Edible Forest Gardening: Planning, site selection, and implementation of permaculture at Messiah College

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Abstract

This research project aims to continue the implementation of an edible forest garden, building on the efforts of Messiah College students Ryan Witmer and Ben Davies in 2007. The forest garden is located within the Rider-Musser development project at Oakwood Hills, adjacent to Messiah College. Current projects include depiction of site change over time using ArcGIS software, georectified historical aerial images from 1937 forward; vegetation analysis of current forest composition; soil type and properties mapping; and an initial planting in the forest garden with selected fruit shrubs. A manual was prepared to provide longevity and future management options for the project. It contains the characteristics of the current plant species of the site and steps for eradication of some invasive species, as well as information about the care and maintenance of species planted during the semester and those that should be implemented in the future.

Keywords

PERMACULTURE, FOREST GARDEN, GIS, SITE SELECTION, HIGHER EDUCATION
Introduction

Permaculture, also commonly known as forest gardening, is a buzzword of sorts today in the ecological sciences, yet few people truly know what it is, let alone how to make it practical. Bill Mollison, the creator of the word and much of the concept itself, defines permaculture as 'the conscious design and maintenance of agriculturally productive ecosystems which have the diversity, stability, and resilience of natural ecosystems,' or 'the harmonious integration of landscape and people providing their food, energy, shelter, and other material and non-material needs in a sustainable way' (Mollison 1988, p. ix). This project aims to continue the proposal of Ryan Witmer and Ben Davies in 2007 to develop an edible forest garden for Messiah College, furthering the plan for its implementation and taking the initial steps. The forest garden will significantly benefit the College community, as well as the residents and patrons of the Rider-Musser development project at Oakwood Hills, the site where the garden is located, providing unique educational opportunities and important intentional green space amidst building development.

Background

In looking at its history and development, it is helpful to look at some of permaculture's first authors, the Native Americans. Although little modern research of permaculture systems has been conducted relative to that of the related fields of agriculture and ecology, its origins trace back to the indigenous people that populated this continent for centuries. While today the common conception of the continent's landscape prior to European settlement is that it was wild and untamed, this was actually not the case. Native Americans 'had widespread influence on their habitat besides the direct impacts of their farming,' (Jacke 2005, p. 14) 'manag[ing] the forest to increase and diversify their food supply' (Denevan 1992, p. 370). Dave Jacke, the author of the two-volume set *Edible Forest Gardens*, asserts that 'they deliberately altered the ecosystem to provide more tree crops and other 'wild' crops, to make hunting easier and game more plentiful, and to eliminate pests and diseases' (2005, p. 15). They knew that all the resources they needed were present in the forest, and they only needed to manipulate a few things in cohesion with the existing patterns in nature in order to live in abundance. The philosophy of Native Americans as it pertained to taking care of the earth is not complicated: preserve it, keep it, promote it,
work with it, not against it. This relationship was highly spiritual, as Gregory Cajete notes in *Native Science*. The 'direct relationship with the earth as the source of knowledge and meaning for human life and community' created the foundation for a culture, and ethic, and a way of life (Cajete 2000, p. 109).

When Europeans settled on this continent, however, the landscape drastically changed. Wes Jackson, in *Becoming Native to This Place* (1996, p. 19), laments that 'from our first arrival [on this continent] we have behaved as though nature must be either subdued or ignored.' In the conquest of nature as a means of establishing the systems of modern agriculture, North American settlers leveled forests and began to plant massive amounts of one kind of crop, abolishing much of the original diversity. It is becoming more of a widely known reality that this technique, called monocropping, is not actually the most beneficial form of agriculture, despite its intentions to be the most efficient. Even more integrated organic farming techniques meet criticism from proponents of the permaculture movement. Jacke (2005, p. 13) argues that this kind of agriculture still relies greatly on external contributions of energy, nutrients, pest and disease control, and water, and are usually composed mostly of annual plants. The reality is, though, that growing food is essential for human survival on this planet, and to do so, humans will unavoidably alter the surrounding ecosystems in some way. In their book *Integrated Forest Gardening*, Wayne Weiseman, Daniel Halsey, and Bryce Ruddock (2014, p. 7) note that as the dominant species on this planet, humans cannot help but leave an imprint of our being here: 'inevitably we will impose patterns on the site[s we use for agriculture], but what of the patterns that already exist?' They, along with other proponents of permaculture, assert that the techniques of forest gardening, by mimicking the plant landscape that exists naturally, provide the sustainable solutions needed today.

A key lesson to learn from the Native Americans is that of healthy diversity. The importance of ecological biodiversity has been well documented and is widely understood to be necessary to an ecosystem's ability to thrive. The biological advantages of multiple species living along side each other are worth noting - recycling of nutrients, soil fermentation, nitrogen fixation, bioremediation of pollution, pest control, natural pharmaceuticals, and plenty more (Pimental et al. 1997) - these alone are reason enough to reject traditional monocropping. In other words, diversity creates resilience (Weisman, Halsey, & Ruddock 2014, p. 15).
However, diversity is more than simply the number of species in a certain community; a vital piece of the diversity of an ecosystem lies in its structure. Jacke (2005, p. 23) asks his readers, 'Have you ever seen a natural temperate-climate ecosystem where everything was laid out in straight rows?... Where vertical space was used sparingly, if at all?' Especially as the planet continues to warm as a result of climate change, structural diversity of ecosystems will be vital to their survival because it buffers the extremes - temperature, drought, storms, etc. - brought about by long-term change (Weisman, Halsey, & Ruddock 2014, p. 17). A garden composed of multiple layers - generally speaking, tree layers, shrub layers, and herbaceous layers - mimics the structure of a natural forest - the canopy, subcanopy, and understory - and provides for the same kind of resilience found in the wild (Jacke 2005, p 70-71).

Another notable benefit of this kind of agriculture is that it allows humans to meaningfully shape culture through the design of permaculture systems. For the Native Americans, agriculture was undoubtedly an intentional expression of culture. Cajete (2000, p. 141) notes that ways of propagating plants for food are specific to regions, societies, and cultures, and that the indigenous people of this continent practiced permaculture 'extensively, effectively, and soundly based on a philosophy of mutual reciprocity.' Hundreds of years later, nearly the opposite is true of modern Americans, the new dominant inhabitants of that same land. Instead of cooperation and respect as standards for ecological interaction, themes of disconnection and dominion characterize the modern relationship to the land. Jacke (2005, p. 22) says that today, just as 'forest remnants are disconnected from each other [and] people are disconnected from the land... culture is disconnected from agriculture.' However, it can be argued that the dominant forms of agriculture today do reflect modern culture, only, it is not same holistic tradition that Native Americans maintained. Acres and acres of one kind of crop, the combine, and factory farms all reflect this culture's prioritization of efficiency: the most output for the least amount of input. As continued research reveals the dangers of these kinds of systems and humans consequently rediscover the need for an environmental ethic of holism, all roads seem to lead to permaculture.

On the campus of Messiah College, an institution that strives for environmental sustainability and that rejoices in the role Christians get to play in the ultimate restoration of the earth, a permaculture system will give
those involved a tangible way to practice these ideologies. Ben Davies and Ryan Witmer, in their research in 2007, provided some valuable insights into the preparation to implement such a system on campus both for research purposes and as another campus effort toward sustainability (Witmer 2007, Davies 2007). These students performed one of the most critical steps in the permaculture design process: site analysis and observation. Wieseman (2014, p. 5) notes that the key to this whole process is meticulous, systematic, and ongoing observation, because it reveals to us the resources available and the patterns already present at the site. However, while these students looked in depth at different methodologies and species that they hoped would be successful and beneficial, they unfortunately were unable to materialize their proposals. While the work that they performed is foundational to this permaculture project, the site is different than what Witmer and Davies originally proposed and needs more observation and analysis.

**Materials and Methods**

The site chosen to host the permaculture project lies within the Rider-Musser Development project at Oakwood Hills, located across the street from the College between Route 15 and Lisburn Rd. The site is steeply sloped in places (up to 25% in places), and a small creek runs south at the base of the slope to a small man-made pond and eventually into the Yellow Breeches Creek. The forest site was chosen largely because of the slope; with such steepness, this site would be impractical to grade and develop with building infrastructure as is most of the rest of the site. This assurance of lack of development is a promising feature to develop a garden that will take many years to become fully established.

**Forestry and Soil Mapping**

Using ArcGIS software, the historical forest cover and soil composition were mapped. Historical aerial images from 1937 and 1967 were obtained from Penn Pilot (pennpilot.psu.edu) and georeferenced to a 1999 digital orthophoto quarter quad (DOQQ) of Lemoyne 's southwest quadrant obtained from the Pennsylvania Spatial Data Access (PASDA) (pasda.psu.edu). On these images, shapefiles were created around the forested areas surrounding Messiah College. The areas of the polygons in square feet were calculated and were compared between the three years (*Figure 2*).
Soil data for Cumberland and York Counties were also obtained from PASDA and mapped using ArcGIS. Interpretation of the PASDA data were obtained from the Web Soil Survey (WSS) (Soil Survey of Cumberland and Perry Counties, Pennsylvania, 1986), inputted into an Excel document and joined with the soil data attribute table in ArcGIS (Figure 3).

**Tree Composition Analysis**

The Spring 2016 Plant Ecology class collected tree composition data at the site using the Point Quarter sampling method (Brower, Zar, & von Ende 1998). Three 100 meter transects along a specific compass bearing were taken for a total of 300 meters sampled. For each quadrat, the tree closest to each point and greater than 10 cm diameter at breast height (DBH) was identified and measured, and the distance of the tree in each quadrat from the point was found using a laser range finder. Then, Excel was used to calculate:

\[
\text{basal area per hectare} = BA/Ha = \frac{(\sum (DBH)^2)}{10000} \times (Ha \text{ sampled})
\]

\[
\text{density per hectare} = Da/Ha = (\text{count of each species}) \times (Ha \text{ sampled})
\]

\[
\text{frequency} = F = \frac{\text{count of each species}}{\text{total number of trees sampled}}
\]

From these, the importance values were calculated for each species:

\[
IV = \frac{Rel. BA/Ha + Rel. D/Ha + Rel. F}{3} \times 100
\]

Results are shown in Table 1.

**Species Research and Manual Preparation**

In order to provide longevity to the project, many species including current invasive species, current useful species, and future useful species were researched using a variety of resources and a manual was compiled for future management of the forest garden. Internet resources including state and national botany information, respected gardening websites, and popular blogs were garnered, as well as information from a variety of books, in order to assemble a well-rounded approach to forest garden management. For current invasive species,
recommendations for eradication were presented; for current native species that have practical use within the forest garden, recommendations for harvesting and maintenance and recipes were presented; and for the future development of the garden, recommendations and recipes for additional species were presented. (A full list of references can be found within the manual.)

Initial Planting

During the Fall of 2015, cost analysis was performed to determine which species would be practical to implement and where they could be purchased. Sylva Native Nursery (Glen Rock, PA) was chosen to be the most cost effective and accessible. A total of two trips were made to purchase a total of thirty seedlings of four species: ten elderberry (*Sambucus canadensis*), ten American highbush cranberry (*Viburnum trilobum*), five persimmon (*Diospyros virginiana*), and five serviceberry (*Amelanchier canadensis*).

The seedlings were planted in two rounds, the first occurring on 23 April, 2016, and the second on 11 May, 2016. The elderberries were planted close to the stream at the base of the site approximately 15 meters apart; the serviceberries were planted even closer to the stream approximately 15 meters apart; the persimmons were planted just north of the elderberries and serviceberries in a section of forest with little understory and significant light penetration, approximately 15 meters apart; and the cranberries were planted slightly higher up on the slope, approximately 15 meters apart (*Figure 1*).

Results

Forestry and Soil Mapping

The area calculated from the shapefiles, while not perfectly accurate portrayal of all forest cover surrounding the College, shows that forest cover has significantly increased between 1937 and 1999, by nearly a factor of two (15,600,000 to 29,400,000 sq. ft.). These results indicate that much of the forest surrounding Messiah College is relatively new, and the aerial photographs show that where many forests are today, pasture or farmland existed previously. The these results imply the need for more research: significant forest stands exist
today that have not been analyzed for composition. In order to manage these forests in the best way, they need to be analyzed for invasive species and greater ecological trends.

The soil data indicates that the soil at the site is primarily Bedington shaly silt loam at 8-15 and 15-25% slopes and Ernest silt loam at 3-8% slopes (Figure 2). Silt loams are known to be useful soils for agriculture, and these two types in particular are relatively acidic, contain a significant organic matter layer, are highly productive, and have good drainage (Soil Survey of Cumberland and Perry Counties, Pennsylvania 1986). These four qualities in particular are specific needs of the four species implemented this semester. Additionally, with a significant slope comes even better drainage, enhancing the already beneficial drainage qualities of the soil.

Tree Composition Analysis

The results in Table 1 indicate that the seven most important species at the forest garden site are all species of oak (Quercus), cherry (Prunus), and walnut (Juglans), all of which already produce edible fruits and nuts, contributing greatly to forest's productivity as a permaculture site. Additionally, the composition does not have the same risk of becoming dominated by red maple (Acer rubrum) as many younger forests in the area do. No one factor can explain A. rubrum's rise to dominance in many northeastern forests, but it generally has less to do with leaf physiology and photosynthetic rates, and is due more to A. rubrum's high genetic diversity that allows it to survive well in a wide variety of ecological conditions: high or low shade, dry or moist soils, low or moderate nutrient levels, and as a early or late successional species (Abrams 1998). Forests at risk of becoming dominated contain a high frequency and density but a low basal area of A. rubrum; however, the consistency of the species' population here is promising that A. rubrum will not dominate this forest site. As more tree species are also implemented, this risk will decrease even further.

Discussion

Implementing a permaculture site has a number of significant benefits, both ecological and social. Shaping a forest in this way will require careful attention and deliberate consideration of a number of factors.
Ecological Benefits

Adding native species to an existing forest will clearly add to the plant biodiversity of the site, but the benefits exceed simply increasing the species index. Increasing the number and types of natives at the site while simultaneously working to remove some invasive species will greatly increase the integrity of this forest. Intentionally shaping the forest in this way will create a native 'hotspot,' an area that could be used for propagation in the future. Additionally, building the forest intentionally will create more habitats for wildlife, thereby potentially increasing the diversity of forest animals at the site as well, particularly birds. Implementation of species such as berry bushes will surely draw birds to feed, and while the purpose of this forest garden is not exclusively for wildlife, it will create an especially diverse habitat for many species.

Social Benefits

The forest garden will firstly benefit the Messiah College community, especially faculty and staff within fields of Sustainability Studies, Biology, and Environmental Science, but also including those of other programs and departments. The forest will provide a learning laboratory, a firsthand glimpse at a growing agricultural trend and the opportunity to take part in shaping it. It will also benefit young students that visit the Oakes Museum of Natural History for the same reasons. The forest garden will eventually provide a profit for the Grantham Community Garden and serve as an extended learning tool for those involved with tending the gardens over the summer. This permaculture site will propel the College forward as a leader in sustainability in a new area; just as the institution has made great strides in energy and waste management, so too will it be a leader in progressive agriculture.

The forest garden will also clearly benefit the residents and patrons at Oakwood Hills. It will serve as an educational tool about permaculture and native plants in general, widening the perception of the general public about what agriculture can look like and helping them to connect more deeply with the native environment. As part of greater green space development, the forest garden will contribute significantly to the community's health and quality of life. There is a large body of research indicating the benefits of green spaces in developed areas in providing a unique aesthetic experience amidst a world of concrete, improving the quality of air, and enhancing
the mental and physical well-being of participants by providing opportunities for exercise and contact with nature. Additionally, shared green space helps to foster a sense of community and social inclusion (Kazmierczak, Armitage, & James 2010). Sharing walking trails, conversation, and even food from within the forest garden will help build community among Oakwood Hills residents, contributing to their quality of life while also giving Messiah College students a chance to see community development via green space in the flesh.

**Future Opportunities**

While significant strides have been taken this semester to implement the forest garden, there is much to be done in the years to come to take full advantage of this opportunity. Rider-Musser's plans for development will certainly inform the growth of the permaculture site, but care should be taken to involve students in that process in whatever way possible. Environmental engineering and sustainability students should help design the green space and walkways if at all possible, planning for the aesthetics of the species already present and newly implemented, as well as those to come. Educational tags or plaques should be placed along the walkways, describing specific species and the nature of permaculture as whole.

The balance between wildlife and human benefits should be considered carefully. While the forest garden is surely intentionally beneficial for the humans who will experience it, it should also be beneficial for the wildlife. How the paths are developed should be considered in light of the deer population that currently inhabits the site; which and how many species are planted near the steam should be considered in light of how riparian planting affects stream temperature and consequently aquatic animals; which invasive species are removed and in what ways should be considered in light of a changing landscape and ecology; which fruit species and how many individual plants are netted to prevent bird feasting should be weighed with the foundational permaculture principle of acting within the natural systems. There are no easy solutions to these tensions, but they could provide interesting research opportunities for Messiah College students that would have direct and necessarily applications.
Conclusion

As a relatively new focus of study in the fields of agriculture and ecology, permaculture is of great significance to those interested in finding more sustainable and holistic methods of food production. In the words of Wieseman (2014, p. 4), 'Permaculture ethic is based on care for the earth, care for all people, and sharing the wealth for the greater good.' In a world that is becoming increasingly technological, these 'new' integrated methods of agriculture allow participants to look back and learn from their ancestors' relationship with the land, to reclaim a lost heritage of working with the earth instead of against it.

Weiseman (2014, p.12) also says that permaculture not only reconnects people with the land, but restores people to better relationships with each other as they integrate, share ideas, and feed each other. The innate hope of this system is boundless. As a Christian institution, one that strives to work for the restoration of all of creation as the bringing about of God's kingdom here on earth, Messiah College has an incredible opportunity to engage in revolutionary agricultural techniques through this project as a step in that direction. Through such a process, participants have the privilege of being culture shapers and architects of a more sustainable future. Permaculture is not just gardening in a forest; it is integrated, dynamic, resilient, and holistic, and is a vital step in creating a more God-glorifying landscape.

Acknowledgements

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References


Cajete, G 2000 Native Science, Clear Light Publishers, Santa Fe, New Mexico pp. 109


Jackson, W 1996, Becoming Native to This Place, Counterpoint., Washington D.C. pp. 19


Figures and Tables

Figure 1

- Elderberry
- Persimmon
- Serviceberry
- Highbush Cranberry
Figure 2
Figure 3
Table 1

<table>
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<tr>
<th>Tree Species</th>
<th>Relative Basal Area (%)</th>
<th>Relative Density (%)</th>
<th>Relative Frequency (%)</th>
<th>Overall Importance Value</th>
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Legend

*Figure 1:* Planting plan for the spring of 2016

*Figure 2:* Historical aerial images from 1937, 1967, and 1999 with corresponding forest cover.

*Figure 3:* Soil types at the project site

*Table 1:* Species at the site with importance values greater than 3.5