event for [Tree Research and Education Endowment Fund \(TREE Fund\)](#). Since 1992, Tour des Trees riders have cycled through



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What is the TREE Fund? (cont.)



communities in the U.S., Canada, and the U.K., planting trees, educating children, and shining a light on the work done by arboriculture professionals and the importance of science-based tree

care.

The Tour des Trees serves to advance TREE Fund's mission to explore and share the science of trees contributing to the lives of people, communities, economies, and the environment, and of the planning, planting, and sustainability of urban and community trees. [TREE Fund research](#) has produced better ways to plant and care for urban trees, making them more resilient, more resistant to pests, and less prone to failure. The Tour also supports [education programs](#) aimed at connecting young people with the environment and career opportunities in green industries. TREE Fund has been able to award more than \$5.1 million in grant and scholarship funding since 2002, and the Tour des Trees has been a key component in the organization's ongoing success.

Event expenses are defrayed by TREE Fund's generous [partners](#), so funds raised by riders can be applied to new grants, payments on multi-year grants awarded in prior years, or added to permanent endowment funds that will sustain research into the future. DID YOU KNOW...Our very own Don Ropollo has participated in 18 Tour des Trees and Cindy Schwab has participated in 9 Tour des TREES. Thank You, Cindy and Don....

The 2023 Tour des Trees will take place from Tuesday, September 26 thru Monday, October 2 starting in Reno, NV, passing Lake Tahoe, and ending in Half Moon Bay, CA.

The 2023 Tour des Trees features both a live ride and our new TdT 350/350 Challenge virtual event, so supporters can ride with us in person or support TREE Fund from home. It is easy, ride 350 miles and get \$350 in donations for the TREE Fund, and get a TOUR des TREES cycling jersey.

PLEASE JOIN ME IN COMPETING IN THE 350/350 CHALLENGE. TOGETHER WE CAN MAKE A DIFFERENCE.

Register for the 350/350 Challenge virtual event here: [Registration link](#)

Register for the 2023 event here:

[Registration link](#)

*Registration for the 2023 Tour des Trees is open until July 31

Did you know that the IAA is a GOLD PARTNER of the TREE Fund? This designation goes to those donating \$10,000 to \$24,999.



Thank you to all that have bought raffle tickets or have made donations towards the TREE Fund.

Exploring and sharing the science of trees, and how they contribute to our lives, our communities, our economy, and our planet is what we do. Together we are building capacity to serve in a swiftly changing world and we are inviting you to be part of the adventure. Together, we can advance science-based tree care to help urban forests grow and thrive. [Click here](#) to give today.

Abiotic Impacts - Lead Water Service Replacement Awareness

by Joe Hansen

The State of Illinois has mandated the replacement of lead water service lines under Public Act 102-0613 which went into effect on January 1, 2022. The legislation mandates a number of specific timelines for inventories and comprehensive plans for the required replacements over the next several decades. This, of course, is a great step forward for the long-term health of citizens of the state. It does however bring with it a number of challenges for land managers and private arborists alike for every community in the state as it will create an uptick of new water service installations.

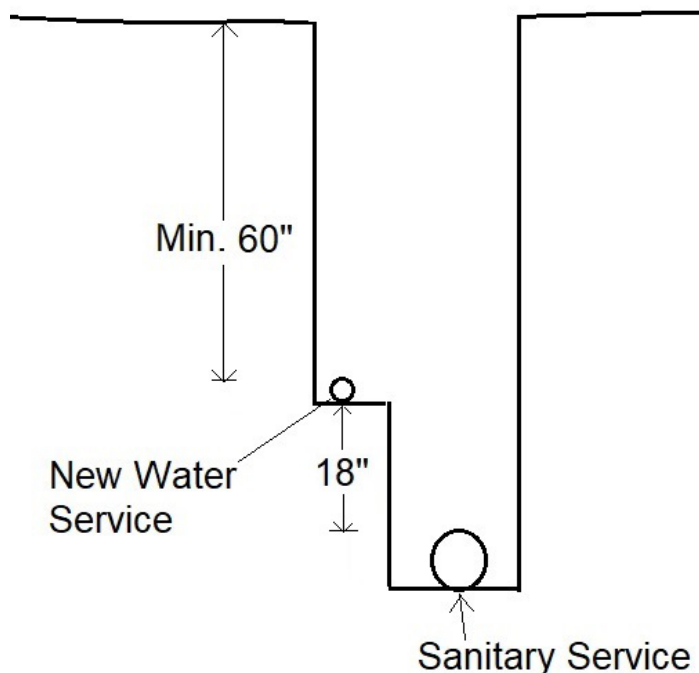
Tree roots, like soil science, are often misunderstood and undervalued. We know that they play an integral role in a tree's health and structure yet we, as a civilization, often damage tree roots by compacting the soil in which they are meant to thrive or severing them through excavation. Similarly, we know that humans need water to survive, much like trees, but we also often overlook tree health in order to get water into people's homes or businesses. What can we do to abate potential conflicts? Unfortunately, that is a pretty loaded question that is not easy to answer.

In order to replace a water service a few things need to happen. First, an excavation needs to take place in order to disconnect the existing service from the water main. Typically, the water main is located somewhere in the street avoiding any potential tree impacts, but this is not always the case. The main may be located in the parkway which presents several potential conflicts, both to trees and other infrastructure such as gas, electricity, communication, storm, and sewer. Once the disconnect from the main is complete we can move on to the location of the new service.

Per Illinois Environmental Protection Agency (IEPA) requirements, the new water service

needs to be located at least 10 feet from the existing sanitary service. If this requirement can not be met then the new water service may be placed at least 18" above the sanitary service resting on undisturbed soil. This is known as a "bench". Additional requirements state that the water service must be placed at a depth of at least 60" to avoid freezing (see bench example). If the 18" bench separation cannot be met a new water service would then need to be cased to prevent potential contamination from the sanitary service. There are what appear to be plenty of options here, which is a good thing, but "digging deeper" into this reveals the real tree conflicts we need to be aware of.

In order to install the new service an excavation needs to take place to install the buffalo box (commonly known as the b-box) which is a valve installed between the main and the house. This is where the municipalities trees are located and as we know there is typically not much space to play around with here. This is also where the majority of tree damage is going to occur. In addition, we still need an excavation in the street, or on the other side of the street in the parkway,



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Abiotic Impacts - Lead Water Service Replacement Awareness

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to connect to the main. Then we need to connect it all together from the main to the b-box to the house. (see example plan)

Often times open trenching is employed to install the new copper pipe which as you can imagine may cause substantial damage to both public and private trees. The preferred option is to use directional boring which is a method that essentially either pulls or pushes the new copper service horizontally underground avoiding the excavating required to open trench. That sounds great but don't forget we still need excavations at the main and at the new b-box location, so it is not the silver bullet. We just do not have a lot of room to move things around or relocate.

As you can see, there are plenty of options to employ but as you will find you will be forced

to either damage or remove a tree in order to get the new water service installed. In the past trees were planted with no concern for their location in relation to other infrastructure, often right on top of mains or service laterals. This is why it is important to attempt to be a part of the process as early as you can in any project. I know this is not always the case but it is up to us to be the voice of reason when it is reasonable.

If you are interested in learning more about what communities are doing to avoid tree conflicts such as these you are invited to join us for a panel presentation and Q&A by a Professional Engineer and two Village Foresters who actively monitor these issues. We will discuss this issue in detail and provide real-world examples. This will take place at our Northeast Municipal Foresters (NEMF) on Thursday, March 16 in Oak Park, Illinois.



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TREE FUND

HOW CAN WE MAKE BETTER USE OF HOST PLANT RESISTANCES IN OUR PHC PROGRAMS?

by Dr. Fredric Miller

We have a number of tools to pick from our Plant Health Care (PHC) toolbox, but one that is probably not utilized enough or even sometimes overlooked is host plant resistance (HPR) or as commonly known, selecting plants are less susceptible to insect pests, diseases and/or abiotic problems. In this article, we will define what we mean by host plant resistance (HPR), types of HPR, how plants use HPR to defend themselves, and how we can use HPR in a comprehensive PHC program. Examples will be provided throughout.

However, before we get too far into the proverbial HPR “weeds”, there are some terms that need defining including **host plant resistance**, **tolerant**, **antibiosis**, and **antixenosis** (non-preferred or “avoided”). Throughout this article, I will be using these terms to illustrate and describe various examples of HPR. First, what do we mean by HPR? Painter, R.H. (1951) defines HPR as “Those characters that enable a plant to avoid, tolerate or recover from attacks of insects under conditions that would cause greater injury to other plants of the same species” (Painter, R.H., 1951). Another definition by Maxwell (1972) is “Those heritable characteristics possessed by the plant which influence the ultimate degree of damage done by the insect”. Additionally, there are many types of resistance including **ecological or pseudo-resistance**; apparent resistance resulting from transitory characters in potentially susceptible host plants due to environmental conditions. Pseudo-resistance may be classified into 3 categories: **host evasion** where the host may pass through the most susceptible stage quickly or at a time when insects are less or evade injury by early maturing. This pertains to the whole population of a host plant. I have seen this with elm trees leafing out in the spring and their susceptibility

to the elm leafminer (*Fenusa ulmi*) (Miller et al., 2014). More on that later. **Induced resistance** is an increase in resistance temporarily as a result of some change in plant conditions or the environment (i.e. amount of water or nutrient status of soil). We see this all the time with trees that are stressed and then become more vulnerable to secondary insects and pathogens (i.e. Armillaria root rot, two-lined chestnut borer). A third type of resistance is “escape” or absence of infestation or injury to a host plant due to transitory processes like an incomplete infestation, and usually pertains to a few individuals of a given host. A more common form of resistance that we commonly hear about it is **genetic resistance** resulting from plant breeding efforts which can be based on the number of genes (i.e. controlled by single gene) and is easy to incorporate into plants by breeding, but is also easy to break by a pathogen and/or insects; or where resistance is controlled by a few genes or controlled by many genes. There is also major gene resistance which includes control by one or few major genes, also known as **vertical resistance**. **Horizontal resistance**, on the other hand, is the cumulative effect of minor genes and is synonymous with field resistance. Some additional miscellaneous categories of genetic resistance include **cross resistance**; a plant variety with resistance incorporated against a primary pest and confers resistance to another insect or **multiple resistance** which incorporates resistance in a variety of ways against different environmental stresses like insects, diseases, nematodes, heat, drought, cold, etc. We see this with some of the newer North American, and complex Eurasian elm hybrids and cultivars developed by Dr. George Ware (i.e. ‘Accolade’, ‘Commendation’, ‘Danada Charm’, ‘Triumph’, and ‘Vanguard’ and others). These cultivars and complex elm hybrids have been shown the ability to tolerate harsh urban conditions, are less susceptible or can tolerate DED, ash yellows, elm phloem necrosis, and are less appetizing to

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HOW CAN WE MAKE BETTER USE OF HOST PLANT RESISTANCES IN OUR PHC PROGRAMS? (cont.)

a variety of leaf-feeding insects (i.e. elm leaf beetle, spring and fall cankerworm, Japanese beetle, spongy moth) (Miller et al. 1999, Miller and Ware, 2000, Bosu et al. 2007, Condra et al. 2010, Miller and Ware, 2022). HPR can also be achieved through the association or co-evolution of the host plant with an associated insect pest or disease. I like to think of this phenomenon as “growing up together”. A couple of classic examples of this are two flat-headed borers, the bronze birch borer (BBB) (*Agilus anxius*) and European white bark birch (*Betula pendula*), and the emerald ash borer (EAB) (*A. plannipennis*) and ash (*Fraxinus* spp.). With the former, you have a native insect and an exotic white bark birch species which is very susceptible to the BBB while native birches are much less susceptible. We see the opposite with the EAB-Ash complex with an exotic insect and native North American ash. In Asia, where EAB is native, Asian ashes are only attacked when they are stressed, but if you plant a North American ash in Russia or China, it will succumb to EAB.

In addition to types of resistance, there are three (3) mechanisms of resistance, **antixenosis (non-preference)**, **antibiosis**, and **tolerance**. **Antixenosis or non-preference** involves host plant characters responsible for non-preference of the insect pest or avoidance for shelter, oviposition, feeding, etc. It denotes presence of morphological or chemical factors which alter insect behavior resulting in poor establishment of the insect. Examples include leaf pubescence, and plant shape and/or color. **Antibiosis or “anti-living”** means the host plant has an adverse effect on the biology (survival, development and reproduction) of the insect and the progeny due to the biochemical and biophysical factors present that are inherent in the plant that may result in larval death, abnormal larval growth, etc. Examples include toxic substances, an absence or lack of

sufficient amount of essential nutrients, nutrient imbalance/improper utilization of nutrients, and/or chemicals like phenols, terpenes, and alkaloids.

Physical antibiosis factors include leaf toughness (i.e. lignin content), thickness, simple and glandular trichomes, spines, and silica deposits. The third mechanism of resistance, tolerance, is the ability of the host plant to grow and thrive despite a pest or disease attack. Factors attributed to this ability are plant vigor, ability to regrow damaged tissue, production of additional branches, and compensation by growth of neighboring plants. Tolerant plants usually require fewer pesticide treatments and apply less selection pressure on pests resulting in less resistance development by the insect or pathogen.

Regardless of HPR definitions, we need to be careful when talking about “resistance” and understand that most people think of resistance as a black and white or “cut and dried” phenomenon where plants are either totally “immune-resistant or never get sick”, or they have no defense against pests and pathogens. In the real world, HPR is a spectrum of susceptibility and resistance. For example, the American elm (*Ulmus americana*) is highly susceptible to Dutch elm disease (DED) while Siberian elm (*U. pumila*) and the newer North American elm cultivars, and complex Eurasian hybrids are either resistant, less susceptible, or are able to tolerate DED (Watson, 2015). Certain viburnum (*Viburnum* spp.) taxa are more susceptible or can tolerate more feeding by the viburnum leaf beetle (*Pyrrhalta viburni*) compared to other taxa (Weston and Desurmont. 2002, Weston et al., 2000). North American ashes (*Fraxinus* spp.) are killed by the emerald ash borer (EAB), but even within ash taxa we find green ash (*F. pennsylvanica*) and black ash (*F. nigra*) to be highly susceptible while white ash (*F. americana*) is considered intermediate in susceptibility, and blue ash (*F. quadramaculata*) appears to have some level of resistant (Tanis

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and McCullough, 2015 and references therein). In Asia, where EAB is native, Asian ashes such as *F. mandshurica* are not killed by EAB and the insect is considered a secondary pest (Eyles et al., 2007 and references therein). Recent research has shown that some of these Asian ashes may have potential in future tree breeding programs (Miller and McMahon, 2022).

As mentioned earlier, over the many millennia, plants, insects, and pathogens have co-evolved and both parties have figured out strategies and mechanisms to “live with each other”. As a result, plants have developed both direct and indirect defenses. **Direct defenses** include mechanical protection and or production of toxic resulting in a minimization of plant health despite insect damage.

Secondary metabolites and plant defense.

Plant-herbivore chemical warfare involves the production of toxic chemicals that plants have in their chemical arsenal. These chemicals may kill or retard the development of plant-feeding insects. These defensive chemicals do not affect normal plant growth and development, but like physical factors, reduce the attractiveness or appear (“taste”) of plant parts and include terpenoids, alkaloids, anthocyanins, phenols, and quinones, just to mention a few.

Indirectly, plants may produce and release a potpourri of volatiles designed to attract parasitoids and predators of the pest insect along with providing supplemental housing and food (extra floral nectaries) War et al., (2012). These indirect defenses are activated due to a combination of mechanical damage and elicitors from attacking insects. Production of volatiles and extra floral nectar (EFN) interact with the plant’s natural enemies, and the pest, reducing the pest

population. Herbivore induced plant volatiles (HIPVs) arise when plants indirectly protect themselves from feeding by emitting a blend of volatiles that are attractive to the pest’s natural enemies or may act as a feeding or egg-laying deterrent. Plant volatiles have also been found to be released from below ground defending plants from microbes, root feeding insects, and attracting natural enemies (War et al., 2012 and references therein).

In addition, to direct and/or indirect, resistance may be present **constitutively or induced** after damage by herbivores. Constitutively responses are preexisting or part of the plant’s normal “constitution”. In Induced responses, due to insect attack, are important to pest management, but come with metabolic costs, and are important in alleviating immediate stress (Painter, 1951, Karban and Myers, 1989, and Karban and Baldwin, 1997). Because they are induced, the plant is phenotypically more flexible or able to adjust and adapt making it harder for the attacker to figure out and overcome the plant’s defenses. In other words, the plant is unpredictable and the higher the variability the better the defense (War et al., 2012 and references therein).

Host evasion

Another aspect of HPR, host evasion, occurs when a host avoids a pest by passing through a susceptible stage (i.e. leaf emergence) before the insect emerges or can cause injury. This phenomenon is more common with annual crops than with perennial plants since perennials are “locked into” a seasonal growth pattern compared to agronomic crops where the planting date may vary from year to year depending on weather and planting conditions. Examining host elm plant phenology and adult elm leaf miner emergence, Miller and Ware (2014) found that leaf out phenology of highly susceptible European elms was highly correlated with adult emergence and oviposition of the European elm

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leaf miner (*Fenusa ulmi*). Several European elm taxa such as *U. procera*, *U. carpinifolia*, and cultivars all experienced less feeding damage and consistently leafed out after peak adult leaf miner emergence. Leaf out of Asian taxa such as *U. davidiana*, *U. japonica*, and *U. lamellosa*, and the Eurasian, *U. pumila* was at the same time as adult elm leafminer emergence, but these elm taxa experienced little or no leaf-mining feeding damage. Two other Asian species, *U. wilsoniana*, and *U. parvifolia* leaf out after adult emergence and oviposition suggesting host plant phenology may be only partially responsible for HPR.

Plant Architecture and HPR

In addition to morphological, chemical, and host evasion tactics, plant architecture (i.e. plant shape, growth habit, height, canopy density) may play a role in HPR. For example, Miller and Danielson (2017) found that short (<1 m tall) arborvitae (*Thuja* spp. and cultivars) experienced less feeding damage by the arborvitae leaf miner (*Argyresthia thuiella*) compared to taller arborvitae species and cultivars. In addition, arborvitae with dense, compact canopies were also less prone to attack. Additionally, it is common knowledge that the EAB is capable of attacking and colonizing both healthy and stressed ash trees, and seems to prefer trees growing out in the open in full sun (Cappaert, et al, 2005 and McCullough et al., 2009). Is tree silhouette, color, or shape attractive to attacking female EABs? We do not know for sure, but there appears to be certain cues that insect is homing in on.

Plant Stress and HPR

We are all aware that certain trees are better at handling stress than others, and stressed trees tend to emit various chemical volatiles making them more attractive to both native

and exotic wood-boring insects like the two-lined chestnut borer (TLCB) (*Agrilus bilineatus*), honey locust borer (*A. difcilis*), bronze birch borer (BBB) (*A. anxiosus*), and a variety of bark beetle species (*Scolytus* and *Dendroctonus* spp.) (Dunn et al, 1990, Hanks et al, 1991, Hanks et al., 1999, Paine, 2002, Nielsen et al. 2011, Showalter et al., 2017, and Villari et al., references therein). For example, outbreaks of BBB are associated anecdotally with drought stress (Muilenburg and Herms, 2012) and cambium feeders appear to be strongly affected by host stress (Larson, 1989). It is thought, host traits considered to be important for tree resistance to wood-borers include those that influence adult oviposition preference and/or larval performance (Hanks et al, 1999 and Villari et al., 2016). Charkraborty et al. (2013) found that drought stress increased the performance of EAB larvae on Manchurian ash. Research by Showalter et al. (2017) indicated water stress decreased tree growth and resistance of Manchurian ash (*F. mandshurica*) to EAB even though, under adequate moisture conditions, it is rarely colonized, and EAB is considered a secondary colonizer of stressed or declining ash trees (Wei et al, 2004, 2007). Water stress had little effect on resistance of the already moderately susceptible white ash (*F. americana*). These results suggest that the resistance of Manchurian ash to EAB may be due to the phloem chemistry resulting in lower larval growth and development, and lower ovipositional preference (Showalter et al., 2017). In addition to chemical volatiles, resin pressure and bark moisture can influence whether wood-boring insects are capable of colonizing a host tree. It has been well-documented that resin pressure is a major deterrent to invading bark beetles (Barry et al., 2017, Reeve et al, 1995, Smith, 1972). If a tree is healthy, then it is usually able to expel invading beetles before they can establish, but if the tree is stressed due to drought or vascular damage, then resin pressure is usually not sufficient to prevent a bark beetle invasion.

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What about fertilization and resistance to plant pests? A common arboriculture practice is fertilization of woody plants with the idea that fertilization may enhance pest and disease “resistance” because the plants are healthier. However, that is not always the case and the scientific evidence does not really support this practice (Herms, 2002). Actually, a number of studies have shown that fertilization reduces woody plant resistance to sap-feeding, leaf-feeding, and wood-boring insects. In fact, there is a great deal of evidence that fertilization actually increases insect performance (i.e. aphids) by increasing the nutritional quality of the host and/or reducing secondary metabolite concentrations (Herms, 2002). In other words, fertilization of moderately nutrient-deficient plants is predicted to decrease secondary metabolism (production of secondary metabolites) if growth is increased, but photosynthesis is not affected. However, fertilization of extremely nutrient-limited plants is predicted to increase secondary metabolism if photosynthesis is also increased (Herms, 2002). Additionally, there is no strong evidence that fertilization increases the tolerance of woody plant to defoliation. Studies have shown that the rate of nitrogen (N) applied is the key factor affecting tree growth, but the form or method of application of N has shown little effect and suggests that insect performance is influenced by a more general plant response as opposed to a particular fertilizer formulation (Herms, 2002). Bottom line, prescription fertilizer practices can be highly beneficial, but must be tempered with the knowledge and understanding of the potential pest management consequences associated with fertilization programs (Herms, 2002).

Now that we have a better understanding

of what HPR is and how plants defend themselves, we need to ask ourselves, “Why has HPR been slow to be implemented into PHC programs?” For one, is low demand from both our clients, and we practitioners. Let’s face it, most of our plant breeding programs have concentrated on the plant’s ornamental attributes (i.e. flowering, fall color, growth habit, etc.) with a high priority placed on plant appearance and aesthetics. That is why they are called “ornamental plants”. Depending on the desires and expectations of the client for very little, if any, plant damage, the use of less susceptible or “resistant” plants can be challenging. Additionally, in a given landscape or community, there may be a large number of different plants that are affected by a variety of disease and/or insect pests, not counting all of the abiotic factors (i.e. drought, flooding, pollution, microclimates, etc.) that may be in play. Also, the development of new resistant plants that meet all of the above criteria can take many years, a great deal of research expertise and funding before they reach the market place and can be planted.

However, with public sentiment, and additional regulations for less use of pesticides, loss of pesticides altogether, and the potential development of pesticide resistance, the use of HPR will become even a more viable and important tool in the future (Herms, 2002a). There are a number of advantages of using HPR including the high economic value of ornamental plants, their high cost of maintenance, societal desire for reduced pesticide use, potential long-term sustainability and effectiveness of HPR, and the relatively low cost of implementation.

Implementing HPR into a PHC Management System

While all of this information is enlightening, interesting and hopefully helpful, how can we practically develop and implement HPR into a

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comprehensive PHC program. Like any PHC tactic, we must weigh the pros and cons.

In general, HPR is a very important component of a PHC program, is usually specific to the target pest(s), and generally does not directly affect natural enemies. It can be cumulative and sustainable; in that it can last for many successive plant and pest generations. By design, new resistant varieties are usually competitive in cost, easily accepted and adopted by end users, and can contribute to overall plant diversity. HPR usually results in a reduction of chemical pesticides, may enhance pesticide efficacy, and helps conserve natural enemies. It is compatible with biological and cultural control, can be cost effective, and in unique situations, HPR can be the tactic of choice for plants of low economic value when the pest is always there and is the major limiting factor for plant growth and development.

On the down side, HPR can be a very lengthy process requiring many years, if not decades, for traditional breeding programs to come up with a workable product. For example, development of some of the new American elm (*U. americana*) cultivars and complex Asian elm hybrids have taken decades to bring to the trade. There is always the potential for insect biotypes (a new insect population capable of damaging and surviving on plants previously resistant to other populations of the same species) to develop due to exposure to new plants. Aphids and whiteflies are good examples. Of course, there are always genetic limitations within the host plant.

How can we make use of HPR in a PHC program? **First**, make sure the plants you select are properly suited for the site **“right plant for the right place”**. Healthy, thriving plants have a better chance of fighting off

most pest and disease problems. Where we get into trouble is trying to “force” plants to grow in an environment (i.e. shade versus sun, poorly drained or droughty soils, heat and cold hardiness) for which they are not adapted.

Second, for plants already in the landscape, focus on keeping them as healthy as possible by properly mulching, applying fertilizer only when needed or justified, regular pruning, and responsible pest management. **Third**, know your pest complex(s). In other words, which pests pose the gravest threat to your plants? Are the pests native or exotic, lethal or just a nuisance, and will they predispose your plants to lethal pathogens and wood-boring insects? How often do they show up, once in a while or consistently?

Fourth, find out what plants are readily available in your area and identify those that are less susceptible to key pests and attempt to “work them” into your plant selection pallet. As is the case many times, we have to work with what we are given. If you have highly susceptible plants, think about replacing them in the future with less susceptible ones. For example, there are a number of crabapple varieties that are less prone to getting apple scab, sycamores that are less prone to sycamore anthracnose, new American elm cultivars and hybrids that can tolerate Dutch elm disease (DED), and lindens that are less preferred by Japanese beetle, just to mention a few. Consider male ginkgo trees for downtown and urban areas where salt, heat, and droughty conditions are common. In chronically wet areas, plant bald cypress, river birch and other “bottomland” species that can tolerate wet soils. **Finally**, be on the lookout for plants that may show resistance. Two programs, the legacy elm and ash tree programs, are designed to identify American elms (*Ulmus americana*) and North American ash (*Fraxinus* spp.) trees that for whatever reason have survived the ravages of DED and EAB, respectively, and to use them as a rich source of future tree breeding material. In summary, while HPR is not the answer to all

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of our abiotic and biotic tree problems, and may not be possible in all situations, we need to make the most of it where we can. As we learn more and more about woody plants and their interactions with pests and diseases, hopefully we will have the opportunity to develop more and more tolerant and/or resistant plants for our landscapes and urban and rural forests.

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