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Inside Agroforestry

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Creating Healthy Soils

The agricultural community is paying more attention to the importance of soil health in moving toward supporting our individual and collective ecological and economic goals. For decades soil conservation has largely focused on keeping soil in place, a very important step. More recently, increasing soil organic matter and biological activity have taken center stage. Agroforestry practices can help improve soil health in a variety of ways. Learn how people are improving soil health through agroforestry.



NAC Director's Corner

A commentary on the status of agroforestry by Susan Stein, NAC Director

As world populations rise and acres under agriculture increase, so does the need to keep our soils healthy and productive. It is exciting to learn about the different approaches that farmers are using to enhance soil health, including no-till, cover cropping, diverse rotations, and, as discussed here, agroforestry. Farmers in the United States and beyond are taking deliberate steps to improve soil health in order to increase crop yields or decrease input costs, as well as to enhance water quality and quantity, crop resilience, climate change adaptation, and wildlife habitat, among other priorities.

Soil conservation has been viewed as an important benefit of agroforestry since the Dust Bowl days, with the establishment of windbreaks and shelterbelts. This benefit continues to be a focus of agroforestry research and adoption today. Both research and practice point to the compatibility of agroforestry with

the other conservation practices mentioned above — cover crops, no or low till, and crop rotation.

In fact, by providing year-round perennial vegetation, agroforestry can provide a risk-reducing backstop for those times of the year when annual crops and cover crops aren't yet established or those years when extreme weather events prevent the establishment of other soil health practices.

This issue of "Inside Agroforestry" provides insights on how people are using agroforestry to meet their soil health needs and long-term goals. The National Agroforestry Center also has other publications available on soil health. Check out our [soil health webpage](http://fs.usda.gov/nac/topics/soil-health.php) at <http://fs.usda.gov/nac/topics/soil-health.php> and our "Working Trees" information sheets: "Can alley cropping support soil health?" and "Can windbreaks benefit your soil health management system?"

New Faces at NAC

The USDA National Agroforestry Center welcomes two new staff members: Matthew Smith, research program lead, and Lord Ameyaw, NRCS agroforester, a shared position with the Nebraska Forest Service.



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Soil Health on a Farm in Hawaii

Richard Straight, USDA National Agroforestry Center

A core tenet of the Haiku Aina Permaculture Initiative (HAPI) on Maui is that renewal of the soil begins with a new relationship between people and the soil. Francis Spalluto explains that humans' relationship with nature should be one of respect, harmony, and adherence to natural law, and not a relationship of people being outside of nature, manipulating it only for personal gain.

However, Spalluto notes that the historical relationship with this 13.5-acre plot of land has been very different. Steep slopes, plenty of precipitation, year-long growing seasons, and annual cropping systems led to leached soils. In fact at HAPI, past agricultural uses of the land had left the soil leached of calcium, leaving high levels of aluminum near the surface and low levels of organic matter.

But that began to change when Jeffrey Bronfman acquired the property with the intent to develop a business on the north side of Maui and a vision to model diversity that could someday be applied at scale. His desire was to use restoration principles he had learned from an ongoing project in Brazil. With teaching and direction from Mauricio Hoffman, agroforestry specialist with Dagroforesta, and hiring Spalluto to manage the property, Bronfman began the process of restoring this 13.5-acre parcel. The restoration process began with the soil.

The HAPI experience began in 2011 with the first project carried out on a portion of the land. In the following years, Hoffman traveled to HAPI twice a year. During the first visit each year, he would provide training and discuss issues and ideas for the next project. In his absence, Spalluto and interns would discuss and develop plans for the project. During the second trip, Hoffman would help fine tune the plan and direct its implementation. Different approaches were used throughout the HAPI land because of the many changes in soil, aspect, and existing plant cover.

Protecting the soil from rain drop impact and leaching were the primary concerns. Simple mulching seemed to stop the leaching process. "In order to feed the soil biome, we often put down 20 to 50 kinds of biomass onto the soil," Spalluto said. "We are trying to move toward a fungal dominance in the soil biome." Along with a diversity of biomass from various plant sources, biologic teas were often added to the soil. The mulch also shaded the soil and helped keep soil temperatures below 73 degrees Fahrenheit. The goal of these activities was to enhance the biological activity in the soil, which can help plants access the minerals and nutrients in the soil.

Plant diversity and pruning were the driving forces of the system. About one-third of HAPI's plants are for biomass,



➤ Consultant Sam Knowlten discusses high carbon mulching during a training session at HAPI. Photo by Adam Lottig.

one-third for timber (to be utilized and sold), and one-third are food-producing plants (both above and below ground). The biomass plants are planted densely and are dropped and chopped onto the ground for mulch. HAPI often overplants bananas as biomass. They provide a water sugar supply to feed both macro-and micro-organisms. Some plants serve dual purposes, like an edible hibiscus. "It is one of the fastest growing plants we have," Spalluto said. "It produces more than we can eat, so the rest of the plant becomes mulch."

By using so many perennial food plants, the soil is host to living plants all year long. Trees are especially good for serving multiple uses (food, timber, and biomass) and have been an important contributor to the success of the systems. For example, one of the early sites was planted with bananas. The first plants were small and produced small racks, so they were cut down and incorporated into the soil. The subsequent banana planting was much more successful. Over time the soil color became much darker, and now more water is held in the rooting zone. An abundance of worms and evidence of fungal growth have also appeared.

In 2016 HAPI began a multistory cropping system with help from the USDA Natural Resources Conservation Service. They removed a small stand of eucalyptus trees, along with about 200 invasive Christmas berry and fiddlewood trees, to create a clearing to grow food. Among the many crops planted were banana, papaya, cassava, sweet potato, taro, jackfruit, soursop, mango, and gliricidia. They also milled about 1,000 board feet of mango and 3,000 board feet of eucalyptus for sale and use on the property.

When asked about how well these systems are accepted by other producers, Spalluto noted, "At first people are overwhelmed by what appears to be this random mass of green plants. But once they see that what we have is a vibrant system, not random at all, with no real pest problems, they become enthused. In fact, one large farmer in the area is considering adopting some of these methods onto 200 acres." 🌱

Hazelnuts and Soil Health: Managing for Multiple Outcomes at My Brothers' Farm

Kate MacFarland, USDA National Agroforestry Center

For Taylor Larson and his brothers, their goals for their land and their land's soil are intertwined. As they use ecological restoration and sustainable agriculture methods to transform their farm, they are creating systems and using practices that support many soil health principles.

Taylor manages My Brothers' Farm with his two younger brothers, along with help from their partners and parents. Their main products are organic hazelnuts, apples, bison, and pigs. The 320-acre home farm has historically grown grass seed. They have been incrementally converting the farm to orchards and pastures. They also lease a 32-acre hazelnut orchard down the road and manage another 26-acre hazelnut orchard on a custom basis. In addition to 140 acres of pasture, they graze pigs in some of the farm's oak stands and in the orchard. Their "big picture" goal has been to perennialize the landscape and move away from systems that require annual tillage.

My Brothers' Farm includes a wide range of production systems that incorporate trees and shrubs to varying degrees. Along with the orchards, they also have 80 acres in riparian restoration projects. With support from the Oregon Watershed Enhancement Board and the Meyer Memorial Trust, as well as the USDA Conservation Reserve Enhancement Program, they have planted 80,000 native trees and shrubs in these riparian areas.



📍 My Brothers' Farm integrates hogs into their hazelnut orchards. Photo by Taylor Larson.

While the perennialization effort supports a number of soil health principles, two systems of note demonstrate how the Larsons achieve soil health goals while supporting the operation in an agroforestry context. When starting to plant their hazelnut orchards, Taylor and his brothers knew they weren't interested in using the typical method for harvesting hazelnuts in the Willamette Valley: waiting for the hazelnuts to ripen and fall to the ground, driving a machine through the orchard to blow and sweep the hazelnuts into a windrow, and driving a harvester over the pile to separate the nuts. This method requires dry conditions and a flat, well-manicured orchard floor without woody debris or vegetation.

This method, although common, was incompatible with the goals that My Brothers' Farm had for soil health and biological diversity, so they had to find new ways to grow and harvest. They looked for options that allowed for more plant diversity, less soil disturbance, and kept the soil covered as much as possible. While they currently hand harvest, they are also working to learn more about shake-and-catch methods through a Western SARE Farmer/Rancher grant. This shake-and-catch system is more compatible with their orchard management goals.

My Brothers' Farm has worked to create diverse orchard ecosystems that resemble woodlands, which incorporate diverse cover crop mixes, woodchips, and other elements to enhance the fungal biology of the system. This species diversity changes the orchard floor and would be incompatible with harvest methods that require vegetation to be short or manicured. My Brothers' Farm also has integrated animals into its orchard system to enhance nutrient cycling, reduce fertilizer needs, and prevent



pests. However, if you apply manure to an orchard and harvest off the ground, there is a very long return interval required between manure applications and harvesting. Harvesting directly from the tree allows for more flexibility in grazing.

In its first year, the shake-and-catch system yielded mixed results. Hazelnuts ripen over three weeks, so identifying the correct timing was challenging. A big wind event the day before harvest also knocked many nuts to the ground. They are continuing to prototype the equipment to gain efficiency. That said, they have a higher tolerance for missed nuts because of their integration of pigs – livestock integration is another soil health principle.

Taylor is also interested in increasing plant diversity within the orchard by adding apples, alders, cottonwoods, and other trees and shrubs. This diversity provides another challenge to the usual drop-and-sweep method of harvesting hazelnuts: apples or other crops in the windrows prevent using typical equipment. The brothers' goal is to figure out how to manage diverse systems instead of monocultures, and do the homework up front on how to be successful.

In addition to investigating innovative harvesting techniques, Taylor has taken other measures to improve hazelnut production without sacrificing soil health. Grazing is an important tool in both enhancing ecological function (including soil health) and finding economic efficiencies. The farm's interest in grazing oak woodlands is not just to gain the benefits expected from silvopasture systems or simply to have extra pasture available for the pigs. It also helps overcome an important economic threat to organic hazelnut production: the filbert worm.

The filbert worm lives part of its life in the acorns of Oregon white oak (*Quercus garryana*). This means that oak woodlands are often home for filbert worms that invade hazelnut orchards. As a result, the typical practice on hazelnut farms is to remove oak woodlands in the area. This is a conservation challenge because



↑ Taylor Larson is testing a shake-and-catch harvesting system for the hazelnuts at My Brothers' Farm. This work is supported by a Western SARE Farmer/Rancher grant. Photo by Taylor Larson.

oak woodlands are one of the most threatened ecosystems in Oregon's Willamette Valley; only 5% of the habitat remains today. Taylor and his research partners are studying whether grazing acorns will reduce filbert worm populations.

Before grazing their oak woodlands, Taylor was a little worried about impacts to understory vegetation and soils. However, so far it's been working great. "The pigs are only in the woodlands for a short period of time – right after acorn fall," he said. Paddocks in the woodlands are usually about two acres, and the pigs are only in there for three or four days out of the entire year. The time of year that the pigs are in the woodlands is also fairly dry, so erosion, compaction, and wallowing are less of an issue. "They have such a strong preference for acorns (or hazelnuts in the orchards) that they don't root," he said. The pigs are monitored one to two times a day to see when they've made it through the available nuts. "There's stiff competition for the nuts among the pigs," Taylor said. "They aren't going after anything else until the nuts are gone."

Still, to better understand potential understory impacts, My Brothers' Farm worked with an undergraduate researcher from the University of Oregon to compare oak woodlands that were grazed and ungrazed. This research found no impact on the understory vegetation. While this project only collected one year of data, it provides a baseline for the future. My Brothers' Farm plans to use the research design to look for changes in vegetation and soil health over time. They will continue collecting data this season. Research is ongoing as to whether filbert worm numbers and nut harvest are improved through grazing.

Using soil health principles to further the farm's goals has been an effective approach for My Brothers' Farm. By integrating concepts of ecological restoration with sustainable agriculture, they are able to meet their economic and ecological goals. 🌱

Soil Nitrogen in Honeylocust Silvopasture

Gabriel J. Pent, Virginia Tech University
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Minimizing competitive interactions between trees and forages is often a primary consideration in silvopasture design. However, potential exists for facilitating beneficial interactions between the plants in a silvopasture. For example, some trees (e.g., black locust (*Robinia pseudoacacia* L.)) or forages (e.g., clovers (*Trifolium* spp.)) can convert atmospheric nitrogen into a biologically usable form that can promote the growth of other non-nitrogen fixing plants within the silvopasture.

Although honeylocust (*Gleditsia triacanthos* L.) trees are in the legume family, they do not form nodules, which are swellings on the roots that typically host the rhizobial bacteria responsible for nitrogen fixation. Recent evidence suggests that some *Rhizobium* species may be associated with the honeylocust rhizosphere and support some level of nitrogen fixation (Ahrenhoerster et al., 2017). This is supported by the observation that foliar nitrogen concentrations of honeylocust trees are intermediate between levels found in nodulating legumes, such as black locust, and nonleguminous trees, such as buttonbush (*Cephalanthus occidentalis* L.) (Van Sambeek et al., 2008).

Well-functioning silvopasture systems can be designed and managed to take advantage of biological pathways that reduce the need for external inputs, such as fertilizers, but little research exists for leguminous trees in temperate zones. Whether these trees can fix atmospheric nitrogen to support both their growth and that of forages remains a question. A 25-year-old silvopasture research site in Blacksburg, Virginia, provides some indication that honeylocust trees are indeed associated with additional nitrogen in the soil, but the mechanism by which this happens is not clear.

At the Whitethorne Agroforestry Research and Demonstration Center at Kentland Farm, two types of silvopasture have been compared to open (treeless) pastures. Black walnut (*Juglans nigra*

L.) trees were planted in one set of paddocks for their nuts and timber, while honeylocust trees (cv. Millwood) were established in other paddocks for their nutritious pods. Both species are “warm season species” and have compound leaves with diffuse canopies. The trees were initially planted in 1995 with 40 feet between tree rows and 8 feet between trees within rows. Over time, trees have been thinned to a 40 by 40-foot spacing.

In 2015, a small set of soil samples were collected from the silvopastures and open pasture. (Each system was replicated three times.) Soil samples were analyzed for inorganic nitrogen (i.e., nitrate and ammonium). Total inorganic nitrogen was nominally, but not statistically, greater in honeylocust silvopastures (table 1). It will be interesting to more thoroughly sample and analyze soils in these systems to truly determine if the honeylocust trees do, in fact, confer a positive nitrogen status to these silvopasture soils.

If these results were found to be statistically significant with additional sampling, another mechanism may be at work contributing to this phenomenon beyond the nitrogen fixation associated with honeylocust trees. Detailed forage species composition analyses were

performed on all pastures throughout three summers (2014-2016). The main grass species were tall fescue (*Schedonorus arundinaceus* (Schreb.) Dumort.) and orchardgrass (*Dactylis glomerata* L.), although the black walnut silvopastures had less tall fescue and more orchardgrass compared to the other pastures. Forage legumes, such as red (*T. pratense* L.) and white (*T. repens* L.) clover, can provide substantial amounts of nitrogen to pastures when they are consumed by livestock and any excess nitrogen is excreted by the animal back onto the pasture. Honeylocust silvopastures had about twice as much clover as the open pastures in 2014 and 2015 (table 2). The presence of the trees in these pastures markedly changed the species composition of the forage sward (figure 1), and it may be that the honeylocust trees provided an environment more suitable for the growth of clovers than open pastures or black walnut silvopastures.

Regardless of the mechanism, honeylocust trees may provide more than just aboveground benefits to the silvopastoral system. Clovers have long been valued by livestock producers for their nutritional contributions to livestock and their nutrient contributions

Table 1

Pasture	Nitrate	Ammonium	Total inorganic nitrogen
Black Walnut	20.9	2.2	23.2
Honeylocust	24.9	3.9	28.4
Open Honeylocust	17.9	4	22.0
P-value	0.4422	0.4103	0.5198

⬆ Soil nitrogen concentrations were not significantly different (P-value \geq 0.05) between treatments, but sample numbers were limited. Nitrate concentrations were numerically greatest in the honeylocust silvopastures.

Table 2

Pasture	Red clover			White clover		
	2014	2015	2016	2014	2015	2016
Black Walnut	4.8	1.1	4.7	4.9	3.8	2.1
Honeylocust	13.6	1.6	1.2	8.6	7.6	1.2
Open	7.3	0.7	2.6	4.4	3.1	1.3
SE*	1.1	1.1	1.1	0.9	0.9	0.9

*SE = standard error

- ⬆ The percent cover of clover declined in all pastures, but was greatest in the honeylocust silvopastures in 2014 (red clover and white clover; P-value<0.05) and 2015 (white clover; P-value<0.05). (SE = standard error.)



- ⬆ Clover is evident in the honeylocust silvopastures (foreground) in this picture from June 2014, while it is less evident in the black walnut silvopasture paddocks (middle) and open pasture paddocks (background). Photo by Gabriel J. Pent.
- ➡ Clover was abundant in the honeylocust silvopastures in 2014. Photo by Gabriel J. Pent.



to pasture soils. Although more work is needed to fully understand and verify these relationships, honeylocust trees may prove to have similar “nitrifying” effects as clovers, or they may facilitate the establishment or growth of clovers in pastures — or both. Regardless, better understanding of the interactions among trees, forages, and livestock can lead to more deliberate facilitation of these factors to maximize the benefits derived from silvopastures.

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[Pennsylvania Association for Sustainable Agriculture Conference](#)
Lancaster, PA
For more information, visit:
<https://pasafarming.org/conference/>

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SW Agroforestry Challenges and Best Practice Solutions
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National
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NAC Mission

The USDA National Agroforestry Center (NAC) is a partnership of the Forest Service (Research & Development and State & Private Forestry) and the Natural Resources Conservation Service. NAC's staff is located at the University of Nebraska in Lincoln. NAC's purpose is to accelerate the development and application of agroforestry technologies to attain more economically, environmentally, and socially sustainable land use systems by working with a national network of partners and cooperators to conduct research, develop technologies and tools, establish demonstrations, and provide useful information to natural resource professionals.

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