Urban Forest – Part 2:

The Wood Wide Web

The underground tree is linked with surrounding trees through mycorrhizal fungi. All images courtesy of John Ball.

By John Ball, Ph.D., CTSP

In Part One of this set of articles on how trees function differently in urban and community forests than they do in the natural forest ("You Can Take the Tree Out of the Forest, But Not the Forest Out of the Tree," *TCI,* November 2017), I discussed how the above-ground tree is shaped by the trees surrounding it. Here, in Part Two, I will cover how the below-ground tree is truly part of a community.

A new moniker for this relationship is the "wood wide web," something we will hear more of in the coming years. This wood wide web is really not much different from the digital web we use; both are designed to improve communication. As you will learn to appreciate, we have left the trees in our communities essentially deaf.

We have known for centuries that intraspecific root grafts allow a tree species to share resources (and diseases) among its members. We have known for decades that different tree species can be linked to share resources through the hyphae of mycorrhizal fungi. Mycorrhiza is a mutualistic relationship where a fungus linked to the tree's roots forages for nutrients for its host in exchange for some of the food the tree manufactures. It's a nice sharing relationship. What we did not fully appreciate till recently is just how sophisticated this sharing can become among trees.

We once looked at the dominant relationship among forest trees as competitive. There are only so much of resources available – water, nutrients, even light – so in order for some trees to grow, others must die. This relationship does occur, of course. As forest trees increase in girth and height, there is usually a corresponding decrease in the number of trees. The trees that were losing the race for sunlight and other resources gradually become suppressed, decline and die. Some species that are shade intolerant – cottonwoods and birches – may find this a very short race, fading out in a decade or two, while shade-tolerant species – maples and beeches – may persist for centuries.

But increasingly, it appears that mutualism – you help me, I help you – is more important in forest-tree relationships than we once thought. Trees, even as seedlings, adapt to become social creatures, sharing their products of photosynthesis, photosynthates (primarily sugars). "I gathered a few more resources to make photosynthates, so I will pass a cup of sugar to any of my mates that need a little help." We are not sure why trees do this, no one can yet speak maplish or oakish, but clearly it must have some advantage to the species as a whole for this trait to persist.

What is even more amazing is that this relationship becomes more complex as the trees mature. Evergreen trees, e.g. pines and Douglas-firs, can move photosynthates in the spring to nearby deciduous trees. After all, the engines of conifers start a little earlier in the spring, so they get out the battery cables and give the surrounding deciduous trees a jump start.

During the summer, the roles reverse. The deciduous trees are gathering in light at a frantic rate and have become the "sugar kings" in the forest. Now it's time to return the favor, that cup of sugar borrowed in the spring, and some photosynthates move back to the evergreens.

Finally, as winter approaches, the deciduous trees settle down for their long winter nap, shedding their primary means of manufacturing sugars, their leaves. Now, once again, the evergreens, which are still undergoing photosynthesis, transfer some photosynthates back to the deciduous trees. Apparently trees are nicer neighbors, and have learned the importance of sharing better than most people.

Sharing food, passing the plate so to speak, is more sophisticated function than we expected of trees. These tall, immovable, creatures do not seem to be likely candidates to work together. However, what is even more remarkable is that they communicate with one another. Trees "talk."

We are not sure if they engage in mindless chatter, as we often endure from adjacent passengers on long flights. I hope they don't, as they cannot politely excuse themselves and move away from a bore. Instead, they communicate the messages neighboring trees really need to hear: "Get ready, something is coming to chew off your leaves."

The "Get ready" implies that the tree can do something to prepare for an impending attack. Another remarkable discovery during the past decades is that trees have very active defenses. We once looked upon trees as defenseless creatures, depending on us to protect them from pests. We would paint pruning cuts to seal them off from pathogens. We would spray trees to kill defoliating insects. We had to do this as trees could not defend themselves, right?

Along came Dr. Alex Shigo to completely blow away the need to paint cuts (and, for anyone else reading this who climbed trees in the '70s, getting rid of those paint pots was reason enough to be happy with this change). Trees could defend themselves from pathogens by creating internal barriers to their movement into and throughout the trunk.

About the same time, tree defenses against insects and other pests were also being given a look. Back in the 1800s, researchers noted that there were substances in plants, including trees, which did not appear necessary for growth and development. They were designated secondary plant compounds or secondary metabolites. Many of these compounds did not seem to serve any function and, like our tonsils and appendix, were thought to be just vestigial structures of some ancient need. However, again like tonsils and the appendix, we found these plant compounds do have a function.

Conifers and deciduous trees can share resources through the wood wide web.

The tonsils protect again infection. They are part of your immune system, and the appendix may serve as a storehouse of beneficial microbes. Similarly, secondary plant compounds also serve a need, as they defend the tree against pests.

Most arborists are familiar with pine resin, that goo that can cover your climbing line and hands while pruning these trees. This pitch is a part of the terpenoid defenses, not against people, but borers. As an insect attempts to burrow into the tree, the resin tries to pitch it back out. It's not a perfect defense (and more complex than this); trees lose when the number of attacking beetles overwhelms them, but it generally works.

There are also defenses that are not as noticeable, biochemicals that permeate leaves and phloem, for example, that make this tissue become distasteful or even lethal. But these compounds are expensive for the tree to make and maintain. They can utilize a lot of photosynthates, food that could be used to build new leaves, vascular tissue and roots. Instead, these defenses are generally made on an "as needed" basis. If the tree is being attacked, these biochemicals can be used to try to stop the invasion. Of course, they just suffered a "surprise" attack, so it may take some time to get their defenses geared up.

But what if you could make them just before the attack? What if you had some warning and could build up the defenses before the attack occurred? Welcome back to the wood wide web.

A tree apparently can communicate an impending attack to surrounding trees. These communications can be through volatiles released into the air and by messengers transferred though the mycorrhizal connection, the web. Again, we are not sure why trees do this, and it might not even be them. Some researchers believe it's the fungi that are passing the messages along for their own good, to keep the trees around that they depend upon for their

Leaving logs to decay in the mini-forest provides a reservoir for microbes and nutrients.

nourishment.

Now back to the problem with the urban and community forest. It's not a forest, it's a collection of trees. Forests function as communities. The urban forest operates as independent trees that happen to be near, but not with, one another. We plant trees as individuals and spaced far enough apart to prevent or reduce communication and resource sharing. Instead, we should be planting trees in mini-forests as much as possible, rather than as individual specimens. This allows them to work together in mutual defense against the stressors of urban life.

We also might consider the value of soil. It functions more than as just a big Christmas-tree stand, holding trees up and as a reservoir for water. It's alive, and we have to have a healthy soil to support these internet connections, the fungal part of mycorrhizae. We might consider allowing coarse-wood debris, a euphemism for the messy collection of fallen trunks and branches on the ground, to stay in place and slowly decay.

We cannot do this with the specimen tree in the middle of a pristine lawn; apparently we cannot even have fallen leaves on these landscapes. But we can in our mini-forest. Turf grasses are not welcome here. Instead, an herbaceous community is permitted to thrive on the forest floor along fallen trunks and limbs. These decaying logs and limbs serve as a back-up system, perhaps like what your appendix may do, a reservoir of beneficial microbes to repopulate the soil after a stress event, e.g. flooding or drought.

I hope that, after reading these two articles on how ill adapted our trees are for "city living," you have a greater appreciation for the unique stresses trees have to endure in our communities. And as much as is practical and possible, let's try to grow trees in mini-forests, even a grove of 10 or so, spaced 15 to 20 feet apart, rather than as individual trees separated by 40 feet or more. Remember, you can take the tree out of the forest, but you cannot take the forest out of the tree.

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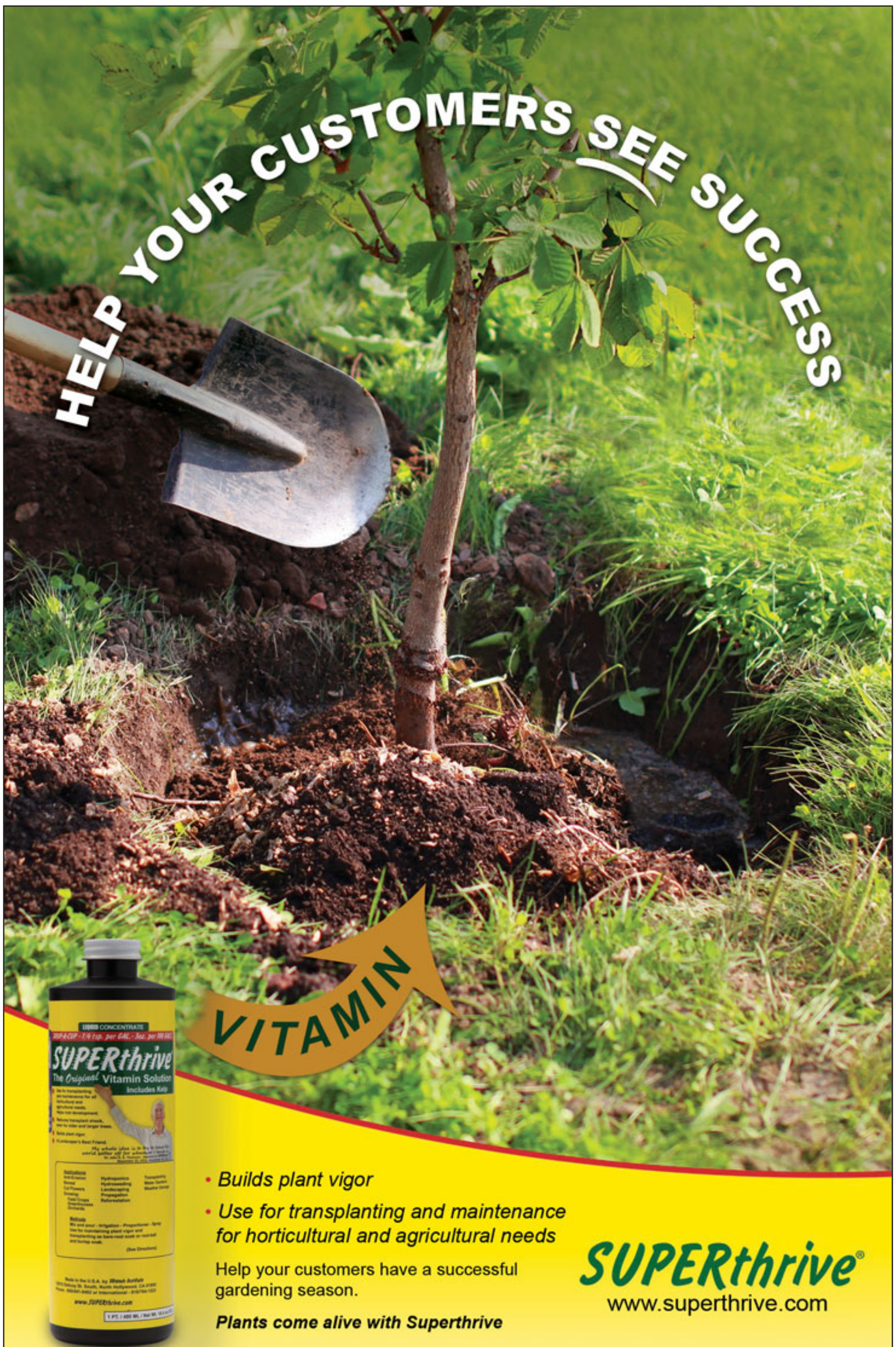

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