Introduction

The food forest is perhaps the oldest way to garden. As ancient people spread around the globe and settled the farthest reaches of the Earth, many settled into forested landscapes.

These forest dwellers soon learned that natural clearings and the edges of forests were the most fruitful places for both hunting and gathering. Across the planet people learned to utilize these clearings and edges, and later to create and manage them. Forest gardens, or food forests, were created in many diverse ecosystems.

Today, food forests are making a comeback on many scales and in many climates. This rediscovery and reimagining of an ancient practice has been led by the development of permaculture design.

Much of the early inspiration for permaculture design was drawn from the study of indigenous horticulture and from research into the value of traditional food systems based on perennial crops. Trees and perennial ecosystems stabilize soil and build fertility, reduce soil erosion, and help moderate climate change by storing carbon in biomass and in the soil.

The root of conventional modern agriculture in the Middle East, North Africa, and around the Mediterranean Sea is a way of farming that degraded soils and transformed forests and grasslands into deserts as populations grew over the millennia. Today this system relies on fossil fuels, ecologically destructive chemicals, and centralization and mechanization on a massive scale to try to maintain production in the face of changing climates and dwindling resources.

The growing movement towards local, organic, and ecological agriculture seeks to reverse course, to conserve resources, regenerate soil, restore

ecosystems, help stabilize atmospheric carbon, and put people back in touch with their food systems and with nature. Organic farms, small-scale intensive market gardens, urban agriculture, community gardens, and backyard gardens are all part of this movement to reconnect with the source of our sustenance and create a permanent culture. The fruitful perennial landscape, the food forest, will play a major role in our local food systems.

Food forests are fun as well! Once you get out there and have a hand in creating an ecosystem, magic awaits. This magic is nature doing what it does—germinating seeds, growing plants you did not expect, filling in empty spaces, and becoming lush and alive. Then the insects and animals respond and become part of the system. Watching this unfold is gratifying and good living.

This book is titled *The Food Forest Handbook*. The food forest is a food-producing garden landscape built around trees and perennials. The handbook part of the title states the intent of this book: To present a practical guide to the planning, design, establishment, and management of perennial polycultures. Many possible combinations of useful perennials can be planted in a food forest. A well-managed food forest is an integrated system, and includes guilds of fruit, vegetables, herbs, medicinal plants, and plantings to promote beneficial insect habitat and balance nutrients. In this context a guild is a group of species that grow well together and interact in mutually beneficial ways. These systems can be simple, with only a few species, or contain dozens of species.

Our six chapters begin with an overview and brief history of perennial polyculture, followed by design and planning details. Other chapters will present crops to include, management and use of perennials, propagation information, and a final chapter to inspire and encourage you to actually put the book to use.

Chapter One introduces the concept of the food forest garden and perennial polycultures. We will place food forests in historical context from hunter-gatherer societies and tree crops in pre-Industrial Revolution societies to present day permaculture concepts. We will review natural polycultures and ecological communities we seek to mimic. We end the chapter with a profile of "Hazelwood Food Forest," a forest garden.

Chapter Two takes the reader through a checklist of goals, a process of site assessment, and a step-by-step design process to plan a productive, beautiful, and manageable landscape. This includes considerations of appropriate scale, place of food forests in the homestead landscape, and pros and cons of food forests.

Chapter Three continues with the design process, taking your food forest planning from concept to details.

Chapter Four profiles a range of perennial crops suited to food forest production, including fruits, berries, herbs, medicinal plants, flowers, mushrooms, perennial roots and tubers, and the integration of annual crops in the system. It discusses the role of crops in diet and nutrition, as well as harvest and storage considerations. Recipes and recommendations for how to use unusual crops are included.

Chapter Five looks at ongoing care of the food forest as it develops. Topics addressed include building and maintaining soil health with perennials, succession plantings, developing biodiversity, pollination, pest control, and pruning. Sources of mulches, choice of ground covers, and water needs are also discussed.

Chapter Six provides guidance for propagation of plants from seeds, cuttings, grafting, and division to aid the reader in creating the food forest from local resources. We also cover what to consider in obtaining and purchasing plants, and offer advice for would-be nursery enterprises.

Chapter Seven, the final chapter, presents a tour of food forests throughout North America. These examples of perennial polycultures give insight and inspiration for the design of food forests in a variety of climates. We close with some thoughts about the role of food forests, in the sustainable, regenerative society.

We want to state clearly up front that while several books have been written about food forests and forest gardens, and many such gardens are being planted around the world, food forest gardens are a living and breathing experiment. We all have much to learn about designing and managing ecological systems. In this book we present examples of existing perennial polycultures, forest gardens, food forests, and generally fruitful landscapes. Yet we also want to convey a sense of discovery. We want to encourage you,

the reader, the gardener, to stretch your boundaries, to experiment, to learn as you go, to observe and interact with nature. This is the way the art and science of food foresting will evolve and grow.

Of course a food forest garden is designed around a long-term commitment. A tree planted, whether apple, pear, chestnut or oak, locust or mesquite, palm or cherry or plum, is expected to live for years and perhaps decades, even centuries. The forest garden is what we plant around the tree: berry bushes, brambles, herbs. Here there is room to play with the landscape, to plant and grow a wide range of plants, inspired by natural ecosystems. Your food forest garden is a personal journey in applied ecology, in horticultural stewardship, and in culinary adventure.

My own (Darrell) forays into perennial polycultures began with foraging wild fruits in the forests of my youth. On family hikes and camping trips I learned to use wild foods. I learned to find and gather mayapple fruits, tea berries, wild blueberries, juneberries, and other edible forest plants. Ramps and brook trout, with Indian cucumber root and birch twig tea, were a tradition at the spring fishing camp.

In my early twenties I began an intensive study of permaculture design. Permaculture as a field of ecological design has been heavily influenced by concepts of integrated design. In the horticultural landscape integrated design is expressed in perennial polycultures, companion plantings, and forest gardens. As I developed Three Sisters Farm, functional perennial plantings have been a major aspect of the farm design. Some of these plantings will be examined in these pages.

My co-author Michelle's work with food forests grew out of her earlier interest in herbalism, gardening, and urban agriculture. When she and her colleague saw a need and a niche for food forest development on the scale of vacant urban lots they got to work, creating one of the country's first urban food forests, the Hazelwood Food Forest. Her story and those of other food foresters are intertwined in the pages ahead.

Together our goal is to help you feel confident and inspired to create your own islands of paradise in your backyard, front yard, street corner, vacant lot, or city park. We foresee a not too distant time when our towns and cities are abundant with bountiful, beautiful, and fruitful landscapes.

CHAPTER ONE

Perennial Polycultures: Past, Present, and Future

The best time to plant a tree was 20 years ago.
The second best time is now.
— Chinese proverb

Perennial: a plant that lives more than two years.
Polyculture: multiple species in the same space forming interrelationships.

A food forest is an ancient concept reborn for the 21st century. As presented in these pages, a food forest garden is akin to the French potager—or English cottage—garden, a mix of perennials and annuals designed to be both beautiful and to produce an abundance of fruits and vegetables, herbs, and flowers. More specifically, the food forest is a perennial garden built around useful trees and designed to mimic a managed forest ecosystem.

In this chapter we introduce the concept of the food forest garden and perennial polycultures and their role in a sustainable food system. We begin with a review of the natural polycultures and ecological communities we seek to mimic. Next we place the food forest in historical context, from hunter-gatherer societies to tree crops in pre-Industrial Revolution cultures to present day permaculture concepts.

A close examination of Mayan—and similar Native American—horticultural practices illustrates the ancient and ongoing management of food

forests by these indigenous forest dwellers. Next we walk though the development of the modern food forest movement. We conclude the first chapter by examining some examples of food forests and perennial polycultures around North America.

If you have drunk shade-grown coffee, or eaten chocolate, most likely you have tasted the products of a perennial polyculture, or food forest. Both cacao (source of chocolate) and coffee grow best in light shade under a canopy tree. The canopy tree may be a legume, such as numerous Acacia species, as well as a wide variety of fruit and nut trees including macadamia, mango, avocado, breadfruit, and useful leguminous hardwoods.

A food forest produces more than food. Many of the plants will have medicinal uses. Craft materials can be grown and gathered. Biodiversity is enhanced through inclusion of habitat for songbirds, beneficial insects, and myriad other critters, which in turn provide valuable ecological services such as pollination and pest control.

A well-designed forest garden is a place to relax and entertain in as well as work. Nature brought home with all the color, song, and buzz of life in the backyard (or perhaps the front yard), provides a connection to the living world that has become scarce in modern life.

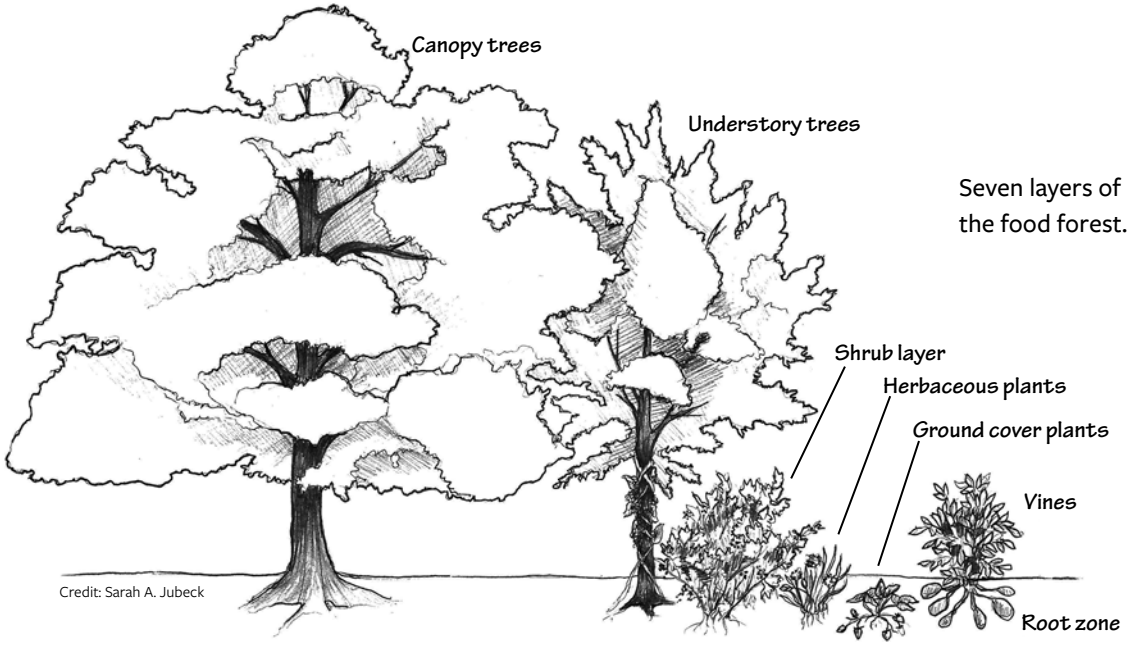
Food forests are designed to gather and store rain, carbon, and nitrogen and activate and utilize minerals from the soil for the long term. Properly planned and managed, a food forest can build up the soil while producing yields.

A value and need that has been often overlooked in modern design and the city landscape is beauty. Aesthetics and a beautiful surrounding contribute to better health. The food forest has many opportunities for beauty—indeed it is almost impossible to avoid!

Forest Ecology

Ecology

A basic knowledge of ecology is necessary for both designing and maintaining a food forest garden. Ecology is the study of ecosystems. An ecosystem is a group of organisms living in a dynamic relationship in a shared environment. In nature, plants, insects, and animals have coevolved over millennia,



Seven layers of the food forest.

adapting to each other and to the land and climate. Most ecosystems are dominated by perennial plants, whether trees in a forest, or grasses in a prairie. In the next section we will examine forest ecology.

Forests

A natural forest can seem to be a place of mystery. Tall trees are spaced in seemingly random patterns. Smaller trees grow in their shade. Tangled vines sprawl over shrubs and clamber up tree trunks. The ground may be covered with a profusion of plants competing for space and light. Fallen branches and leaves litter the ground, decaying into the earth and smelling of earthy mould. Mushrooms push from the ground and other fungi cling to the trees. Unidentified flying insects zoom past or hover near your head. Small forest creatures scurry among the undergrowth and birds flit among the branches. To one unschooled in ecology, a natural forest may seem wild, jumbled, and unruly.

Studious observation reveals a different story. Seemingly random collections of plants become complex communities woven together into networks

Credit: Darrell E. Frey

Perhaps the best use for trees: climbing!

of interacting species. Larger trees, forming the canopy, shelter understory companions from weather extremes and suppress grasses from dominating the ground layer. Plants share information through airborne chemicals and nutrients through a subterranean web of roots and mycelium. Seasonal periods of growth and dormancy are timed to maintain essential nutrients in the community. Plants protect the soil from drying winds and heavy rain, allowing rainfall to soak into the soil and be stored in the ground.

Examining the structure and ecology of the forest will help us understand the patterns of natural perennial polycultures and the various roles plants, animals, and fungi play in the forest. In Chapter 2 we will put this information to use to design and plan productive systems based on this deeper understanding of forest ecology.

A forest is an ecological *community*. In an ecological community all members of the community interact with one another in a network of relationships. Through photosynthesis plants create new material from air, water,

and soil. Different plants have different abilities to extract essential nutrients from the soil, or in the case of legumes, the air. Plants are the base of the food chain providing food, as well as shelter, for animals. As they complete their lifecycles, dying or being consumed by animals, plants return the organic matter to the forest floor. Decomposers, including fungi, insects, arthropods, slugs, snails, and other organisms break down organic matter and return nutrients to the community. Nutrients cycle between the soil, fungi, plants, and animals. The structure of the forest itself moderates the climate, gathers and stores rainwater, and minimizes soil erosion. Pollen and seeds are moved around by air currents and by insects, birds, and other animals. Pest and predator relationships keep a balance of insect and animal populations.

The dominant player in the forest ecosystem is the tree. A natural forest tends to have a mix of tree species, usually of various ages. Different species of trees fill different *niches* in the system. Some like a dryer soil, some can handle a high water table, some like a warmer south-facing slope, some prefer the cooler northern slopes. The dominant trees form the forest *canopy*. *Understory* trees, shrubs, and plants grow best in the shade of other trees. *Ground layer* plants benefit from the reduced competition from grasses and the moderated climate provided by the upper layers.

Succession is an important concept in understanding forests. Storms, fire, and the death of older trees create clearings in the forest, allowing sun-loving annual and herbaceous perennial plants to germinate and grow. Pioneer species, such as aspen, sassafras, hawthorn, or black locust grow quickly in these clearings. As the pioneer trees mature, second-stage hardwood trees germinate and grow in their shade. When these second-stage trees mature, smaller understory trees fill in among a ground cover of shade-tolerant annuals, fungi, herbaceous perennials, shrubs, and vines.

Eventually, a native forest can develop into a climax forest of mature old-growth trees, with less diversity. An old-growth forest generally includes a mixed-age patchwork. Once again trees die or are toppled by wind storms, or consumed by wildfire. In the newly opened clearings the cycle begins anew.

As we shall see below, traditional native food forests mimic these natural forest clearings. It is likely that these food forests were inspired by

indigenous people's observation of the increased diversity and productivity of the natural forest clearing. Humans have been managing forests for thousands of years. Observation and management of the landscape has been an aspect of human culture since we learned to control fire. So has utilizing plants for making crafts and tools, for medicine as well as food. Certainly our Paleolithic predecessors used fire to control forests and maintain grasslands and savanna landscapes. They first did this to promote the growth of grasses for the grazing animals they hunted. Later, when cultures worldwide developed horticulture, fire was used to reset the succession in the forest to a productive state.

More About Ecology

Community

All life on Earth exists in relationship with everything else. The basic pattern of life on Earth is the network. Also known as the web of life, this network is made up locally of interconnected communities. The forest community, the meadow community, the riverbank community, the aquatic community—each has their own species of plants, animals, and insects that live within them. Birds and animals move between these plant communities as they forage or hunt, transporting nutrients in their daily and seasonal travels.

Biodiversity

A healthy ecosystem teems with life. The diversity of plants and fungi provides food and habitat for wildlife. Predatory animals maintain a balance of animal populations over time. Insects move pollen from flower to flower to promote fruit and seed. What tree is complete without birds? When we shake ripe purple mulberries from branch to sheet on the ground, a great variety of insects falls onto the sheet as well. Leafhoppers, small cicada, fireflies, other small six-legged critters, and assorted lime-green inchworms and various spiders scramble to get out of the bowl as berries are sorted from leaf and twig. The same bird that samples our fruit also consumes hundreds of insect pests and feeds as many to their young. Field mice consume fallen fruit, seeds, and nuts, as do groundhogs, chipmunks, deer, and rabbits. All are part of the great web of life.

Edge

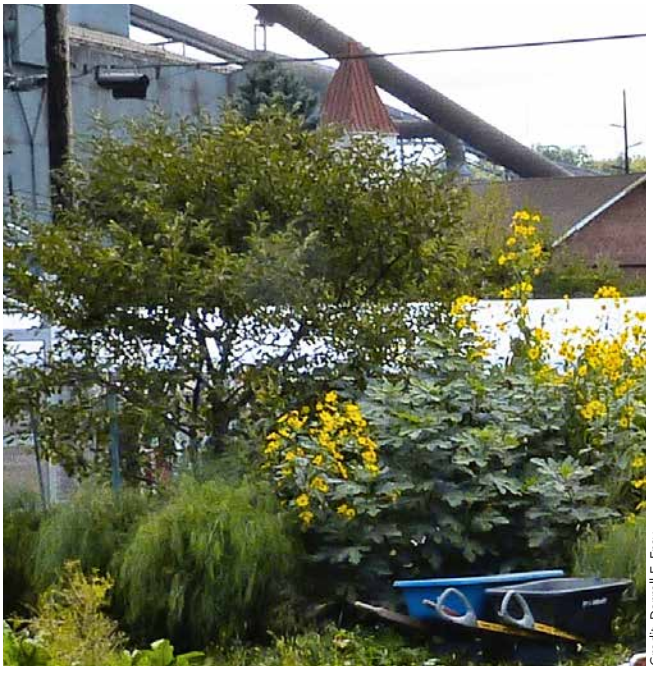
Edge is a term used in ecology to describe the meeting of two or more ecological communities. The space between a meadow and a forest is a third system. The edge may contain species of both ecosystems and many species that prefer the edge. Many plants that might not be able to compete with the dense grasses and forbs of the meadow, or grow in the shade of the forest, thrive on the edge. The edge between two systems provides unique habitats and microclimates that nurture increased diversity of life. A forest garden is often modeled on the forest edge, with a sunny side and a shady side, creating a range of niches in a small area.

Plant Guilds

The *plant guild* is an important concept in forest gardens. Bill Mollison introduced the concept to permaculture students in *Permaculture: A Designers Manual* (Tagari Publications, 1998). A guild is a beneficial assembly of plants and animals. The guild concept is derived from the study of natural ecosystems and is the basis of forest garden design. In the pages ahead we will discuss guilds in some detail. To learn more about plant guilds you only need to walk in a natural ecosystem near your home. No plant grows in isolation. Forest landscapes tend to be diverse in structure and species. Many types of plants are found together. Smaller trees and shrubs rise beneath taller trees. Vines climb trees and scramble over shrubs. Smaller perennial and annual plants grow on the ground layer and ground cover plants hug the earth. Beneath the surface roots and tubers are found among fungal mycelium. If you count the layers—subsurface, ground cover, ground layer plants, brambles and shrubs, vines, small trees, and large trees—you can see there are seven layers to the forest. The diversity of species is also plain to see.

Competition or Cooperation

Natural ecosystems include countless interactions between plants, fungi, insects, and animals. Researchers are continually discovering new ways plants communicate, store information, and interact with their environment. Nutrients are shared and exchanged between trees of the same species and, at times, with other species. Smaller shade-tolerant species live in harmony



Credit: Darrell E. Frey

This polyculture guild at Braddock Farm, in Braddock, Pennsylvania, includes an apple tree with fig, asparagus, and Jerusalem artichoke.

with taller canopy layer trees. However, many plants also have evolved mechanisms to control their neighbors. Numerous plants have been identified that produce allelopathic compounds. These compounds, exuded by roots, bark, and/or leaves, can inhibit seed germination or plant growth. As we will discuss later in this book, various members of the walnut family produce juglone, an allelopathic chemical that can persist in the soil for decades. Many useful plants are resistant to juglone and so a walnut tree guild can be designed. Other plants, though, such as rye grass or goldenrod species, have much less tolerance for these allelopathic compounds.

Perennial Polycultures

As we have seen above, in the natural world diverse perennial plant communities are the basis of the vast majority of ecosystems, whether prairie, savanna, or forest. For the purpose of this book, we define perennial polycultures as *the cultivation of perennial plants in functional groupings*. When we design perennial polycultures we are creating guilds of plants that mimic natural ecosystems, while producing a good yield. The seven layers of the forest become seven layers of food, craft materials, medicines. Some plants in the system attract and nurture pollinating insects and others help cycle vital nutrients from the soil and make them available to other plants. Mycorrhizal fungi develop connections between plants and the soil forming a network of communication and nutrient exchanges.

Everywhere I look I see perennial polycultures. In our towns and cities many are ornamental in nature, or unharvested. But most have the potential for productivity. As I am writing this book, I am seated in a bustling café in a middle-class neighborhood of Pittsburgh. Buses pass by among the busy

traffic. My outdoor seating is flanked by trees. On one side a black walnut tree drops nuts on the sidewalk. These are quickly gathered by the local squirrels. On the other side a tall mulberry tree grows from a 25-square-foot plot raised planter. Around the base of the tree are roses with small rose hips, hostas, and violets. The street is lined with gingko trees, many of them with nut-bearing fruit, again to be gathered by squirrels. All these are useful plants and give a hint of the potential for productive urban landscapes. Most landscapes in this neighborhood have small trees, shrubs, and understory plantings. Replace a few plants here, add some plants there and an unproductive yard becomes a part of the home food system.

Agroforestry

There are a number of perennial polyculture systems related to food forests. We will examine some of these in more detail in Chapter 2.

Agroforestry is the use of tree crops in agricultural systems on a large scale, including pastures and croplands. These practices, which will be examined further in Chapter 2 include the following.

Alley cropping systems are annual crops planted between widely spaced rows of trees. These may be any nut or fruit, timber or legume trees. Alley cropping is more common in tropic and subtropic climates but is also used in temperate zones to obtain a second crop between tree crops, or to get a crop as the trees mature.

Silvopasture systems integrate trees and shrubs into pasture systems. Leguminous trees can add nitrogen to the pasture. Forage crops such as acorns and honey locust supplement grazing. Some specialized systems include planting acorns, apples, and hazelnuts for forage in hog pastures.

Forest farming generally involves production of crops on the forest floor. This is generally done in existing native forests and denotes a larger scale than the food forests that are the main focus of this book. In a forest farm, crops such as ramps, shiitake mushrooms, and native medicinal plants such as ginseng, blue cohosh, and goldenseal are managed beneath mature timber trees, native nuts, or sugar maples.

Windbreaks are multilevel rows of trees and shrubs which buffer downwind structures and landscapes from prevailing winds. Windbreaks and tree

lines between fields offer many opportunities to plant useful crops, moderate wind speeds, and promote biodiversity.

Riparian forests protect floodplains and shorelines from erosion during floods. Riparian zones can be planted with many useful species. A riparian food forest guild might include butternuts, walnuts, paw paws, raspberries, groundnuts, vines, and medicinal herbs.

Food Forests Through Time and Around the World

Native people around the world have tended food forest gardens for millennia. This next section will briefly examine some of these societies to gain insight into traditional food forests. We begin with some concepts and strategies used in food forests, and then look a little more closely at several tropical food forest systems, as well as an historical account of a temperate food forest.

Swidden

Indigenous food forest managers around the world have employed techniques known as swidden, also disparagingly called slash and burn agriculture. While slashing and burning can indeed be an environmental disaster on

Credit: Darrell E. Frey

Fire is used to clear land and return mineral nutrients to the soil in a Mexican mountainside.

Credit: Darrell E. Frey

The Xi'ui people in Central Mexico practice the age old milpa system, beginning the cycle by cutting back and burning the brush to prepare for planting corn.

a large scale, indigenous swidden agriculture on a smaller, village scale was and is often a sophisticated horticultural technique.

In a well-managed swidden system plots of land are cleared and the trees and shrubs are selectively pruned or cut. The plots are carefully burned to release minerals in the form of ash and preserve carbon in the form of charcoal. After a period of use the plots are shifted from annual production to perennial crops or left fallow for natural rejuvenation. Below we will examine the Mayan milpa and Kichewa chacras versions of swidden agriculture in more detail.

Biochar

In the past decade the terms *biochar* and *terra preta* have come to the attention of students of regenerative agriculture. Terra preta means "black soil" in Portuguese. Terra preta is rich in carbon, in the form of charcoal or biochar. Biochar—biologically active charcoal—is extremely porous and therefore has a high capacity to store water and nutrients. This provides excellent habitat for soil microorganisms.

The formation of terra preta in the Amazon was the result of a horticultural practice that increased soil fertility by a swidden system that incorporated composted human and agricultural waste and charcoal into the soils.

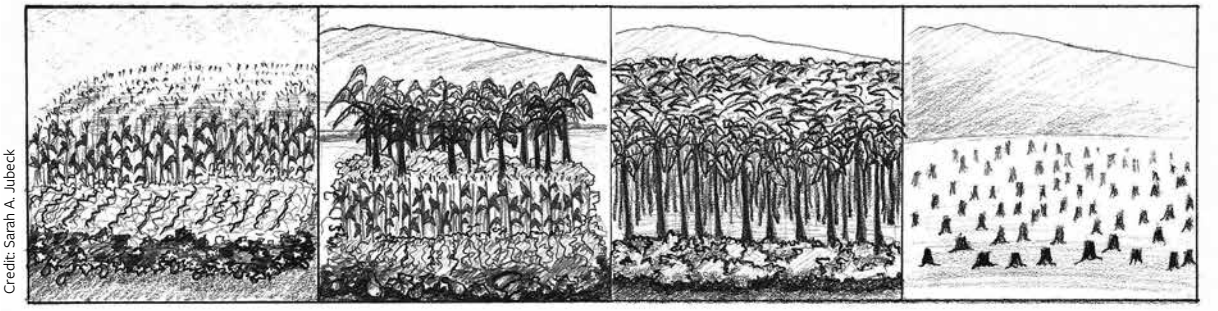
Before 1492, the Amazon Basin was much more densely populated. Native people throughout North, Central, and South America practiced complex horticulture and had domesticated many crops. Recent research has shown that large areas of the Amazon region were once a cultivated ecosystem, a web of interconnected villages, garden sites, and food forests. Extensive areas of fertile soil—tens of thousands of square miles—were the product of ancient, pre-Columbian horticultural practices. Diseases introduced by European explorers and settlers decimated whole nations and greatly reduced the population of the native people. Only recently have we begun to appreciate the extent of the communities there and the well-developed agriculture they practiced.

The Mayan Milpa: Central American Food Forests

Perhaps the best documented food forest horticulture is the *milpa* system of the Maya. The Maya are indigenous inhabitants of large areas of Southern Mexico, Belize, Guatemala, Honduras, and El Salvador. The Mayan milpa system of indigenous agroecology has been practiced throughout the Americas for thousands of years. The roots of the term milpa meant "cultivated place" in the Mayan language. A traditional Mayan household maintains and intensively cultivates a home garden and a number of milpa fields located further from the home.

The Mayan Forest Garden (Annabel Ford and Ronald Nigh, Left Coast Press, 2015) documents 8,000 years of forest gardening in Central America, describing the development and role of perennial polycultures in Mayan communities and explaining the role of the food forest in sustainable agriculture for Central America today.

To create a food forest, Mayan farmers make a clearing in the forest by trimming, pruning, and cutting down forest trees. They may preserve existing useful trees, cutting them back to reinvigorate their productivity with new growth. They then carefully burn the wood to release minerals from the forest biomass and return it to the soil in the form of ash and charcoal.



Credit: Sarah A. Jubeck

The milpa cycle begins by clearing and burning woody vegetation. Corn, beans, and other annual crops are grown for several years as perennial crops are established and grow into a food forest. After a couple decades the cycle will begin again.

The first season and for up to four years, according to Ford and Nigh, corn is the primary crop, interplanted with beans and squash and many different annuals. Over the next two to three decades the polyculture system develops in complexity as a succession of trees, shrubs, and annual crops are established. These include grains, vegetables, fruits, and medicinal and craft material plants. Crops that may be familiar to the reader include amaranth, peppers, banana, plantain, cacao, fig, papaya, and avocado. Many other crops less familiar to people outside the region are also grown.

Over time the milpa goes through succession, moving from open field crops to light shade crops to full canopy (as in mature trees casting heavy shade). Perennial crops planted in the first few years provide cooling shade needed for later plantings to become established. As the soil becomes less productive for maize, other crops take precedence. A new milpa is then established for maize and a new cycle begun as the previous milpa's crop yields come from more perennial crops. Management of the milpa includes managing wildlife for hunting, late succession foraging, and beekeeping. Traditional Mayan agricultural land consists of a network of milpas in various stages of development.

The end result of thousands of years of forest gardening is that the dominant trees in Mayan forests are major crop trees for the Mayan people.

The Mayans who manage milpa systems are practicing an ancient permanent agricultural system rooted in a deep knowledge of agriculture, horticulture, soil management, water management, ecology, and the multitude of crops they tend. Traditional indigenous land management has resulted in a rich soil, high in carbon, with a high capacity to store nutrients and water.

Quechuan Chacra: South American Food Forest

Throughout the western Amazon, from Colombia south through Ecuador, Bolivia, Peru, Chile, and Argentina various indigenous people, collectively known as Quechua, traditionally practiced a horticulture similar to the milpa called *chacra*. As with the milpa, chacras are located at a distance from the home, and both are used for market production and to supplement home garden production. As described by Thomas Perreault in the article "Why *chacras* (swidden gardens) persist: Agrobiodiversity, food security, and cultural identity in the Ecuadorian Amazon," (*Human Organization*, 64(4): 327–339), the chacra does have an important distinction from the Mayan milpa.

Perreault studied the Kichewa (a sub-group of the Quechua) of the Ecuadorian Amazon at the turn of the 21st century. He found the chacras are slashed but not burned as the milpa generally are, and maize production is not as important as manioc.

Beginning with an old site, existing trees and shrubs are cut and composted for mulch. The soil is prepared by hand, with machete and hoe, and planted with manioc, bananas, and plantains. Over the next few years, other useful plants are added. Perreault reports that up to four dozen species of useful plants are cultivated in the chacras. The products of the chacras and Kichewa home gardens are grown primarily for family use, but some products may be sold at market.

Traditionally, as with the Mayan milpa, several chacra plots are maintained by a family, with a new one established every few years to produce a range of crops in rotation. The great variety of crops include maize, peppers, peanuts, coffee, banana, cacao, sugar cane, papaya, avocado, citrus, pineapple, guayausa (a relative of yerba mate), and many more useful plants.

While the Kichewa diet is becoming more dependent on imported foods, the chacra and home garden remain an important part of the local culture and food system for many communities in the region. They provide a strong element of food security and some cash crops for each household.

The milpa, the chacra, and similar food forest systems around the world have supported indigenous people while continually regenerating the soil and biodiversity of their land for thousands of years. The pattern of intensively managed home garden, supplemented with a long-term food forest

holds lessons for modern food forest and food systems design. By rotating small plots, tending and replanting perennial polycultures in an ecological succession through a managed cycle of cultivation, growth, and fallow, the gardener can produce a diversity of food, as well as craft and medicinal plants, in an endless circle for generations to come.

Ancient Forest Gardens of Indonesia

The Sakuddei people in Indonesia, the subject of a 1974 documentary, *Disappearing World*, lived in communal villages and tended family food forest gardens. Their lifestyle was just one example of native food forests in Southeast Asia. Each Sakuddei village had a common house where people gathered for major events, such as weddings and funerals. Each family also had a garden camp where they planted and tended forest gardens, growing coconuts, many types of fruit, taro and vegetables, and craft materials. They also raised pigs and chickens. The roots of these highland tropical forest farmers may go back tens of thousands of years. Modern versions of forest gardens in Indonesia can include cash crops such as coffee and cacao and may have over one hundred crop species per hectare (approximately 2.5 acres).

Polynesia

Polynesians also practiced forest gardening and carried the practice, and plants, with them as they settled the Pacific. Crops such as sweet potatoes, banana, taro, and medicinal plants were grown beneath breadfruit and leguminous Acacia species. Today coffee and cacao are added to this mix, as noted earlier.

Elsewhere in the South Pacific islands, forests farms include canopy trees such as mango, breadfruit, and coconut, which shelter understories of cacao, citrus, banana, and ground layer plantings of yam, taro, cassava, and other crops.

North America

Native Americans managed forests for food and craft materials throughout the Americas. Early settlers to Pennsylvania noted the well-established agricultural systems of the Delaware and Iroquois peoples. Both of these

nations of Eastern Woodland Indians practiced forms of shifting, swidden agriculture.

Land would be cleared and used to cultivate corn, beans, and squash for a period of time and then allowed to revert to forest for a while. The Delaware, who had abundant fish resources, would fertilize their fields with fish, maintaining fertility for a decade or two before shifting the garden villages. A "village" would actually utilize a number of village sites in a given year, fish camps in fish season, maple syrup camps in the late winter, hunting camps at various times. By shifting the garden village sites in regular cycles, fertility was maintained and resources conserved.

A more fully developed forest garden was documented in the late 1700s just south of Erie, Pennsylvania. When European settlers first arrived in northwestern Pennsylvania in the late 18th century, they encountered a landscape that had been managed by humans since the Laurentide Ice Sheet's retreat 10,000 to 12,000 years earlier. Savannas and meadows stretched for miles along the French Creek valley near Meadville. Native Americans maintained these meadows with fire to provide grazing areas for game animals, including deer, elk, and woodland buffalo.

At the site of present day Saegerstown, where Woodcock Creek enters French Creek, early settlers found what was most certainly a Native American food forest. This site, which apparently covered several hundred acres, was an example of tended and perhaps selected nature. A visit by early American settlers to this ancient food forest was described as follows by a Captain McGill circa 1792, as quoted in *In French Creek Valley* by John Earle Reynolds, published by the Crawford County Historical Society:

> The banks of French Creek were fringed to the water's edge with evergreen bushes and trees, while ranged along on the higher bank was a row of stately pines beautiful in their majesty as the cedars of Lebanon. In rear of the pines half a mile in extent was a very gently undulating plain on which grew great old oak trees with spreading tops, the rare old oak that tells of Centuries, a variety that now seems to be extinct. They grew with ample space between without underbrush or obstruction to the view, to the limits of this wonderful park.

> Around the outer semi-circle of the park there arose a little plateau, not ten feet in elevation, and from its base flowed springs of pure cool soft water, which fed a circlet of mighty elms, unrivaled in size and beauty…there were hundreds of these great trees with wide spreading branches supplementing in grandeur the great oaks they encircled. Beneath these grew hazel bushes, blackberry and raspberry bushes, hawthorn and crabapple trees and many varieties of beautiful shrubs and plants while near the northern extremity there was a veritable orchard of wild plums bearing a great variety of large red and yellow fruit.
>
> The ground rose from the river margin in regular successive plateaus of easy grade covered with the finest timber of the most valuable and useful kind. The view was enchanting and they moored the canoe to the bank to make further explorations. Here they were met by John Fredebaugh, who had located a claim that took in Woodcock Creek and joined on the north the land that had attracted their attention. His land…was naturally alluvial and very rich…a forest of white walnut (butternut) with here and there a great sycamore towering above and extending its weird white arms over the umbrageous growth beneath. The wild grape vine interlaced the trees and hung in festoons from the branches, forming arboreal recesses of rare and inviting beauty. Birds of bright plumage and resonant song fluttered in the trees and woodcock and grouse in great numbers clucked and crowed unawed by the presence of man.

This site was rich in resources for the native inhabitants. The oak forests would have provided acorns to feed both humans and their game animals. The elms described provided native villagers with bark to cover their longhouses and wigwams. The understory of hazelnuts, berries, and other plants described would have likely included many medicinal wild flowers. The forest understory in this part of French Creek Valley now includes ramps, ginseng, goldenseal, blue and black cohosh, trilliums, mayapples, and numerous other wildflowers that are medicinal or food plants. The wild grapes, plums, and butternuts described were all used in the native diet. Other edible plants

still found in this area include the viburnum nannyberry or wild raisin, service or juneberry, and groundnut. The mixed timber trees described here would likely include black walnut, American chestnut, sugar maple, and other trees used for food, crafts, and construction.

Fungi are also abundant in this region and would certainly have been present here. Black morels, the first to appear in the spring, are followed a week or two later by white morels. At various times from summer through fall this food forest would have provided yellow, cinnabar, and black trumpet chanterelles, bolete mushrooms, sulfur shelf, and sheep's head as well as medicinal fungi such as turkey tail and reishi.

In *In French Creek Valley*, John Earle Reynolds credits Native Americans with creating and maintaining this landscape. He writes: "…for centuries this very spot has been the playground at the backdoor of the longhouse of the Six Nations (Iroquois). It was not a work of chance or enchantment. He who had planned and watched over this valley for eons of time surely had a purpose for making these acres so enchanting."

This passage is a rare documentation of the Eastern Woodland Indians' land management. It points the way towards a true stewardship of learning to farm the forest and gain sustenance from its bounty.

Food Forest Developments in the 20th Century

Next we will look at the story of the roots of the recent development of food forests through a series of book reviews. The modern temperate climate food forest has its roots in tropical systems, adapted for more trying climates, and in the study of agroforestry practices to address many problems of agriculture in the early 20th century.

In 1929, J. Russell Smith (1874–1966) published his treatise on perennial horticulture, *Tree Crops: A Permanent Agriculture*, (Island Press). Smith, a professor of geographic economics at Columbia University, made a strong case for the development of agriculture based on tree crops. Drawing on inspiration from his correspondence and his journeys to tree crop farms around the world, he proposed a radical transition to a new agricultural landscape. In particular, Smith studied the use of tree crops as human food and livestock feed. The use of chestnuts as pig forage in Corsica and the use

of honey locust for livestock forage in Appalachia particularly caught his interest.

Smith researched and wrote during the North American dust bowl years, when a combination of poor tillage practices and drought led to massive windblown erosion in the US Midwest. He documents the value of tree crops not only for erosion control, but also for using marginal, sloping land for soil building and water management. *Tree Crops* makes a strong case for what Smith called a permanent agriculture featuring tree crops and pasture systems. He proposes farm pastures planted with acorn-bearing oaks, mulberry, persimmon, and honey locust to feed pigs and poultry.

Tree crops can yield a greater amount of feed than grains, while conserving and even building soil. They also can be grown on steep land and other land considered marginal for more conventional agriculture. Today this approach to integrating tree crops into pasture systems is known as silvopasture.

Smith also calls for more selection of tree crops as human food. He suggests researching chestnuts, hickory nuts, pecans, butternuts, walnuts, mulberries, and acorns to identify and develop superior cultivars and to extend their range and harvest seasons.

Much of the work of selecting useful varieties that he proposed has been begun in the United States by commercial plant breeders and individuals (see page 74, North American Fruit Explorers and Northern Nut Growers Association) but much more needs to be done.

It is well worth spending time reading *Tree Crops* and considering Smith's message. The book is in public domain and is available for free downloading as a pdf. It is also still in print for purchase as hard copy or ebook. Describing the full scope of *Tree Crops* is beyond the space available here. Full chapters are devoted to over a dozen tree crops, and other sections look at tropical plants and growing methods. *Tree Crops* was a strong influence in the development of permaculture and in food forest research in the early 20th century.

Forest Gardening, by Robert A. de J. Hart (Chelsea Green, 1996) presents Hart's pioneering work by featuring his own food forest in rural England, and served to inspire David Holmgren and Bill Mollison as they developed

permaculture as a design system. Subsequent work in developing food forest design concepts were informed by both Smith's and Hart's books and research. Robert Hart's food forest work has given him icon status among permaculturists. Smith's *Tree Crops* inspired a Japanese researcher, Toyohiko Kagawa, to develop silvopasture systems in Japan beginning in the 1930s. Hart was inspired by Kagawa's work and related research to develop his own property in the English countryside into a mixed species forest garden. Hart's food forest produced fruits and vegetables.

Forest Farming: Towards a Solution to Problems of World Hunger and Conservation by J. Sholto Douglas and Robert A. de J. Hart (ITDG Publishing, 1985) presents a broad background for the use of tree crops in agricultural systems around the world. This book builds on Smith's *Tree Crops* and presents a great deal of information on the design of large, farm-scale forest farms. Douglas refers to "3D farming," using multiple perennial crops to obtain diverse yields. Included are windbreak design, use of leguminous trees for crop yields and fertility, silvopasture systems, and other examples of using tree crops for food, fodder, fuel, and oil.

Another important inspiration in the development of permaculture and food forests was the work of Japanese natural farming pioneer Masanobu Fukuoka. Fukuoka is mostly known in North America for his book *One Straw Revolution* (Rodale Press, 1978). *One Straw Revolution* documents his work in developing a method of growing summer rice and winter grains in a continuous rotation in a clover ground cover without tillage, fertilizers, or excess labor.

Less well known is his orchard management system. From the 1930s until his death at age 95 in 2008, Fukuoka managed his orchard as a food forest. His book *The Natural Way of Farming* (Bookventure, 1985) provides details of his theories and practices of farming in the image of nature. Fukuoka produced commercial yields of a variety of crops, including Mandarin oranges, grapefruits, lime, avocados, mangos, and ginko nuts.

Trained as a plant pathologist, Fukuoka left his government research post in the late 1930s to return to his family farm. There he began to put into practice his evolving theories of studying nature to develop natural farming systems. As his orchard system evolved he developed some clear practices

that provided high yields with minimal input. Newly planted trees are grown with minimal pruning and allowed to find their natural form. The orchard is interplanted with a variety of leguminous trees, shrubs, and herbaceous plants, such as alfalfa and white clover, to provide nitrogen. Perennial and annual vegetables are interplanted with the fruit trees.

Fukuoka did not make compost. He practiced what we call "chop and drop," cutting back cover crops and letting leaves and other crop residue break down and return to the soil naturally. Over a couple of decades of trial and error, his orchard became highly productive while building soil and promoting a diversity of spiders, insects, frogs, and birds to provide pest control.

Permaculture Design

The creation and spread of permaculture design as a system of land use planning in the late 1970s and the development of permaculture-inspired gardens and farms since then has led to the establishment of food forests, forest gardens, agroforestry, and silvopasture systems worldwide. As stated above, Bill Mollison and Dave Holmgren were partly inspired by indigenous forest gardeners and the writings of Smith, Hart, and Fukuoka as they developed the first books describing permaculture. Even the name, permaculture, is derived from Smith's subtitle "Permanent Agriculture." Permaculture has developed as an ongoing search for solutions to the dilemma of our human impact on the land and our planet, as increasing populations continue to deplete the planet's resources and affect global climate.

Throughout this book we will refer to permaculture concepts and practices. We do not want to use too much space explaining permaculture here, as there are many good books available for that. Some explanation is in order however for the sake of clarity. In Chapter 2 we will provide a closer look at permaculture design. Here we will note the work and writings of several permaculture researchers and writers regarding food forests.

Permaculture took root in Great Britain in the 1980s much like it did in North America. In 1996 British permaculturist Patrick Whitefield published *How to Make a Forest Garden* (Permanent Publications). Written from an English permaculture gardener's viewpoint this book is a fairly basic introduction to forest gardening. Whitefield's work helped inspire food forest

experimentation, building on the work of Robert Hart and other food forest tenders. Whitefield explains early in the book that he would prefer the term woodland garden, as a forest garden is more akin to open managed woodlands rather than a dense forest.

In 2005 the two-volume *Edible Forest Gardens* (Chelsea Green) was released by David Jacke and Eric Toensmeier. This two-part publication was a landmark in forest garden design theory and practice. These books are extensively researched and provide a wealth of information to the design student and professional. They are an important tool for professional designers of sustainable food systems. We highly recommend seeking them out for the wealth of charts and data on trees and their companions. The authors delve deeply into a study of ecology and the relationships between trees, other plants, and the various forest dwellers. They present many details about the design process and its application to food forests.

Food Forests in the 21st Century: The New Cottage Garden

Certainly growing plants in light shade has the benefit of protecting crops from the more direct sunlight of the tropics and subtropics. And so there has been a compelling logic to preserve polyculture systems there. But for the most part, as modern forms of agriculture developed they became more and more centralized and compartmentalized. Monoculture was the focus of agronomists and became the norm. As Western culture became more industrialized, society shifted to less interaction with their food in general and maintaining systems of gardening specifically.

In recent decades, concerns about food safety, nutrition, and the security of our food systems has spawned the growing local foods movement, with a renewed interest in small-scale regional food systems. Concurrently the development of permaculture and ecological design has helped to revive traditional practices and develop new innovative models of agriculture. Most recently, the rise of urban agriculture has accelerated the development of small-scale intensive food production. The resurgence of small farms, urban agriculture, community gardens, and home food systems has begun to include tree crops and food forests.

Today food forests are being planted around the world. In North America

they are found from Nova Scotia to British Columbia, from Florida to Washington state, from Massachusetts to Texas and in cities, towns, and farms in all states. The current rise of urban and peri-urban farming and our growing understanding of ecosystem dynamics are being combined in 21st century food forests.

The earliest cottage gardens of England and the French peasant potager in centuries past were planted with a mix of small fruits, nuts, herbs, flowers, and vegetables. Each cottage garden was unique to the grower and the home, but they had common elements. More horticultural (garden cultivation) than agricultural (field cultivation), they were the base of the home food system. Walls and buildings created sheltered microclimates for more tender plants. Fruit trees were interplanted with fruiting shrubs. Herbs, flowers, and vegetables were interplanted intensively, usually in permanent beds. The forest gardens that are being planted today are similar. But we are building on the traditional knowledge of home-scale horticulture with added insights into the science behind plant dynamics. Some plants deter companions with chemicals they produce. Other plants feed and nurture one another. As we stated in the beginning of this chapter, food forest design is still evolving. We will continue to learn to get the best yields from our landscapes as we tend and grow.

A Food Forest Grows in Pittsburgh: Hazelwood Food Forest

In the summer of 2009, my partner Juliette Olshock and I (Michelle) embarked on creating the first food forest in the city of Pittsburgh, Pennsylvania, on vacant urban lots. Vacant lots here are often strewn with trash, their soil contaminated with lead from old paint. Many lots have buried dilapidated houses, in which the house had been imploded into the basement and covered with a thin layer of soil. It took almost a full year of planning, acquiring materials, and working with local government and organizations to go from idea to planting. The food forest was planted in the spring and summer of 2010.

Having recently completed my Masters of Science in sustainable systems, I had practiced many skills and points of knowledge including composting, lead remediation, creating sustainable systems, and permaculture design and

Credit: Michelle Czolba and Juliette Olshock

The site was an abandoned urban lot with little soil and tons of bricks. It was shaded to the south by a three story brick building.

really wanted to share and express that by creating a public oasis. Involved with herbalism for years, I had just begun to grow food as well. A food forest combined all of this. Creating it on vacant lots represented even more to me: a chance to make wastelands new again, evolve space, move energy, and mold this energy to form. It was also valuable in envisioning and bringing into material existence new ways of living in the world, in particular what to do with urban spaces that have become wastelands.

Our starting point was our vision: a food forest as a multi-layered, permaculture-based system of food production, specifically fruits and nuts. The permaculture-based food forest model involves three or more layers of production and is more permanent than an annual-based food system. The layers are made up of canopy trees such as pear, a bush and shrub layer with plants such as blueberries, and understory species of more traditional annual crops. Herbs figure prominently in any permaculture design, for in addition to medicinal and culinary value, they act as nectar plants, attracting bees and beneficial insects, are beautiful, and form companion relationships with other plants.

A permaculture system is intentionally created to meet the needs of humans, animals, and plants, includes food, medicine and sensual delights,

and does this by mimicking nature. While working with the ecosystem, the landscape is manipulated to form microniches, for example, a south-facing, U-shaped arrangement of sun-loving plants to capture all that sunlight. Permaculture design is all about co-creation, acting in partnership with the Earth and learning from the natural systems all around us.

The Hazelwood Food Forest design included 56 species: 4 semi-dwarf trees, 7 dwarf trees, 9 bushes, 3 vines, and 33 herbs. A snap shot of plants that are at the food forest are Asian pear (*Pyrus pyrifolia*), sassafras (*Sassafras albidum*), paw paw (*Asomina trilobota*), peach (*Prunus persica*), red currant (*Ribes rubrum*), echinacea (*Echinacea purpurea*), black cohosh (*Actaea racemosa*), and comfrey (*Symphytum officinale*).

How It Started

After intense collaboration with various local groups, we found a site that suited our needs and was available. It was located on what were four vacant city lots in Hazelwood

Credit: Michelle Czolba and Juliette Olshock

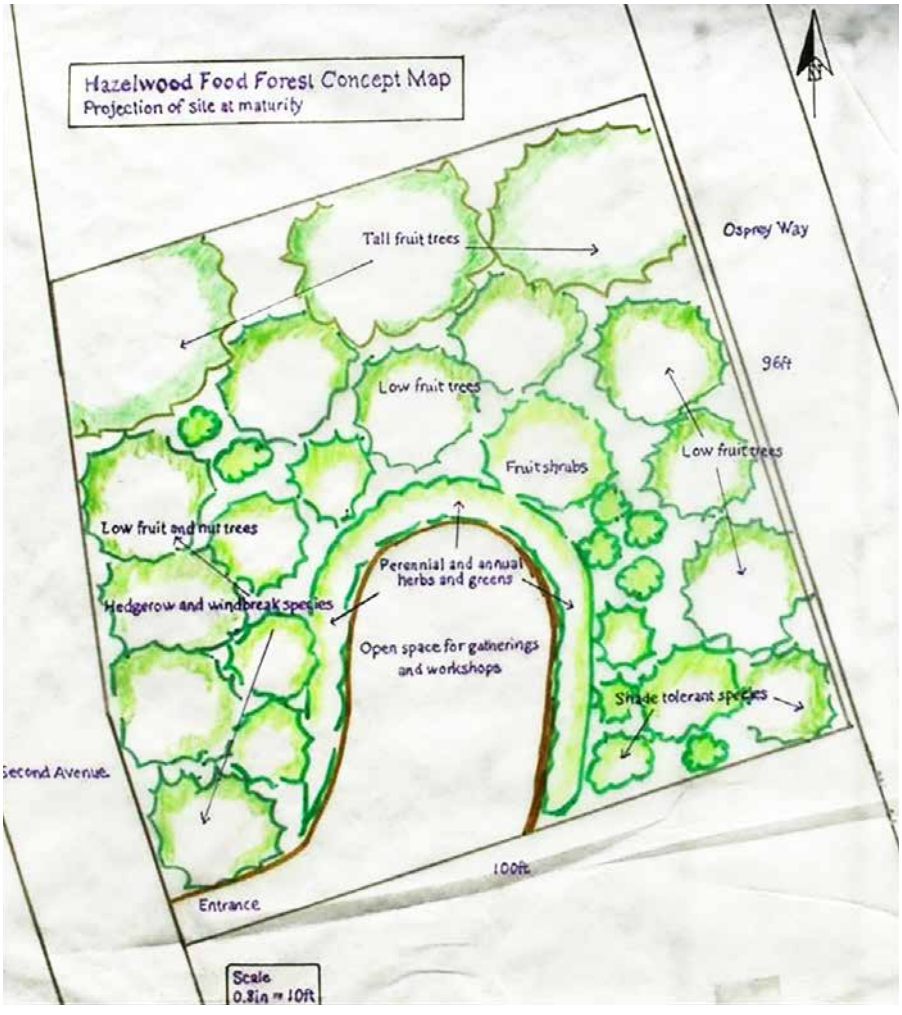
Volunteers moved bricks, and spread compost and mulch to prepare the site.

Credit: Michelle Czolba and Juliette Olshock

Trees were planted and sheet mulched the first year.

Credit: Michelle Czolba and Juliette Olshock

Sheet mulching with cardboard and compost suppressed invasive weeds and began the soil building process.



The concept map for the Hazelwood Urban Food Forest guided the site development.

(a neighborhood within Pittsburgh city limits). The site encompassed a 100-foot by 96-foot area (0.22 acre).

Much work needed to be done to go from vacant lot to edible landscape. We sheet mulched the whole site during the course of two community workshops and then weekly during many workdays. We distributed 70 cubic yards of compost throughout the site, hauled out a bunch of trash, and planted trees, bushes, and herbs. We kept many of the excavated bricks onsite and used them for various projects like creating designated beds and raising a rain barrel the requisite 18 inches.

We had harvests of elderberries (*Sambucus nigra*), strawberries (*Fragaria* x *ananassa*), peaches, plums, and pears along with tons of purslane (*Portulaca oleracea*), spearmint (*Mentha spicata*), and lamb's quarters (*Chenopodium album*) within the first few seasons.

Other cities with food forests (sometimes known as urban orchards) include Boston, Philadelphia, Los Angeles, Asheville, and Seattle's well-known Beacon Food Forest. The Philadelphia Orchard Project and Earthworks Boston were both inspirations for this concept.

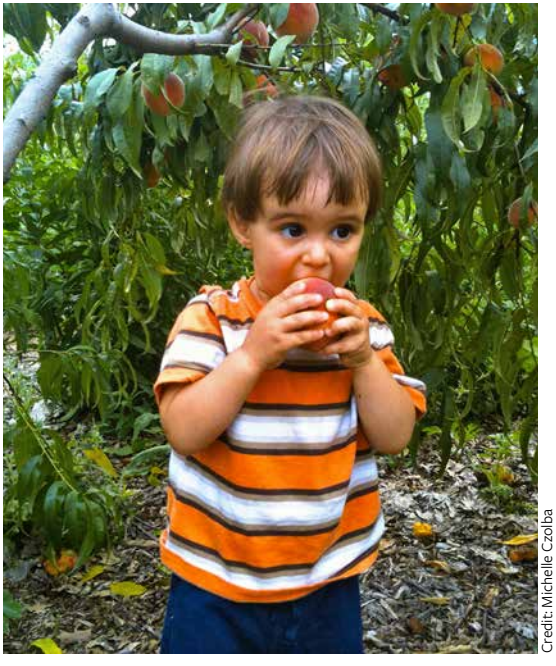
Lessons Learned

It was a lot of hard physical work to keep the Japanese knotweed at bay, and paths open through the site. Knotweed is only a problem in that it does not let other plants grow. I recognize it as a useful and valuable plant with a role in the ecosystem as a protector. However, I noticed a significant decrease in its range over the course of our time at the site. I attribute that to a direct response that the plant had to our intentions, along with using a clear plastic to scorch the plants and roots.

Much of what we planted thrived. The grapevines sent out tendrils well beyond the trellis; sunflowers grew to ten feet tall; and we had milkweed throughout the central area that called in beautiful monarch butterflies. Huge swaths of medicinal and edible plants grew up from the soil bank; none of these were intentionally planted. Some of these include purslane (*Portulaca oleracea*), mugwort

Credit: Michelle Czolba and Juliette Olshock

Within three years the Hazelwood Food Forest was dense with foliage and flower.



Credit: Michelle Czolba

Michelle's son Lorenzo enjoys the first fruit of the food forest.

(*Artemesia vulgaris*), burdock (*Arctium lappa*), coltsfoot (*Tussilago farfara*), lamb's quarters (*Chenopodium album*), cleavers (*Galium aparine*), and bull thistle (*Circium vulgare*). The tomatoes and sunflowers became volunteers, growing back from seed every year. The site became a healthy ecosystem attractive to many bird species, deer, rabbits, and groundhogs.

After five full years of working on the original site, we were both at a place of deciding what to do next and asked to leave the space. We had support in moving many of the developed plants and trees to a new site that is affiliated with a local church. The original site was then used for a commercial garden center business.