The Many Roles of a Tree

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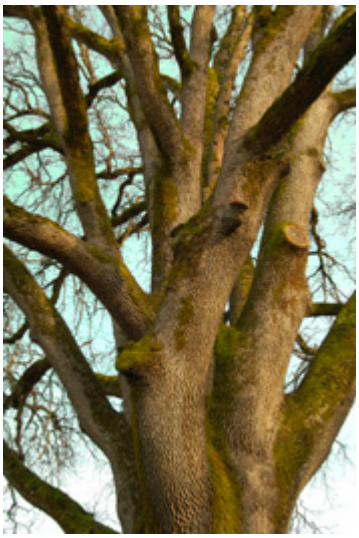

The following is an excerpt from Gaia's Garden: A Guide to Home-Scale Permaculture *by Toby Hemenway. It has been adapted for the Web.*

As I've said, when we look at a plant, we often see it as doing one thing. Take the hypothetical white oak I referred to above. Some home owner placed that tree in the backyard to create a shady spot. But even this single tree, isolated in a lawn, is giving a rich performance, not simply acting as a leafy umbrella. Let's watch this oak tree to see what it's doing.

It's dawn. The first rays of sunlight strike the canopy of the oak, but most of the energy in these beams is consumed in evaporating dew on the leaves. Only after the leaves are dry does the sunlight warm the air within the tree. Above the oak, however, the air has begun to heat, and a cloud of just-awakened insects swirls here. Below the canopy, it's still too chilly for the bugs to venture out. They roil in a narrow band within the thin layer of warm air above the tree. Together the sun and the oak have created insect habitat, and with it, a place for birds, who quickly swoop to feast on the swarm of bugs.

In the cool shade of this tree, snow remains late into the spring, long after unprotected snow has melted. Soil near the tree stays moist, watering both the oak and nearby plantings and helping to keep a nearby creek flowing. (Early miners in the West frequently reported creeks disappearing once they'd cut nearby forests for mine timbers.)

Soon the sun warms the humid, night-chilled air within the tree. The entrapped air dries, its moisture escaping to the sky to help form clouds. This lost moisture is quickly replaced by the transpiring leaves, which pull water up from roots and exhale it through puffy-lipped pores in the leaves, called *stomata*. Groundwater, whether polluted or clean, is filtered by the tree and exits through the leaves as pure water. So trees are excellent water purifiers, and active ones. A full-grown tree can transpire 2,000 gallons of water on a hot, dry day. But this moisture doesn't just go away—it soon returns as rain. Up to half of the rainfall over forested land comes from the

trees themselves. (The rest arrives as evaporation from bodies of water.) Cut the trees, and downwind rain disappears.

Sun striking the leaves ignites the engines of photosynthesis, and from these green factories oxygen streams into the air. But more benefits exist. To build sugars and the other carbon-based molecules that provide fuel and structure for the tree, the leaves remove carbon dioxide from the air. This is how trees help reduce the level of greenhouse gases.

As the leaves absorb sunlight and warm the air within the tree, this hot, moist air rises and mixes with the drier, cool air above. Convection currents begin to churn, and morning breezes begin. So trees help create cooling winds above them.

Closer to the ground, trees block the wind and make excellent windbreaks. Wind streaming past a warm building can carry off a lot of heat, so one or more trees on a house's windward side will substantially reduce heating bills.

The oak's upper branches toss in the morning breeze, while down below the air is still. The tree has captured the energetic movement of the air and converted it into its own motion. Where does this energy go? Some scientists think that captured wind energy is converted into the woody tissue of the tree, helping to build tough but flexible cells.

The morning breeze carries dust from the plowed fields of nearby farmland, which collects on the oak leaves. A single tree may have ten to thirty acres of leaf surface, all able to draw dust and pollutants from the air. Air passing through the tree is thus purified—and humidified as well. As air passes through the tree, it picks up moisture exhaled from the leaves, a light burden of pollen grains, a fine mist of small molecules produced by the tree, some bacteria, and fungal spores.

Some of those spores have landed below the tree, spawning several species of fungus that grow symbiotically amid the roots, secreting nutrients and antibiotics that feed and protect the tree. A vole has tunneled into the soft earth beneath the tree in search of some of this fungus. Later this vole will leave manure pellets near other oaks, inoculating them with the beneficial fungus—that is, if the owl who regularly frequents this oak doesn't snatch up the vole first.

This tree's ancestors provided Native Americans with flour made from acorns, though most contemporary people wouldn't consider this use. Now, blue jays and squirrels frolic in the oak, snatching acorns and hiding them around this and neighboring yards. Some of these acorns, forgotten, will sprout and grow into new trees. Meanwhile, the animals' diggings and droppings improve the soil. Birds probe the bark for insects, and yet other birds and insects depend on the inconspicuous flowers for food.

Later in the day, clouds (half of them created by trees, remember) begin to build. Rain droplets readily form around the bacteria, pollen, and other microscopic debris lofted from the oak. These small particles provide the nucleation sites that raindrops need to form. Thus, trees act as cloud seeders to bring rain.

As the rain falls, the droplets smack against the oak leaves and spread out into a fine film, coating the entire tree (all ten to thirty acres of leaves, plus the branches and trunk) before much rain strikes the ground. This thin film begins to evaporate even as the rain falls, further delaying any through-fall. Mosses and lichens on this old oak soak up even more of the rain. We've all seen dry patches beneath trees after a rain: A mature tree can absorb over a quarter inch of rain before any

reaches the earth, even more if the air is dry and the rain is light.

The leaves and branches act as a funnel, channeling much of the rain to the trunk and toward the root zone of the tree. Soil close to the trunk can receive two to ten times as much rain as that in open ground. And the tree's shade slows evaporation, preserving this moisture.

As the rain continues, droplets leak off the leaves and splatter on the ground. Because this tree-drip has lost most of the energy it gathered during its fall from the clouds, little soil erodes beneath the tree. Leaf litter and roots also help hold the soil in place. Trees are supreme erosion-control systems.

The water falling from the leaves is very different from what fell from the sky. Its passage through the tree transmutes it into a rich soup, laden with the pollen, dust, bird and insect droppings, bacteria and fungi collected by the leaves, and many chemicals and nutrients secreted by the tree. This nutritious broth both nourishes the soil beneath the tree and inoculates the leaf litter and earth with soil-decomposing organisms. In this way, the tree collects and prepares its own fertilizer solution.

The rain eases toward sundown, and the sky clears. The upper leaves of the tree begin to chill as night falls, and cold air drains down from the canopy, cooling the trunk and soil. But this chill is countered by heat rising from the day-warmed earth, which warms the air under the tree. The leafy canopy holds this heat, preventing it from escaping to the night sky. So nighttime temperatures are warmer beneath the tree than in the open.

The leaves, however, radiate their heat to the sky and become quite cold, often much colder than the air. All these cold surfaces condense moisture from the air, and the resulting dew drips from the leaves and wets the ground, watering the tree and surrounding plants. Leaves can also gather moisture from fog: On foggy days the mist collects in such volume that droplets trickle steadily from the leaves. On arid but foggy coasts, tree-harvested precipitation can be triple the average rainfall. By harvesting dew and fog, trees can boost available moisture to far beyond what a rain gauge indicates.

As we gaze at this huge oak, remember that we're barely seeing half of it. At least 50 percent of this tree's mass is below the ground. The roots may extend tens of feet down, and horizontally can range far beyond the span of the tree's branches. We've already learned how these roots loosen and aerate soil, build humus as they grow and die, etch minerals free from rocks with mild acid secretions, and with sugary exudates provide food for hundreds or even thousands of species of soil organisms that live with them.

Roots gather nutrients from deep in the ground, and the tree uses them to fashion leaves. When these leaves drop in the fall, the carbon and minerals collected from the immense volume of air and earth around the tree are concentrated into a thin layer of mulch. Thus, the tree has harvested a diffuse dusting of useful nutrients, once sprinkled into thousands of cubic yards of soil and air, and packed them into a rich, dense agglutination of topsoil. In this way, trees mine and concentrate the sparse ores that surround them to build fertility and wealth. This wealth is shared with many other species, which root and burrow, feed and build, all nourished by the tree's gatherings.

But there is more: This tree's roots have threaded toward those of nearby oak trees and fused with them. A tree's roots, researchers have shown, can graft with those of its kind nearby, exchanging nutrients and even notifying each other of insect attack. Chemical signals released by an infested

tree prompt its neighbors to secrete protective compounds that will repulse the soon-to-invade bugs. If an oak has grafted to its neighbors, does it remain an individual tree? Perhaps trees in a forest are more like branches from a single subterranean “tree” than a group of individuals. One of the largest organisms in the world is a forest of aspen trees that is in fact a single individual. Above ground, it looks like a grove of separate trees, but beneath the surface, they are all connected via their entwined roots. Each of these aspen trees is genetically identical.

The ways in which a single tree interacts with other species and its environment, then, are many. I’ve barely mentioned the swarms of insects that this oak supports: gall wasps and their hymenopteran relatives, beetles that tunnel into twigs and bark, and all manner of sucking and chewing bugs and their many insect predators. Then there are the birds that feed on these bugs. And we shouldn’t forget the myriad nearby plants that benefit from the rain and nutrients collected by this tree.

Through this tree, we glimpse the benefits of ecological thinking. Instead of viewing a tree simply as something that looks nice or provides a single offering such as apples or shade, we can begin to see how deeply connected a tree is to its surroundings, both living and inanimate. A tree is a dynamic element embedded in and reacting to an equally dynamic landscape. It transforms wind and sunlight into a variety of daily and seasonally changing microclimates, harvests nutrients, builds soil, pumps and purifies air and water, creates and concentrates rain, and shelters and feeds wildlife and microbes. Add to all this the better-known benefits for people: fruit or nuts, shade, climbing and other fun for kids, and the beauty of foliage, flowers, and form. We start to see how tightly enmeshed is a simple tree with all the other elements in a landscape. Now we can begin to imagine the richness of a landscape of many plant species, all interconnected by flows of energy and nutrients, nurturing and being nourished by the animals and microbes that flap and crawl and tunnel among them.

Each plant modifies its environment. These changes in turn support or inhibit what lies nearby, whether living or not. Recognizing that plants don’t stand alone can radically affect the way we place the features of our gardens.

The first edition of *Gaia's Garden* sparked the imagination of America's home gardeners, introducing permaculture's central message: Working *with* Nature, not against her, results in more beautiful, abundant, and forgiving gardens. This extensively revised and expanded second edition broadens the reach and depth of the permaculture approach for urban and suburban growers.

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