2011: Project Commencement

Site Preparation Discussion

"Mainframe Design"

Although observation and basic design began in 2010, we did not commence the garden in earnest until January of 2011. After analyzing our site's conditions and forming a basic long-term vision for the garden, I had to figure out a path to get us there.

The most pressing matters to begin solving fall under what Geoff Lawton likes to call "mainframe design." Water, access, and soil are fundamentals that need to be examined before moving onto finer details; getting these right (or close to it) from the start will make the rest much easier. Before examining how these were designed, let us look at the overall strategy for each.

Water

Water is the most important factor, as it can either act regeneratively or destructively in the landscape. *Figure 2-1* describes how methods (yellow) are related to concepts that improve infiltration and storage of water on site, which eventually leads to an abundant water situation. Oddly, water is one of those resources where the more you put it to work, the more you have- hence the permaculture mantra "slow, spread, and sink water." Two main ways to increase the amount of water is to support soil infiltration and storage capacity. To improve infiltration, we can implement water harvesting techniques and engage in decompaction activities.

Water harvesting can be achieved through swales, mulched pits, ponds, and fungi. You will notice that fungi play an important role in all of the relationships with water. On our site, according to the authors of Edible Forest Gardens, swales should be more narrow and deep due to our high clay content. This will also minimize the amount of space they require. Second, mulched pits (Zai bowls) will be useful to accommodate the large amount of runoff we receive from the neighbor- the heavy mulch will provide a niche for fungi that can help to reduce the impact of chemicals used on the neighbor's lawn. Unsealed ponds allow for rapid groundwater recharge as well as increased habitat. Lastly, fungal mycelium (the "root-like" body of fungi) grow very densely in the soil and are able to intercept, absorb, and store vast amounts of water. Mycorrhizal fungi also have the ability to link between separate species and shuttle water amongst their symbiotic partners.

Decompaction can be achieved through well planned access pathways, double digging, the use of diverse pioneer species, and fungi. Pathways are critical in that they efficiently guide human traffic. They provide easy use of the growing beds, movement of resources, and decrease the potential for disease spread through avoidance of unwanted contact with plants while opening the garden to airflow. Double digging, in conjunction with all of the other methods of improving water use, will immediately allow for greater infiltration. It is only useful if applied in tandem with pathways. By avoiding stepping on double dug beds, the soil is allowed to develop much more rapidly (and prevent undoing all the hard work of digging in the first place). Pioneer species are usually well suited for degraded properties as they are able to withstand poor soil, water, and ecological conditions. Oftentimes they have deep tap roots which can break up the soil, furthering decompaction and infiltration. Fungi construct a highly complex matrix in the soil where mineral elements and biotic elements are intertwined. Their physical growth decompacts the soil. Along with improving infiltration, storage is improved through the deliberate increase in soil pore space and facilitation of organic matter into the soil.

Lastly, if we wish to increase water storage (and decompaction), we absolutely must increase the soil's organic matter. Adding compost, using mulches, fostering diversity in the plant kingdom, and supporting fungi will all work together towards this end. Compost, as a well broken down form of organic matter, is ideal for improving topsoil's water storage. Mulches protect the soil (and biologically active compost) from the elements and feeds soil organisms as they break it down, further increasing storage and infiltration. By growing many types of plants with different types of root systems together, we can use the whole of the soil profile for water storage. Another use of polycultural systems is for growing plants specifically for mulching, breaking up the soil, and other uses that simple monocultures do not allow for. Lastly, fungi with their dense networks of mycelium further increase the amount and time that water can stay within the garden.

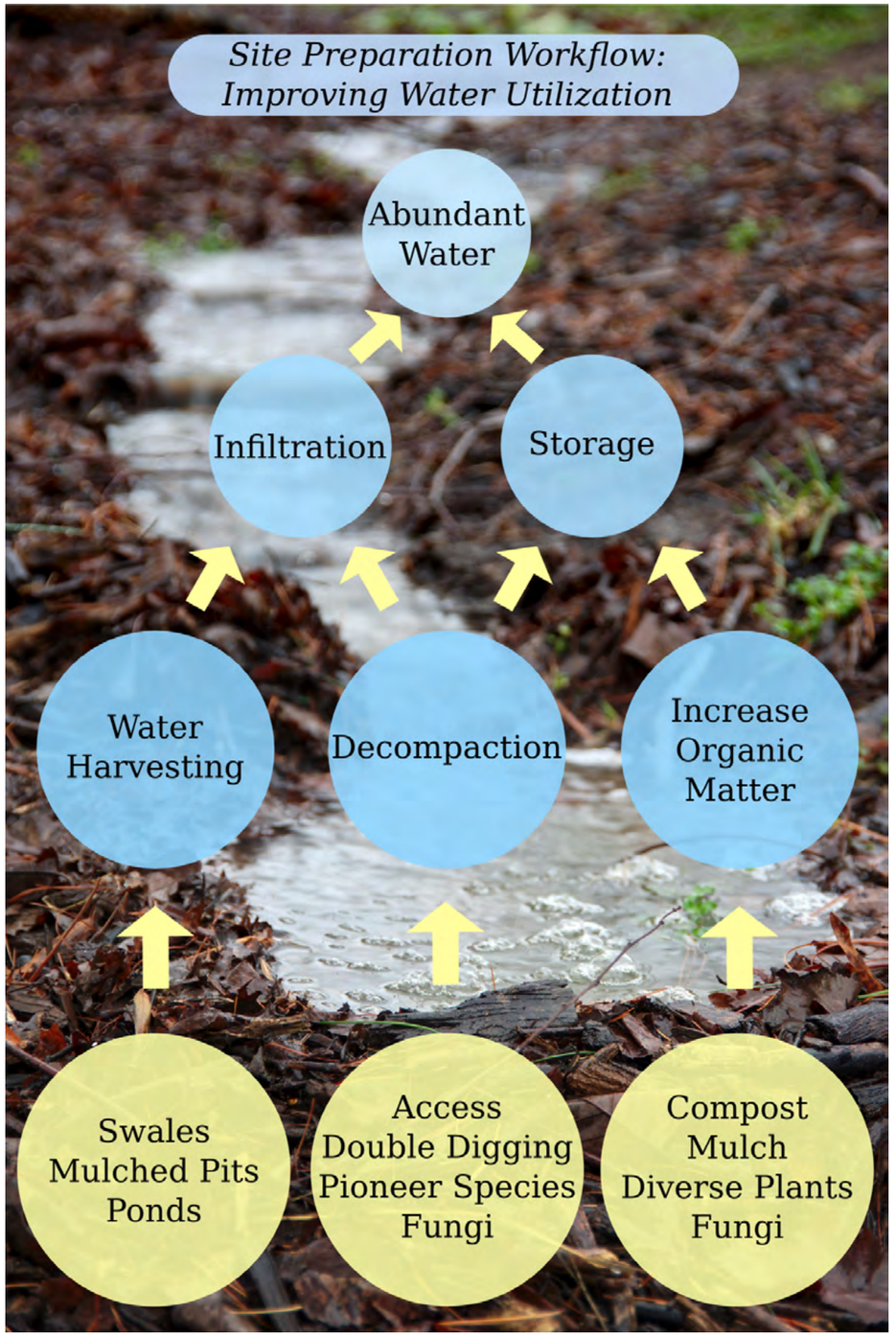


Figure 2-1 Site Preparation Workflow: Improving Water Utilization

Access

Access also ranks as a mainframe design feature simply because it is what allows us to actually interact with the space. Access greatly impacts our enjoyment of a site as well as its productivity.

We can impede access through the use of fences. Fencing should be multifunctional. Most importantly, fences deter destructive behavior. Other animal impact can usually be effectively controlled through fencing: keeping deer out (our privacy fence), dogs out of the garden (both fences), and/or non-burrowing/very high jumping creatures can be kept from entering with proper fencing. In addition, fences can also act as facilitative features by channeling the movement of animals and people. Fencing can also impede other kinds of destructive behavior; by masking activity and ensuring privacy,

they prevent outside social criticism which is often worse than destructive behaviors from animals. If fences are nonliving, they are perfect places for vining crops. If they are living, it would depend on the species whether or not you would want to include a vine layer. Fencing should work in conjunction with a system of paths: gates, for example, lead people directly to main pathways and direct traffic.

If we take a facilitative tack, our main tool will be pathways. Together with fencing, they increase usability, help to decompact soil, and help to manage water. Paths which mimic natural growth, such a rhizomatous or radial pattern, will increase efficiency. Rhizomatous patterns are those that mimic the growth of roots. Radial patterns allow access to points of resources or can simply be included due to their aesthetic appeal.

Smart and standardized pathways, laid out mimicking natural patterns, are key ways to improve efficiency and produce a sense of coherence in the garden. If our pathways are designed with a clear hierarchy of needs in mind, growing space can be maximized through the relationship in space between different kinds of pathways. Identifying key resources and special locations in the garden is the first step towards deciding how to construct

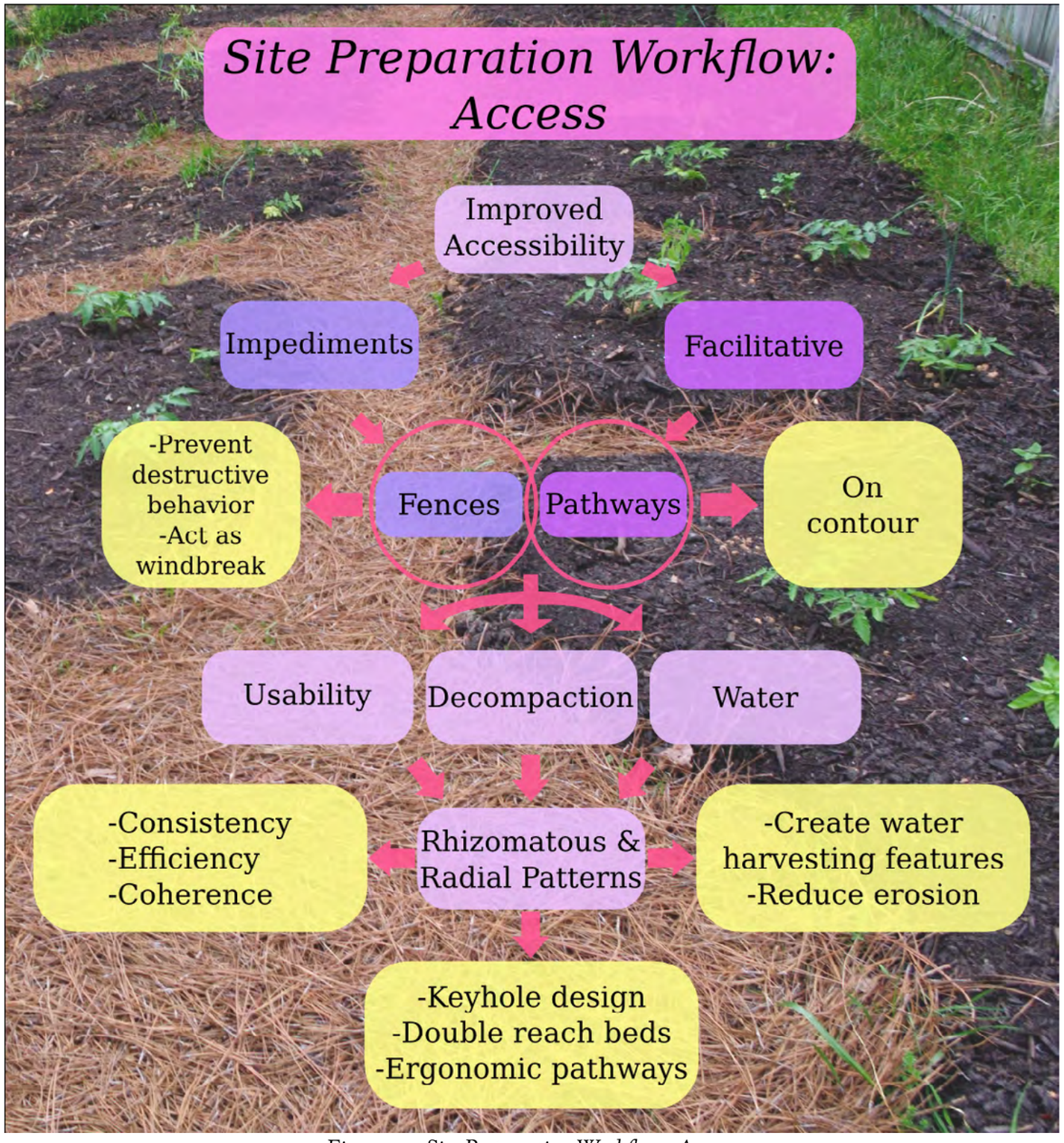


Figure 2-2 Site Preparation Workflow: Access

the pathways so that high priority spaces are linked with main pathways, while growing beds and less-frequented areas can be accessed through smaller pathways. Having a clear hierarchy where every sized pathway follows a standard and has a clear, easily understood pattern underlying its implementation, improves coherence in the garden.

Features of smaller pathways can be that they branch off using keyhole design to give access to double-reach beds. These are simple strategies for maximizing growing space and minimizing space dedicated to pathways without compromising the fundamental use of the pathway. Keyholes are simply small pathways that extend into a garden bed and are capped with a circular point. From this turn around point, one can easily reach into the center of each bed. Double-reach beds are simply those which one can reach the center from two opposite sides of the bed- meaning that the entire bed is accessible from multiple points.

Placing pathways on contour, whenever possible, allows for greater control over erosion. As pathways will be continually compacted due to use, it is best to avoid pathways that run perpendicular to the contour. Perpendicular-to-contour pathways easily double as high-speed water channels during precipitation events- which is the exact opposite of slow, spread, and sink. In addition, contour pathways are more user friendly since they are level. This, of course, influences the efficiency of the garden as well because the flow of people and material is made much smoother. Setting objects down on the pathway is safer too, since they will not slide. If pathways are not on contour, they can be designed so that they channel water to a specific water harvesting feature, such as a swale or a plant's micro water harvesting feature.

Soil

As the most dynamic of the three main mainframe design elements, soil deserves a lot of attention. Once water infrastructure is established, it should remain in working order for decades, if not centuries. Similarly, access should be planned and implemented so that changes occur over a long time frame. Think about succession- your initial pathways may be useful for a good 5-6 years while the system gets underway. Once a garden begins to mature, new considerations such as the ease of harvest from trees and shrubs will come into play and so pathways will shift.

Soil, though, will undergo rapid change and requires almost constant observation. This is also the natural element that we have the power to change rapidly. Simply put, humans do not produce food. All sustenance comes from nature- other organisms. What we can do, though, is make sure that the organisms we want to foster, that we want to help, are given what they need. To accomplish this, we have a wide range of techniques, materials, and organisms that we can encourage, bring into the system, or otherwise bring into interaction with our gardens.

Figure 2-3 demonstrates how closely related each of these elements are and how together they bring about soil health. Soil health needs to be comprehensively addressed. Water capacity, soil life, and nutrient capacity can all be increased through balancing the soil pH, increasing organic matter, and decompacting soil. Both balancing pH and decompacting soil are also accomplished through increasing organic matter. The former can also be done through the application of lime to jump start the pH change while organic matter is accumulated. Likewise, compacted soil- like we have- can be alleviated through double digging (along with the implementation of good pathways). Long term decompaction is achieved through deep-rooted perennials, increased soil organic matter, and avoidance of compaction by humans, animals, and machines/tools.

Increasing organic matter is a never ending journey. We can do this by promoting living material and managing dead material. Diverse plants, soil life, and fungi are in a constant dance with dead organic materials: composts, fish meal, bone meal, mulches, etc (as well as things like rock dust). Compost, of course, should not be dead, however it is created through the fostering of decomposition organisms feeding on once living feedstocks. For maximum soil health we need to facilitate the right kinds of relationships at the right time. Which is all quite easy and comes naturally as the seasons progress. A permaculture site's dynamism stems from how we use our imagination to bring all of these factors together in response to changing conditions.

Site Preparation Conclusions

With the overall strategies for the mainframe design components elucidated, we can now approach the plan of action. Taking into consideration the conclusions from the site analysis, as well as the understanding that upfront, decisive, and effective mainframe design component action alleviates many problems further down the road, a rigorous course of site remediation was decided upon. (...)

Figure 2-3 Site Preparation Workflow: Soil. Brown techniques, organisms, and materials support the creation of living and dead material, improving soil qualities which culminate in improved soil health.

This would include implementing water harvesting techniques, double digging a very sizable portion of the property, liming and fertilizing the double dug beds, importing large quantities of organic material (leaf mould compost and wood chips), and radically boosting diversity (in comparison to baseline levels).

What we are aiming to establish in the first year is a working framework for soil improvement in addition to learning new methods of maintaining the property. Before investing in more expensive, long-lived species, it makes a lot of sense to prepare the groundwork first. The soil tests revealed just how degraded our property really was. To expect that even with sheet mulching, guild design, and a lot of care that plums, apples, peaches, or other fruit trees would survive, let a lone thrive, would be wishful thinking. Not only would the soil fail to support healthy growth, but the lack of ecosystem diversity would also make the struggling plants open targets for herbivores and disease. This is because plants are always releasing "chemical scents" into the atmosphere and herbivorous insects are especially adept at picking up on the scents released by stressed plants. Stressed plants are less able to mount a solid defense (through the production of foul tasting chemicals, poisonous, and maintaining a rigorous immune system) and so are easy targets.

Although double digging would relieve many of the poor soil conditions, the soil itself would remain rather poor (both structurally and

biologically) and would have a hard time retaining the additional nutrients. Therefore, to make the most of the impending changes, we chose to include a series of nutrient nets. The backbone of this nutrient net system is comprised of swales and dynamic accumulators (inoculated with their appropriate mycorrhizal associates) situated so that we could stack water and nutrient harvesting in the same feature. We would rely heavily upon the Bocking 14 cultivar of Russian comfrey (Symphytum uplandicum) on the swale mounds and the along main water courses to gather nutrients and produce biomass before the canopy closes.

The other significant nutrient net would be our system of small ponds connected to one another through a wetland ecosystem. Instead of relying upon one larger pond, this design allows for greater functionality: the upper pond and wetland can act as a filter for the second and larger pond. In the upper pond, we would begin the cultivation of water hyacinth, which are one of the fastest growing plants on earth. This plant has an extraordinary ability to strip water of nutrients and produce biomass at astounding rates. Unfortunately, it is also one of the few species that can be truly labeled "highly dispersive." Luckily, we are not connected to any water ways (*Figure 1-4*, p. 6) so vegetative reproduction into the surrounding ecosystem is not an issue. Water hyacinth seeds, on the other hand, are highly dispersive when eaten by birds and other wildlife. So we would have to take careful measures to ensure that this plant would be dead-headed every time it tries to flower. This is an easy task with our small pond systems. It is also functional because we need to ensure that the plants do not cover 100% of the pond, but rather about 50-60% in order to allow for better gas exchange, light infiltration, and continued harvesting for mulch. These plants also harbor algae in their root system, allowing any mosquito control fish to eat vegetation as well as proteins from insects. In addition, they would help keep the pond water cool during our hot summers and offer additional habitat for the new arrivals: frogs, water insects, and other creatures.

By connecting the overflow of the upper pond to the lower one through an artificial wetland, we can once again use biology to filter surface flows. Other dynamic accumulators such as horse tails (Equisitum spp), rushes, cat tails (bull rush Typhus spp), and Russian comfrey can make use of this nutrient laden water and also act as a physical barrier to any water borne organic materials. The living soil here will build rapidly, quickly acting as an important filter for both small and large materials.

We will also cultivate water hyacinth in the larger pond, but at a slower rate due to being shaded by the willow oak. This larger pond will be the main hub of water life and arrests all except the most intense storm water flows. With its central location and size, it may be able to buffer temperature fluctuations too.

The third nutrient net would be the annual garden the first spring-fall. Many annual vegetables are heavy feeders: tomatoes, cucumbers, corn, squash, and others can draw nutrients from the soil in short order. This way we could lock up the organic fertilizer we applied during the double digging phase in organic matter. Most of the nutrients will remain in the plant's vegetation and root systems- not in the portions we eat. Therefore, by allowing these to decompose (which is not composting) in place over winter, we will have a slow release fertilizer as well as a carbon boost. Additionally, placing our emphasis on an annual garden would allow us to judge the quality of the soil beyond what we learned from the soil samples. As I was still new to gardening in general, it would be much easier to assess the health of the soil and the local ecosystem by observing the growth patterns of annual vegetables that I am familiar with. In theory, a dense planting of annual vegetables coupled with mycorrhizal inoculation would mean that we would effectively blanket the garden with strong mycelial growth, allowing each succeeding generation of plants to access a well-established network. Cover cropping immediately following the demise of our annuals would be essential in keeping them going (with additional inoculation for good measure). This third nutrient net is referred to as the "Stress Test" later on.

The deliberate inoculation of mycorrhizal fungi into the soil from the outset could be considered a fourth nutrient net that we put in place. This is because our soils were highly depleted and inhospitable to healthy mycorrhizal activity. After double digging & providing good access, the addition of compost and mulch, and the huge input of roots by the annual vegetables, we created the ideal location for them to thrive.

The sum of our approach in the establishment phase was to stem as much nutrient loss as possible and to initiate the change towards a resilient system. The very large annual garden- complete with three large guilds of companion plants- would act as a stress test for the site. After the first year, we would be able to benchmark not only how much work we would be willing to put into gardening, but also the starting point for site remediation.

Initial Site Plan

In the first year, we aimed to develop the system of nutrient nets and our Zone 1 garden through mainframe design. The buried power line, which extends well into the back yard and loops around the willow oak, would be the boundary for double digging as well as Zone 1's western edge. It also limits the extent of our water harvesting earthworks- at least for the first year.

The upper (or first) swale would be located far enough down the slope (*Figure 1-2* p. 5, *Figure 1-5* p. 8, *Figure 2-6* p. 9) to begin gathering water. Situated uphill of the first tree (the red maple), it would directly benefit its health. The second swale would be located between the willow and easternmost river birch- far enough down the slope to capture more water as well as cut through the least amount of roots. At the base of the hill, where the engineered mound begins (and so forming a valley of sorts), a series of ponds and wetlands would be dug. A final water harvesting feature, the north swale, would be dug behind the fence to passively aide the development of that area.

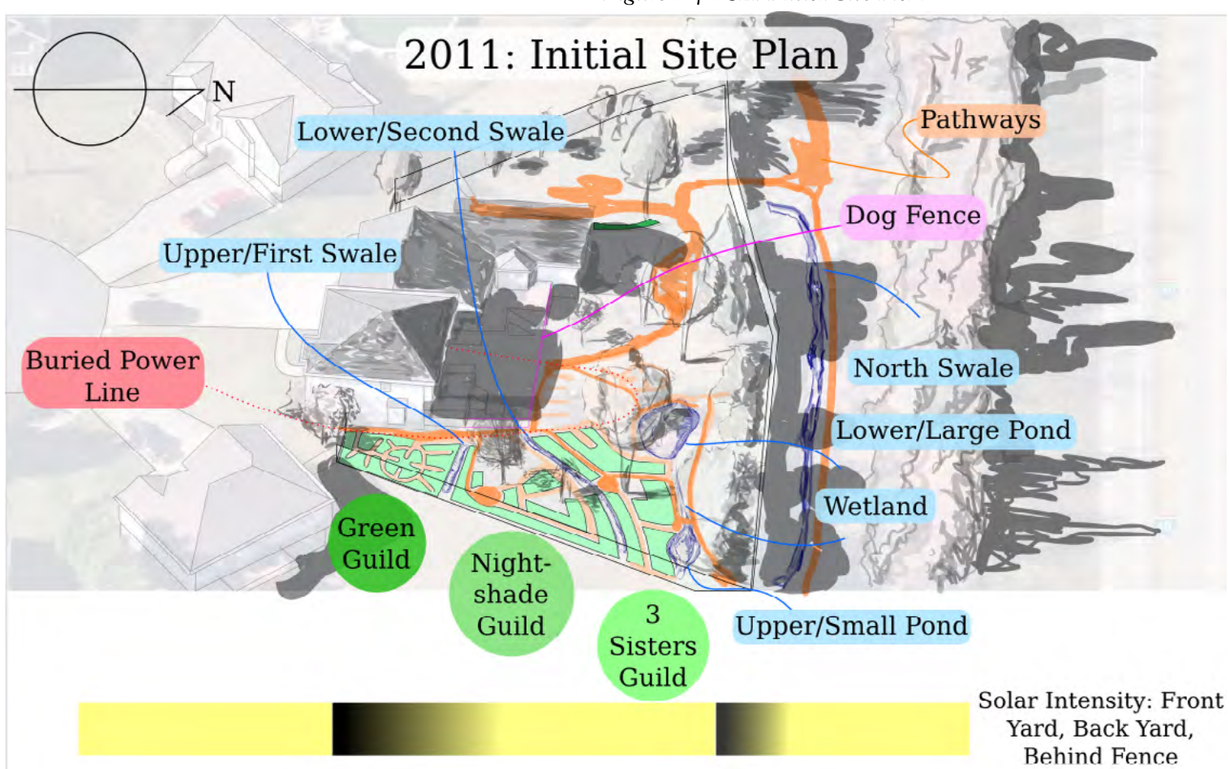
As *Figure 2-4* shows, the guilds for the Zone 1 Garden align with the amount of sunlight available. Our green guild, focusing on herbs and cool season greens, would receive the least amount of sun; the nightshade guild of tomatoes, peppers, and eggplants a much greater share; and lastly the four sisters guild would have nearly full solar access.

Finally, a dog fence would keep animals out from the garden and ponds.

Permaculture Zones of Use

Dividing the site into zones of use is a particular technique used in permaculture to emphasize the relationship between time and behavior. Zone 1 is closest to the house, easiest to access, and typically the location for the most demanding plants: annual herbs and vegetables. Our Zone 1 will be one large annual garden the first year, to be switched over to cover cropping and niche development after the first year. Zone 1 is visited on a daily basis and tightly managed. Zone 2 is visited multiple times during the week and is an ideal place for perennial fruits and vegetables which need less care. Zone 3 is occasionally visited; ours will serve as the site for biomass import and storage (compost and mulch [Bulk Materials Depot]). Zones 4 and 5 are located behind the privacy fence and the distinction between them is blurred because we will very infrequently visit this area of the property due to access restriction and the amount of poison ivy. In order to make Zone 4 an integrated part of the site, we will have to plan a significant disturbance using

Figure 2-4 2011: Initial Site Plan



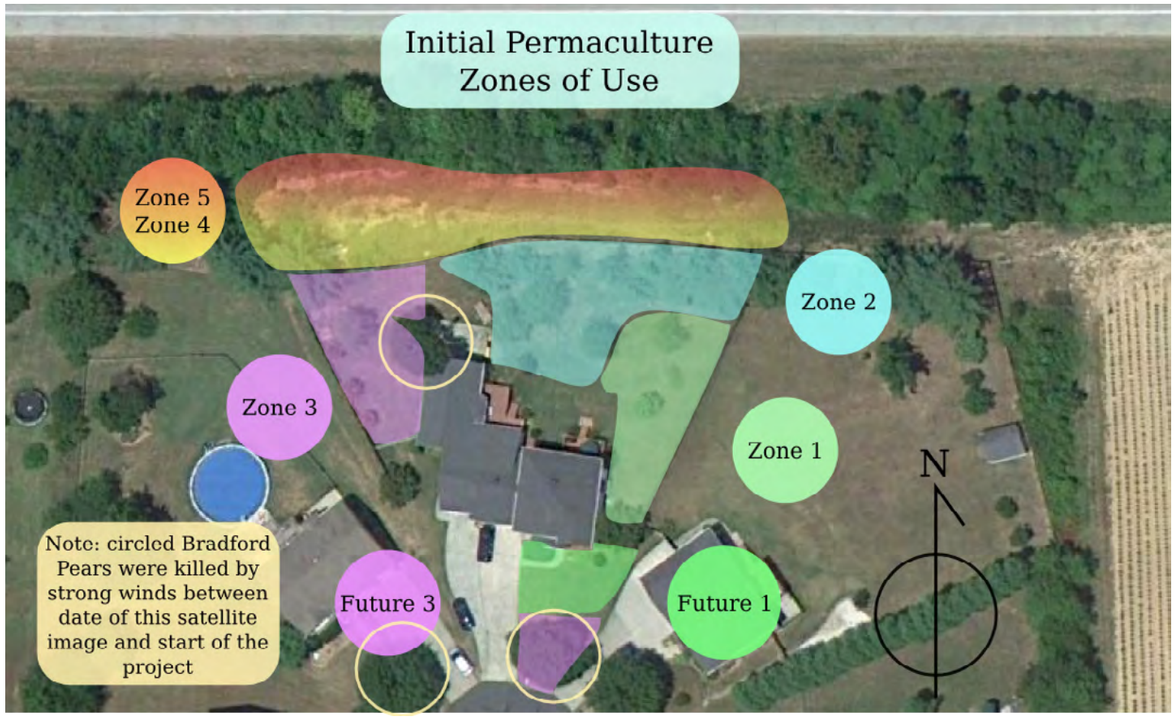


Figure 2-5 Initial Permaculture Zones of Use

goats and chickens to prepare ground for direct implementation of desired species (a multifunctional wind break that also screens the highway in winter). As shown in the Initial Site Plan, a swale will be dug to aid in alleviating the dry conditions there. Since this is a passive water harvesting feature with a small catchment, future maintenance of the swale will be negligible. Zone 5 is most of the area behind the fence, directly on the fence that prevents access to the highway. No intervention- besides perhaps delaying the encroachment of poison ivy- should be made here.

Future Zones 1 and 3 are in the front yard. We will not implement any real changes there until we are more comfortable with permaculture design and have enough plants to plant out entire guilds. The reason for this is that the social climate around permaculture- and differing landscape management schemes generally- is unfriendly. Things done in the public eye should be done to the best of our ability and resources in order to avoid general criticism and social stigma (also known as putting your best foot forward). Future Zone 1 will be an excellent location for sun, heat, and dry loving species such as figs, pomegranates, and other plants that are hardy to USDA zone 7. Future Zone 3 will be adjacent to the road and the utility lines. We can plant native grasses and wildflowers here as a buffer between the managed Future Zone 1 and the public eye. These types of plantings- native wildflowers- are more accepted than fruit trees, herbs, and vegetables in the front yard. They will serve as a visual buffer to the tender plants in Future Zone 1.

Photograph 2-1 Ornamental plum (Prunus cerasifera) blooming in our Zone 2. March 23rd, 2011

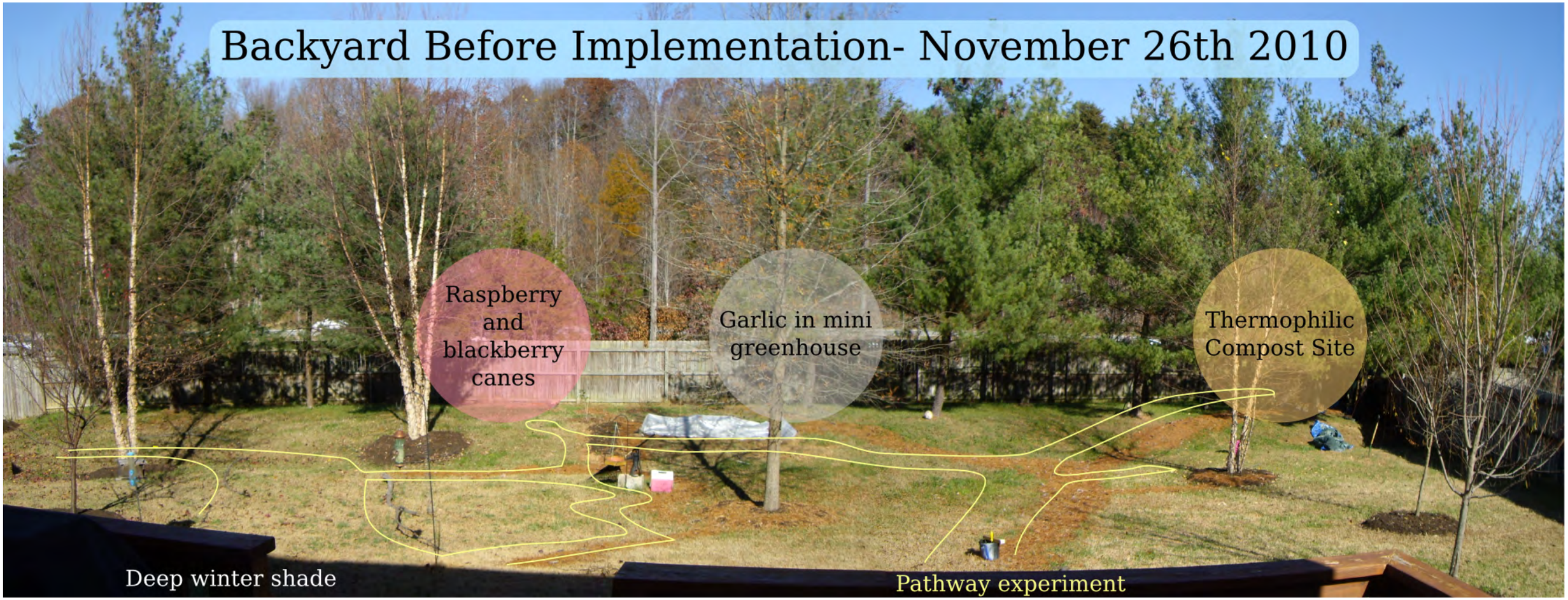


Figure 2-6 Backyard Before Implementation. November 26th, 2010

Mainframe Design Implementation

Implementation of this design- taking into consideration the conclusions of site analysis and mainframe design conclusions began in January 2011. The order of business was to begin capturing water, design access (coupled with growing beds), and then remediate our compacted soil through double digging. This process took about five months of almost daily work. This section will discuss the procedures I took to implement these ideas and end when the frost free growing season, which begins in May each year.

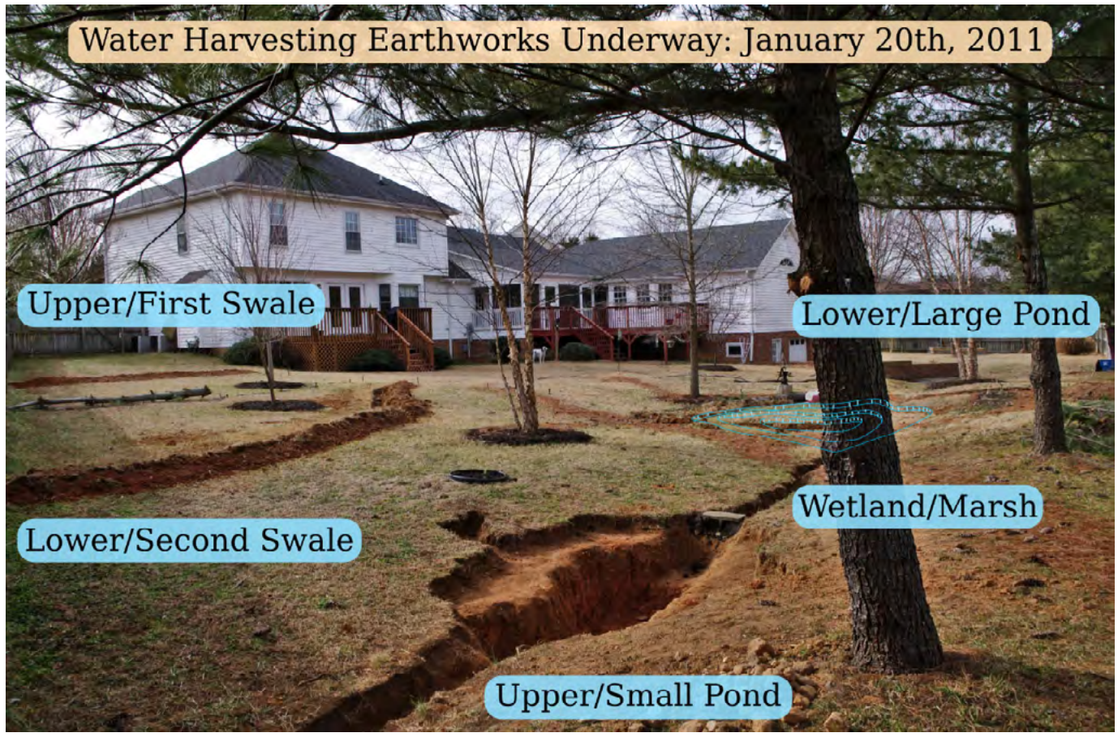
The implementation phase, particularly those addressing mainframe design components, is the most physically, emotionally, and monetarily demanding time period in the lifetime of a permaculture site. However, with sufficient forethought and enduring attention to detail, this is work that should not have to be repeated. With the vast majority of the physical labor completed, monitoring and further development of these mainframe design features will continue indefinitely through tweaks to the system.

Prior to any earthworks or soil remediation, I had been playing around with some of the ideas regarding access. *Figure 2-6* is a stitched panorama of two photographs showing the breadth of the back yard, but without the side of the house to the east (right side). The area of deep winter shade marks the where we will erect a dog fence as the boundary of the garden. As you can see, we had a few points of interest that I wanted our main pathways to lead to. A clear hierarchy of pathway size and use was already being developed. As a consequence, one can begin to envision where planting beds might go. This would serve until earthworks would frame the next phase of access.

Water Harvesting Earthworks

We chose to implement water harvesting before double digging as a means of beginning rehydration of the landscape as soon as possible and because

Figure 2-7 Water Harvesting Earthworks Underway: January 20th, 2011



earthworks offer boundaries to work between. I chose to prioritize passive water harvesting and ecosystem services over pathway design. I would rather have as much water being harvested and put to use than physically larger garden beds or planting areas. This is simply because the benefits that come with passive water harvesting are extremely necessary to overcome the consequences of living in a degraded ecosystem. At the same time, better hydration equals more production from a smaller area. Lastly, as noted previously, earthworks such as these should last for centuries while pathways will inevitably shift as the vegetation changes.

If you look closely at the lower/second swale, you can see that it is obviously off contour. This was the most egregious error I made during site preparation. I relied too much on my own eye to find the contour line, rather than going through the few minutes it would take to build an A-frame and get it dead level. So what happens is water from the western side (towards the house) drains into the lower section (where the bend is, about 1/3 of the way from where it begins near the house), leaving about 1/3 without the benefit of improved infiltration. Luckily, this can be remediated through the placement of steps within the swale to create, in effect, multiple swales along the same trench (Drawing 2).

Both swales, upon completion, began rehydrating the property and provided us with locations to catch fertility with networks of dynamic accumulators.

In addition, I dug one small pond (also called the upper pond) to capture and store the runoff from our neighbor's property as high in our landscape as possible. This little "valley" bottom was a perfect place for such a water harvesting and ecosystem repair feature. One addition function of this particular pond is to provide "first flow diversion." This means that with the first flow of water into our system, both the physical feature and biology of this pond would be able to act as a shock absorber for any chemicals and water-borne nutrient.

Upon filling, the pond would then overflow into a little wetland/marsh- which would further slow, sink, and clean storm water. Lastly, this would empty into a much larger, lower pond. By having a series of ponds, rather than one large one, we would increase our edge and dampen any effects of chemical lawn maintenance on fragile aquatic lifeforms such as amphibians (frogs, salamanders, etc). I did not have time to finish digging the larger pond before the time for double digging arrived.

Both ponds were dug with the idea of creating different zones within them by building steps, shelves, and deep holes for fish to retreat in

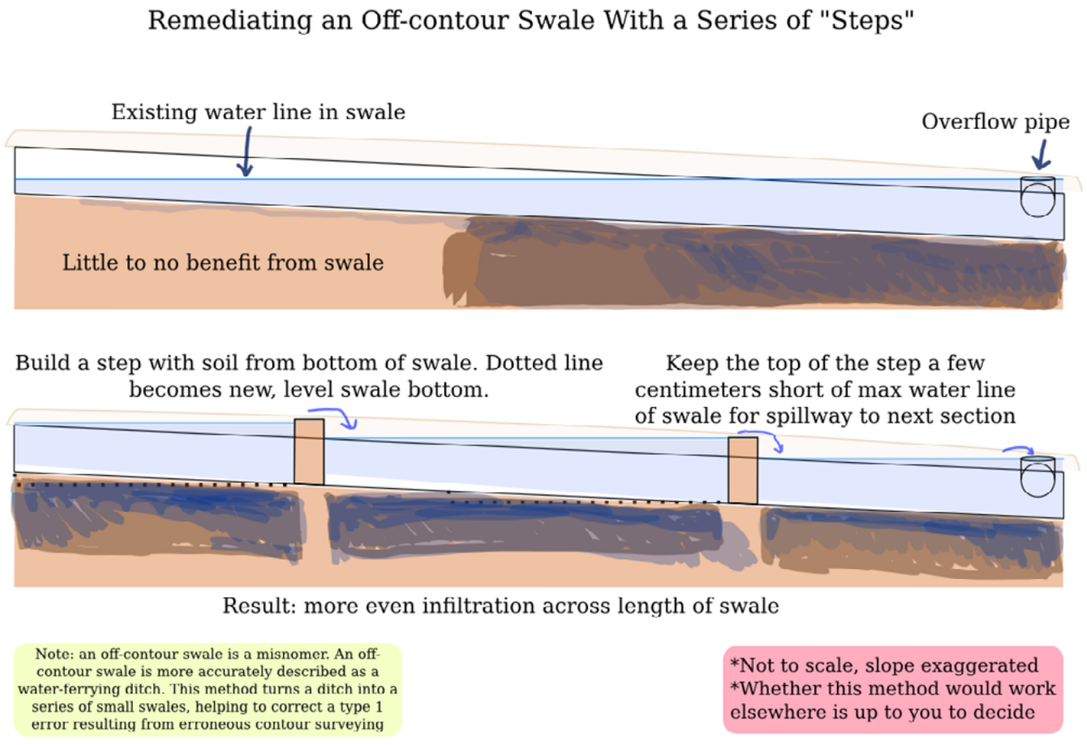


Figure 2-8 Remediating an Off-contour Swale With a Series of "Steps"

times of cold weather. Structural diversity, high amounts of edge space, and attention to these details means that our ponds will be able to provide effective functionality. While our soil is very high in clay content, they still drain relatively quickly. They were not compacted with machinery. Over time, they should self-seal as organic material begins to accumulate. This is very important as the pond bottom can not be amended in the same way as the terrestrial growing beds. These systems absolutely need to be supported by proactive planting of "native/indigenous" species.

The excavated soil was put to use on mini hugelkultur beds that were built underneath the pine trees. My hope was that these places would be highly protected in the summer (continuous shade from the trees), but in the winter with the sun at a very low angle, would be able to have a higher temperature due to their southern-facing exposure, potential reflection of light from the ponds, and insulation from the pine canopy. They do not really have enough wood to have all the benefits from hugel beds, but they were still fun to build. Without a lot of branches, they won't settle much, which will allow woody plants.

Photograph 2-3 Sinuous hugelkultur beds constructed with soil from pond excavations

Photograph 2-2 Birds congregate near lower/large pond excavation site. January 31st, 2011

Pathways and Double Digging

With swales and ponds standing in for natural boundaries between sections of the garden, it became possible to lay out double reach beds and a network of pathways before remeliorating the soil conditions. Using an abundant mulch material like pine straw, I could experiment with different pathway configurations. It became clear later in the garden's life that I did not make enough pathways that were wide enough for comfortable wheelbarrow use. While I did incorporate wheelbarrow turnarounds and work nodes, when taller plants were close to the pathway, it was difficult to get the wheelbarrow to them.

When that was complete, it was time to move to double digging. Double digging began at the south end of the garden, the highest point. It should be noted that this section was double dug completely by hand. There were multiple reasons for beginning there:

1. When soil is disturbed and oxygen becomes readily available, nutrients become more mobile as any carbon stores are utilized by an energized soil community (note, our soil carbon levels were almost zero, see p. 21). Therefore, it makes sense to put as much physical space and potential recapture features between any soil disturbance and the exit points of the property. Starting high in the landscape achieves this.
2. Water harvesting. While there is potential for erosion and nutrient mobility, the decompacted soil will infiltrate more water (especially with the addition of compost and mulch). Starting from the top means that any infiltration will be available further down the slope.
3. Available sunlight. This area of the garden has the least amount of sunlight and in order to take advantage of increased sunlight in spring, remediating this location first meant that salad greens could be planted there as soon as the weather conditions were favorable. As I would move down the slope, each subsequent section has access to more sunlight than any other, so they can afford to wait.
4. Moving materials up a slope- even a slight one like this- takes more energy that moving across or down one. Accomplishing this task early in the spring means that the temperatures were more conducive to moving this much material.
5. Gravity. Once my partially finished compost was moved to the top of the hill, it would be much easier to "roll" this compost down the hill to protect newly exposed double dug beds as leaf mould compost and wood chip mulch became available to secure the completed sections.

Photograph 2-4 Double-reach beds and pathways in what would later be the nightshade guild. February 28, 2011

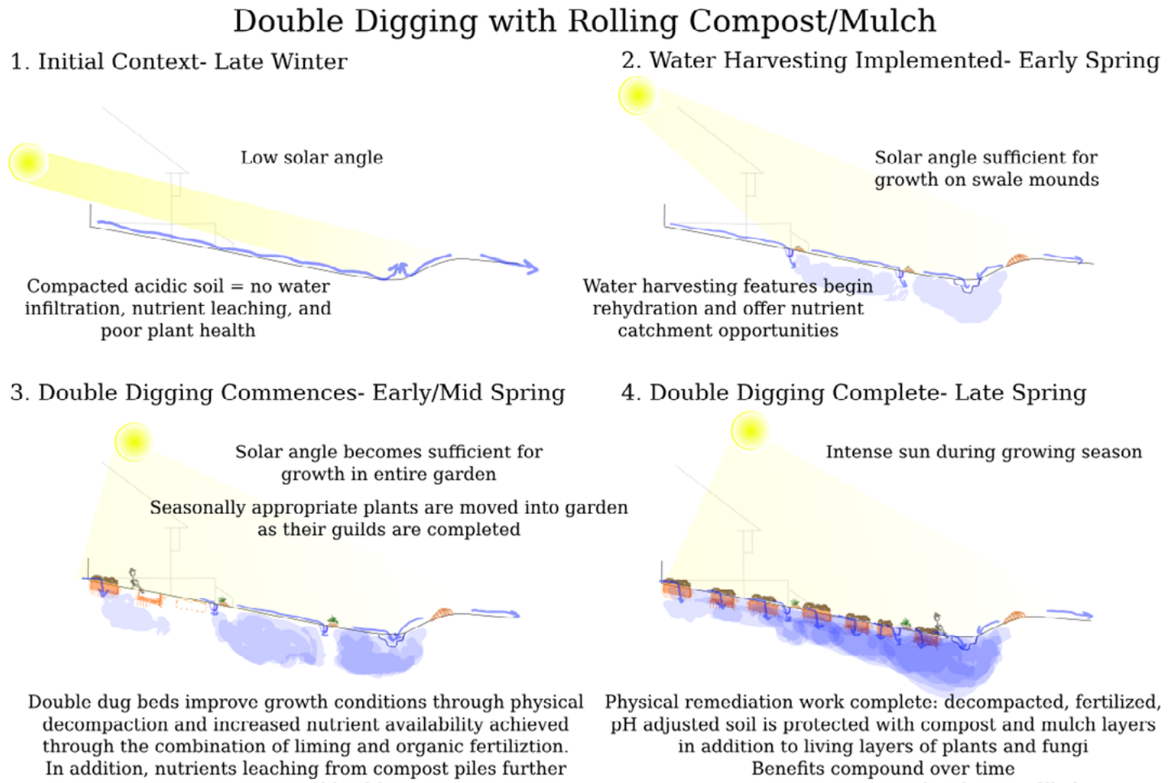
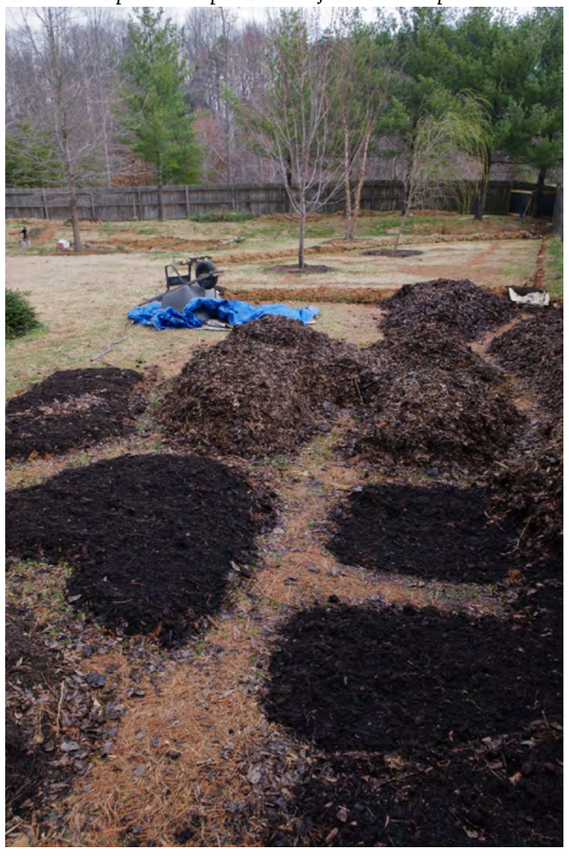


Figure 2-9 Double Digging with Rolling Compost/Mulch. Graphic interpretation of the action plan

As each section was completed- with ample dolomitic lime and organic fertilizer mixed into the top section- a large layer of compost was added to protect the vulnerable soil from the elements. Once leaf mould compost became available from the city and could "finish" the beds, it was easy enough to roll these leaf compost piles down the slope to new beds. Soon, the weather and sunlight would allow me to transplant green guild plants into this location.

Chosen plants for this area were those which do not require a lot of sunlight nor summer temperatures to produce, hence the choice of salad greens. Lettuce, mustard greens, arugula (rocket), and garlic would make up the majority of plantings here. Although this area is the highest behind the fence, it still receives some drainage from the front yards of our house and the neighbor. I chose to plant some Russian comfrey in this guild to capture some of those nutrients, provide mulch for the guild, and to see how they perform in low light situations.

Photograph 2-5 Double digging the future green guild. February 28th, 2011



Before showing photos of double digging the next guild section, *Photograph 2-5* shows how malnourished the red maple was in January 2011. At first I feared that the addition of some compost near the base of the tree had infected it, but upon closer inspection it was clear that this tree had been suffering for a few years. Notice that there appear to be old wounds that have healed, only to be opened anew. Traditional tree care methods- removal of all organic matter, severe water stress from compacted soil and no water storage capacity due to low organic matter content, low pH reducing their ability to uptake already depleted nutrients, and of course, living in a severely degraded ecosystem without access to a healthy living soil- all combine to starve trees of the nutrients they need to heal from bark splitting. By the same time in 2012, the tree had healed significantly due to our efforts to alleviate these poor soil conditions.

After finishing the green guild, it was time to move on to where the nightshade guild would be planted. Although it appears much larger than the green guild, the amount of space is actually not so much greater. Still, as the temperatures began to climb, the task of double digging and working a full time job would take its toll. Even aided by a small rototiller (only about the width of a shovel), the soil was so compacted that it took the use of a mattock and pick to break the clay into clods that the tiller could get its tines into. I should note that for each section that I double dug, I removed the grass layer. This would help remove many seeds as well as most of the roots of creeping grasses. These were then transported to the hugel beds to help build the mounds . Once that was complete, the bare clay was then hacked with the pick end of a mattock, opening up small holes. I would then take the pick- which was about twice as long as the mattock's pick, but more slender- and swing it into the holes. This was so I could rock the pick back and forth, breaking up clods of soil that the rototiller could then get a grip into. Once the upper layer was sufficiently decompacted, I could then do the job of removing one strip of soil and start the double digging process on the sub soil. Which, of course, required the mattock and pick treatment to accomplish. Besides the amount of physical effort required to even put the tiller to use, another issue arose that caused a lot of set back: small stones. Stones that were just small enough to jam the tiller and require extra effort to dislodge from the tines.

By the end of April, which heralds the onset of summer, I was fairly exhausted by this routine. I managed to complete about 40% of the four sister's guild by the second week of May. With the threat of frost behind us, it was time to transition to the cultivation phase of "the stress test," whether the ambitious double digging project was complete or not. Both the green guild and the nightshade guild had already been transplanted for a couple of weeks by this time and only experienced temporary transplant shock.

Photograph 2-6 Red maple (Acer rubrum) disease January 30th, 2011

Photograph 2-7 Russian comfrey and crimson clover begin their task of netting nutrients. April 8, 2011

Photograph 2-8 Nightshade guild double dug with nightshade guild plants hardening off (center). Note the space outlined with pine straw mulch that will become the four sisters guild. Pathways continued to the left never were double dug. April 15, 2011

Photograph 2-9 Almost half of the four sisters guild complete (foreground) with nightshade guild completely transplanted already. May 13th, 2011

Stress Test

I envisioned the first year as a means of benchmarking a number of different factors in the garden. As you might imagine, the rigorous course of double digging and soil remediation that took place was the most physically demanding portion of this stress test. 2011's stress test would reveal:

I. Just how much physical work we (well, mostly myself) would be willing to do.
   - A. The aim of all of this physical work was two fold:
     1. Being young and in decent shape, I wanted to lay the foundation for the garden by alleviating the major drawbacks of our site: compacted and infertile soil
     2. Compare and contrast the amount of work that goes into setting up an ecological garden versus a standard, even organic one where this amount of tilling and "soil remediation" can sometimes take place on a yearly basis (although the size of our site is more similar to that of a community garden, or even a market garden)

II. Assess how the regime of double digging, liming, organic fertilization, and addition of compost and mulch would impact plant growth
   - A. This was easiest to do by planting fast growing guilds of annual crops
     1. These annual crops, with their high nutritional demands, would also be able to utilize the organic fertilizer that we had amended the soil with and bind it in stable organic matter so that we would not lose too much fertility
   - B. As I was still very new to gardening, I wanted to be able to see how the plants were affected and whether or not my physical effort had been worth the trouble
     1. Assessing the health of woody perennials and other "forest garden" species would be more difficult to me because I have no experience cultivating them
        a. In addition, the cost of purchasing these plants would be too great in regards to the fact that our soil was so poor- even after amending, we were not sure what kind of shape it was in

III. Produce as many vegetables as possible while also planting into the system some easier to cultivate and utilize perennial herbs which would be ready for division and further propagation in the coming years.

Planting Preparations

I have decided to talk about the stress test in more detail now because although the physically exhausting portion- double digging an area roughly 2,800 sq ft (260 sq m)- was almost complete, there is no way to ascertain the results without actually cultivating plants. Allow me to backtrack to our seed choice and propagation.

Before the growing season had even begun, we were fast at work ordering seeds for the coming year. Although it is hard to see, we have multiple varieties of each vegetable along with some indigenous varieties of plants along with others which we felt would fill some important niches. For example, we purchased seeds for both cardinal flowers and great blue lobelia (Lobelia cardinalis & L. siphilitica, respectively). These two species are native to eastern North America and are adapted to wet & shady conditions, which I wanted to fill with perennial flowers as soon as possible.

Heading another direction, we also purchased seeds for Old World-origin cover crops like white, red, and crimson clover, common vetch, and alfalfa (along with Rhizobium bacteria) so that as soon as our season of annual vegetable production was drawing to a close, we would have seed to immediately transition into a period of intense cover cropping. These species are well known to be highly efficient and easy to grow: exactly what

Photograph 2-10 Seed packets for the stress test and coming transition to cover cropping. January 20th, 2011

we would want to use initially. Native nitrogen fixers, especially perennial ones such as the *Baptisia* and *Thermopsis* families are a little more difficult to germinate (along with costing more for seed).

As often as possible, we chose open pollinated varieties over hybrids in the hope that we could collect seed or even allow plants to self sow. One thing I chose not to take into consideration was cross pollination between, for instance, the six varieties of tomatoes and three varieties of melons. Our intention was to cultivate crops for food, not to produce pure offspring. That said, same varieties would be planted out into the same patches in the garden to make harvesting a little easier. The only hybrid we purchase was the "Sun Gold Cherry" tomato. This little tomato would actually turn out to be a favorite. We don't need to exclude hybrids as much as understand that they aren't in line with the ideal of self perpetuating gardens.

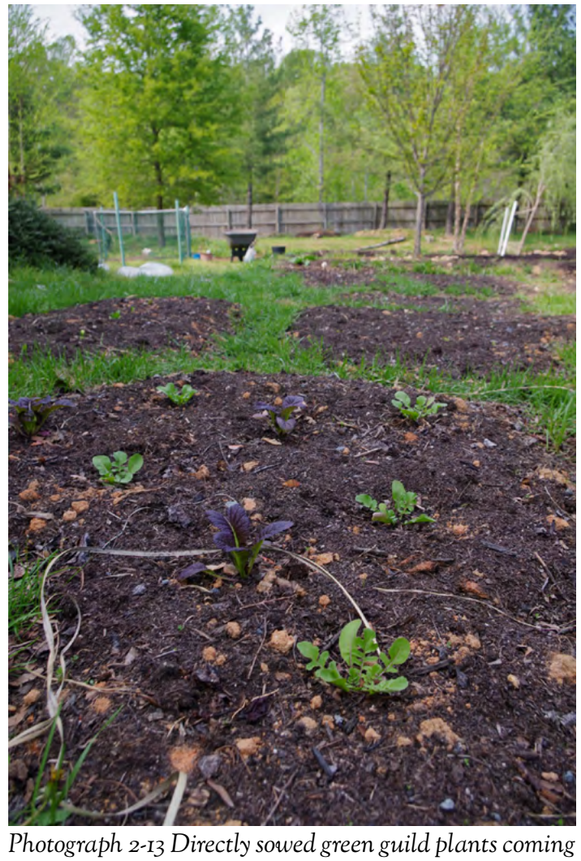
I began starts for all of our guilds early in the year inside under a fluorescent light system (in addition to being situated by a south facing window). All of the plants we started were inoculated from the beginning with appropriate mycorrhizal fungi and planted into biologically active potting soil. About once per week I also sprayed them with a compost tea solution. If a seed won't germinate in biologically active soil, then I don't want it growing in our garden. Strong growth continued under this regime. The shallow containers was not deemed as a problem since the tomatoes would be transplanted as deeply as possible (leaving only their top set of leaves above ground) and the rest of their companions were much slower growing, keeping a balanced root to shoot ratio.

I also direct sowed lettuce, spinach, mustard greens, arugula (rocket), and onions into the green guild early in the spring. I grouped them according to whether they associated with mycorrhizal fungi. However, in retrospect, I should have mixed them even more (same would go for the other guilds) so that mycorrhizae would have begun colonizing each patch and not just those with say, lettuce). I had also planted rhizobium-inoculated white clover seeds along the edges of the pathways in the green guild. The idea here was that they would spread out into the pathway, offering a multifunctional, foot tolerant ground cover. Nitrogen fixing and pollinator support in one package.

In preparation for transplanting, but also to protect the soil, we began importing wood mulch and leaf mould compost from the city of

Photograph 2-11 Members of nightshade guild maturing indoors. April 1st, 2011

Photograph 2-12 Nightshade guild members hardening off on the back deck. April 8th, 2011



Photograph 2-13 Directly sowed green guild plants coming up in a French intensive pattern April 18th, 2011

Kernersville. Although we technically live in Winston-Salem, the long drive to get "free" mulch would outweigh that enticing benefit. Kernersville, on the other hand, has their mulch and compost operation within 10 minutes from our home and at reasonable prices. Taking yet another page out of Edible Forest Gardens, we located our strategic materials depot (bulk materials deposit, p. 15) where we had easy access with a trailer.

Photograph 2-14 Mulch and compost materials, west end of backyard. April 19th, 2011

The quantity of material necessary to properly enhance our soil (by feeding from above- not tilling it in!) was staggering. What was also quite surprising was the amount of garbage inside these materials. This demanded yet another time consuming task: using a make-shift filter (two boards and a piece of mesh fencing bound together) to separate the bits of plastic, glass and other random pieces of garbage out from the imported material.

One note: the importation of mulch and compost is something that is up to each individual to decide to do or not. Our plan was to jump start the transition to healthy soil with the addition of organic material. Our poor soil needed this material and finding the quantity necessary without importing it was out of the question. That said, I do not suggest anyone should import these quantities of materials on an endless basis. Instead, these are meant to solve the problem of low organic content in our soil, protect our remediated land, and provide the necessary requirements so that we can begin producing our own mulch. Each successive year brings about less demand for mulch material as the garden begins to take care of itself.

Since leaf mould compost is not necessarily the most biologically active, especially when it comes from heaping mountains of material from the city, I chose to inoculate it before spreading. We bought a biologically active soil conditioner and mixed the two together in generous ratios so that, with time, the leaf mould compost would be colonized by beneficial bacteria and fungi.

Another thing that we did in preparation for transplanting would be to brew both compost tea and willow water. Compost tea is great for a number of different applications, especially helping plants overcome transplant shock. This is because the sheer number of organisms present in compost tea helps to compete with disease causing organisms, reducing the chance of a problem arising there. In addition, plants are able to extract significant quantities of nutrients from leaves and stems. By spraying their leaves and stems with nutrient rich (but not excessive) broad spectrum nutrients (achieved through the addition of things like kelp), the plants have direct access to the minerals they need to begin growing once again. This is especially true when the root system is not always able to immediately find what is required for proper nutrition.

Willow water, on the other hand, has only one purpose. By harvesting new growth from willow trees and either steeping in room temperature water or in hot water (not boiling) and allowing the stems to sit overnight, the natural rooting hormone that allows willows to strike root so readily is transferred to the water. This solution is then diluted with fresh water and used at transplanting time (and a few days afterwards during establishment) to deliver rooting hormones to other species. We did not set up any controls to see whether or not this was actually effective. I will say, though, that we did not lose any of our plants during the transplanting process. I think that the combination of healthy plants started in biologically rich soil, transplanted into well remediated soil with a generous dressing of biologically active compost and protected with a layer of mulch, and given the first aid of compost tea, willow water, and additional mycorrhizal inoculation pretty much ruled out the chances of failure.

Planting Out

The first guild to be transplanted was the nightshade guild. Although May 1st is our traditional last frost date, I was confident at the end of April that we would be spared any further freezing temperatures and so decided to plant out early. One last precaution was taken to engender success: the soil was given help in heating through the application of painters plastic as a miniature greenhouse to warm the soil for a few days.

A few weeks later, the entire nightshade guild was beginning to grow. Each section was planted with up to four tomatoes with garlic, basil,

Photograph 2-15 Using painter's plastic to raise soil temperature prior to transplanting. April 18th, 2011

oregano, peppers, and eggplants planted together. Additionally, cosmos flowers, Mexican marigold, lemon balm, cilantro (coriander), yarrow, New Zealand spinach, and parsley made their homes in this guild. I also had a handful of Monarda (prairie mints) that were strong enough to be planted there too. Later in the summer, I would plant a patch of okra. The area around the red maple was left uncultivated, but it was sheet mulched with cardboard and wood chips.

Since I wanted to maximize the size of the beds, my pathways were made a little too narrow. I thought I would be able to get the wheelbarrow through to the turnaround nodes without any issue. However, as the season grew on, the sheer size of the plants showed that this was a very poor idea. I am generally pleased with the layout of the pathways themselves, so widening them at the expense of the size of the beds will be ongoing. The pathways hierarchy has also changed through the years, so not all pathways need to be widened.

Photograph 2-16 Nightshade guild (mostly) planted out and beginning to grow. Pine needles on the pathways, although making the soil a little more acidic, provide a stark contrast with the wood chipped beds. May 7th, 2011

Photograph 2-17 "Green or Bronze Frog" (Rana clamitans) in the upper/small pond. They have been documented traveling up to 3 miles (4.8 km) from their birthplace to find new ponds. May 14th, 2011

The amount of time spent transplanting the nightshade guild took away energy that would have been directed to double digging the rest of the four sisters guild. Still, the plants needed to get into the ground as their water needs were rapidly growing. The sooner the plants could start fending for themselves (which never really happened), the better.

While transplanting and continuing to plan other sections of the garden, new visitors began to arrive almost daily. Bringing the most joy were the first frogs. They must have sensed the ponds from the nearby intermittent stream and made the journey over the course of a night. With frogs and fish the help control any potential mosquito breeding in the ponds, the little water features were beginning to pay off.

With summer just beginning, the cane fruits of raspberries and blackberries we had purchased the year prior were beginning to show signs that they would take over their planting place on the berm. So I decided to move them behind the privacy fence and into zone 4/5. Here they would be planted in small double dug beds adjacent to a swale with large water harvesting bowls dug in front of each new bed. These raspberries were meant to colonize the majority of this zone and use competitive exclusion to hold the site clear of undesirable plants. Before they became too large, I had hoped to establish some nitrogen fixing black locust for a future fencepost copse. Alas, this plan was a reach too far in terms of site management: the soil was too poor for the raspberries to grow well and eventually the seed bank overpowered our efforts.

It wasn't until the end of the first week of June that the four sisters guild was finally double dug,

Photograph 2-18 Raspberries on north swale behind fence. May 24th, 2011

Photograph 2-19 Four sisters guild double dug and nearly completely transplanted and sown. June 7th, 2011

amended, transplanted, and sown. The completion of this task capped a laborious six month process during which I moved tons of soil with only a shovel and wheelbarrow to help me. Three swales, hundreds of square feet of beds, one small pond, were finished with only the larger pond left to dig. Six months of hard labor, while working a full time job (40 hrs a week), nearly led to a breaking point. But with a week of rest (while mostly transplanting the other guilds), the final push in digging led to a huge sigh of relief. The most stressful phase of the stress test was finally brought to a close. I could now move onto the closing objectives of the stress test (p. 53): monitoring plant health and assisting the plants in providing yields.

Just a week later, we were into mid-summer. The green guild was in its final productive phase while the nightshade family was beginning to come into its own. Between irrigating with water from the ponds and brewing compost tea, I still had my hands full. But at least my back was given a rest!

Photograph 2-20 Chia (Salvia hispanica) getting ready to flower in the four sisters guild. June 7th, 2011

First Summer in the Garden

By avoiding the use of straight lines, monocultures, and monotonous patterns, our garden was even visually appealing. While my own patterns were far from revolutionary, the plants were responding to the double digging efforts quite well.

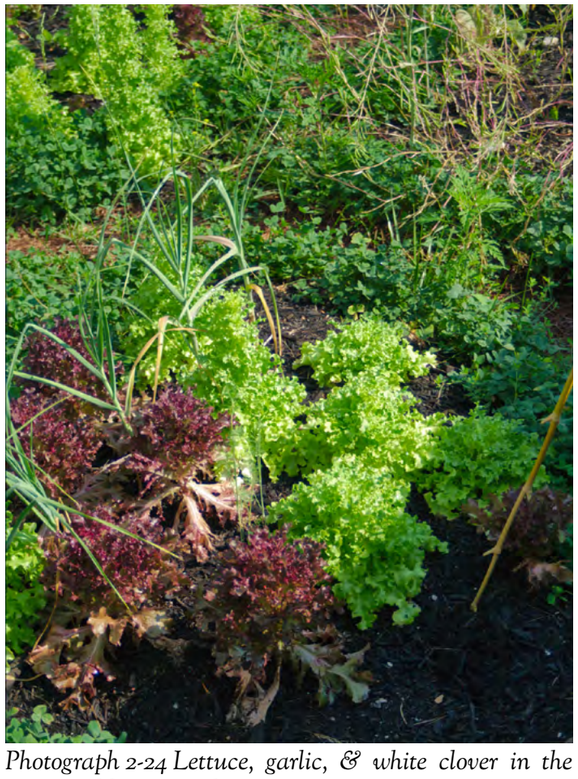
The only drawback from such a large garden was that the soil, even with remediation, was still lacking in the kind of structure that comes with age. The backbone of good soil structure is, of course, organic matter. Even with a good layer of mulch protecting another satisfactory layer of compost, the inability of the soil (even clay!) to hold enough water to get such a large vegetable garden through a summer where temperatures soar into the 90 degree F range (30's C) was staggering. That meant our garden needed plenty of watering.

Morning misting of compost tea and evening watering sessions just managed to keep the garden alive. Much of this water came from the small ponds I had dug, while at other times, we had to rely upon the municipal system to provide us with water to fill the swales during periods of extreme heat and drought. The green and nightshade guilds were filling out the best with this approach, while growth in the four sisters was at deceivingly strong.

Photograph 2-21 Compost tea ready for spraying. June 14th 2011

Photograph 2-22 Most of the green guild and the section of the nightshade guild adjacent to the first swale approaching mid-summer. June 14th, 2011

Photograph 2-23 Small section of the nightshade guild with an over story of tomatoes. June 14th 2011



Photograph 2-24 Lettuce, garlic, & white clover in the green guild. June 29th, 2011

Photograph 2-25 (Opposite) A section of the four sisters developing well considering transplanted corn. June 14th, 2011

Photograph 2-26 Older section of the four sisters guild with the upper pond's cucumber trellis in the foreground. The running water from the hose is actually from a small electric pump to aerate the pond. June 14th, 2011

Photograph 2-27 Cucumbers creeping across the trellis. Their shade would decrease evaporation while benefiting from the temperature moderation of the pond. June 14th 2011

Only a few days stood between the feeling of accomplishment and disappointment as one of the hottest summers on record helped fuel the kind of destructive summer storms the States are famous for experiencing.

A combination of factors led to the total collapse of the four sisters guild. The four sisters, perhaps the best known gardening polyculture in Western countries, relies upon crucial timing to partition the garden's physical space and soil resources.

Corn is first planted on small mounds such that each mound has a close cluster of plants for good pollination. After the corn has sprouted and is a few inches high, smaller mounds between the corn mounds are sown with different kinds of squash and melons. These grow very fast to fill the space between the mounds- an edible ground cover/living mulch. Hence why the corn needs a head start to avoid smothering. Next, when the corn has reached at least 10 inches in height, climbing beans are sown at the base of each corn stalk. Beans, when properly inoculated with *Rhizobium* species of bacteria, will grow rapidly from the resulting nitrogen fixation. With the corn now tall and strong enough to act as support, the beans will grow up the stalks providing nitrogen for the plants and protein for us. The fourth sister in this act can be any kind of pollinator-friendly plant which will further boost production by improving fruit set in the squash/melons. I chose to use sunflowers as they are both very tall and provide a "specialist" insectary role- a food source for predatory insects. In addition, it would be possible (if one were interested) to press the resulting sunflower seeds for a healthy oil. That is the theory behind the "four sisters" polyculture in a nutshell.

One thing you should never do, however, is transplant the corn. Corn needs to be sown in place because of its rapid growth habit- transplanting will only stunt the development of a healthy taproot and render the plants highly vulnerable to wind (which is necessary for corn pollination). I did not mean to transplant about 200 corn plants, but I did. What happened?

Well, my energy level plummeted after five months of double digging and I miscalculated the amount of time it would take for me to double dig the four sisters guild. In my hastiness, I figured that since the digging would take place after the last frost date, I should get a jump on the corn by soaking it overnight and giving it a few days heads up. That way, as soon as a space was finished, I could plant the seed and they would begin growing almost immediately. What I did not count on, however, was that the corn would begin sprouting the day after I put them in a moist paper towel!

Afraid to lose almost 200 plants, I rapidly sowed them into shallow trays in the hopes that my double digging would finish before any serious harm was done. Unfortunately, this did not come to pass. The corn was about a foot tall before it could be transplanted and I even had to fertilize them before transplanting. So, I wound up with hundreds of weak corn plants with stunted root systems being put into the ground.

This probably wouldn't have been so bad if something else didn't happen: a series of strong storms producing straight line winds ripped through the area from the west (See Local Sector Analysis and Microclimates) on three occasions within a week. Straight line winds are strong winds produced by certain types of thunderstorms. They easily reach 60 mph (96 km/h) and level anything in their path. While the tomatoes in the nightshade guild were secure in strong bamboo trellis, the weak corn plants without a strong root system (further complicated by the timing of the storm, if the storms had occurred later, perhaps they would be strong enough to withstand the wind) were extremely susceptible to damage. After the first storm pummeled the garden, I ventured out to right the fallen corn and hope they would be able to recover. When the next line of storms arrived and the plants fell again, I did the same. After the third storm barreled through, I gave up.

The entire four sisters was in disarray. Almost all of the corn was finished, but some of the sunflowers survived. The beans, which are highly flexible, survived too. What resulted was a jumbled mishmash of beans, squash, melons, and sunflowers.

This was my first real setback in the garden. During this time we also had to deal with squash bugs (Anasa tristis), but their damage to the garden was actually quite minimal after we manually removed them from as many plants as possible and fed them to the gold fish. Fortunately, the rest of the garden (as well as the older sections of the four sisters Guild) was chugging along quite well. Not so thirsty after the triple deluges we received with the wind, the plants were reaching maturity and beginning to produce fruit. The tomatoes did the best, with peppers lagging behind, and the eggplants suffering from some insect infestation.

Photograph 2-28 Four sisters Guild in disarray after third strong storm brought yet another round of 60+ mph straight line winds into the equation. July 1st, 2011

Photograph 2-29 Squash bug (Anasa tristis) nymphs on volunteer squash plant on blueberry mound. June 16th, 2011

During this time, I continued to rely upon compost tea and the occasional manual removal of bugs. I spent most of my time observing. Taking photographs during all hours of the day (when I could with my work schedule) and watching how the plants changed over time. I allowed many of unknown species to move into the garden to watch their growth habits. At the same time, the heavy mulch layer was able to prevent a lot of other plants from establishing themselves in the beds. One note about the mulch though: wood chips, once dry, become a serious impediment to infiltration of rainwater. This is something to consider when a new garden is started and the soil itself lacks a healthy amount of organic matter. I will discuss this further in the conclusions for the stress test.

Although production of food was definitely one of my goals, I also wanted to see when, or if, natural predators would find any of the herbivores. Turns out that most of the plants remained healthy enough through the height of summer without any serious intervention, but this was probably more to do with the garden being new enough to avoid being home to many of the herbivores that would destroy garden crops. One thing from the squash bug infestation period stuck out in my mind though: my premonition that intercropping with guilds would not be enough to confuse or cause predation of herbivores to make any serious difference turned out to be true. Again, I'll talk about this in the conclusion as well.

Stress Test Conclusions

Being in a long distance relationship at the time, it was necessary for me to travel to Finland to visit my girlfriend. I left for the month of August and by my return in September the garden was an entirely different place. Because the annual vegetable garden was by all measures "finished" by September, I have decided to draw conclusions based on the time I was there before taking time to discuss what happened while I was away for a month.

First off: soil remediation, even after taking drastic measures to alleviate poor growing conditions, is a process which will take years. That said, I do not regret the decision to feed from above with the compost rather than physically mix it into the soil. This is simply because it will take, first of all, the bulk of the growing season for the roots of plants to penetrate into the amended layer. Additionally the time it takes for mycorrhizal fungi to begin building their network is long enough that expecting huge improvements in plant health to become extant in

Photograph 2-30 Summer in the green guild and tomatoes climbing skyward in the nightshade guild. July 7, 2011

the course of three months- even in a "subtropical" region like ours- hints at an underlying desire for instant gratification. Of course, those two actors- the roots and fungal hyphae- are only the physical embodiment of the two largest organism actors in the soil. Along side them are the untold numbers of micro and macro organisms which just had their entire world turned upside down. Even though the process of double digging maintains the soil layers, the entirety of the underground ecology is disturbed when you till. No matter what.

The soil, as an ecological place- a biome, if you will, needs time to restructure after disturbance. Those earthworms, beetles, and other macro organisms are fast at work healing from any wounds, building new tunnels and burrows, and otherwise fighting to stay alive and reproduce. Organic matter, with the sudden influx of oxygen into the system, will be burned at high rates by the metabolism of these creatures. It is the subsequent action of the human beings managing the system to decide whether this disturbance was worth the damage it caused. Solid access and a plan for directing the succession of ecological development in the site is critical. Without good planning, all the hard work

Photograph 2-31 Sample harvest from the garden. Six varieties of tomatoes, eggplants, melons, peppers, okra, squash, and cucumbers (not to mention the greens we could still harvest or any herbs). July 30th, 2011

that you have put into creating a disturbance and guiding it for a short period of time can be laid low in short order. Usually by other human beings.

Postulations aside, we did observe strong growth in the annual guilds we planted. But their strong growth rested on constant irrigation during the hot, dry periods. Because we were starting from such an impoverished condition, the water holding capacity of the soil was still very low. Relieving compaction makes it easier for plants to extend their root systems, however, the increased rates of infiltration mean that the lag between transplanting and a soil profile marked by fully fledged root systems (not to mention the entire structure of the soil being lacking, see above) creates a period in which any irrigation is going to sink rather quickly into the deeper reaches of soil. Of course that does not mean that the decompaction is not worth it, but it does account for the fact that plants need deep and regular watering in order to survive- even in amended soil.

I will say with a lot of confidence that the measures taken to alleviate our poor soil conditions were worth it because the strong growth of the annual plants throughout the double dug area was able to accomplish a few goals in our quest to develop the soil. First of all, the highly mobile nutrients were able to be quickly locked up into living organic matter. Those nutrients were able to fuel the growth of plants, which as they increase the amount of photosynthesis, are able to increase the amount of root exudates into the soil, further feeding the underground ecology. If the plants would have been struggling in compacted soil, lack of nutrients- in addition to lack of nutrient availability brought about by low soil pH- the development of the soil as a living entity would have been slowed. When the annuals reach the end of their lives, the nutrients they have extracted from the soil will become available to decomposer organisms in the soil and will feed the coming generations.

With all of this in mind, it becomes apparent that even robust measures to improve soil health in the establishment period are, as expected, only the very beginning of a very long process of overturning centuries of degradation. Yes, measures such as these are able to produce an abundance of food for ourselves and the system at large within a season. But over eager pronunciations that a "permaculture makeover" is able to do anything other than put a

system on the path towards regeneration are just that- over enthusiastic spin. The soil has not been fixed. The soil has, however, been given a strong dose of medicine and therapy to help overcome the abuse that has been heaped upon it. Our job is to continue monitoring the soil, as well as our own behavior, so that over time resilience (and perhaps, antifragility) can become reality.

When we turn to water harvesting and over all water use, the first summer demonstrated that our techniques were beginning to work. Still, just as the soil remediation efforts will take time to fully demonstrate their worth, so too will strategies related to water. Swales can only be filled in a number of ways other than the preferred precipitation event: springs or water from the mains (including gray water). As we do not have a spring and gray water harvesting is illegal in North Carolina, our water harvesting systems were reliant upon rain from above or from judicial applications of potable water. Using potable water from the city's water infrastructure to water plants is a last resort and should be avoided if possible. With the state of our soil and the severe disturbance of the implementation phase, it made sense be smart about water usage to prevent the loss of a year's growing season.

Since the swales and ponds in our system are fed by precipitation, the number of irrigation events during the time between their construction and the end date of the stress test is the key metric in determining how well they worked. The swales had less than 8 months of collection to begin recharging soil. Contrast that with the oft quoted line from Geoff Lawton that it takes up to seven years of water harvesting before the measures bring you back to a rehydrated situation. Taking that into consideration, it makes little sense, once again, to believe that swales and ponds are immediate cures to the underlying problem. Let me repeat this fact: soil still needs to be restructured, it still needs to be recolonized and organized by life (which takes years of root growth and death, fungal growth and death, and the burrowing of organisms along with the balancing act that comes with years of root exudates and soil life competition!), and it needs to accumulate all of this life into forms of organic matter that will hold water well.

Once again, however, just because the journey has only just begun does nothing to preclude the fact that our water harvesting features did their job well. Especially the ability of a pond to bring into play aquatic and marginal species of predators that otherwise would not have been present. Let me reiterate that point: frogs and dragonflies may venture away from their preferred habitat to seek prey or new territory, but they only do so for a fraction of their time. By purposefully creating ponds and trying to fulfill their niche requirements, we were able to entice them to *establish* new territory in the garden. While I do not have "hard evidence" of just how many herbivorous creatures they were able to hunt as prey, it is well established that their mere presence in a system means that the food web becomes more complex and therefore there will be a reduced number of their prey. I consider their early adoption of the site as an good omen for the future.

Moreover, the ponds also allowed us to utilize captured water as irrigation water the majority of the time. We were able to fill five gallon buckets with regularity from these water bodies, shuttle the water uphill, and feed the system. Any water not taken up by the living soil would eventually find its way back into those ponds.

As discussed earlier, the second and larger swale was not dug on contour. In early July, with significant rainfall, the swale burst over the mound and caused even more damage in the four sisters guild (*see p. 50*). While thinking of the best way to fix this situation, I merely remulched the area and put in lines of stones (one rock dam style) to help slow any water that made it over. It was nothing more than a patch for something that needed a true fix.

Next, I would like to talk about integrated herbivore management. This is the idea that by building ecosystem diversity and providing for the niche requirements of predatory organisms, that the numbers (and kinds) of herbivores can be held in some kind of check naturally. This is a strategy that even with some planning for the first year, will take years to reach any level of actual use. The diversity of spider species alone, reported as the best predators in the garden, means it will take more than one growing season to attract enough to make a difference.

Reliance on direct predation is an excellent means in established systems to reach a balance and share the sun's energy with the natural world instead of hoarding it for ourselves. Additionally, we are interested in the purported ability of some plants to repel certain types of bugs. Aromatic pest confusers, as they can be called, have some hints of scientific credibility, but are not yet fully established. Still, we planted many of these species around the garden in an attempt to use an "all of the above" strategy of herbivore management.

Other tactics that we used were the tried and true methods of reducing stress and competition through proper plant spacing along with our soil and water regeneration methods (available fertility and mulching, for instance). With a large array of defenses again herbivores, we encountered little problems for most of the year (at least when it came to bugs). The only plant that suffered from intense attack were our squash plants. The mulch and compost from the city must have introduced both seeds and bugs into the garden. Some of those seeds were squash plants, which volunteered and quickly became targets of the bugs which had accompanied them. It did not take long for the bugs to find their way into the four sisters patch and begin wrecking havoc. I knew that they were squash bugs early on, but was hoping that some of the predators would take care of most of them. I was proved to be wrong, so we countered them by hand and fed them to the fish.

By now it should be obvious that when dealing with integrated herbivore management, time is the deciding factor. It simply falls within the same category of "not fully established." When a garden is started, even the most well thought out and cared for guilds of plants are not going to demonstrate all of the qualities for which they were chosen. This is true whether or not the plants are annuals, perennials, or a mix of both. It is a simple fact that the beneficial organisms (as well as the undesirable ones) will take time to discover your garden and set up shop. Many of their niche requirements may not be met yet and some may never even make it. Some of the first arrivals may be taken as prey by other predators and the whole waiting for Godot situation arises again!

So if there is one thing that I can truly conclude from the first spring and summer during which we established the new management regime in the garden is this: work with time. If I did not understand the fundamental fact that time is the deciding factor when it comes to ecosystem establishment and regeneration, I could have spent this section lamenting,

"My tomatoes didn't produce as much as my neighbors! Those ladybugs never showed up! Basil doesn't prevent worms on the crops! I have to water too much! This whole thing is a lie!" Et cetera.

Instead, each time a problem arose, my knowledge of ecosystem dynamics and an appreciation for time was able to temper my disappointment or disaffection. This stress test was only the beginning- and a strange one at that- of a very long process in which we will be attempting to stitch together a tiny little ecosystem situated in a damaged ecological neighborhood. We were able to observe, over an extended period of time, that many of the techniques being implemented need to be presented with qualifications rather than being promoted in an incontrovertible manner.

Photograph 2-32 Midsummer four sisters (left) and nightshade guild (right). June 16th, 2011

Return From Europe: Stress Test's Coda

For all my reminiscing about what amounts to "earth care," something was left out. Didn't I mention that part of the stress test was to observe the impact on us, the people? Now is the time for a little bit of "people care" talk.

The scope of the stress test was, predictably (although I avoided doing so at the time), too much to bear for the family without my presence. See, I was the one putting the vast majority of the work necessary to keep the project moving. I love tending to plants and the ecosystem at large. It is something I feel I was called to do. When I left during at the onset of summer to visit my fiancée, I left a difficult void to fill by the family.

And the garden broke. The rain ceased, the plants were reaching stages of maturity during which they would need more than water to continue producing, and many of them were just simply reaching old age. Many of the small plants that had accompanied the compost and mulch from the city, which I had left to see what they were, quickly took advantage of the situation and made a seed run. In particular were the morning glories- a species that is well adapted to disturbed soil and available nutrients (like our garden). With its vining habit, the morning glories quickly overtook the garden and smothered just about all of the annuals.

The pressure of maintaining the garden's appearance so that I wouldn't be disappointed upon return was felt most by my mother, who was the only one truly interested in keeping the garden. Of course, due to a variety of factors, she was- bless her- unable to keep the garden as healthy as I did. When it became apparent that even with her best efforts, the lack of solidarity in the family unit meant that the garden collapsed. During my time away from home, I was never notified about the state of the garden.

This was perhaps the worst part about the return. Having not received word, I knew that the garden was going to be in trouble. But I did not expect what greeted me. The garden was in state of decay and stasis at the same time: annuals withering in their trellises and a family on edge. The garden could heal: the paths were still there and upon examination, almost all of the perennials had survived underneath the morning glories. The family strife, however, was real. The dog fence had been moved and the garden effectively severed in half: the plum, two birch trees, a handful of pines, and the berm extension now lay open to the dogs and lawn mower. Despite months of work and discussion about the need to protect the soil, the lawn mower had been brought out with a vengeance. Set to its lowest cutting level, many places were effectively scalped of life and laid bare to the sun.

Inside the diminished garden, grasses had begun to overtake many of the beds. Most of the morning glories had already set seed and were on their second round of flowering when I returned. It took nearly a week of very careful removal of morning glory seed heads before I could begin

Photograph 2-33 Morning glories, not beans, climbing the remains of sunflowers and trailing across the entire garden! Their seeds arrived in the mulch from the city. September 7th, 2011

Photograph 2-34 Set to its lowest cutting level, the lawnmower scalped the earth near the ornamental plum where we had begun soil building. September 7th, 2011

Photograph 2-35 A female yellow garden spider (Argiope aurantia) with her web strung between tomato cages and the fence. Basil understory continues to produce, as do the hybrid tomatoes. Lady's Thumb (Persicaria maculosa), an immigrant from Eurasia (looks similar to native P. pennsylvanica, but with a black triangle on the leaves) blooming at bottom. September 18th, 2011

the work of reclaiming beds and moving into the perennial-based garden paradigm that we actually wanted. For those who don't know, morning glory seed pods burst with the slightest pressure, sending the seeds quite a ways from the parent- so one needs to be very careful to capture them at this moment and put them into a container. The container can then be filled with water, the lid closed, and put into the sun. The seeds will sprout and die. Then they are safe to put into the compost (or fed to worms).

Social considerations are the number one aspect of any permaculture project and my failure to ensure that the family understood just what the stress test was about was mostly my own fault. That said, the basic infrastructure, the mainframe design aspects, was still intact. The stress test, unsparing as it was, had revealed some extremely valuable information about the family's ability to maintain a garden.

First of all, a garden of that size- dedicated to annuals- is beyond the ability of a single family without a dedicated plan and skills to maintain it. The only reason I was able to get it started and keep it going was that I had the knowledge and will to invest my leisure time (when not at my full time job) observing and absorbing new information. It amounted to another full time job, and, in hindsight, could have been a paying job if I had wanted market the produce. That was the sheer size and scope of the stress test's annual garden. The test truly was merciless. It was almost cold hearted when I think about it now, three years later.

The stress test could easily be coined as a reality check. Annual agriculture is hard. Even when you combine strategies to make it easier, to shift some of the burden to the ecosystem rather than take it all on yourself, raising those kinds of plants can turn into a nightmare. Both of my parents had childhood experience with growing large gardens. I too, had developed my own experience in the previous few years. Still, it took the fateful decision to launch into this stress test (and yes, I did call it that at the time, this isn't all white washing!) to truly shock us into what the sheer productive power of this plot of land was. Released from the mower blades and encouraged through all of the above strategies, the land under our facilitation surged ahead with an amount of energy I am sure none of us truly could have foreseen.

Photograph 2-36 Year old cardinal flower (Lobelia cardinalis) along fence line. This native attracts hummingbirds! Usually they flower in their second year according to most sources. September 18th, 2011

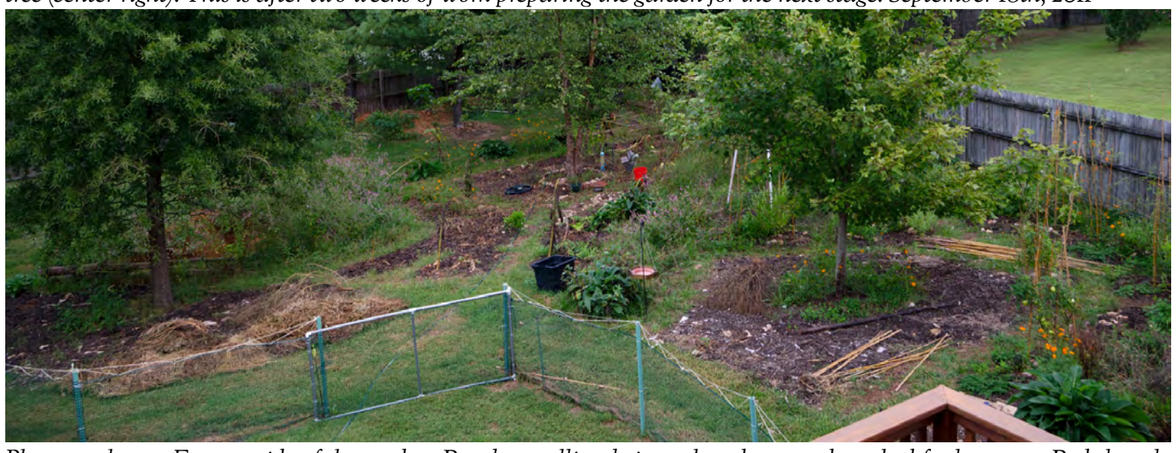
Photograph 2-37 Year old great blue lobelia (Lobelia siphilitica) along second swale. Bumblebees love this native plant. Usually they flower in their second year according to most sources. September 22nd, 2011

The steadfastness of the hardy perennials I had selected to bring into the system in the first year was evidence of the power of the kind of cultivation we truly wanted to move into. Despite the drought, the relentless heat, and the encroachment of aggressive plants such as morning glories and Bermuda grass, the perennials held the line. By early fall they were thriving. The stress test may have broken us, but it did not break the system.

And in that lay the encouragement to consolidate the lessons learned and forge ahead into the fascinatingly bewitching world of perennial-based systems. The year had taught us just what happens to those who desire to take most (as we were not interested in a take-all approach) from a system that has been starving for years. It taught us the importance of relinquishing as much responsibility for system services as possible back to nature, while adopting the stance of a facilitator at the same time. With the reality check dealt us by the stress test, we were better equipped to understand the might of the natural system and the amount of work it would take to control rather than steer it. These were messages that would not have come across to us if we had avoided the opportunity to have some knowledge dropped on us by mother nature.

So was the stress test a failure? Was it an unnecessary punishment? I think not. The best lessons often come from disappointments and the test was chock full of those, but with plenty of rewards to be discovered once the surface layers were peeled back and the fundamentals examined.

Photograph 2-38 Western side of the garden. Note the new location of the dog fence and state of the lawn under the trees outside of the fence (left). Morning glories and other undesirable plants, especially Bermuda grass, piled near the oak tree (center right). This is after two weeks of work preparing the garden for the next stage. September 18th, 2011



Photograph 2-39 Eastern side of the garden. Bamboo trellises being taken down and stacked for later use. Beds largely cleared of undesirable species in preparation for a winter crop. Notice how huge the Russian comfrey has grown (bottom center near black container & extreme bottom right). September 18th, 2011

Cover Cropping Begins: Transition to full-time Ecosystem Facilitation

With the results of the stress test fresh in our minds, the move towards forest gardening could begin. By embracing more permaculture techniques going into the second year we were able to notice quite quickly how much better the social situation became.

The coming period from fall to spring would see us sowing a wide variety of plants to build the soil as well as perhaps provide us with edible yields. In the old green and nightshade guilds, red clover and alfalfa were chosen as our primary soil improving crops. Into them we sowed winter greens for additional diversity. In the old four sisters guild, we switched the cover crop over to common vetch with many winter vegetables given that the area receives much more winter sun than the other two sections of the garden. Sowing these crops in September and seeing them fill in as fall progressed was a satisfying experience.

It was decided that beyond assisting the seeds in their germination, the plants would be left to their own devices to grow accustomed to the site conditions. We did, however, inoculate the nitrogen fixing species with appropriate bacteria as well as fungi. This is in the interest of establishing the populations of beneficial organisms early on so that as the years progress we will be planting into strong soil food webs.

Interestingly, many volunteer tomatoes from the imported mulch- as well as some of our own- continued to produce excellent tomatoes well into fall. The chili peppers and eggplants continued to produce until overnight temperatures brought an end to their first year in the garden. Because of this continued harvesting from warm weather crops, we were encouraged to continue seeding winter crops even into November in case of a mild winter.

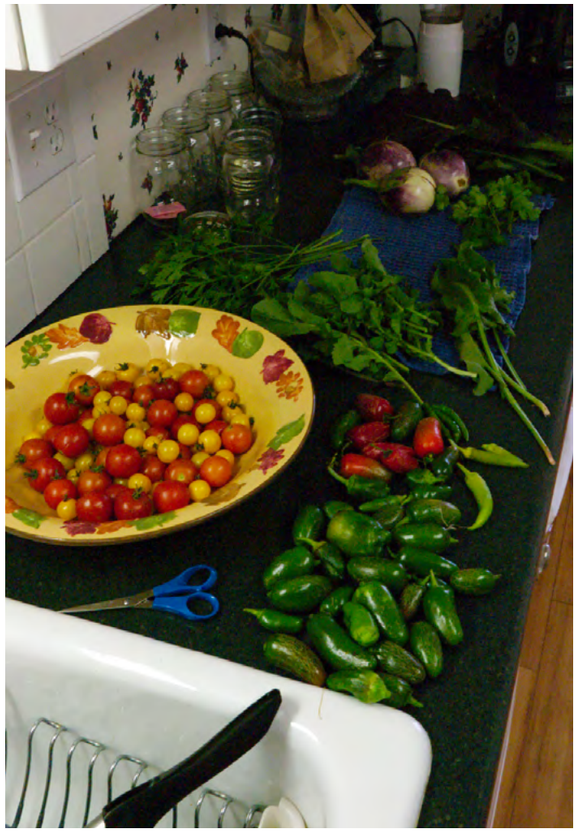
Much to our surprise, winter never arrived in earnest that year. Between 2011 and 2012, the winter months were extremely mild which allowed almost all of the crops we sowed to thrive throughout the season.

After the course of the fall and winter, I became certain that plants can tell when they have mulch cover or not. Whether they know it was their own leaves doesn't matter as much as the fact that the garden, with its large pioneer trees, was able to produce quite a lot of leaf litter from the outset. This reduces the amount of mulch we would need to import early in the project's life. It is also quite clear that comfrey continues to chug along without any sign of slowing down. In addition, even though the lawn grass enters dormancy, our choice of

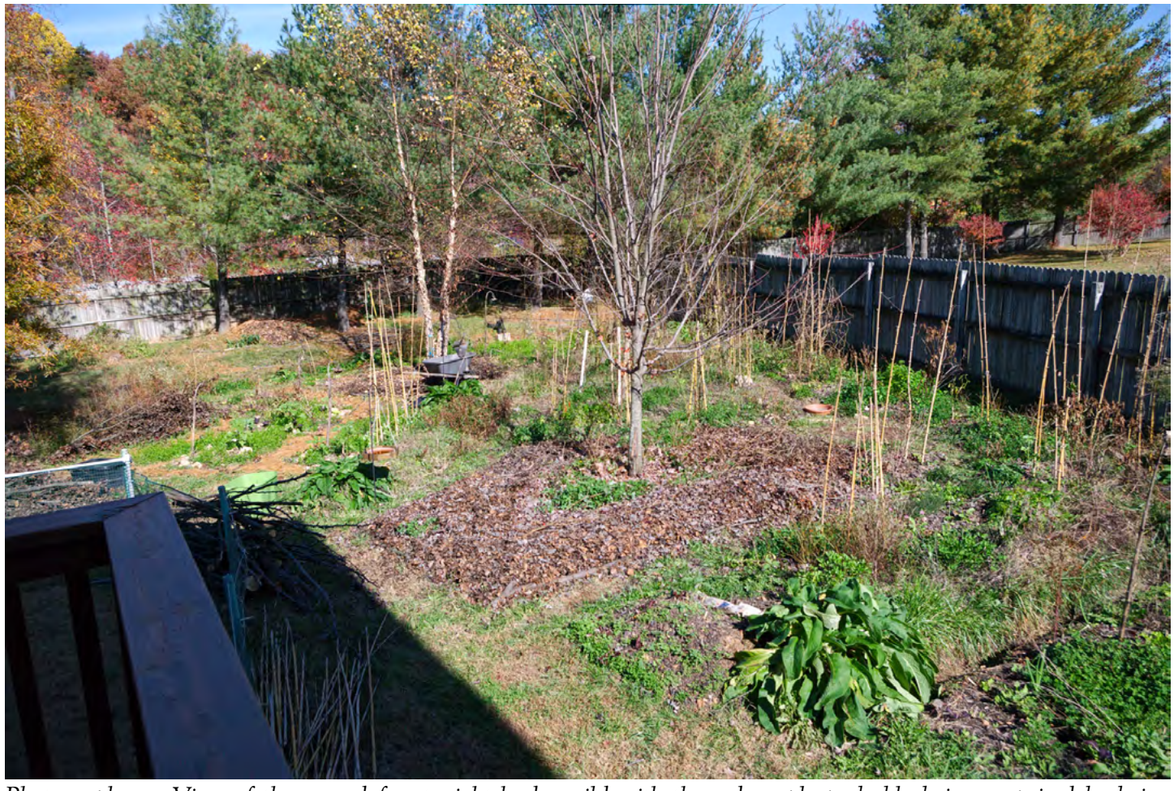
Photograph 2-40 Winter spinach (Spinacia oleracea) nestled amongst stones and a cover crop of common vetch (Vicia sativa)

diverse winter crops is extending the period in which photosynthesis can occur, thereby increasing the time in which the garden's soil is able to self structure.

Cover and winter cropping is nothing new, but the actual practice of such techniques is very rare. Given North Carolina's tendency to have mild winters, I was actually quite surprised that many people believed that the growing season was over.



Photograph 2-41 Summer extending into autumn: various tomatoes, peppers, herbs, and eggplants. November 2nd, 2011



Photograph 2-42 View of the now defunct nightshade guild with the red maple probably being surprised by being allowed to keep its leaves to itself for the first time in its life. November 9th, 2011

Further north, into the retired four sisters guild, our crop of vetch and winter vegetables was looking even better. This area receives the most winter light as it is beyond the reach of the shadow cast by the house. Old sunflower stalks were left standing in order to serve as overwintering sites for insects. Small stones, while white (reducing their heat absorption), were piled around small plants in the thought that they might, perhaps, buffer the temperatures. Probably not since they are too small, but its the thought that counts sometimes.

Large branches can be seen piled up on the left, with their leaves on, to slightly defray some wind that comes from the north. Again, these may not have had any real effect, but the implementation of ideas that we know work at different scales keeps them fresh in the mind. I have seen in other places where very small windbreaks made of peas have encouraged strong growth of adjacent species in very demanding conditions in Finland, so every little bit of microclimate creation and encouragement helps.

Winter is a key time to observe microclimates and to think about where to encourage new ones. I was very hopeful that the sun would eventually sink low enough in the sky to encourage strong growth during the winter on the little hugel beds underneath the pines. Here, kale is mulched with ornamental pear leaves obtained from neighbors. Additionally, the branches of the pear tree were used to begin outlining pathways on this berm. If you recall from the site analysis section, this berm actually is quite high in nutrients and the pH is not so terribly low. I hypothesize that the berm was built with actual topsoil from the construction site that was not removed and sold. You can also see that one of the blueberry hugel mounds is still covered in all kinds of plants that I just did not get around to "cleaning up."

Another thing to note during the changing seasons, especially in a place that may or may not have a winter, are the cold climate species which emerge. Henbit, false nettle, crow garlic, chickweed, and many other species break out of dormancy in the fall. These can be observed in the bottom of the photograph, a place where we would sheet mulch to extend the garden onto the berm and take advantage of the largest section of the south facing berm possible. Seasonally shifting plant species represents partitioning resources through time, as well as space. Adapted to cooler conditions, these plants will continue sending root exudates into the soil, feeding the organisms that are in the process of structuring the soil. They also absorb any mobile nutrients and can keep the mycorrhizal fungi

Photograph 2-43 Common vetch serves as a ground cover among winter cabbages, mustards, spinach, garlic, peas, and other winter vegetables. Late-sowed sunflowers look healthy, but small. November 9th, 2011

network in use.

In *Photograph 2-45*, you can see my haul of ornamental pear from a neighbor's yard. Their Bradford Pear fell victim to high winds and was chopped into small pieces to be left for "green waste" pick up. I had other ideas and dragged the haul into the garden for digestion. Leaves were stripped off into the wheelbarrow for mulch, while smaller branches were broken up by hand to use as woody mulch under the red maple. Large branches were put into the ponds and other places where we could use some structural diversity.

As 2011 came to a close, I was quite satisfied with the transition from stress test to cover cropping and looking forward to seeing the results of our work come back in the form of soil tests. The bare bones establishment period was over and we were now ready to begin guiding the system into a new stable state.

Photograph 2-45 Never let your neighbor's waste go to the dump! November 9th, 2011

Photograph 2-44 Kale planted on a south facing slope of the mini hugel beds that were being finalized as I finished digging the large pond. November 9th, 2011