

UNIVERSITY OF CALIFORNIA, SANTA CRUZ

**FOREST GARDENING: ORIGINS, METHODS, GOALS, AND THE EMERGING
FOREST GARDEN AT PICA**

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By

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ABSTRACT: Forest gardening, a method of producing food that mimics the structure and interactions of a natural forest, has a great potential for small scale, sustainable gardening and farming. It has been used for centuries in the tropics and is now being adapted for every climate. In Spring 2009 a small forest garden was planted at the Program In Community and Agroecology on the UCSC campus. Because forest gardening takes place over a longer time scale than most gardens, it is yet to be seen how successful this garden will be. I analyzed the methods and goals of this garden, and considered future maintenance and expansion. I developed a new area of the garden and researched site preparation and uncommon plants that are possible to grow in the Santa Cruz climate. Most of these plants are perennial vegetables and I attempted to grow them from seed in the PICA greenhouse, and although most of them died I suggest that with better care these plants could be implemented in the forest garden at PICA and other places in coastal California.

KEYWORDS: Forest gardening, food forests, permaculture, agroforestry, tropical home gardens, PICA, perennial vegetables.

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Introduction

“Backyard, small acreage forest gardening is the gardening method of the future for the future”

- Jade Woodhouse

Forest gardening is a dynamic approach to sustainable food production that draws upon centuries old horticultural wisdom as well as contemporary ecological knowledge. Briefly, a forest garden is a small-scale production system that has a diverse number of species growing together, mimicking the spatial arrangement of a natural forest. Contrary to the trend of modern agriculture, forest gardens seek to maximize ecological complexity and interactions. These interactions, rather than being detrimental, are managed in a way that maximizes beneficial processes, creating systems with a high ratio of output to input. Indeed, these systems have long been understood as being very efficient, and like their natural forest analogs, lack the need for chemical fertilizers and agricides. Despite this, they are scarcely implemented, and in areas where they already exist they are declining, because they do not fit into the current tendency towards large-scale monoculture production and the commodity chain that defines modern agribusiness. However, as the ecological problems that plague agriculture today become increasingly apparent, and as fossil fuels and other resources become scarcer, forest gardening is gaining popularity. Forest gardens offer a model that can be adapted to a variety of scales and virtually any climate, and along with other practices, provide an alternative vision for sustainable food production.

Section one: Origins

The Tropics

Forest garden systems have existed for thousands of years, particularly in the tropics. Southeast Asia, tropical Africa, Central and South America, and even some arid areas like the Middle East all have a history of diverse, multi-story perennial polycultures. These continue to exist today and are usually simply called home gardens, or huertos familiares in Central America. Home gardens are similar to shifting cultivation (swidden) and agroforestry systems, but because they are located so close to the household they are generally more intensively managed and more diverse, and they can be continuously cultivated (Eyzaguirre and Linares 2004). However, McConnell (2003) points out that terms like these can become blurred, indeed even the distinction between agriculturalists and hunter gatherers is often unclear in these systems, depending on how close the system is to the natural forest. In this light, local, indigenous names are probably the best at describing the particularities of these farming systems. For the purposes of this paper they will be called forest gardens. Forest gardens vary in size but are generally a few acres or less. They can be in rural and urban settings, and can be mainly for subsistence or have a focus on generating income for the family (Eyzaguirre and Linares 2004). In some cases they reach a village scale, as in areas of Java where 15 to 20 percent of village cropland is multi-storied perennial forest gardens (Reijntjes et al, 1992). In other words, depending on many factors like climate and desired outcome, these systems vary considerably from region to region.

Some of these systems are very old, multi-generational systems that have been productive for hundreds of years. For example forest gardening was practiced since up to 4,000 years ago by the Mayans as part of their Milpa rotation, in which they implement corn bean and squash intercrop, short lived trees, and mature forest gardens in a temporal rotation mimicking natural succession over several decades (Ford and Nigh, 2009). These systems are on a timescale completely different from that of the farming and gardening systems of the modern world gardens and farms. Permaculture designer Geoff Lawton describes a forest garden system in Morocco that is 2,000 years old and is farmed by 800 people (Lawton). 2,000 years is far longer than the lifespan of a single tree. Parts of this system have likely died and been replanted many times, and perhaps to a certain degree regenerates by itself, as does a natural forest through successional processes.

When some of the first westerners found these systems, they were not aware that they were productive, food producing forests, and mistook them for wild jungle or forest. Or, even if it was apparent that they were food gardens, they were not considered valuable because they did not conform to familiar patterns of food production. For example, in Mexico the Spanish would often encourage their animals to graze in Indian gardens, and they insisted upon draining the incredibly productive and sustainable *Chinampa* canals in favor of wheat fields or cattle grazing (Wright 1992). This underestimating of the productivity of traditional agriculture is in part because some of these systems mimic the natural forest very closely, except that their managers have selected the species they want and removed the ones they don't. These systems may seem random, unplanned, or even messy when compared with the food production patterns that we are used to in modern mechanized agriculture. However, there is certainly a good deal

of thought that goes into their design and maintenance. Jacob and Alles (1987) say of the forest gardens of Kandy, Sri Lanka that,

“...it is not logical to conclude that a system that has evolved over centuries and is still providing *good sustenance* to the farmers, could be casual about location, spacing and site conditions of perennial cash crops. It can be surmised that those who practice the system know, in a practical way, what and where to plant and how to manage the plants.”

Due to the age of some of these systems, it could be said that they have been more extensively planned than many modern farming systems that degrade land in only a few decades.

One pervasive characteristic of traditional forest gardens is their astounding diversity. For example over 350 plant species have been counted in traditional Mayan forest garden systems in Belize, 42% of which are trees (Ford 2008). This level of plant diversity provides a diversity of outputs for the communities that manage them. In addition to food, forest gardens provide a host of other services, including wood, medicine, spices, and income from selling extra food and ornamentals. This diversity is a kind of insurance, because if one crop fails there are always many more, and there is always likely to be something producing at any given time of the year. For example, in the forest gardens of Kandy, Sri Lanka, the average number of crops harvested each month on the farms out of a total of about 30 crops, is very similar, ranging from 3.3 to 6.3 (Jacob and Alles, 1987). Some of these crops no doubt yield continuously for long portions of the year. Income is also distributed around the year, although it depends on which crops the farm may be focusing on. In addition, it has been proposed that forest

gardens are important for a nutritionally diverse diet, and that many people would be nutritionally lacking if their diet were entirely based on grain monoculture. (Buchmann 2009). Because they are designed for subsistence as well as income, forest gardens implement an array of plants that can't be grown on a commercial scale. This ties into overall self-sufficiency, which is another important facet of these systems. People with productive forest gardens do not rely on state sanctioned agriculture and its concomitant fluctuations in price (Buchmann 2009). Therefore forest gardens can be a source of food security for marginalized people.

Biodiversity in a larger context is another important aspect of forest gardens. First of all, they are a bank of plant material and seeds that are selected, bred, and developed over generations. This is especially important considering the fact that the major food crops are being narrowed down to only a handful of varieties of a few plant species—The FAO estimates that in the last 100 years 75% of crop plant diversity was lost (Crop Genetic Resources 1998). Eyzaguirre and Linares (2004) note that forest gardens can function as nurseries, both for agricultural varieties and natives for restoration. Because they maintain species diversity and don't entail a loss of ecological resilience as does conventional agriculture, they can be considered as a part of the surrounding, less managed forest. Additionally, they can often act as refugia for wild plants that have become endangered due to development in nearby areas. For example, six plants on the International Union for the Conservation of Nature's red list were found in home gardens in Bangladesh, and most of the forest gardens in that region have at least a few of these endangered plants intentionally planted in them (Kabir and Webb 2008). Forest gardens are much more forgiving of plants and animals that do not directly

produce a yield, and because they are so similar to the structure of natural forests they provide an abundance of niches. Perera and Rajapakse (1988) surveyed 125 farms in the Kandy region of Sri Lanka and found that over 50% of the species on these farms had no reported household or economic use. Most agricultural planners would find this to be inefficient, even backwards, but the fact is that these plants act as a bank of genetic resources that is potentially extremely useful. These aspects make them important for ecological conservation as well as food production.

Forest gardens are also critical for the community and culture of the people that maintain them. There are usually social traditions ingrained in home garden culture, such as trading plant material, and often the gardens are communally managed and the yield is distributed equitably (Buchmann 2009). Also, there are often plants that are grown for ceremonial purposes in local traditions (Eyzaguirre and Linares 2004). Many cultures have 'sacred groves' or areas that cannot be harvested from because it is believed that gods or spirits inhabit them. In some areas of Java that have been largely converted to rice fields, the only remaining trees are in forest gardens and sacred groves (McConnell 2003). Therefore, productivity and conservation aspects aside, tropical forest gardens can be considered important for their social and religious functions.

Unfortunately, in many places in the world forest garden systems are on the decline. This is due to modernization and the proliferation of mechanized, monocrop agriculture. Often, farmers have less of a capacity to grow their own food because they are too engaged in trying to make a living with commercial cash crops for export. Forest gardens have never been considered productive or useful by most governments, even though they have been the foundation of subsistence agriculture in many regions for

centuries. However, researchers are increasingly finding small-scale home gardens to be extremely productive. For example, in 1999, 800,000 tons of fruits and vegetables were produced in urban sectors of Cuba in backyards and other smallholdings (Buchmann 2009). This figure is no doubt due to the unique conditions of Cuba being under a trade embargo from the US and with limited fossil fuels after the collapse of the Soviet Union, but it proves the potential productivity of home gardens anywhere in the world.

Lack of understanding and misconceptions about forest gardens abound, but there have been attempts to scientifically and economically document them. In his book *The Forest Farms of Kandy and Other Gardens of Complete Design* McConnell outlines a system of 34 criteria that can be used to evaluate any farming system, on scales from the local household and village to the public, economic and social scale to issues of global importance. The criteria include factors such as yield, diversity, sustainability, employment, irrigation, soil conservation, and energy use, and McConnell uses these to compare forest gardens to other farming systems. This is in contrast to the majority of agricultural planners who for the most part only consider productivity and profit. While it can be conceded that forest gardens might not always be as productive per tree as a monocrop orchard, they are more efficient on almost every other count (McConnell 2003). In fact, in a survey of the forest gardens of Kandy, Sri Lanka, McConnell found that they were much more productive than wet rice production, and most of the smallest farms had above average incomes, proving that they are indeed economically viable (17). This income is also much more *stable* because of the diversity of products. Because their output is dispersed temporally, forest gardeners do not need to rely on the annual cycle of debt that many farmers who have adopted the green revolution's technological package

are burdened with (24). Forest gardens are exceptional at holding and conserving water and soil resources, sequestering carbon, and limiting toxic inputs. Of course, they are not a perfect system, and some of the weaknesses of forest gardens found by McConnell are that because they require so few external inputs, they don't need hired labor and therefore don't distribute their economic gains equitably across the village—in other words mainly those who can afford to own land are benefitting from them. Also, because many forest garden products are perishable to the point that they can't be shipped to markets outside of the village, forest gardens aren't as good at distributing their produce as some other farming systems. This presents problems, as “buyers are not amused by having to lope round the countryside picking up a shoebox of nutmegs here, a cattie of kapok seed there, half a peck of cardamom somewhere else” (35). However, these discrepancies could no doubt be solved with a bit of tinkering, and it would certainly make more sense to adapt markets to forest garden systems than to level or simplify them in favor of monocultures, considering the ecological disasters that would entail.

McConnell has also demonstrated that in addition to the conservation benefits of forest gardens, they can also be used for rehabilitation of land that has been degraded by past agricultural destruction. Because forest gardens are technologically appropriate to poor farmers, they are a practical method of increasing productivity in way that is relevant and beneficial to the local population (44). For instance, much of South East Asia is plagued with unproductive grass “wastelands” (23% of the Sri Lanka is *Imperata* grasslands), the result of slash and burning or large-scale cash crop monocultures that have quickly depleted the soil. The shade of trees is the only lasting method of getting rid of this grass, and at the same time agroforests can be planted which feed and provide

income to the local population (45). One of the greatest potential virtues of forest gardens is that they can be planted almost anywhere, and repair degraded land.

So why haven't agricultural planners accepted, or even promoted the forest garden model? This question elucidates the larger issue of the schism between the interests of traditional farmers, agribusiness, and the state. Diverse polycultures don't fit into the state because, as James C. Scott points out in "The Art of Not Being Governed", it would be next to impossible to tax and appropriate an agricultural system with 60 or more species in it. Forest gardens, because they represent the past, are not appealing as a political vehicle for development and industrialization. Much more appealing to politicians are tractors, fertilizer factories and grain silos (McConnell, 11). This is a deep-rooted class and race conflict that has gone on for hundreds of years. In fact, in 18th century urban Mexico, growing your own food was banned because large landowners were not content with indigenous city dwellers being independent of the grain economy (Wright 1992). Regardless, it is important that traditional systems are studied and documented so that their value can be appreciated, in terms of agricultural sustainability, cultural significance, and ecological conservation. Forest gardening is beginning to gain popularity around the world, and these traditional systems are an important source of information, plant material, and inspiration.

Temperate Forest Gardens

The forest gardens of the tropics have been well documented, but what about in temperate regions? Temperate regions do not have the same history of diverse, perennial polycultures that the tropics have. There are, however, a few historical examples of practices that had similar methodology and goals as the tropical systems described above, as well as an emerging movement to implement forest gardening in the developed, temperate regions of the world.

The forest management practices of the Native Americans of North America was similar to forest gardening. Many tribes used fires in grasslands to suppress the growth of certain plants and maintain “park-like” landscapes with a few large trees (Timbrook et. al, 1982). The main goal of this practice was to select for oaks, which are fire adapted, as well as to increase productivity of many species of herbs, which thrive after fires. Fires also likely helped boost quantity and health of game (Lewis, 1973). From this evidence we can see that temperate forests were modified and developed just as they were in the tropics, even if there was less actual planting.

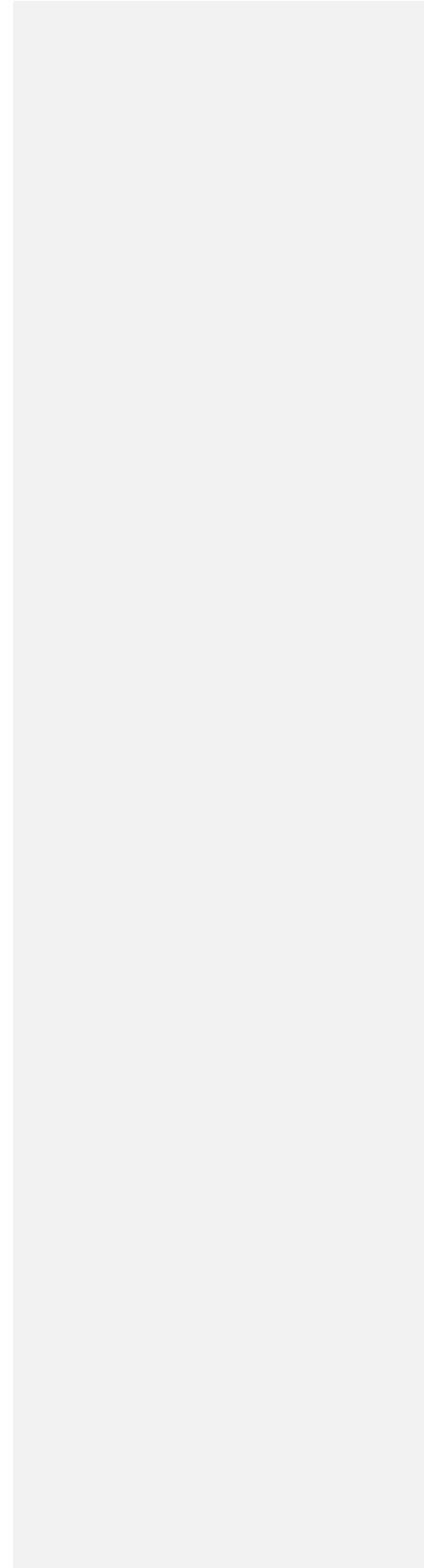
Another example of ancient temperate agroforestry was the coppice forestry practiced in European woodlands. Before the forests of Europe were largely deforested, man-made landscapes that consisted of a mosaic of woodland and meadows were created and managed, and this is still practiced in some areas (Haeggstrom 1998). Coppicing, a practice in which young branches are cut periodically, producing stakes, wood, and fodder. There was also a variety of fruit trees mixed in the system, and hay was grown underneath ((Haeggstrom 1998). Thus, ancient Europeans managed their forests, integrating crops and animals.

The first intentionally planted forest garden in the temperate world, or at least the first to be extensively documented, was Robert Hart's forest garden in England. Robert Hart was inspired by tropical systems that he studied, and decided to develop a model for sustainable, low input, high output forest gardens in the temperate regions of the world. Although his forest garden was rife with design errors that Dave Jacke points out in his case study of the garden, it still satisfied Hart's goal of a multi-story, long term garden mimicking the processes of a forest. Hart had a goal of gardens like these being the basis for a new global system of small scale, local and ecologically sound economies. He wrote a book titled *Forest Gardening: Rediscovering Nature and Community in a Post-Industrial Age*, which was seminal for the modern forest gardening movement and made it a popular practice in England.

In 1929 J. Russell Smith wrote *Tree Crops: A Permanent Agriculture*. Smith's book is a passionate critique of grain monoculture and the ecological destruction that it entails, especially on hilly land. When he was writing, topsoil was being lost at an alarming rate in the United States. Smith called for the use and improvement of tree crops such as oak, carob, mulberry and various nuts. He suggested that these could provide animal forage as well as food for humans, without the terrible degradation that annual crops like corn entail, and he repeatedly called corn "the enemy of mankind's future". He wrote that "This permanent agriculture is much more productive than mere pasture, or mere forest..." (19). This "permanent agriculture" that Smith proposed inspired Bill Mollison and Holmgren when they came up with the permaculture concept; indeed the name likely comes from Smith's title.

In Bill Mollison's 1991 "Introduction to Permaculture" there is a section detailing diverse orchards with an understory or "guild" of associated species. These include nitrogen fixing and other fertility building plants, insectary plants, and more. He goes into stacking trees, shrubs and vines into layers, and gives sample species and techniques for various climates. However, this section is quite brief and does not delve deep into the specifics of forest gardening. Other permaculture books also include sections like this, but they are included as part of the larger picture of permaculture design, including elements like energy efficient building, water and earth works, and postulations as to what an economy and political structure that took permaculture principles into account would look like. In other words, these books are of a general nature and not specifically geared towards forest gardening theory and design. Robert Harts *Forest Gardening* and Patrick Whitefield's similar *How To Make a Forest Garden* are forest gardening specific books. More recently Dave Jacke and Eric Toensmeier's two volume *Edible Forest Gardens* is no doubt the most detailed design manual for forest gardening so far. It is essentially a forest gardening textbook, replete with ecological theory, tables of plants that fill specific niches, and case studies of forest gardens around the world. Permaculture designer Geoff Lawton, although he hasn't formally written anything on forest gardening, has done extensive work developing forest gardens around the world and produced a DVD titled *Food Forests the Permaculture Way*. This DVD is very informational and inspiring as it details forest garden structure and design, as well as examples at Lawton's Permaculture Research Institute farm in Australia. Forest gardens are sprouting up all over the world in every climate, for example Erik Ohlsen in California is planning on creating a food forest campaign and to "Install food forests like a brushfire" (Food

Forests Across America). Forest gardening is beginning to attract attention and be adapted to the developed, temperate world.



Section Two:

Design elements and goals of forest gardening and how they apply to the emerging garden at PICA.

During the course of my independent study last winter, I read Dave Jacke and Eric Toensmeier's *Edible Forest Gardens*. This is a two volume work, the first being focused on ecological vision and theory, and the second being focused on design and practice. I read the first volume almost page for page, and started the second, but realized that it was very repetitive of elements of the first and probably best used as a reference book. This section starts with a map (figure 1) of the garden and a description of the five areas that compose the garden (For a detailed hand-drawn map of the garden with each species specifically labeled, and the initial planting strategies and projects, see Erik Seyster's senior project paper, written in Spring 2009). Next is a description of the elements and goals of forest gardening from *Edible Forest Gardens* that I found to be the most useful and interesting, and how they apply to the garden at PICA.

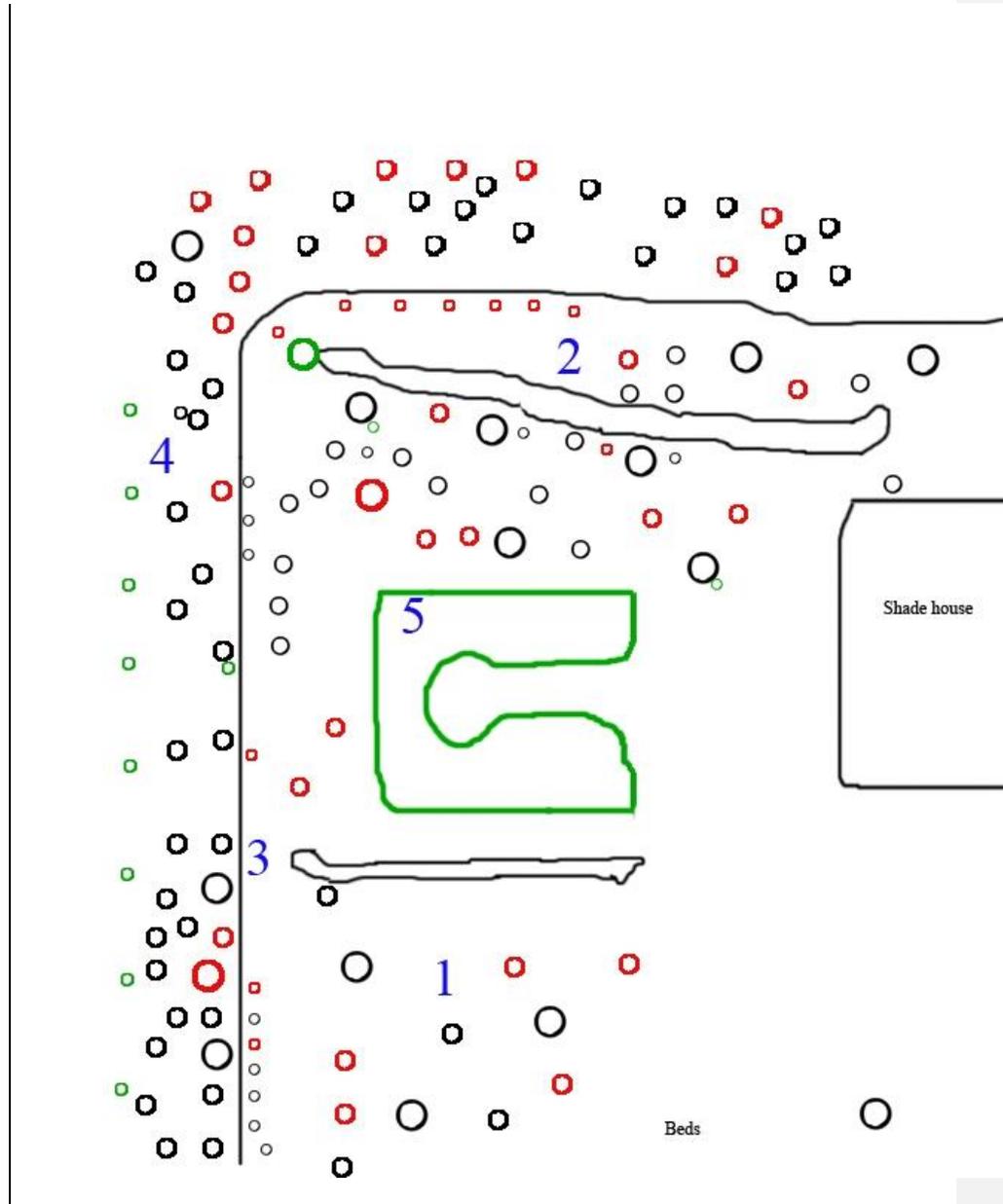


Figure 1: A simplified map of the food forest garden. Large circles indicate a tree, medium circles a shrub, and small circles an herb, vine, or other small plant. Red

circles indicate a plant that died or that was never planted, and therefore represents an open space. Green indicates additions to the garden since Seyster's work. The garden is split into five sections: Section 1 is the avocado guild area, section 2 is the upper swale area, section 3 is the fence plantings, section 4 is the windbreak, and section five is the keyhole bed.

Section 1: The Avocado Guild Area

This area now includes three small avocado trees, two *Buddleya* shrubs, and a *Ceanothus*. Two other *Ceanothus* were planted but lost (one, of the variety 'Julia Phelps' is still alive, but barely hanging on). Artichokes were planted in this area, but they are mostly gone now.

Section 2: The Upper Swale Area

The trees of this area are the Lapin's cherry, Walnut, three Oaks, and heartnut. The red circles in figure 1 indicate the medlar and American persimmon, which were planned for but never planted. The green circle indicates a new lemon tree at the western end of the swale. The shrubs of this area include California hazelnut, silverberry, princepia, *Ceanothus*, goumi berry, huckleberry, mugwort and yerba mate. Some of these have been lost, including a hazelnut, mate, seaberry, and California gooseberry. Additions include two large Aster flowers at the base of the cherry and lemon.

Section 3: The Fence Plantings

The fence plantings consist of vines planted along the inside of the fence. Towards the bottom, near the office building, are grapes (two of which appear to have died). Further up by the keyhole bed are hops. Losses include a ‘Maypop’ passion fruit vine, California honeysuckles, and a California morning-glory (which has been removed from the fence but is now growing on the ground).

Section 4: The Windbreak

This section consists of all the plantings outside the fence, and wraps around to the west and north. There are only three trees here for now, a pomegranate, loquat and an Oak. An Orange tree was planned for but never planted. There are many shrubs, including *Buddleya*, mountain mahogany, bee’s bliss sage (which now forms a large, low mat), wax myrtle, scarlet sage, black sage (which has also spread into a large shrub), Mexican elderberry, *Ceanothus*, toyon, coyote bush, barberry, wild rose, snowberry, and tobacco plants. Losses include *Ceanothus*, barberry, coyote bush, yerba santa and some artichokes, mostly along the northern end, probably due to deer. Additions include aloe plants along the western edge by the road.

Section 5: The Keyhole Bed

This entire section is new. See Figure 2 and the perennial vegetables section below for details.

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Scales and Applicability

Forest gardening can be implemented at a variety of scales. A dwarf deciduous fruit tree with perennial greens underneath can fit in a very small space, even in a small container. Therefore to a limited extent forest gardening can be adapted to urban environments, on roofs and balconies or in empty lots. Ornamental and weedy wild fruit trees could be grafted with improved varieties. Probably the best context, however, is in suburbs. Suburbs are an area with relatively high population density, and most everyone has a small piece of land (Jacke 2005). For the time being, most of this land is compacted, heavily fertilized lawns. As it stands in the US, our lawns use much more energy and chemicals than our agriculture, and use 270 billion gallons of water a week during the peak of summer (Coburn 2005). This land could be transformed into productive, food producing gardens that use far less inputs. Jacke and Toensmeier detail a potential “suburban forest ecology of the future” in which forest gardens have taken over suburbia, sprouting up as cottage industries focused on different products or communally managed plots that merge together (Jacke 2005). This may be a long way off, but it’s an inspiring vision. Forest gardening can also be applied on much larger scales, albeit in a simplified form.

Planting strategies

On pages 38-42 of *Edible Forest Gardens* Volume 1 Jacke and Toensmeier detail different initial planting strategies for forest gardens. The first, “Wood’s edge forest gardens”, is where existing tall trees are planted around, creating a tiered edge effect of decreasing height and shade tolerance, and taking advantage of the productive edge effect. This method does not apply to PICA since we don’t really have existing 50-foot

tall trees to work around. Two other methods do apply, one is “instant succession”, when all the successional stages are planted at once. In this method, everything is allowed to more or less grow on its own with little maintenance, just a little guidance. In the “relay plantings” method, plantings are temporally stacked. First the early succession species that like full sun are planted. As these first plants grow and change the conditions of the site, shade and stress tolerant species are added, and useful crops can replace the initial fertility builders. This method is especially useful for sites that initially have highly disturbed and degraded conditions. The PICA garden is a combination of these. Erik Seyster planted multiple successional stages and planted everything at once, except a few things he didn’t have money for or suggested that future people plant. In that this is an on going design process, it is a relay planting. Erik made sure to use many nitrogen fixing *Ceanothus* on this highly disturbed site, and suggested that these be replaced in the future by crop species. Because the site was so disturbed, many species are not appropriate to plant until soil fertility is improved and a favorable microclimate is created by the trees.

Spacing

Spacing is very important when planning forest gardens, as is the percent cover of the system, for both the garden as a whole and each layer. In a forest, there is 100 Percent tree cover, which entails intense competition for light, space, and nutrients (-Jacke 2005). This is definitely *not* what we are trying to mimic with forest gardening. Instead, we should strive to mimic a woodland, where tree crowns are not touching or overlapping, but tree coverage is at least 40 percent (-Jacke 2005). This mid-succession environment

creates the most diverse mosaic of vegetation patches. Because the canopy has gaps, shrubs and herbs can be grown in patches. This is ideal for forest gardens.

In the PICA garden, it is really too early to effectively measure percent cover and assess spacing. However, we can estimate how big the plants will grow. The garden is fairly dense, but definitely not over planted, especially since some plants, such as the *Ceanothus*, were designed to be phased out and others can be cut back if they get too big. There is plenty of path space and space in between the plants, I don't think the garden will become too dense or hard to get around in.

Root spacing

Root spacing is possibly just as important as above ground spacing. Jacke tells us that, despite the common belief that tree roots spread only to the canopy drip line, roots can often extend well past it. In infertile, dry, shallow soils roots can spread 3 times the crown diameter, or a total root area that is up to 9 times the crown area (Jacke 2005). Considering this, there may be some root competition in the future, especially since the soil here is dry in the summer and likely infertile, which means they will spread out in search of nutrients and water. However, because there really aren't too many tree species in the garden, I wouldn't say that this will be a big problem. Also, some tree species that we have, like the walnuts and oaks, have deep root systems that allow for shallow rooted species to grow near them (Jacke 2005). Regardless, there isn't much we can do about it now if there is a problem, but in future plantings we should keep root competition in mind and space appropriately, or use species that we know have different root patterns.

Ecological analogs

On page 168 of *Edible Forest Gardens* volume one Jacke tells us that “local native plant communities are the best, but not the only, models”. What this means is that we should strive to use as many natives in forest gardening as we can, because they are best adapted to local conditions and provide habitat for local fauna. However, natives do not always produce large yields of desirable products, and therefore non-natives must be used. We should select non-natives that are as similar as possible to natives in that they can adapt well to our climate, and certainly we shouldn’t choose species that have the potential to escape, naturalize and cause problems in our local ecosystems. Because of the conditions of the site, drought tolerant natives are a good choice. *Ceanothus* as a nitrogen fixer and coyote bush as a pioneer to break up soil work well, since they are adapted to this area, and across California they are often the first shrubs to grow in disturbed areas. However, I think some of the natives could have been replaced with similar but more useful species. For example, the California hazelnuts near the Oak. First of all, I am not sure that they even produce a reliable edible crop, and second of all, there are hundreds of them all around campus and nearby. A similar, more productive plant (such as an improved hazelnut variety) with a similar niche and place in the oak guild could have been put here. This applies to some of the other plants—a large proportion of the plants provide bird, beneficial insect habitat or other uses, but I think these functions should be secondary compared to edible yields for humans (I also understand that Erik had a limited budget and was donated many native species).

Layers

The layers of a forest garden can be defined in several ways. Typically there 7 layers: the overstory tree layer, the understory short tree layer, the shrub layer, the herb layer, the rhizosphere or root layer, the groundcover layer, and the vertical or vine layer. In the tropics palms can also be considered a layer, as they emerge through the canopy with their thin, tall structure (Lawton). It should be kept in mind that layers are not always distinct and can blend into each other. This is especially true when the trees are young and it is easy for shrubs or even herbs to be taller, and the term “overstory” may be confusing. Indeed, because the plants haven’t filled in, it is hard to assess the layers at the PICA garden, I will use four general spatial layers, as does Jacke in volume one. The functions of these layers are not yet apparent. Regardless, detailed below are what I see the layers of the garden being.

Tree or shrub overstory

This layer essentially defines all the others. The tallest trees will eventually use the most sunlight, nutrients, and water, and will affect any plant beneath them (Jacke 2005). This will be the avocados on the lower end and the oaks, walnut, cherry and heart nut on the upper end. Because the American persimmon and Medlar that Erik planned on were never planted, this layer can be filled in more. In the windbreak, it will be the pomegranate and loquat, but here too the tree layer is open. For now plants like the *Salvia*, *Ceanothus*, and *Buddleya* are the tallest layer.

Understory tree and shrub layers

In a natural forest, these plants are shade tolerant. They are either productive in the shade, slowly grow to the canopy, or wait for a gap in the canopy caused by a disturbance (-Jacke 2005). Shrubs also add structural diversity and productivity to the forest.

Because the trees are mostly still fairly short, this layer is now as tall as or taller than what will become the tallest trees. For example the *Buddleya* by the avocados has grown fast and is much larger than the avocados. Shade is not yet an issue as the whole garden for the most part receives full sun. Later on, when there is more shade, species that can produce in partial shade should be added into the garden. Jacke suggests the paw paw tree, a great fruit producing understory tree. Also, the *Ribes* genus, which includes gooseberries, currants, and cross between these two called jostaberries, has been demonstrated to fruit in shade (-Jacke 2005). For now the shrub layer around the avocados could be expanded, especially with nitrogen fixers since a *Ceanothus* died here. On the upper swale the shrub and small tree layer is well developed, perhaps even- *too* well developed, because in forest gardening we are aiming for a woodland rather than a shrubland, so again, more trees could be implemented.

Herb and ground layers

The herbs and groundcovers should essentially cover the garden, around trees and in open areas. They play important roles in covering bare soil and positively interacting with other plants. In sunny areas, herbaceous plants can be a large portion of the yield of a forest garden. There are also many shade tolerant, leafy plants including many

medicinal herbs. Also, ephemeral plants have evolved to grow beneath trees in the spring when the tree is still leafless. Some of these are edible, such as wild leeks, but even if they aren't edible they play an important role in nutrient cycling (-Jacke 2005). They use nutrients at a time when they are susceptible to being leached out of the soil due to rain and lack of cover, and then they die, allowing the tree to use the nutrients when it grows its leaves (-Jacke 2005). The herb and groundcover layer is therefore very important not only because of its yields, but because of its associative interactions with the other layers.

In the avocado area this layer is the artichokes, which have actually grown larger than the trees, yarrow and a very large chard plant. Around the Oaks and walnuts there are also artichokes, as well as mugwort, and now a morning glory that is spreading over some of the bare ground on the swale. In the windbreak there are yarrow, some prolific *Nicotiana*, and aloe. This layer could still be developed a lot. I suggest nitrogen fixing, insectary, and dynamic accumulator groundcovers and herbs around all of the trees and shrubs. Although the garden is mostly pretty bare, I witnessed the beneficial effects of the groundcover layer working quite well with the lamb's ear that is around one of the avocados, as the immediate area around that avocado was weed free all year. Erik planted a lot of yarrow, a great insectary for generalist and specialist beneficial insects as well as a dynamic accumulator and medicinal herb, and it has been very successful, in fact it appears that yarrow has naturalized in the garden, as last year's plants are beginning to die but seedlings are growing almost everywhere. There is only one successful comfrey plant, however. Some of the trees and shrubs are now so small that the ground cover might overtake them, for example I cut back a lot of yarrow and a large lupine as they were taking over the plants that they were planted under. With this in mind, we should

wait to plant members of this layer that are very vigorous and tall, or be diligent about cutting them back. An example of a good groundcover is members of the genus *Lotus* as they are a great nitrogen fixing, mat forming plant and are native.

Vine layer

This layer should intertwine with the other layers, and maximizes spatial efficiency by utilizing vertical space. In the forest gardens of Sri Lanka, pepper vines growing on coconut palms are a significant component of their polyculture (Jacob and Rajapakse 1987). In our climate we don't have trees quite as tall, straight, and bare that act as a climbing surface, but vines are still an essential element on their own or integrated with trees or structures. In the PICA garden the trees and shrubs are still far too small, and vigorous vines might overtake them, indeed there were some very vigorous vetch that I removed, as it was tangling some shrubs like the Goumi (luckily it had already filled its role as a short lived nitrogen fixer). The fence is the best place for vines, and so far there are grapes on the lower end and hops on the upper end. Apparently California honeysuckle vines were planted in the back behind the upper swale, but they must have died. The main species that I would suggest adding to the fence is 'Maypop' passion fruit. Erik planted one of these but it died, and I unsuccessfully tried to propagate them from seed. There is still quite a bit of fence space to implement vines into the system.

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The soil foodweb

It is becoming increasingly understood that sustainable agricultural production must take soil microorganisms into account. While microscopes may not yet be a standard tool for farmers, the mantra of organic gardening, “feed the soil to feed the plant”, is sage advice indeed. The soil foodweb is a complex system of microflora and fauna, including algae, organic matter, fungi, bacteria, nematodes, arthropods, earthworms and more. These act as producers, decomposers, grazers, shredders, carnivores etc. They break down organic matter and pass it through their bodies, making it available to plants or other microorganisms. This is extremely important for nutrient cycling in any ecosystem, and it defines the above ground ecosystem and its plants, birds, reptiles, mammals etc (Jacke 2005). Woody perennial plants especially rely on this foodweb. In fact, some plants put up to 40 percent of their photosynthetic energy into products that are exuded into the root zone and used by microorganisms (Jacke 2005). This seems wasteful, but it shows just how much these plants rely on having a healthy array of soil life around their roots. The microorganisms assist in nutrient uptake, root growth and many other factors. A common example of this is the nitrogen fixing *Rhizobia* bacteria that form root nodules in leguminous plants, and other similar organisms provide many benefits to plants. This is extremely important to consider in forest gardening, especially the role of fungal associates. Depending on which mycorrhizal fungi, or lack of them, are in a soil, different types of plants are encouraged to grow. 70 percent of plants are obligate mycorrhizal, that is, they depend upon mycorrhizal fungi to grow, and another 12 percent may or may not form fungal associations. The plants that do not form fungal associations are generally opportunist,

weedy species (Jacke 2005). We can surmise that early succession species do not require mycorrhizal fungi, and these species thrive in bacteria dominated soils. Later succession shrubs and trees need fungal associations of one kind or another. Also, fungal soils can suppress plants that are not hosts of mycorrhizal fungi (Jacke 2005). Therefore, if we can create fungal dominated soils, we will be selecting against the opportunist annuals we don't want, and facilitating the woody perennials that we do want. The transition from bacterial to fungal soil happens in natural succession, albeit very slowly. Grasslands can have up to 40 times more bacteria than fungi in their soils, whereas a coniferous forest may have one thousand times more fungi than bacteria (-Jacke 2005). How can we speed up the process? How do we know what kinds, if any, of mycorrhizal fungi our soil has? I would guess that because of the history of disturbance, and the presence and success of annual grasses and brassicas, that the soil at PICA does not have a healthy fungal element. Practices like mulching and adding organic matter will no doubt help mycorrhizal fungi to develop and spread. Other practices include inoculating plant roots with mycorrhizal fungi when planting them. Depending on the type of plant, it may need arbuscular, ectomycorrhizal, or other types of mycorrhizal fungi (Jacke 2005). It is hard to say if this is really necessary, but it could be tried. Another idea is to take a small amount of natural forest soil, which is no doubt replete with fungus, and put it into the planting hole (-Jacke 2005). It would be interesting to do trials with these methods and see if they improve plant performance.

Goals of forest gardening

On page 46 of *Edible Forest Gardening* volume one Jacke and Toensmeier begin their discussion of what they outline as the seven goals of forest gardening. What follows is my assessment of how the PICA garden is or will be fulfilling these goals.

Grow an abundant diversity of tasty, nutritious food and other useful products.

Although the garden is not yielding much yet, it has been designed with several different species of fruit, nuts, berries, as well as other products, and now vegetables. Eventually there should be pomegranates, loquats, cherries, walnuts, avocados, and other berries, vegetables, and medicinals. However, it is yet to be seen how well this garden will yield, and what improvements can be made. I did get to try some berries from the gumi bush, and some herbs like the oregano are very prolific. If somebody wants to research how to roast mate, there will be plenty of that as well. For now, there are plenty of open spaces and niches to be filled with more food producing plants.

Create a stable, resilient garden ecosystem, driven by solar energy that largely maintains and renews itself.

This goal is pretty far off. The sheet mulching did a pretty good job of blocking weeds, but weeds still overtook much of the garden in Spring. Even though there are several mulch plants that can be coppiced, this will be a regular problem. Again, we should plant groundcovers to block the weeds. As far as water, the swales might help but irrigation will still be necessary, this is simply due to our climate and I doubt any design

could self maintain its water needs at this site. Hopefully as the trees establish they won't need as much water. Self-renewing nutrient cycling is likely far off as well, but this will improve as the plants grow and the soil gets improved. In the meantime we should continue to add compost, sheet mulch, and anything else we can do to build soil and encourage the soil microorganisms to help with nutrient retention and cycling.

Protect and restore ecosystem health

This has been attended to well. There are many native species to attract native birds and insects. I often see small birds such as flycatchers perching on the fence or the oak, and as the garden fills in it will provide more habitat for them. I also often see lizards scampering around, no doubt they enjoy the warmth and protection of the rock piles. The yarrow and other flowering plants attract beneficial insects and many bees. So far, there is still a high abundance of opportunistic weeds. Although they are performing their own function in the succession of this site, we can strive to eliminate them in the future.

Embody beauty, elegance, and spirit in the landscape

Certainly this site looks better than it did before. Again, this is a goal that will be attained with time and work. The garden certainly looked unkempt in the Spring when weeds were taking over. My suggestion is that more time is spent on the garden during PICA workdays and classes. The addition of the hammock did make it a more appealing place to spend some time and relax; every forest garden should have a hammock. Ideally

in some years the plants will fill in, block sight of the road, and create an outdoor refuge of beauty and elegance.

Improve economic sustainability

As Dave Jacke says, “forest gardening usually requires a large initial investment of time and materials... and this can cost money. Once a garden is established, however, the expenses should drop substantially” (Jacke 2005). Plants can be quite expensive, and if the garden is to be improved and expanded it will require more funding. However, after a few years, it will likely be inexpensive to maintain. Over time, the garden may pay for itself and more, as some fruits like avocados can be expensive. Besides, it will provide some fruits and vegetables that probably can't be found in any market in Santa Cruz, or the United States for that matter. This is valuable in itself, and like the forest gardens in the tropics, this garden can act as a bank of plant material that can be propagated and distributed to other gardeners in the area.

Cultivate a new paradigm for human participation in the ecology of cultural and natural landscapes

This last goal is very important, because it is essentially what PICA stands for. Nobody really knows or understands the garden as it stands. Because it is so young, it now essentially looks like a random assortment of plants. I would suggest that it is added into the general practicum of PICA, and students should be encouraged to take on its maintenance and improvement. A sign that announces the space, what it is, and its design elements would be helpful in this regard. Permaculture and forest gardening are great

ways to get people excited about ecology, and more importantly how we can participate with, guide, and benefit from ecological processes.

Expansion

The best place to expand the forest garden would be directly on the other side of the greenhouse. Here there are already two mulberries and some other fruit trees below towards the compost bins, and even some small swales. This area could be developed with more trees, shrubs, and groundcovers. More swales could be created, and the existing ones deepened.

If it were possible to expand the PICA forest garden into the great meadow and beyond, I think that Martin Crawford of the Agroforestry Research Trust's methods would be effective (if altering the great meadow doesn't sound desirable, these techniques apply to any large, open piece of land). Crawford has done extensive research in England about forest gardening. His method of planting a two-acre site is described on page 46 of *Edible Forest Gardens* volume one, and he also recently wrote a book titled *Creating a Forest Garden* where he no doubt details this process as well. Martin used a relay planting strategy, first planting 250 trees as the overstory. Then he used eight-foot wide strips of black weed suppressing plastic to kill the grass, each year moving the strip across the site. In the area where the grass had been killed, he planted mulch and fertility building ground covers. These ground covers prevent re-establishment of the grass and some have usable products. Then he planted clusters of shrubs around the trees, in the new groundcover layer. The next step will be to convert the lower layers into more shade

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tolerant plants as the tree canopy fills in. Crawford was able to do this entirely by himself in only a few years. This is a great method for rapid establishment of a large area.

Section Three: My contributions to the PICA forest garden

Sheet Mulching and the Keyhole Bed

Since I decided on forest gardening as the subject of my senior thesis in Fall 2009, I have worked on several projects in the emerging PICA food forest. Many of these were suggested in Erik Seyster's thesis paper. The first thing I did, in October 2009, was planting some aloes to be the lowest layer of the windbreak and transplanting some comfrey plants from the Foundational Roots garden. The aloes, perhaps due to transplant shock or direct sunlight, are a bit desiccated but still alive. The comfrey plants died, probably because they didn't get enough water even though they were planted near trees around existing drip emitters. Also around this time I broadcasted a seed mix of chicory, clover, vetch, Austrian field peas, daikon, and lupine, to help break up the soil and add nutrients. I did this in the fall so that the winter rains would water this cover crop mix. As far as I know, none of the seeds came up. Perhaps it was because they were only broadcast on the surface and not dug into the soil. Also the vigorous weeds dominated any open space in the garden after the rains. If this is tried again, which I recommend, more effort should be taken make sure the seeds infiltrate the soil and that the weeds are kept in check. During this time, despite the extensive sheet mulching, the weeds started to strangle and shade many of the small trees and shrubs, and I made sure to clear these out.

My main efforts were on preparing and creating the keyhole bed, and researching and planting the perennial vegetables. Because of the poor, hard packed clay soil that we are working with, I knew that some serious soil building would be necessary to create a garden at this site. At PICA we have proven the double digging method to be quite effective at improving this type of soil, and the Chadwick garden has also done so for a much longer time. However, instead of double digging, I decided to try a different method to see if it is as effective. I used a method detailed in Toby Hemenway's book titled *Gaia's Garden, a Guide to Home-Scale Permaculture*, something he calls the "ultimate bomb proof sheet mulch". The benefits of this method are that it doesn't till and disturb the soil, and it is a lot less work intensive. This sheet mulching method is much more involved than the normal sheet mulch, which consists of a layer of cardboard and mulch and is mainly geared towards weed suppression. First, the soil is aerated but not turned, by using a digging fork to poke holes as deep as possible. Also, all existing weeds are cut at the surface, the roots left in to add organic matter (there is no danger of them re-growing because so much material is piled on top). At this stage soil amendments can be added, I would suggest that if this method is used again a soil test should be done first, and if the soil is lacking in anything the appropriate amendment can be added. Next, a thin layer of nitrogenous material is added. This can be manure, blood meal, or green material. I used the existing weeds and cardoon leaves. The idea behind this first layer is to attract worms and beetles to begin loosening the soil. Then a layer of cardboard or newspaper is added, to block light and prevent weeds from germinating. The structure of cardboard also seems to be conducive to the growth of mycelium. Next is another nitrogen rich layer, I used more green material, to encourage the worms to come upwards

as the cardboard breaks down. The next layer is the largest, 8-12 inches of bulk organic matter. This can be many different materials, but I used straw. On top of that is a 1-2 inch layer of compost or manure. Jim Leap from the CASFS farm let me use some of their leftover grape material from Bonny Doon vineyard that is used as compost, and some PICA compost. The final layer is a thin covering of weed seed free material, for which I used wood chips. This was allowed to break down for about 5 months before I planted. To plant, I pushed away the mulch, and dug into the soil. When I dug into this soil in July, it was clear that it has worked. The soil is dark, damp, and crumbles easily when squeezed. Every shovel full is busy with an astounding number of earthworms. I can't say how far down these effects have reached, as below six inches down it may be the same compacted clay, but hopefully the worms and future plant roots will change that. Also, it seems that the bulk organic matter layer of this mulch didn't break down too well. Hosing it down between every few inches when laying it down would have helped, as would have adding more nitrogenous material to the whole sheet mulch. Hemenway suggests planting seeds into the top compost or soil layer, and as the plants grow their roots will penetrate into the composting mass below. I couldn't really do that as I planted mostly potted plants, and it made more sense to me to push aside all of the layers and plant into the original soil. Regardless, I can say with confidence that this is a great method of turning around a difficult site and producing fertile, healthy soil.

On top of this sheet mulch, I decided to create a keyhole bed. Keyhole beds have been an element of permaculture for a long time, likely first detailed by Mollison. The main proposed benefit of a keyhole shape is that it maximizes bed space and minimizes path space. Hemenway calculates that in a layout where each bed has a single row of

plants and a path between each bed, half of the garden is dedicated to path space. In a raised bed pattern, with its thicker beds, reduces path space to about 30 percent. However, if the raised bed is wrapped into a horseshoe shape with only one small path in the center, less than 25 percent of the space is devoted to the path (Hemenway 2000). Nature uses this concept all the time, as with the folded pattern of lungs that maximizes surface area (Jacke 2005). If there is enough space, multiple keyhole beds can be combined together, creating sinuous network of paths that maximizes growing space. There is also aesthetic value to a pattern like this, as straight, rectangular rows can be monotonous and certainly aren't a pattern that exists in nature (Hemenway 2000). The zones of use concept of permaculture applies to keyhole beds, on a very small scale. The plants that are harvested most frequently are positioned closest to the path, and those that are harvested infrequently or once are planted in the back (Jacke 2005). I attempted to do this by planting celery, strawberries, basil, and tomatoes in the inner ring, close to the circle at the center of the bed. I put less frequently harvested plants like Yacon and artichoke around the outer edge. However, since this bed is easily accessible from all sides, my main goal was to have it structurally patterned so that the tallest plants are on the outside, and the smallest on the inside. The keyhole pattern certainly makes it more difficult to break up and till the soil with methods like double digging, but since it is intended to be a perennial garden, it won't be dug as much as an annual bed. Although I did include some annuals, hopefully this goal will be considered as best as possible with future plantings, and fertility can be maintained with more compost and mulch.

Perennial Vegetables

“One has to ask, why is this remarkable plant not more widely grown and available? ...With luck this magnificent vegetable of ancient and noble lineage will someday be widely grown again. Meanwhile it is up to enthusiastic gardeners to keep the plants going”

-Eric Toensmeier, about perennial branching bush kales, but could be said about most of these plants.

In the winter of 2010 I did extensive research to try to find perennial vegetables. I was inspired by Eric Toensmeier's book "Perennial Vegetables", which contains over one hundred vegetables and fruits that are similar to the annual plants we know, except they live at least three years. The book is full of exciting plants that I had never heard of, like air potatoes and walking onion. Many are not suited for the climate of Santa Cruz, but pages 206 and 207 provide a list of all the plants in that book that are suitable for Southern and Coastal California. These plants are often incredibly hard to find, only available in obscure catalogs that can be very difficult to order from, and expensive. Often they are only available at certain times of the year, which made some unavailable to me for that reason. A lot of the more promising ones are available as small potted plants, but because I was gone in the Spring I didn't want to buy potted plants and then wait for months to plant them, so I decided to mostly order seeds and a few bulbs. I figured there would be enough time for them to grow out. In the end, many of them either did not germinate or germinated but did not grow past the small seedling stage. Because I couldn't watch them during the spring and early summer most of these small seedlings died in the greenhouse. I was left with very little of what I planned on having, but it was

quite a learning process on researching, planning, and ordering plants nonetheless.

Through other means I was able to find plants to fill in the garden. What follows is a brief description of every plant from Toensmeier's book that I ordered or acquired seeds or other plant material, plants that are in bold actually made it into the garden. Figure two is a diagram of the bed showing where each plant is.

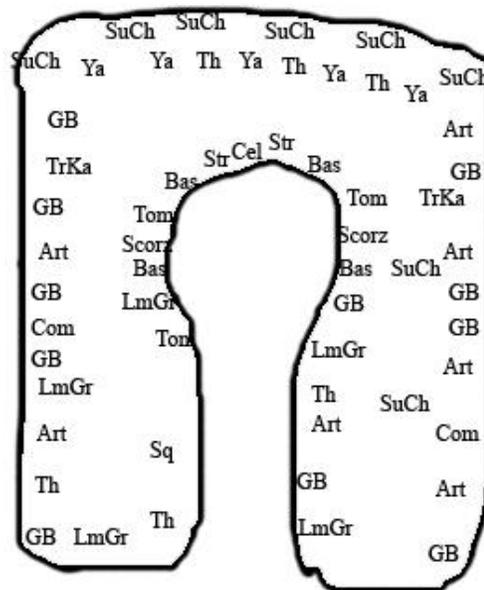


Figure 2: The keyhole bed. Ya: yacon, SuCh: sunchoke, GB: goji berry, TrKa: tree Kale, Art: artichoke, Com: comfrey, LmGr: lemon grass, Th: thyme, Sq: Squash, Tom: tomato, Bas: basil, Scorz: scorzonera, Str: Strawberry, Cel: celery. There are also various flowers throughout.

Alliaceae: The onion family

Allium cepa proliferum “walking onion”. This was one of the plants that first caught my eye in Toensmeier’s book. This is an onion that sets small bulbs on the top of their stalks, instead of flowers. This weighs the stalk down, and it falls over and gets buried. Next year a new onion sprouts from this, and so it “walks” around. I looked all over for this plant, and finally found a nursery online that sells bulbs. I bought a package, after which I should have just put them in the ground but due to the delay in planting I kept them in their package for a while and then in a pot in the greenhouse. Two of them sprouted, but must have died while I was away. I still recommend this species for the garden, as it is a great example of how interesting and fun these plants can be.

I also planted some onions from seed, likely *Allium fistulosum*, Welsh onion or scallions. These can be considered perennial because they form a bunch of onions, some of which can be kept in the ground for next year. These have been grown successfully in PICA so they would be a good candidate for the permaculture garden, but my seedlings didn’t get very big. Perhaps they would do better from bulbs.

Apiaceae: the celery family

Levisticum officinale Lovage. This plant is similar to the celery we are familiar with but bigger (can grow 6 feet tall or more) and perennial. Its young shoots are good cooked, and the seeds and roots are also edible. It is popular in Europe and Toensmeier notes that the traditional way to drink a Bloody Mary is to use a hollow stalk of lovage as a straw. Most of my lovage seedlings perished, but I did plant one seedling.

There are two other Apiaceae plants that I was unable to find, but look promising. One is *Arracacia xanthorrhiza* or Arracacha. Arracacha is an Andean root crop, and Toensmeier

says that it is delicious, very high yielding, and can probably grow in California. The other is *Sium sisarum*, Skirret. Skirret is also a root crop that forms dense clumps of pencil like roots. It is adapted to colder climates than Arracacha. Both of these plants could act as insectaries if allowed to flower.

Asteraceae: the aster family

Chicorium intybus, Chicory. Chicory was one of the seeds that I broadcasted across the whole food forest in the fall, along with fertility builders, nitrogen fixers, etc. None of them came up, but Chicory could definitely be included as a pathside plant in the keyhole bed.

***Cynara scolymus*, Globe Artichoke.** Artichokes are one of the only plants in “Perennial Vegetables” that everyone is familiar with. I found seeds of the variety ‘green globe’ and it was one of the few seeds that had a good germination and seedling survival. I planted several of these in the keyhole.

***Helianthus tuberosus*, Sunchoke, Jerusalem Artichoke.** Sunchoke are hardy sunflowers that produce an abundance of crisp, sweet tubers. Apparently they contain a starch called inulin which is difficult to digest, so I would advise caution when eating them. I planted tubers around the outside edge of the keyhole bed, because these plants can get quite tall.

***Scorzonera hispanica*, Scorzonera.** Scorzonera is a root crop, that can only be harvested once, but it also has edible leaves that can be kept for multiple years. It is hardy and cold tolerant. My Scorzonera seeds had a good germination rate, but also didn’t do well in the

hot greenhouse. Two seedlings made it into the keyhole. For now they look like blades of grass.

***Smallianthus sonchifolia*, Yacon.** Yacon is an Andean root crop that makes large, crisp tubers that can be eaten raw. It forms clumps and can grow 6 feet tall. I was fortunate enough to be given several well-established Yacon plants by Marshal Chrostowski, an organic farmer in Santa Barbara. He told me that if you mound dirt up around the plant, it will keep producing tubers that get over a foot long. I divided these into five sections and planted them. They were in 5-gallon pots, and even in this small space they had formed clumps of small tubers. They are indeed quite tasty, similar to Jicama but better in my opinion. To harvest, dig out the tubers periodically. I am not sure if these plants will die in one season, if they do, leave a few tubers in the ground so it will grow back.

Brassicaceae: the cabbage family

***Brassica oleracea* ‘tree collard’, ‘walking stick kale’.** This is a perennial kale that grows on a long stalk, getting up to 12 feet tall. In fact, in Europe they were once grown for their sturdy stalks to use as walking sticks (Toensmeier). I got several cuttings of these, and potted them in the greenhouse. Some rooted, some didn't. They should have been planted sooner, but the bed was not ready at the time. There are 4 sticks in the keyhole, hopefully they will survive the summer, as I know that they can be quite prolific, and are one of the best perennial leaf crops.

***Crambe maritime* Sea Kale.** Sea Kale grows wild on European coasts, and has been harvested there for thousands of years. Its young leaves are blanched, and it can be productive for up to 10 years. My seedlings didn't survive to be planted, however.

Chenopodiaceae: the goosefoot family

Chenopodium bonus-henricus Good King Henry. This is an ancient vegetable from Europe. Almost all parts of it are edible but it is mainly grown for its asparagus-like shoots. None of my seeds germinated, perhaps it was the wrong time of year for them, but I have also noticed there can be mini microclimates of success or failure in the greenhouse.

Another Chenopodiaceae that Eric Toensmeier is emphatic about is *Atriplex halimus*, saltbush. He says that tasting a shrub at the Plants For a Future site in England "...really changed my life in terms of understanding the potential of perennial vegetables". This was no doubt an improved variety given good care, because the wild *Atriplex* I tasted in the Mojave Desert was not very palatable.

Meliaceae: the neem family

Toona sinensis, Fragrant Spring Tree. This plant is intriguing because it is a woody leaf crop that can be grown from the tropics all the way into Canada. Toensmeier suggests that it is best used as a culinary herb, but apparently it is used as a vegetable in China. I was able to find some seeds, but none germinated. The directions on the seed pack said to soak them in warm water for several hours, but Toensmeier says they need to be cold stratified for 90 days.

Polygonaceae: the smartweed family

Rheum x cultorum, Rhubarb. Rhubarb has been grown successfully at PICA before. My seeds didn't really get past the dicotyledonous stage. Toensmeier notes that it is usually used in pies, but traditionally in Asia it is used in savory dishes.

Rumex spp, Sorrel. A perennial leaf crop that can be eaten raw or cooked. Perhaps its for the better that my seedlings died because it has a potential to become weedy, although *Rumex acetosa* 'Profusion' is a variety that never flowers, which is probably safe.

Solanaceae: the nightshade family

***Lycium barbarum* and *Lycium chinense* Goji berry.** This is an ancient Chinese plant that is gaining popularity here. It produces edible berries and, according to Toensmeier, the leaves can be eaten as well. Erik made several cuttings and Jim Velzy kept them at the Thinman greenhouse for over a year, and one of them finally made it into the food forest garden. I was also given many small seedlings by a friend, which I used to fill gaps in my plantings. These plants are now very small, but apparently they can get up to 12 feet tall.

***Physalis peruviana* Cape Gooseberry.** This is a perennial plant in the same genus as the tomatillo, but can be eaten like small tomatoes. I have heard they are excellent. Decent germination rate. One small seedling made it into the garden.

Physalis pruinosa Ground Cherry. Similar to *P. peruviana* except that it is a self-seeding annual. This had good germination.

Some other plants made it into the garden, perennials and some annuals, to make up for all the ones that died in the greenhouse. These are:

Cucurbita spp. A summer squash. This actually volunteered, likely from a seed in the compost I added to the sheet mulch. Without any watering it survived, and now with water it should produce.

Thymus vulgaris. Thyme. I used some Thyme plants as a groundcover and culinary/medicinal herb.

Cymbopogon. Lemongrass. These five lemon grasses sat unused for over a year under the shade cloth, so I finally planted them. They are a great culinary herb in Southeast Asian cuisine.

Symphytum officinale. Comfrey. The classic dynamic accumulator and bee attracter.

Ocimum basilicum. Basil. I included several plants from the farm adoption table as pathside plants

Solanum lycopersicum. Tomatoes. I planted two tomatoes, also from the farm adoption table. I believe they are green tomato.

Fragaria × ananassa. Strawberries. I acquired two strawberry plants and put them in, I don't know the variety.

Flowers. Two kinds of flowers were also from the farm adoption table, but since they weren't labeled I don't know what they are. One is an aster, so it will attract beneficial insects. Also a showy pinkish red *Begonia* from the campus greenhouse that Jim Velzy gave me.

Apium spp. (?). Perennial celery. This plant was, like the Yacons, given to me by Marshall Chrostowski. I'm not sure what the name of this plant is, all I know is that it is a perennial celery that can probably be used like cilantro. At the very least, if allowed to flower, its umbellate inflorescence will act as an insectary.

Case Study:

Quail Springs Permaculture Farm and Learning Oasis

In early July, 2010 I was invited to give a talk about forest gardening at Quail Springs in the Cuyama valley. I was able to observe and hear the story of their new forest garden, which is now one year old. They face the problems of the high, cold desert-- lots of frost and little precipitation. There is not much published on forest gardening in this climate, but they are learning a lot in the process.

The site consists of several swales on contour, on a slight slope, South facing. The swales are filled with mulch, and plantings are done in the swales, which is a dry land permaculture strategy. Everything is heavily mulched in the garden. Initially a cover crop with many N-fixers was planted. The central aspect is a small pond surrounded by mint. Over this hangs a large (15 ft. tall) year old willow tree, which shades the pond. This tree is quite young, just under five years old, but it already protects the east side of the garden from cold winds which have caused some losses on the west side.

The pioneer trees being used are locust trees. There are many of these throughout the garden, and they are surprisingly big (10ft) for their age (they must have been well established before the forest garden was planted). Amongst these are mulberries, pomegranate, apple, and stone fruit trees. In the understory are more nitrogen fixers (a mimosa), and an abundance of sunchokes, which are a very prolific perennial vegetable and provide a huge yield. In amongst this are many flowers which likely act as pest repellents and insectaries for beneficial insects. The garden is very densely planted, and Warren Brush, one of the main residents and teachers at Quail Springs, had an interesting anecdote about this. When Quail Springs was just starting, and the first fruit trees were

being planted, they brought in an orchardist from UCSB to look at their plantings. He told them that their trees were planted far too close together, and that if they want optimal yields, they should take out about half of the trees. Later, Australian permaculture designer Geoff Lawton came, and said that they could probably fit in about twice as many plants in the same area. This is an amusing example of the difference between the forest gardening model and the conventional orchard model. Certainly if the trees are well spaced and have nothing growing around them they will have a higher *per tree* yield, but when Lawton suggested more plants go in, he was factoring in *total system* yield.

The forest garden is irrigated by both the small pond at its center and a larger pond nearby. Nesting pairs of red winged blackbirds live in the cattails of the larger pond, which absorbs their nutrient rich droppings. This combined with fish emulsion additions helps irrigate and fertilize, or “fertigate” the forest garden. Warren Brush, wants to implement ducks and pigeons in the future. The ducks will provide eggs and meat as well as possibly pest control. Pigeons apparently also have phosphorous rich droppings and will act as a source of fertilizer. I also saw the most frogs I have ever seen in one place in my life, attracted by this rare desert pond, and they too no doubt provide pest control.

All of this was able to happen with water, and is tied in with Quail Springs’ riparian restoration work. They are using gabions, a kind of dam that lets water through, to raise silt in their stream, which then helps raise the water table. The goal is to reduce down cutting erosion and keep water on the land, rather than having it rush off as soon as it comes, as the “slow it, spread it, sink it” mantra of permaculture design suggests. They are also planting many riparian trees like cottonwoods around their property. Warren mentioned the idea of “riparian food forests” which seems to be exactly what they are

doing. This is a case in point example of how forest gardens can both provide food for people and repair surrounding degraded ecosystems, and embodies Jacke and Toensmeiers' 7th goal of forest gardens, which is to cultivate a new paradigm for human participation in the ecology of cultural and natural landscapes.



Figure 3: The Quail Springs forest garden. The willow tree above protects this mulberry from harsh winds. The understory in the foreground is sunchoke and an apiaceae flower.

Epilogue

Overall, I enjoyed the process of researching forest gardening and working with the PICA forest garden. I learned a lot ecology, succession, soil, and of course plants. However, during the process of learning about this subject I found myself doubting many aspects of it. Sometimes I am disillusioned by the fact that we live in a social and economic system that is inherently opposed to forest gardening. Besides, could forest gardens really be implemented on a wide scale? Would all of the methods in *Edible Forest Gardens* really work? Are the plants that Toensmeier is so emphatic about in *Perennial Vegetables* really that great, or are they just disappointingly unpalatable like cardoons? What kept me motivated is my belief that we won't know the answers to questions like these until we try things out. Forest gardening is a new idea, at least in California, and it will take some trial and error to figure out the best plants and methods. Also, as interesting as design and theory can be, I found it frustrating get bogged down in them. Few of us have the horticultural knowledge to really know what works best. That's why I think what is most important is that we start planting trees, and figure it out as we go along. And, if forest gardening ever does take off, it won't matter what kind of social and economic system we have. As Geoff Lawton puts it, "you can solve all of the worlds problems in a garden". Well, maybe not *all* of them, but its definitely the best place to start.

I would love to continue working with forest gardening. I could see this happening in several ways. I could be a designer for landscapes here, or I could get into agroforestry and work in the tropics. I am also interested in creating a nursery that is geared towards the interesting trees, shrubs, and groundcovers that all of the books on

forest gardening I have seen suggest using, yet they are next to impossible to actually find. Regardless, I know that someday I will design and plant my own forest garden, when I have suitable time and land. It would be really fascinating to apply what I have learned on a long-term project, so see how it evolves over time. Of course, having food growing in my backyard all year would be the best part.

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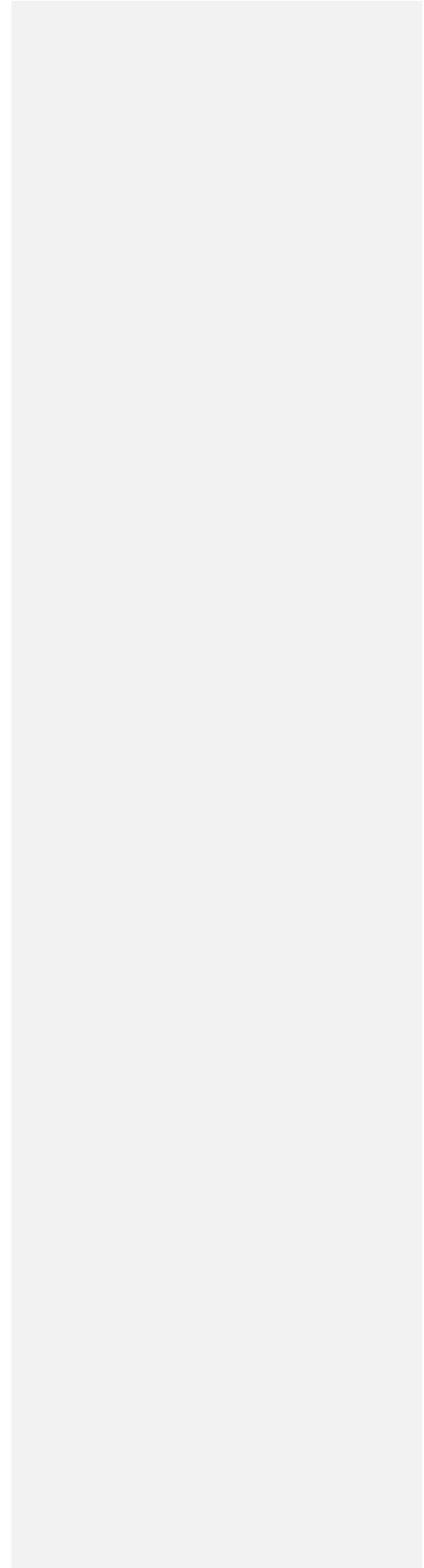
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Edible Forest Gardens has 31,958 members. Forest gardening is an idea whose time has come. We can consciously apply the principles of ecology to the...^Â One of them walked over with a fresh watermelon straight from his garden and was determined to share it with me. Gifts from the hearts of some of the poorest ones are the greatest gifts ever. They soften me right up. Forest gardening is a low-maintenance sustainable plant-based food production and agroforestry system based on woodland ecosystems, incorporating fruit and nut trees, shrubs, herbs, vines and perennial vegetables which have yields directly useful to humans. Making use of companion planting, these can be intermixed to grow in a succession of layers, to build a woodland habitat.