Along the Towpath

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Trees, Fungus and Complexity Science

By Trent Carbaugh

Anywhere we go on the C&O Canal we will find trees. In some places they will be sparse and in others they are parts of large forests. Although most of the forest around and in the park has been cut at least once, we are fortunate that there are some true old growth trees still surviving. These trees are hundreds of years old and give us a little glimpse of what the original trees of the giant eastern forest that grew from the Atlantic shore to the Mississippi river valley looked like. It must have been a truly grand sight to behold.

Every now and then a new discovery about the natural world changes our perception of what is around us. Sometimes new information confirms those things that our subconscious minds understand on some level, and the proverbial light bulb turns on. This happened to me after reading a book about the subject and admittedly I'm quite fascinated with the concepts described in this article.

Most people love trees and most understand that trees are vital to keeping nature in balance. We need trees; not only do they convert carbon dioxide into oxygen, but they also provide microclimates that influence weather patterns both locally and on a larger scale if a forest is big enough. On a hot summer day going into a forest will cool you down (in some cases 10–15 degrees cooler) and you'll feel a little better because of the higher level of oxygen that you breathe in under the trees. Trees also give us timber, the wood we use for houses, furniture, paper and all the other things wood can be used for. Wood is a constantly renewable resource.

Much of the science of forestry is supported by commercial interests, both private corporations and governmental agencies. The idea is to get the biggest yield of usable timber, as well as the highest profit, as fast as possible. After old growth

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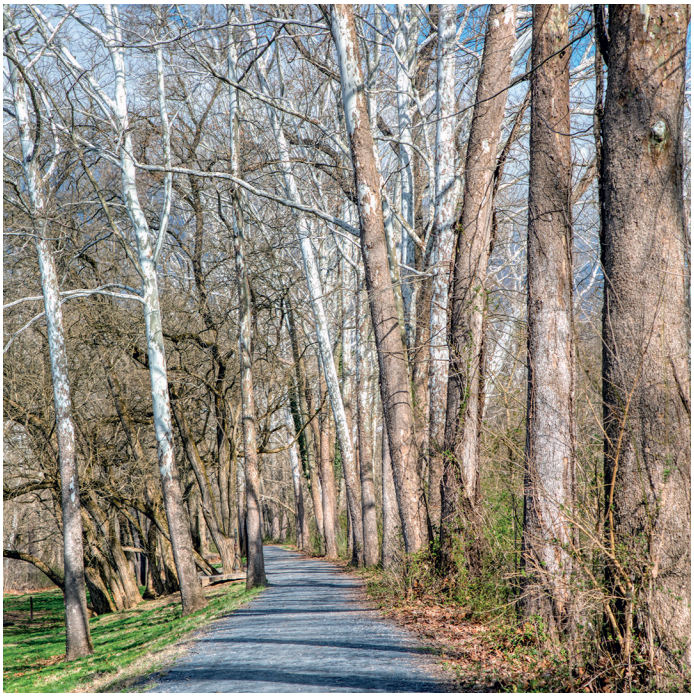

Trees are a fundamental part of the C&O Canal experience any time of year – Photos by Steven Dean

Trees, Fungus and Complexity Science – *Continued from page 1*

trees in an area are cut, faster growing trees, usually conifers of some type, are replanted. To make a long and complicated story short, this is not the best way to run a forest. It's counterproductive to a forest's growth, not to mention a complete forest's health. Nature is a complex collection of interacting systems that function on a global scale. The more we examine these systems the more we learn just how complicated they are.

This brings us to a Canadian forestry biologist, Dr. Suzanne Simard. She was not the first scientist to understand the complex nature of tree and forest life cycles; in fact, the First Nations peoples in her beloved western Canadian forests were well versed in the life cycles of the forests that they lived in. Most scientists, though, don't have that rare gift that Dr. Simard does: the ability to explain complex scientific ideas in a way that anyone can understand as well as place it in a human context. Although Dr. Simard and her colleagues and students' work was and is done in the massive forests of the Pacific Northwest, the principles appear to be true for any forest in the world.

Competition versus Cooperation

Conventional forestry science works on the idea that trees compete with each other all of the time for resources, water, sunlight, and nutrients. As noted earlier in this article, it is believed that to get the highest yield of desirable trees for timber forests need to be heavily managed. Mature trees are cut and target species are replanted in neat orderly rows to facilitate later harvesting. This practice often does not work the way it is expected to and is bad for the trees as well as animal life that depends on them.

Small mycelia just under the leaf litter; deeper down in the soil they can be larger – All photos by Trent Carbaugh

What Dr. Simard and others have posited is that forests work by cooperation, not competition. Completely different species of trees share resources with each other on a regular basis. The idea of leaving trees to their own devices, or replanting with compatible species, increases the overall health of the entire forest as well as ensuring a diversity of species for the benefit of all creatures concerned. It also increases the productivity of the target tree species for later logging.

Mycelium Networks

Take a walk in the forest, or even a small stand of trees. Anytime, except the coldest parts of the winter, you will see fungus growing on dead trees or as mushrooms popping up from the ground. Those mushrooms and their cousins are the fruiting

The Scientific Method

Scientific method **is a set of steps used to prove or disprove a hypothesis. Different scientific disciplines modify the use of the method to fit the specific parameters of the needs of a particular discipline, but the basic method is always the same. The basic steps are:**

1. ***Make an observation.***
2. ***Ask a question.***
3. ***Form a hypothesis or come up with a testable explanation.***
4. ***Make a prediction based on known facts and your hypothesis.***
5. ***Test the hypothesis by experimentation.***
6. ***Carefully examine your results to confirm your hypothesis or form a new hypothesis or prediction.***
7. ***Repeat as necessary.***

For this process to work, good records need to be kept so that other scientists can repeat your experiments to prove the validity of your hypothesis. If a hypothesis is shown by experimentation to be valid a detailed paper is produced and subjected to peer review. This is a long, sometimes painful, process but it is how new ideas enter science.

The Reductionist Method – Occam's Razor

Attributed to John of Occam, a 14th century Franciscan monk and theologian, Occam's Razor is a thought process that allows you to "shave" down explanations to bare facts. This is a useful tool to use when examining a new or modifying an existing hypothesis.

Occam's Razor states:

"The simplest explanation that will account for a circumstance or event is most likely the correct explanation."

Sir Arthur Conan Doyle's character Sherlock Holmes put this idea in even simpler terms: "*When you have eliminated the impossible, whatever remains, however improbable, must be the truth.*"

bodies of a complex and massive network of fungi growing under the forest floor. This is known as a mycelium network, or how the journal *Nature* describes it when publishing Dr. Simard's first paper on the subject, the "Wood Wide Web."

In simple terms the mycelium network connects the tips of tree roots together and facilitates the transfer of nutrients and other resources between trees. Chemical information is also passed along this network; for example, a tree being attacked by insects will put this "information" out on the network and other trees will excrete enzymes distasteful to the invaders to ward off damage. For facilitating this exchange of chemical information, the fungus receives photosynthesized sugars from the trees in trade. It is much more complex than this simple description; different species of fungi are adapted to work with specific tree and shrub species, and others break down dead wood, etc.

Reductionist Science and Complexity Science

There are different ways to commit acts of science. All of them use the tenets of scientific method and the check of Occam's Razor. How a particular researcher gets to a result is up to the researcher, but it basically boils down to experiments that can be reproduced by other scientists and repeatedly getting the same results. This is accomplished by either reductionist science, or a newer (or really old, depending on your view of the history of science) way of thinking: complexity science.

In reductionist science samples are broken down into their constituent parts and analyzed. This process can tell us what chemicals and compounds something is made of as well as often where they came from. It can also tell us that things move around, but not how they move. Reductionist science is mostly done in lab environments with complicated equipment and nice white lab coats, what many folks think all scientists do.

Complexity science on the other hand, looks at the whole of a system to ascertain how all of the elements of the system function either cooperatively, competitively or neutrally. This can be as small as studying the interactions of microscopic plants and animals in a drop of water or as massive as how oceans, land, atmosphere and planetary mechanics produce weather patterns. Complexity science is mostly done in the field and involves much direct observation, on site experimentation, and critical thinking on the fly to figure out how things work, and more importantly how things work together.

"Mother" Beech Tree

Both methods have their place and complement each other. As we pay attention to what is going on around us and use the constantly improving ways we have to examine what we see; we find out that what was often considered a simple thing turns out to be so complicated that we have to radically alter our thought processes and preconceived assumptions just to start to understand something. The problem is when new ways of thinking go against the entrenched ideas of the past, some folks have a difficult time changing, (or simply can't stand being proven wrong) and when you add in potential business interests, it can get even worse.

Mother Trees

If you know what to look for you can see this complexity all along the towpath in forested areas. The accompanying photographs are from an area that has beeches, oak, and the ever-present sycamores, all three species being some of my personal favorite trees. This delightful place is just off the towpath slightly west of McCoy's Ferry across the berm at Culvert 144. If you choose to see for yourself, please tread lightly (and carefully).

I'm going to use beech trees as an example as they are subject to much research and they cover most ways that trees cooperate with each other, they are also easy to recognize if one is not familiar with tree species. In the small stream valley between the canal and railroad tracks there are beech trees of all ages and one very large beech, which is a mother tree. This is a term coined by Dr. Simard to describe an

View of the small valley near McCoys Ferry with beeches, sycamores and other trees

older tree that takes care of its own genetic progeny as well as other younger trees and neighbor trees in distress.

Now, to be fair to the trees, a large tree could just as well be a father tree as it could be a mother tree, but the point is that trees in the position of being older and more mature seem to "act" in a way that is very similar to how human parents treat their children. Perception is nine-tenths of reality and putting difficult concepts into a human framework, if done with care, often is an enlightening way of explaining difficult scientific concepts to non-scientists.

The large beech that is seen in the photos connects to all of the beeches on the west side of the creek. The bank is eroded enough that an observer can easily see the root system connecting the smaller trees in places. Beech trees reproduce both sexually and asexually which means that the smaller beeches growing directly from the root system are essentially clones of the parent tree. Beeches also sexually reproduce by pollen distribution which ultimately produces beechnuts. These get distributed around the forest by squirrels and other animals spreading genetic diversity of the beech population over a larger area.

Beeches that grow from beechnuts, as well as the ones growing from the mother tree's roots, also connect to the mother tree and other trees by the Common Mycorrhizal Network (CMN). This is a system of fungal tubes created, in

Asexually reproduced beeches growing from the mother tree's root system

Beechnuts provide food for squirrels, who distribute the nuts around the area

The mother tree's surface root structure growing around a limestone outcropping above the stream bank

Beeches growing so close together with their roots joined that they are virtually one tree

the case of beeches by ectomycorrhizal fungi, connecting root systems to not only the mother tree but to other compatible tree species in an area.

The currency of the tree world is sunlight. Trees need light to photosynthesize carbon dioxide into sugars for energy. Trees also need minerals for various purposes that are often not available in the immediate area. Trees need to have large canopies of leaves (or needles, in the case of evergreens) to provide the energy for this process. But if our mother beech tree has a large canopy the smaller beeches under the canopy are not getting enough sunlight to thrive. So, Momma can send sugars to the young trees to bolster their energy needs, and not just to the young beeches! Any youngster attached to the network benefits from the transfer of sugars. The trees seem to understand that species diversity is very important for the overall health of a forest.

During times of stress, such as droughts, a mother tree will withhold resources from the total system and support only her own offspring till the resource situation improves. All of this is facilitated by the CMN for the cost of some sugar. Communication between trees and fungi is done by enzymes that science is just beginning to understand, which travel through the network.

Chicken of the woods fungus that breaks down wood on both live and dead hardwoods

Yellow wart mushroom

Pheasants back mushroom

In time, large trees die and fall down. Their wood is broken down by other fungal species and insects, and the leftover resources are transferred about the neighborhood. The biggest benefit to younger trees is the reduction of the upper canopy letting more sunlight onto the shorter younger trees starting the process over again. This complex system benefits the trees, the fungi, the thousands of insects that inhabit the forest floor and soil, and on to all of the animals living in the area.

To be fair, there is some resistance to the idea of a cooperative forest. Arguments against this idea range from "There's just not enough research to form conclusions" to "Competition is how everything in nature works." Some objections are valid, and some are not, but new information is always suspect by those who prefer not to change. Should you have those kinds of questions I invite you to peruse some of the following resources.

Remember that science is not just for folks that have letters after their names. Anyone can and should participate in science. Once you understand how scientific research is done (it's not difficult) and apply your critical thinking skills, draw your own conclusions. Our world is a wondrous place, and we owe it to ourselves and our descendants to learn as much about it as we can. The C&O Canal National Historical Park is a protected area, aside from its unique historical treasures it is also a fantastic outdoor laboratory to study nature in all of its infinite variety.

Resources

These are popular works that are excellent introductions to the study of trees:

Finding the Mother Tree, Discovering the Wisdom of the Forest, Suzanne Simard, Knopf, 2021

The Hidden Life of Trees, What They Feel and How they Communicate, Peter Wohlleben, Greystone Books, 2015

In addition to these resources, the **Mother Tree Project** is a great source of information and has a library of scientific papers should you want to delve deeper. Visit mothertreeproject.org for further information. The QR code at right provides a link to the project site.