

*Starting from Scratch:  
Building a Forest Farm*



A Thesis Presented to the  
Faculty of the Graduate School  
of Cornell University  
in Partial Fulfillment of the Requirements for the Degree of  
Master of Professional Studies in Natural Resources

by  
C. Chad Cully  
August 2022

© C. Chad Cully

### *Abstract*

This project and its collaborations intend to serve landowners of Appalachia, both urban and rural, who are eager to incorporate one or more of the six agroforestry practices into their land-management strategies: 1) riparian buffers, 2) alley cropping, 3) forest farming under an existing canopy, 4) silvopasture, 5) windbreaks, and 6) forest gardening like a forest. Our focus is primarily forest farming and forest gardening, although all practices will be covered in outreach and instruction. As many of the eastern deciduous forests reach maturity, they will cease to be a carbon sink and become a carbon source if not managed properly. It is imperative that private landowners are provided as many tools as possible to manage these forested regions specifically for carbon and water. Food forests can assist with these goals while also creating agency for individuals and communities that desire to grapple with food security or climate change locally. Climate change adaptations are opportunities and inevitabilities.

### ***Biographical Sketch***

Chad is completing his Master of Professional Studies in Natural Resources at Cornell University, with a concentration in Agroforestry, Forest Ecology, and Ecological Restoration. He also completed an Associate of Applied Business in Sustainable Horticulture at Cincinnati State Technical and Community College and received a Bachelor of Fine Art from the Art Academy of Cincinnati.

## *Acknowledgements*

Many millions of thanks to my unofficial advisor and mentor, the “Sage of the MacDaniels Nut Grove”, Dr. Kenneth Mudge. None of this was possible if you had stayed in retirement; I am in your debt. It is my sincerest hope that the MacDaniels Nut Grove continues to be a place where our community learns and shares without any exclusivity, as modeled by you in the *Practicum in Forest Farming*. Thank you also to Dr. Stephen Morreale who offered me the opportunity of a lifetime at Cornell University. I am humbled by the generosity that you show the people around you, thank you.

To my professors from Cincinnati State, Heather Augustine, and Mark Deacon; the wisdom and encouragement you imparted on me was fundamental, and without it, I would certainly not be at Cornell. I cannot possibly thank you enough.

Steve Foltz and the Cincinnati Zoo and Botanical Garden; my experience working at the Zoo was pivotal, I have fond memories of my time working for you. The opportunities to learn about new methods, research, and plants at the Zoo was a truly unique and exceptional moment in my development.

Dr. Christopher Nietch, thank you for seeing something in me that I couldn't see. You inspired confidence that propelled me. Thank you.

Joe Hollis, thank you for accepting me as a member of your community. I believe that my time working for you was the moment where things ‘gelled’ for me. Not a single thing was possible until I became an actor in your visionary ecological theatre. The work you do at Mountain Gardens is a National Treasure in the truest sense. Thank you for all that you have done for the world and the open platform you provide us all at Mountain Gardens. You are an inspiration.

**Contents:**

*Abstract*.....3

*Biographical Sketch*.....4

*Acknowledgments*.....5

*Introduction*.....7

*Goals*.....8

*Background: (Bellevue, Kentucky and Dayton, Kentucky Natural Climate Solutions: Multistrata Urban Agroforestry in Residential Lawn-scapes)*  
.....11

*Education and Outreach: PLSCI 2260 Practicum in Forest Farming and NTRES 6940 Seminar in Agroforestry in Practice*.....28

- *Introduction*.....29
- *Syllabus from 2021-2022; PLSCI 2260 Practicum in Forest Farming/NTRES 6940 Seminar in Agroforestry and Practice*.....31

*Starting from Scratch: The Plants*.....43

- *Plant Installations at the MacDaniels Nut Grove of Cornell University and Blue Rock Station in Ohio*.....44
- *Apios americana*.....46

*Conclusions and recommendations*.....59

## *Introduction*

This project began in 2016, in Dayton, Kentucky, where about \$1200 of nursery plants were installed into a 2000 square foot peri-urban garden. Upon the maturation of many of the plants, it was observed that they might be easily multiplied for sale or for further use at 812 Dayton Avenue. Since that time, thousands of plants have been created from those original plantings of 2016 and disseminated to agroforesters in Melbourne, Kentucky; Granville, Ohio; Bellevue, Kentucky; Van Etten, New York; Cincinnati, Ohio; Boone, North Carolina; Burnsville, North Carolina; and Bluffton, South Carolina. But most notably, ongoing projects were started in Philo, Ohio and Ithaca, New York in 2018 and 2020, respectively.

In 2018, native medicinal woodland plants and berry producing shrubs were incorporated into the landscape of *Blue Rock Station* in Philo, Ohio. Thus, establishing a partnership between Jay and Annie Warmke, owners of *Blue Rock Station (BRS)*, with advisement and planting stock supplied by Chad Cully, and culminating in the expansion of the *BRS* agroforestry project into abandoned pastureland on the property in 2020. Planting at Blue Rock Station has continued, and in 2022 we marked the 5<sup>th</sup> year anniversary of the food forests at BRS. In the future we hope to continue our work in Philo and other parts of Central Appalachia, and expand our outreach to others who would like to participate in this experiment.

Since that time, the project has grown at *BRS* and transitioned to planting demonstrations within the *MacDaniels Nut Grove (MNG)* at *Cornell University*, and a 2-credit course co-taught with Dr. Kenneth Mudge in 2021 and 2022, also at *Cornell University*. Forest farm demonstrations, planting, and outreach continues in 2022 at MNG.

## *Goals*

A key realization was made in 2018, when plantings began at BRS: We could not continue our work in a reasonable timeframe without propagating plant material for ourselves, due to expense. Upon beginning a project of this type, land managers at properties like BRS and the MacDaniels Nut Grove (MNG) will be faced with their first big hurdle, the expense of plant material. We seek to trial plants and fungi that might be propagated easily, with limited expense, experience, or facilities, which also perform reasonably well in the shade of large trees. Because ultimately, our main motivation is to create livelihoods that preserve trees and forests.

Discovering and choosing plant material that performs in the shade (forest farming), and provides a marketable harvest of some type, is a big and intimidating first step for an aspiring forest farmer. It's doubly difficult because books or primary literature often cannot solve problems on very local scales. For example, Philo, Ohio is in USDA planting zone 6b, and at a glance, Dayton, Kentucky is, too. However, at my home in Dayton, Kentucky, I can attest that my neighborhood operates like USDA planting zone 7.

Between BRS and Dayton, we were finding that some plants didn't really work in Philo. Dayton often has different soil, due to its proximity to the Ohio River. Temperature fluctuations seem buffered by the river and the urban heat island. The result is a slightly different set of parameters. Philo tends to be excessively dry, with hard packed clay in the late summer, and much colder winters. Even if we compare Dayton, KY to neighborhoods just slightly north of the immediate downtown Cincinnati area, we find a similar phenomenon.

In terms of selecting plants that are meant to provide a harvest of food or medicine, these subtle changes mean a lot, especially if the study area is in the shade. Working hyper-locally is important. When first time forest farmers purchase expensive nursery plants for the first time it would be nice if extension workers could provide a list of five or ten \*potentially successful\* plants

to people in each county and to also note the various micro-climates and soils in the region that could change the parameters. Adoption and success in these multi-functional forest gardens is important as climates become volatile.

We hope to inspire practical and achievable first steps that will build confidence and increased adoption by new practitioners. Ultimately, new forest farmers might protect large healthy trees by maximizing growing space and creating income opportunities without removing large old trees that store carbon and perpetuate healthy forests and stormwater management. We will provide step-by-step instruction, focused on affordable plant propagation and practically minded plant selection for beginning agroforesters.

The aligning circumstances of an existing forest canopy and shade farming could in theory combine to extend the duration between timber harvests and prolong the capture of carbon while also creating greater biodiversity. In addition to fruit, medicinal and other non-timber forest products, or nursery plants, Appalachian woodlot owners in states like Kentucky, Ohio, or New York might incorporate tree sap production and tourism to extend income opportunities; once again, maximizing carbon potential and biodiversity. Afforestation of depleted pastureland that incorporates forest gardening design strategies can help to buffer soil and water health while also achieving similar goals. The forest gardens at Blue Rock Station began this process in 2018, while the MacDaniels Nut Grove in Ithaca serves as a time-tested example of forest farming, dating back to the early 1930s. Making the MacDaniels Nut Grove in Ithaca a unique and enduring example of this practice, where so few examples of this length exist.

The goal of our educational component is to provide confidence and exposure to new plant material and methods for their propagation. Working with farmers or urban woodlot owners across different planting zones in New York, Ohio, Kentucky, North Carolina, and South Carolina has given us a much clearer picture of the best possible plant material in a changing climate for a

variety of conditions. Students will learn to identify plants and propagate them sexually; or propagate them vegetatively without spending large sums of money at a plant nursery. Ultimately, a farmer who is knowledgeable about plants and propagation can expand their design across the landscape rapidly with a small budget. In contrast to purchasing all plant material from nurseries, which would render the project dead before it began.

Through workshops and coursework, students will be instructed in the basics of plant selection, plant propagation, and nursery production. Eventually, this will lead to modules that explore the best possible location for each student's plant material; transplanting, mulching, marking, and establishment of the plants. Hands-on practice is prioritized although farmers will be exposed to the current primary literature and textbooks; the philosophical underpinnings of what makes an appropriate plant selection in these contexts, reviews of popular suppliers, materials and techniques that prioritize thriftiness and upcycling, ethnobotanical basics that aid in market exploration, and some simple design strategies of forest farming and forest gardening. The goal is open-source forest farming that practitioners might share beyond their own properties. Finally, the research portion of this project is to include crop fact sheets on all the plants that meet our project requirements at either the MacDaniels Nut Grove or Blue Rock Station (see page 46, *Apios*).

*Background:*

*Bellevue, Kentucky and  
Dayton, Kentucky Natural Climate Solutions:*

*Multistrata Urban Agroforestry in Residential Lawn-scapes*



### *Abstract*

The eastern half of the U.S. is home to many large metro areas, and temperate forest biomes. Scattered and hidden within urban areas, are vast expanses of underutilized turfgrass. Turfgrass is the largest irrigated crop in the United States (Milesi 2005). Underutilized turfgrass represents a fantastic opportunity for communities to produce natural climate solutions at a micro scale and re-learn the importance of human roles as a part of the ‘natural world’. Edible forest gardens could produce affordable and perennial subsistence strategies for households, businesses, and institutions, while also helping to offset carbon emissions. Data from the forest garden at 812 Dayton Avenue, in Dayton, Kentucky, established in 2016, is studied here to better understand the carbon impact of this style of horticulture. Random sampling data applied here shows that Cincinnati, Ohio has about 28 km<sup>2</sup> of empty turfgrass, and 2 miles away, on the south bank of the Ohio River, Bellevue and Dayton, Kentucky have an additional 1 km<sup>2</sup> of empty turfgrass. By replacing empty turfgrass with forest gardens, Cincinnati would increase annual carbon sequestration by about 28% and Bellevue and Dayton would increase sequestration by 37%. The city of Cincinnati has a target of 84% reduction in community emissions by 2050 (Cincinnati 2015), which would require a total reduction of approximately 6.3 M mt CO<sub>2</sub>e per year, down from 7.6 M mt CO<sub>2</sub>e emissions in 2015. Forest gardens in Cincinnati could reduce emissions by about 670525 mt CO<sub>2</sub>e over the next 25 years, if the results of 812 Dayton Avenue, in Dayton, Kentucky are replicated city wide.

## *Introduction*

Residential lawns are opportunities to create a variety of different natural climate solutions. In aggregate, climate solutions at a home scale can become a tool against current global changes that are outpacing cultural capacity for redirection. The purpose of this work is to illustrate the potential of aggregating urban home-scale forest gardens to sequester carbon in the temperate forest biomes of eastern North America. Carbon storage by urban U.S. trees does not represent the largest percentage of the overall carbon storage; however, the 3.2% of carbon storage in urban systems (Nowak 2013), is nearest to all the largest U.S. populations and demographic groups. Urban trees might store carbon, produce food, or manage stormwater, but those same trees serve as a reminder of human reliance and connectedness to trees and grasses, which have the power to shape the hearts and minds of everyone involved.

Turfgrass covers roughly 1.9% of the continental United States, or about 163,800 km<sup>2</sup>, which makes turfgrass the single largest irrigated crop in the United States (Milesi 2005). Moreover, Jo and McPherson (1995) noted of the participants in their urban greenspace study, “Residents indicated that most of the water was used to maintain grass” (Jo 1995). Jo and McPherson also give guidelines. They state, “The estimation of landscape carbon inputs and outputs for the study area indicated that soils and woody plants were carbon sinks, while grass was a net carbon source. Grass released annually, through mowing alone, is 1-5 times the carbon sequestered. If carbon emission at power plants in factories by grass maintenance is included (e.g., electricity used for irrigation, manufacture of fertilizers, mowers, and sprinkler systems), annual carbon release from grass would be much more significant. Therefore, less intensive grass management and reduction of lawn area are recommended to reduce carbon release” (Jo 1995).

Much of the eastern United States is privately owned land, and large amount of that space is home lawn-scape; converting turfgrass into trees, particularly in the eastern temperate deciduous

forest biomes, could drive an increase in rates of carbon sequestration, biodiversity, and much needed cooling of urban streets and homes. Forest gardening, an (unofficial) agroforestry technique, attempts to create a garden that mimics a forest. Over time, this system will become a multistrata homegarden that produces natural climate solutions from the ground upward into the tree canopies. “One general trend is that natural forests sequester the most carbon, followed by multistrata systems, followed by tree plantations, followed by annual agriculture” (Toensmeier 2016).

### ***Edible Forest Gardening and Agroforestry***

Agroforestry can be defined as, “the combination of crops (plants, animals, fungi) and trees in forest-inspired agricultural systems that benefit human communities through greater connection to landscape, improved stewardship of resources, and enhanced economic opportunities” (Mudge 2014). Five methods are generally accepted to be temperate agroforestry practices: alley cropping, riparian and upland buffers, silvopasture, windbreaks, and forest farming. Forest gardening is not generally considered an agroforestry technique, so this warrants more clarification. It seems that forest *gardening* and forest *farming* are essentially the same, but the simple difference is that forest *gardening* starts with an empty space, whereas forest farming attempts to farm under an existing tree canopy.

The results can be very similar but starting with an empty residential lawn-space affords a very liberal plant selection and process, while farming under an existing forest canopy is not only less likely in urban areas, but less likely to resemble the local forests. Of course, much of the space is already being used in an existing forest, as well. Other factors, like urban heat islands, which on average make the growing season 15 days longer in urban areas (Raciti 2012), or increased C and N in urban soils (Raciti 2008), demand that forest gardeners select plants for urban ecosystems that may not perform well outside the city, even at the same latitude. For example, our study area of

'812 Dayton', can grow *Camellia sinensis*, a plant that typically grows in the planting zone to the south of us, but not in ours. Without the urban heat island, this would probably not be possible. In essence, although urban lawns are small, these spaces might offer some different opportunities not given to their rural counterparts.

Interestingly, residential lawns, *because* they are small, also make possible a range of choices that would otherwise be cost or time prohibitive. Fencing or irrigating is expensive on large farms, but on a small peri-urban residential lawn a bigger range of quality products are affordable for many individuals or households. Again, *because* urban lawns are small, it's possible that more residents can afford the plants, materials, *and* most importantly, *the time* to maintain a small plot. Greater accessibility means that forest gardens could become relatively affordable ways for most people to create small and regular subsistence strategies in private lawn-scapes (including part-time work). As more people take up these practices; increasing biodiversity, storing carbon, managing stormwater, strengthening marginalized communities, and re-building connections to the earth, all become powerful realities.

Edible forest gardening incorporates useful (food, medicine, fuel, fiber, fodder, fertilizer) herbs, vines, shrubs, and root crops underneath taller trees. "In other words, a forest garden is an edible ecosystem, a consciously designed community of mutually beneficial plants and animals intended for human food production" (Jacke 2005). Although the focus of this style of horticulture is typically food or medicine, it's often noted by many practitioners, that forest gardens serve multiple purposes, not excluding income opportunities, management of stormwater runoff, or carbon storage. "Food is recognized as an iconic entryway into the consciousness of communities and a common pathway for generating excitement and building momentum around urban forest gardens; however, forest ecosystems provide more than food and addressing cultural connections to other products and services can increase the meaning and magnitude of associated civic and

environmental outputs” (Hemmelgarn 2020). The focus of this work is to determine the usefulness of home-scale forest gardens both in isolation or as a community of small farms, and their contribution as a natural climate solution.

Forest gardening is factored into the carbon storage potential of the communities of Bellevue/Dayton, Kentucky, along with the city of Cincinnati, Ohio. Two temperate forest gardens are referenced. The first is the forest garden of the Agroforestry Research Trust in Devon, UK (Lehmann 2019), and the second is a private residence located at 812 Dayton Avenue in Dayton, Kentucky. The Agroforestry Research trust was established in 1992, and ‘812 Dayton Ave.’ was established in 2016. Both forest gardens are small, home-scale plots: 0.64 ha and 0.01804 ha in size, respectively. These small-scale demonstration areas are applicable to many of the homes in the peri-urban areas of Cincinnati, including Bellevue and Dayton, Kentucky. Because substantial carbon data was collected in Devon, comparing these two gardens together helps give a more complete picture of temperate forest gardens regarding carbon.

### *Methods*

Raciti et al. defines ‘urban’ as a 990 x 990 m neighborhood with at least 25% impervious surface area (Raciti 2012). Approximately 24% of Bellevue/Dayton is impervious surface area (ISA), and nearly 14% is miscellaneous underutilized private turfgrass or roadsides (i-Tree Canopy 2021). Within the city of Cincinnati city limits, about 34% is impervious surface area (ISA), and is also about 14% miscellaneous underutilized private turfgrass or roadsides (i-Tree Canopy 2021). The combination of Northern Kentucky neighborhoods is about 7.42 km<sup>2</sup>, and the city of Cincinnati contains roughly 206 km<sup>2</sup> (i-Tree Canopy). All these cities have an average temperature of about 13° C, contain mostly urban complex soil, and receive about 113 cm of rain each year. Devon, UK has an average temperature of 11° C and 83 cm of precipitation.

Randomized sampling done with i-Tree Canopy v7.1, in May of 2021 was conducted with the main goal of finding empty or underutilized turfgrass in the urban Cincinnati area, although consideration was made for other types of formations, including ISA. Underutilized turfgrass area is of particular consideration primarily because it appears to be a carbon source (Jo 1995), and reversing this trend, even minimally, is of critical importance regarding global climate change. Micro-scale and home forest gardens spread the cost and labor out, but also are likely to focus the cost on residential landscapes of greater size, and correspondingly, points more at communities with the necessary means to accomplish and maintain dense forest garden canopies. “The diversity of products harvested from these long term perennialized gardens also contributes to social and economic development, where women, in particular, participate in and benefit from the homegarden culture as stewards of knowledge, seeds, and harvests” (Hemmelgarn 2020). Future research and conversation should be undertaken to investigate inequities or sociocultural improvements that this horticultural practice might create.

The results of these surveys conducted for the region produced some information regarding carbon sequestration and carbon storage. These figures were compared to field data from 812 Dayton Ave, as well as previous peer reviewed literature on urban forestry and greenspace. Any turfgrass plots (random computer samples) that landed in parks, sporting/recreation areas, cemeteries, airports, golf courses, levees, or otherwise useful turfgrass is not categorized in this study as ‘underutilized’ and are therefore not recognized as a candidate for use as a forest garden. Careful consideration was made for each plot (seasons, construction, time, utility ROW), and intimate knowledge of the landscape features contributed to more accurate interpretation of each location when surveyed with Google Earth and i-Tree Canopy. The estimated empty lawn space in the region also does not include agriculture in the aggregate underutilized turfgrass area.

In addition to the scientific literature cited throughout, the two online tools that were utilized to create an accurate interpretation of underutilized lawn-scapes in Bellevue/Dayton and Cincinnati, also helped to develop more accurate carbon and CO<sub>2</sub>e rates. Both the NC State Carbon Calculator and i-Tree Canopy v7.1 generated carbon estimates for the study area at '812 Dayton' that were like the results described in the primary literature focused on urban and residential areas (table 2). Of course, i-Tree Canopy v7.1 assisted in providing 800 random samples made throughout Bellevue and Dayton, 250 samples made at 812 Dayton Avenue, and 1500 samples made in the city of Cincinnati. The resulting data yielded a total Bellevue/Dayton underutilized turfgrass of around 1.01 km<sup>2</sup>, and in Cincinnati the area of underutilized turfgrass was about 28 km<sup>2</sup>.

After collecting estimates (tables 1 & 3), the data from '812 Dayton' will be applied to the rest of the 7.42 km<sup>2</sup> in Bellevue/Dayton and the 206 km<sup>2</sup> in Cincinnati. Urban carbon storage regionally, averaged with the food forest in Devon, UK, are around 38947 kgCha<sup>-1</sup> (table 2) (Lehmann 2019, Raciti 2012, Nowak 2001) are below the typical urban forests, about 116000 kgCha<sup>-1</sup> (table 2) (Raciti 2012), and still less than the carbon storage at 812 Dayton, about 51045 – 65998 kgCha<sup>-1</sup> (table 2) (NC State, i-Tree Canopy). The range of CO<sub>2</sub>e for table 2 is roughly 142806 kgCO<sub>2</sub>eha<sup>-1</sup> to 425333 kgCO<sub>2</sub>eha<sup>-1</sup>. Measurements for each tree was made on-site in Dayton, KY for the NC State Carbon Calculator and i-Tree data is derived from random sampling.

Carbon sequestration rates from (table 3) are also averaged, arriving at 1547 kgCha<sup>-1</sup>yr<sup>-1</sup>. Measurements of each tree, made on site at '812 Dayton', using methods described in Zirkle (2012), produced a nearly identical rate of 2610 kgCha<sup>-1</sup>yr<sup>-1</sup>, to the 2615 kgCha<sup>-1</sup>yr<sup>-1</sup> estimate given by i-Tree Canopy. The average urban area in the U.S. falls somewhere around 2050 kgCha<sup>-1</sup>yr<sup>-1</sup> (Nowak 2013), consistent with random and field samples in this study. Extrapolating from the rate derived in (Zirkle 2012), *'812 Dayton' sequesters carbon at a rate of 9570 CO<sub>2</sub>e ha<sup>-1</sup> yr<sup>-1</sup>*. A very encouraging

number, for a small space. This (9570 CO<sub>2</sub>e ha<sup>-1</sup> yr<sup>-1</sup>) is the figure used to scale up from Dayton Ave. to Cincinnati and Northern Kentucky.

### ***Results***

Scaling up to apply the rates from the forest garden at 812 Dayton, illustrates the carbon potential in greater detail. Dayton and Bellevue contain about 1.01 km<sup>2</sup> of underutilized turfgrass or 101 ha and the city of Cincinnati contains about 28 km<sup>2</sup> of underutilized turfgrass. Applying the rates of sequestration made at 812 Dayton Avenue to the cities of Cincinnati and Bellevue/Dayton produces significant increases in CO<sub>2</sub>e sequestered by urban trees. Cincinnati could see a 28% increase and Bellevue/Dayton would see a 37% increase. Over time, the backyards of cities could work with forests to regulate the carbon feedbacks produced by emissions, while producing food for humans and habitat for birds. The results could factor into the long-term carbon emissions goals and tree programs that cities are developing. However, what's important is not necessarily that this works, or even the cumulative effects of the trees; intuitively everyone knows that urban areas need more trees.

“Urban forest research has the opportunity to advance science by increasing our awareness of people's relationship with the land. Because urban forests are largely created and maintained by people, urban research is inevitably people oriented. Urban forest research and monitoring programs can train, educate, and include people in their studies. Science and environmental education programs can be integrated to reach urban populations that otherwise would have little contact with the natural resources” (McPherson 1997).

The magic of a forest garden is at the intersection of management, planning, and the harvest. The emotional impact of forest gardens will help to change hearts and minds and shouldn't be discounted as an unscientific strategy to combat climate breakdown. Generations of families living

under a patch of paw paws or a canopy of persimmons, defining their relationships with trees and birds, as opposed to empty lawns, are generations of people that understand and care about the lives that the trees support. It is truly impossible to overstate the importance of trees, and the cumulative understanding that comes with every successive year of harvesting and stewarding a small forest garden. The benefits of aggregating urban forest gardens in cities would create negative feedbacks in carbon over time, and the benefits of replacing turfgrass with forest gardens is a finer point that we typically overlook. After all, we only notice the shade of large trees in the middle of the summer. And these trees still do more by annually removing noticeable amounts of, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter; all of which do damage to the lungs first, but many other human organs as well, even affecting cognitive function. Trees create such a long list of improvements to our world, it's difficult to project comprehensively.

In 2015, Cincinnati set a goal of an 84% reduction in community emissions by 2050. Current estimates from i-Tree Canopy, in this study, indicate that within the city limits of Cincinnati, current trees sequester about 93000 mt CO<sub>2</sub>e yr<sup>-1</sup>. Utilizing all the empty turfgrass in Cincinnati at the same rate as '812 Dayton' (excluding parks, cemeteries, etc.), would add an additional 26821 mt CO<sub>2</sub>e yr<sup>-1</sup> of sequestration. This is a 28% increase over current sequestration by trees. Over 25 years this adds up to an additional 670525 mt CO<sub>2</sub>e toward the 84% reduction goal of Cincinnati (Cincinnati 2015). Cincinnati recently reported 7.6 M mt CO<sub>2</sub>e emitted in 2015 (Cincinnati 2015). This increase in sequestration amounts to significant gains over 25 years.

The results in this study show that converting underutilized turfgrass into forest gardens could have significant impacts on the carbon cycle. Urban trees don't represent the biggest impact to the carbon cycle, globally, so it's important that future research on this topic should explore the sociocultural impacts of urban forest gardens. How we feel about our lived environment impacts the health of a city in many ways, and considering that most humans now live in urban areas, ideas like

this are relevant to many people. Home lawns are a great place to interact with native trees or store carbon. They're also an excellent place to grow food and medicine. It's also important to note, properly managing urban trees means continually replanting and caring for existing trees. Improperly managed trees, poor plant selection, or inconsiderate locating of plants into the landscape could drastically impact the ability of the urban ecosystem to sequester carbon. Ongoing research and oversight by local parks districts and extension agencies will help improve outcomes. The real reason to grow an urban forest garden may not be just carbon storage alone. Still, results here show that increasing urban canopy can produce changes in carbon sequestration.

### *Conclusions*

Nowak and Crane compare carbon emissions from automobiles to offsets by trees by noting: "In a simulation of planting 10 million trees annually in energy conserving locations over a 10-year period with 100% survival rates, carbon storage by these trees at year 50 was estimated to be 77 million tonnes of carbon, with carbon avoidance from power plants at 286 million tC. In this case, the potential carbon avoidance was four times greater than the direct carbon sequestration rate. The total carbon stored and avoided by the 100 million trees (363 million tC) is  $\leq 1\%$  of the estimated amount of carbon emitted in the USA over the same 50-year period. Increasing fuel efficiency of passenger automobiles by 0.5 km/l over 50 years would also produce the same carbon effects as the 100 million trees (Nowak 2001)". The preceding statement tells us just how difficult it is to offset automobile emissions as more households continue to rely on automotive transportation. Clearly, reducing emissions must be a part of the path forward if humans value things like clean air, trees, and biodiversity. Simply planting trees, in any case, especially in cities, will not solve the entire problem.

Another item of concern in urban areas, although not discussed at length here, is nitrogen deposition. The results of one study show that urban lawns might sequester atmospheric-N deposition in vegetation and surface soils at similar or higher rates than some forests (Raciti 2008). Nitrogen deposition can acidify soils and watersheds, but also has the power to alter the production of urban ecosystems. Urban areas typically experience higher rates of nitrogen deposition, due to emissions. At first glance, it might seem that higher nitrogen deposition, higher average temperatures, and rising atmospheric CO<sup>2</sup>, would increase carbon and nitrogen storage for urban lawns. But this is not a simple problem. “A major question is how long lawns can continue to sequester high inputs of N. Previous research suggests that lawns may decrease in their capacity to retain nitrogen as they age, thereby increasing the potential for over fertilization” (Raciti 2008).

To complicate things a bit more, it is not perfectly well understood how increased long-term N deposition in urban areas will change long-term production of urban forests and residential ecosystems, as rising temperatures in urban areas also increase decomposition. “The broader evidence for C and N sequestration in the urban and residential soils suggest that changes associated with urbanization tend to increase plant productivity and enhance soil C and N sequestration more strongly than they enhance decomposition; however, in this study, the evidence for N sequestration is more compelling than the evidence for C sequestration, which suggests that increased N inputs to the system may not lead to stoichiometrically equivalent increases in soil C sequestration (Raciti 2012)”. Greater research is needed to develop a fuller understanding of urban nitrogen and carbon cycles.

Finally, none of this should be discouraging. Urban forest gardens are fantastic avenues for retreat and inspiration. Intimate relationships with trees or forests, even in urban areas, are of great value, and the importance of this cannot be overstated. Trees literally save lives. A recent study published in 2021, found that existing tree cover in Baltimore, Maryland reduced annual mortality

by 543 deaths (Sinha 2021). In the summer of 2020, 812 Dayton Ave. produced 62 lbs. (28.12 kg) of food and medicine, during the global SARS-CoV-2 pandemic. And again, in the summer of 2021 the Dayton Ave. property produced 68 lbs. (30.8 kg) of food. Every 170 g of blueberries delivered from Chile to nearby Indiana cost about 0.3 kgCO<sub>2</sub>e (Chapa 2019). Purchasing 62 lbs. of blueberries from the neighborhood grocery would cost about 49.6 kgCO<sub>2</sub>e, in carbon terms. Maybe the fruit harvested, or the carbon sequestered at 812 Dayton Ave hardly made a dent in the U.S. carbon budget; but projects like this create agency for individuals and communities that desire to grapple with food security and climate change locally and could inspire other communities to do the same thing.

## Tables:

Table 1	<u>Carbon storage</u>		
	<i>biomass</i>	<i>location</i>	<i>rate per kg C ha<sup>-1</sup></i>
Lehmann 2019	<b>Avg. understory</b>	Devon, UK food forest	3690 kg C ha <sup>-1</sup>
Lehmann 2019	<b>Avg. overstory</b>	Devon, UK food forest	39530 kg C ha <sup>-1</sup>
Raciti 2012	<b>Avg. residential</b>	Boston, USA (MSA)	46000 kg C ha <sup>-1</sup>
Nowak 2001	<b>Avg. urban</b>	Ohio, USA	35400 kg C ha <sup>-1</sup>
Nowak 2001	<b>Avg. urban</b>	Kentucky, USA	30900 kg C ha <sup>-1</sup>

Table 2	<u>Carbon storage comparison</u>	
	<i>biomass surveyed</i>	<i>rate per kg C ha<sup>-1</sup></i>
Avg. from table 1	urban residential	38947 kg C ha <sup>-1</sup>
Raciti 2012	Avg. urban forest (Boston MSA)	116000 kg C ha <sup>-1</sup>
i - tree	812 Dayton Ave.	65998 kg C ha <sup>-1</sup>
NC State	812 Dayton Ave.	51045 kg C ha <sup>-1</sup>

Table 3	<u>Carbon sequestration rates</u>		
	<i>biomass</i>	<i>location</i>	<i>rate per kg C ha<sup>-1</sup> yr<sup>-1</sup></i>
Lehmann 2019	<b>Avg. understory</b>	Devon, UK forest garden	160 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Lehmann 2019	<b>Avg. overstory</b>	Devon, UK forest garden	1880 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Nowak 2001	<b>Avg. urban</b>	Kentucky, USA	1000 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Nowak 2001	<b>Avg. urban</b>	Ohio, USA	1100 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Nowak <u>2013</u>	<b>Avg. urban</b>	Milwaukee, WI	1780 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Nowak <u>2013</u>	<b>Avg. urban</b>	Boston, MA	1680 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Nowak <u>2013</u>	<b>Avg. urban</b>	Baltimore, MD	1680 kg C ha <sup>-1</sup> yr <sup>-1</sup>

Table 4	<u>Carbon sequestration comparison</u>		
	<i>biomass</i>	<i>location</i>	<i>rate per kg C ha<sup>-1</sup> yr<sup>-1</sup></i>
Zirkle 2012	<b>Avg. tree</b>	812 Dayton Ave. forest garden: 3.4 - 5.9 kg C x number of trees (4)	1031 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Zirkle 2012	<b>Avg. shrub</b>	812 Dayton Ave. forest garden: 0.07 - 0.23 kg C x number of shrubs (106)	881 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Zirkle 2012	<b>Avg. turf</b>	812 Dayton Ave. forest garden: (254 - 2043 kg C ha <sup>-1</sup> yr <sup>-1</sup> )	avg. min. turf @ 698 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Zirkle 2012	total from 1st three rows	812 Dayton Ave.	2610 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Avg. from table 3	<b>Avg. urban/residential</b>	multiple locations	1547 kg C ha <sup>-1</sup> yr <sup>-1</sup>
i - tree	<b>Avg. urban residential</b>	812 Dayton Ave.	2615 kg C ha <sup>-1</sup> yr <sup>-1</sup>
Nowak 2013	<b>Avg. urban</b>	USA avg.	2050 kg C ha <sup>-1</sup> yr <sup>-1</sup>

table 5	<b><u>CO<sub>2</sub>e storage and sequestration comparison</u></b>		
	<i>location</i>	<i>rate of CO<sub>2</sub>e sequestered (kgCO<sub>2</sub>e ha<sup>-1</sup>yr<sup>-1</sup>)</i>	<i>stored CO<sub>2</sub>e (kgCO<sub>2</sub>e ha<sup>-1</sup>)</i>
i-Tree, Zirkle, NC State	812 Dayton	9579 kg CO <sub>2</sub> e ha <sup>-1</sup> yr <sup>-1</sup>	214579 kgCO <sub>2</sub> e ha <sup>-1</sup>
Lehmann 2019	Devon, UK	7480 kg CO <sub>2</sub> e ha <sup>-1</sup> yr <sup>-1</sup>	158473 kgCO <sub>2</sub> e ha <sup>-1</sup>
Nowak 2001	AVG urban for OH & KY	3850 kg CO <sub>2</sub> e ha <sup>-1</sup> yr <sup>-1</sup>	121550 kgCO <sub>2</sub> e ha <sup>-1</sup>
Nowak 2013	AVG urban for nearby Mil, Bos, Bal	6282 kg CO <sub>2</sub> e ha <sup>-1</sup> yr <sup>-1</sup>	.....
Raciti 2012	AVG urban forest (Boston- MSA)	.....	168667 kgCO <sub>2</sub> e ha <sup>-1</sup>
Nowak 2013	USA urban forests AVG	7517 kg CO <sub>2</sub> e ha <sup>-1</sup> yr <sup>-1</sup>	.....
all	AVG all sequestration	6798 kg CO <sub>2</sub> e ha <sup>-1</sup> yr <sup>-1</sup>	.....
all	AVG all storage	.....	166065 kgCO <sub>2</sub> e ha <sup>-1</sup>

table 6	<b><u>CO<sub>2</sub>e Sequestration Comparison</u></b>					
	<i>location</i>	<i>total area</i>	<i>area of underutilized turfgrass</i>	<i>current rate of sequestration by urban trees in mt CO<sub>2</sub>e (i-Tree)</i>	<i>amount of increase if (x) km<sup>2</sup> of underutilized turfgrass is converted to 812 Dayton 'forest garden'</i>	<i>% increase</i>
i-Tree, Zirkle (812 Dayton)	Bellevue/Dayton, KY	7.42 km <sup>2</sup>	1.01 km <sup>2</sup>	2579 mt CO <sub>2</sub> e yr <sup>-1</sup>	967 mt CO <sub>2</sub> e yr <sup>-1</sup>	37% increase
i-Tree, Zirkle (812 Dayton)	City of Cincinnati	206 km <sup>2</sup>	28 km <sup>2</sup>	93000 mt CO <sub>2</sub> e yr <sup>-1</sup>	26821 mt CO <sub>2</sub> e yr <sup>-1</sup>	28% increase

## **References:**

Cincinnati Greenhouse Gas Inventory and Analysis. (2015). City of Cincinnati Environment & Sustainability. <https://www.cincinnati-oh.gov/oes/climate/2015-greenhouse-gas-emissions-inventory-pdf/>.

Chapa, James; Salazar T, Maria Belen; Kipp, Sierra; Cai, Hua; Huang, Jen-Yi. (2019). A comparative life cycle assessment of fresh imported and frozen domestic organic blueberries consumed in Indiana. *Journal of Cleaner Production*, Volume 217, 2019, Pages 716-723, ISSN 0959-6526. <https://doi.org/10.1016/j.jclepro.2019.01.237>.

Feliciano, D.; Ledo, A.; Hillier, J.; Nayak, D.R. (2017). Which agroforestry options give the greatest soil and above ground carbon benefits in different world regions? *Agriculture, Ecosystems & Environment*, Volume 254, 2018, Pages 117-129, ISSN 0167-8809. <https://doi.org/10.1016/j.agee.2017.11.032>.

Griscom, B.W.; Adams, J.; Ellis, P.W. et al. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences – USA*. 114:11645-11650. <https://doi.org/10.1073/pnas.1710465114>

Hemmelgarn, Hannah and Munsell, John. (2020). Exploring beyond-food opportunities for biocultural conservation in urban forest gardens. *Urban Agriculture and Regional Food Systems*, volume 6 issue 1. <https://doi-org.proxy.library.cornell.edu/10.1002/uar2.20009>.

Huai, H.; Hamilton, A. (2009). Characteristics and functions of traditional homegardens: a review. *Front. Biol. China* 4, 151–157. <https://doi.org/10.1007/s11515-008-0103-1>

i-Tree Canopy. (2021). i-Tree Software Suite v7.1. Web accessed 05/01/2021 – 05/18/2021. <http://www.itreetools.org>

Jacke, David; and Toensmeier. (2005). *Edible Forest Gardens, Ecological Vision and Theory for Temperate Climate Permaculture*. White River Junction, Vermont, United States: Chelsea Green Publishing.

Jo, Hyun-Kil; McPherson, Gregory E. (1995). Carbon storage and flux in urban residential greenspace. *Journal of Environmental Management*. 45(2): 109-133. <https://doi.org/10.1006/jema.1995.0062>.

Lehmann, Lisa Mølgaard; Lysák, Marin; Schafer, Luke; Henriksen, Christian Bugge. (2019). Quantification of the understorey contribution to carbon storage in a peri-urban temperate food forest. *Urban Forestry & Urban Greening*, Volume 45, 2019, 126359, ISSN 1618-8667. <https://doi.org/10.1016/j.ufug.2019.06.002>.

McPherson, E.G., Nowak, D., Heisler, G. et al. (1997). Quantifying urban forest structure, function, and value: the Chicago Urban Forest Climate Project. *Urban Ecosystems* 1, 49–61 (1997). <https://doi.org/10.1023/A:1014350822458>.

Milesi, C., Running, S.W., Elvidge, C.D. et al. (2005). Mapping and Modeling the Biogeochemical Cycling of Turf Grasses in the United States. *Environmental Management* 36, 426–438 (2005). <https://doi-org.proxy.library.cornell.edu/10.1007/s00267-004-0316-2>.

Mudge, K., Gabriel, S. (2014). *Farming the Woods: An Integrated Permaculture Approach to Growing Food and Medicinals in Temperate Forests*. United States: Chelsea Green Publishing.

North Carolina State Carbon Calculator. (2021). The Carbon Calculator 2011 – present. Web accessed 05/01/2021 – 05/18/2021. <http://www.carboncalculator.ncsu.edu/>.

Nowak, David J.; Crane, Daniel E. (2001). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution*, Volume 116, Issue 3, 2002, Pages 381-389, ISSN 0269-7491. [https://doi.org/10.1016/S0269-7491\(01\)00214-7](https://doi.org/10.1016/S0269-7491(01)00214-7).

Nowak, David J.; Greenfield, Eric J.; Hoehn, Robert E.; Lapoint, Elizabeth. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States, *Environmental Pollution*, Volume 178, 2013, Pages 229-236, ISSN 0269-7491. <https://doi.org/10.1016/j.envpol.2013.03.019>.

Raciti SR, Groffman PM, and Fahey TJ. (2008). Nitrogen retention in urban lawns and forests. *Ecological Applications* 18: 1615–26. <https://doi-org.proxy.library.cornell.edu/10.1890/07-1062.1>

Raciti, S.M.; Groffman, P.M.; Jenkins, J.C. et al. (2011). Accumulation of Carbon and Nitrogen in Residential Soils with Different Land-Use Histories. *Ecosystems* 14, 287–297 (2011). <https://doi.org/10.1007/s10021-010-9409-3>

Raciti, S.M.; Hutrya, L.R.; Rao, P.; Finzi, A.C. (2012). Inconsistent definitions of “urban” result in different conclusions about the size of urban carbon and nitrogen stocks. *Ecological Applications*, 22: 1015-1035. <https://doi-org.proxy.library.cornell.edu/10.1890/11-1250.1>

Reinmann, Andrew. (2016). "Edge effects enhance carbon uptake and its vulnerability to climate change in temperate broadleaf forests". <https://doi-org.proxy.library.cornell.edu/10.7910/DVN/AZGSQV>. Harvard Dataverse, V1, UNF:6:5DohL7oEeTPOzs7ELcWVzA== [fileUNF]

Sinha, Paramita; Coville, Robert C; Hirabayashi, Satoshi; Lim, Brian; Endreny, Theodore A; Nowak, David J. (2021). Modeling lives saved from extreme heat by urban tree cover, *Ecological Modeling*, Volume 449, 2021, 109553, ISSN 0304-3800. <https://doi.org/10.1016/j.ecolmodel.2021.109553>.

Toensmeier, E.; Herren, H. R. (2016). *The Carbon Farming Solution: A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security*. White River Junction, Vermont, United States: Chelsea Green Publishing.

Zirkle, Gina; Lal, Rattan; Augustin, Bruce. (2011). Modeling Carbon Sequestration in Home Lawns. Carbon Management and Sequestration Center, The Ohio State University, Columbus OH 43210; The Scotts Miracle-Gro Company, Marysville, OH 43041. *American Society for Horticultural Science*, Volume 46, 2011: Issue 5 (May 2011) in *HortScience*, Page Count: 808–814, Print ISSN: 0018-5345, Online ISSN: 2327-9834. DOI: <https://doi.org/10.21273/HORTSCI.46.5.808>.

Zirkle, G.; Lal, R.; Augustin, B.; Follett R. (2012). Modeling Carbon Sequestration in the U.S. Residential Landscape. In: Lal R., Augustin B. (eds) *Carbon Sequestration in Urban Ecosystems*. Springer, Dordrecht. [https://doi.org/10.1007/978-94-007-2366-5\\_14](https://doi.org/10.1007/978-94-007-2366-5_14)

*Education and Outreach:*

*PLSCI 2260/NTRES 6940  
PRACTICUM IN FOREST FARMING/  
Seminar in Agroforestry in Practice*



## *Introduction*

Beginning in the summer of 2020, plans were made to bring back the *Practicum in Forest Farming* course taught at the MacDaniels Nut Grove by Dr. Kenneth Mudge from the School of Integrative Plant Science. Dr. Mudge taught the course in the early and mid-2000s but had since retired. The Nut Grove had been largely unmanaged since around 2015. We were lucky to have the encouragement of Dr. Stephen Morreale, who united us all with his interest in reviving the site and the course.

Throughout the summer of 2020, the collection and propagation of plant material began at the forest gardens on 812 Dayton Avenue, in Dayton, Kentucky. Plant material was sourced on-site in Dayton, under the advisement of Dr. Morreale and Dr. Mudge. I carefully followed directions in the USDA Woody Plant Seed Manual and incorporated books by Michael A. Dirr where needed, to collect, clean, store, and stratify seeds for propagation and use at the MacDaniels Nut Grove. Occasionally, seeds were collected from the parks in Cincinnati, Ohio, if unavailable on my property at 812 Dayton Avenue.

The potted plants from Kentucky would eventually become part of course modules at Cornell, and site restoration in the forest farming course with Dr. Mudge at the Nut Grove. Several hundred berry bushes, woodland medicinals, and nut trees were grown out and eventually I transported them to Ithaca from Kentucky. In the spring of 2021, the plants now at Cornell University, were cared for at the Kenneth Post Laboratory Greenhouses until the Practicum in Forest Farming in the fall of 2021. The small plant nursery persists at KPL currently and continues to be a cornerstone of both classroom modules and MacDaniels Nut Grove restoration in 2022.

Over the course of the summer of 2021, general maintenance to the Nut Grove was a daily affair. Trails were re-cut, water lines re-drawn, and mushroom logs were re-stacked and sorted. The Nut Grove classroom was rebuilt with fresh locust logs, and new stairs were dug into the hillside

with leftover logs. Invasive plant removal was performed where possible, and new garden beds were established with the plants from Kentucky in place of them. General maintenance and upkeep of the Nut Grove continues in 2022. Starting in July of 2022, I began installation of several hundred seedling trees, shrubs, and herbs in the Nut Grove. Planting will continue until the end of 2022.

The final piece of the puzzle, the syllabus, lives on today as part of the course in 2022. Dr. Mudge unearthed the syllabus from years past and we revised the contract for the 2021 course. The 2021 course was originally listed as PLSCI 2260, but in 2022 was expanded to add a module for graduate students. In 2022 the course is co-listed as PLSCI 2260 PRACTICUM IN FOREST FARMING/NTRES 6940 Seminar in Agroforestry in Practice. What follows is the syllabus from 2021, which has been updated for the 2022 course. Both were collaborations between Dr. Mudge and Chad Cully.

Revised 8/18/22

PLSCI 2260  
PRACTICUM IN FOREST FARMING -  
NTRES 6940 Seminar in Agroforestry in Practice

Syllabus for Fall, 2022  
1 or 2 credits, S-U option  
Thursday 1:30-4:30

Location:

- 1<sup>st</sup> class, August 25 – Meet in KPL 170 classroom > walk to MacDaniels Nut Grove (MNG)
- *Saturday Field Trip to Arnot Forest, October 15<sup>th</sup> (9-5)*
- *Field Trip to Hawk Meadow Farm, Thursday, September 22*
- Group oral presentations/feast – December 1, 2022
- All sessions, unless otherwise noted – @ MacDaniels Nut Grove

Attendance: Do your best to be on time. Most of our classes will be held in the MacDaniels Nut Grove near the Cornell Library Annex. It's a long bike ride or walk, so we won't take attendance until 2pm, but please try to be in class at 1:30pm if you are able to make it by that time. The course is very craft-based, so being in class is important. Most of your grade is based on participation and attendance.

Instructors:

*Kenneth W. Mudge*, Professor Emeritus, Section of Horticulture,  
607.339.6950, [kwm2@cornell.edu](mailto:kwm2@cornell.edu)

*Chad Cully*, Department of Natural Resources and the Environment,  
859.907.2851, [ccc289@cornell.edu](mailto:ccc289@cornell.edu)

*Stephen Morreale*, Associate Professor, Department of Natural Resources and the  
Environment, [sjm11@cornell.edu](mailto:sjm11@cornell.edu)

*Tom Whitlow*, Professor Emeritus, School of Integrative Plant Science, [thw2@cornell.edu](mailto:thw2@cornell.edu)

What is Forest Farming?

Forest Farming is one of several agroforestry practices.

Agroforestry is any intensive land-use management practice combining trees and/or shrubs with crops and/or livestock in order to achieve economic, ecological, and/or social benefits. Agroforestry consists of five interrelated practices. *Agroforestry practices* include forest farming, alley cropping, silvopasture, riparian buffers, windbreaks, and forest gardening/food forests.

Forest Farming is an ecologically based *agroforestry* practice involving the sustainable production of non-timber forest products (NTFPs) within an existing forest or woodlot. It is particularly well suited for the Northeast, given the abundance of privately-owned forest land.

An understanding of forest ecology is important for the design of environmentally sustainable forest farming systems. Forest farming has much in common with the ecologically based approach to design known as *permaculture*.

## **Course Description**

*Practicum in Forest Farming* is a hands-on, experiential learning opportunity for students who wish to acquire the skills involved in planning and implementing the agroforestry practice known as forest farming. This course will involve working with and learning about various non-timber forest products (NTFPs), forest site assessment, design, and the implementation of a crop-oriented group project. Weekly hands-on activities will be integrated with reading assignments and through the process of journaling.

Students will be directly involved with the planning and management of the forest farm and public demonstration sites. This will include not only physical (and biological) development of the actual site, but will also contribute to the planning of the site and development of interpretive resources for public education.

## **Course learning outcomes:**

- Work with cultivated plants in a natural forest ecosystem.
- Compare the biological and ethical consequences of non-traditional agroforestry/forest farming to traditional agricultural systems (horticulture, agronomy).
- Explain the concept of productive conservation as it applies to forest farming.
- Integrate sustainable forest farming practices in natural forest ecosystems with minimal negative ecological consequences.
- Empowering ourselves as land managers and forest farmers to sustain the health of forest trees and ecosystems, while recognizing our own needs for resource and economy.
- To respect the legacy of our forests and recognize how we have changed that trajectory.

## **Textbook:**

*Farming the Woods* by Ken Mudge and Steve Gabriel, 2015, Chelsea Green Publishers

## **Location of the MacDaniels Nut Grove (MNG).**

MNG is located to the South of the Cornell Orchards and just to the North of Cascadilla Creek along the East Hill Recreation Way. It lies to the West of the Library Annex, and East of the Dilmun Hill Student Farm (Blair Barn). You can approach by foot from either the Dilmun Farm, along the East Hill Recreation Way, or from the Library Annex.

**From the Dilmun barn** (Blair Barn), access the East Hill Recreation Way (EHRW), through a gate across the field, SW of the barn, up the stairs to the paved Recreation Way. Turn left and follow the paved trail approximately ¼ mile to the sign (on the left) to the MacDaniels Nut Grove. Descend the stairs, and follow the path, crossing the bridge, and you are there.

**From the Library Annex** parking area. MNG is across the open field into the woods directly west of the Library Annex. At the “MNG” (MacDaniels Nut Grove) sign, enter the woods and follow the trail, down the stairs to MNG.



## Access to course resources via CANVAS

### Activities and Timing

The schedule of activities is presented below. Changes necessitated by weather or other circumstances, will be posted via the CANVAS Announcements section. Weekly activities include: 1) Working (hands on) with and learning about non timber forest crops. 2) Development and management of the MNG (infrastructure, plantings, etc.). 3) Field trips to local sites involved in forest farming activities.

Each week one of the main instructors or guest instructors will teach various skills associated with forest farming including mushroom and ginseng cultivation, nursery production and planting non timber forest crops, infrastructure development and maintenance. See course Schedule (CANVAS) for more details on what will happen week-to-week.

**\*\*\*\*\*On three occasions during the semester a Journal assignment intended for you to reflect on and integrate weekly activities with reading assignments, will be submitted for a grade. Due dates are shown in the schedule.\*\*\*\*\***

### Field Trips

There will be two field trips, both of which are an essential component of the overall learning experience. Transportation will be provided.

October 15th, 2022, all day SATURDAY (9am-5pm) field trip to the Arnot Forest, where students will learn about:

1. The basics of maple syrup production and the integration of other forest farming activities with an existing sugar bush from Aaron Wightman, Maple Specialist, (Dept. of Natural Resources, Co-Director, Cornell Maple Program), arw6@cornell.edu
2. Research involving deer management on this 4200-acre research/teaching forest will be presented by Steve Morreale, Sr. Research Associate (Dept. of Natural Resources, Conservation Ecologist), sjm11@cornell.edu
3. Exploration of wild-simulated cultivation of American ginseng (*Panax quinquefolium*) and ramps (*Allium tricoccum*), led by Ken Mudge and Bob Beyfuss - <https://www.porcupinesoup.com/gardening-tips>

Bring lunch and dress accordingly. Attendance required.

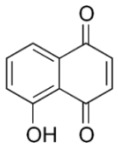
Thursday September 22, 2022, Thursday afternoon field trip to Hawk Meadow Farm, Trumansburg, NY, where students will learn about integration of forest farming with other farming and agroforestry practices. Presented by Steve Sierigk, farmer and Specialty Mushrooms and Agroforestry Specialist

### *Existing sites at MNG*



**Mushroom Laying Yard** – We will practice forest cultivation of specialty and medicinal mushrooms, including log acquisition and inoculation of bolts with Shiitake spawn as well as inoculation of totems with oyster and lion’s mane. Laying yard management and other aspects of forest mushroom cultivation will be covered.

Species: suitable substrate tree species (oak, hard maple, etc.), shiitake and other mushrooms including lion’s mane and oyster.



**Walnut Island / Riparian buffer**– Assess and manage a “juglone tolerant” polyculture, plant several species of small fruits, and develop a stream-side riparian buffer.

Species: black walnut, pawpaw, brambles, *Ribes spp.*, other fruit crops, stream-side willow, and elderflower



**Medicinals** – Assess and determine successes of current raised beds for woods cultivation of American ginseng and other medicinal crops. Renovate and/or rebuild beds and engage in soil conditioning.

Species: ginseng, goldenseal, black cohosh, and others.



**Nut trees, small fruits, and vegetables** – Assess current management strategy and the role of nut trees on the forest ecosystem. Nut harvesting will be fun and tasty.

Species: Shagbark and other hickory species, black walnut, ramps (wild leek), ostrich fern, haskap, elderberry, ground nut and others.



**Nursery** – Investigate some basic nursery tools and methods, including seed collection and storage, vegetative propagation including cuttings, layering, and grafting. Nursery production systems including field-grown, container, and pot-in-pot will be considered. Repair/rebuild nursery and install pot-in-pot systems.

Species: small fruits and medicinals

## Journals

Three times over the semester each student should prepare a one or two-page summary of weekly activities and reading assignments.

- *Journal assignments* – Based on weekly activities and reading assignments: Write about what you did, what you learned from the previous week's activity, and how it relates to the reading assignment, including the assigned chapter from the text (*Farming the Woods*), as well as one additional reading from the *Module* section of the CANVAS website. You may also include suggestions about how the activity might be improved in the future. Reflect on the activity. Express your opinion; hold forth on your passion.

### **Group Project Non-Timber Forest Crop Fact Sheet and Economic and Cultural Issues** **Oct 6, 13, and 20**

The goal of this exercise is to practice selecting quality plants for our nurseries that might supply our forest farms with fast reproducing, inexpensive plant material that meets our needs as a crop. Secondly, it's important to have an instinct for site selection. Finding the best spot for your plants in the forest is a complicated process. We will practice those things in this exercise. There will be a journey from seed or cutting, to planting and harvesting throughout the semester. This project is the culmination of the first part of that process. Toward the end of the semester, we will talk more about harvesting and value-added products.

For this exercise, we can imagine ourselves as the owners of small budding forest farms in the Ithaca area; like the MacDaniels Nut Grove. Everyone will be presented with plants from our small nursery at KPL. You will be asked to research those plants and then decide where to plant them in the Nut Grove near the end of the semester. The result is two parts: 1) A crop fact sheet and 2) the installation of your plant material during class time in October (6<sup>th</sup>, 13<sup>th</sup>, and 20<sup>th</sup>).

We want to consider that different targets per each style of land management or agroforestry system will vary wildly as related to end goals and ecosystems. A productive plant nursery and choices of plant materials within each nursery might simply provide a forest farm with a consistent supply of new plants or might also provide a stream of income. Nearly any plant could be an economic opportunity if the landscaping industry demands it. But a conventional production nursery is very different from a low-tech home scale nursery that is primarily meant to provide plants for a singular forest farm/garden.

In the most successfully managed parks or botanic gardens, many trees, shrubs, or herbs are planted every year. Growing your own woody plants can be a huge boost for a forest farm in a similar way.

In this section of the course, which will take place on October 6<sup>th</sup>, October 13<sup>th</sup>, and October 20<sup>th</sup>, we imagine ourselves as the managers of the Nut Grove. Groups of two will be assigned a plant accession that will be installed into the MacDaniels Nut Grove during this course. Each group explores: 1) The basic plant requirements and 2) the potential uses of that plant in an imaginary temperate deciduous forest farm.

Basic plant requirements are things like water, sunlight, and moisture.

Potential uses of the plants can be many things. We'll examine both straightforwardly economic opportunities, such as the production of food, medicine, ornamental plants, or timber; however, we're not limited to these definitions of 'economy' and 'usefulness', and could possibly include things like biodiversity, conservation, subsistence, agrotourism, craft, nitrogen fixation, wellness, or pollination.

This will involve both an oral presentation by each group on either October 6<sup>th</sup>, October 13<sup>th</sup>, or October 20<sup>th</sup>; as well as a short write up (**Due date is Oct 6<sup>th</sup> for all written portions**). Presentations and written portions are meant to be brief and informal, we will be sharing and discussing. There are no wrong answers.

You will be provided an outline for the written portion. It will amount to a simple fill-in-the-blank exercise and should take less than an hour to complete. This step will help us learn about the plants before we put them into the ground in October. So, this factsheet will help you decide where to install your plants in the Nut Grove during our exercise. Bring a hard copy of it to class that day.

**Please print enough copies of your crop fact sheets to share with everyone in class on the day of presentation (Oct 6<sup>th</sup>).**

**Graduate students:** Your final project will be an extended version of this module. You will be asked to create a several page crop fact sheet on the specific plant that you have been assigned. **We will discuss this on the first week of class, and you will be provided with a model for this exercise.** Please be thorough with your work, it will become part of the class next year.

**You will be graded on:**

**Quality information, 40 points:** All the information important to a forest farmer is included.

- plant habits & resources (the general information that plant nurseries list)
- general plant history, cultural use, ethnobotany, and especially North American Indigenous use when relevant (we're located in North America)
- Plant guilds, associations, and communities
- Economic value or potential economic value
- Laws, regulations, policy
- Conclusions & recommendations
- At least 5 references

**Format, 20 points:** clearness, spelling, grammar, use of images, clearness of images, infographics, range maps (**RANGE MAPS MUST BE INCLUDED**), use of charts or tables, relevance of charts and tables, writing style, etc.

**Creative license, 40 points:** PLEASE think 'outside of the box' in this assignment. Especially when researching possible uses and markets/economic value for this plant. Don't limit these fact sheets to only food or medicine perspectives. Look closely at how people used these plants 1000 years ago. Is there anything there for 2022 or 2040? Don't limit sources to one time-period, continent, or culture. Innovation is everywhere. Finally, if a dollar value could be applied to each plant in terms of something like carbon sequestration, engineered wetlands, or insect biodiversity; how would that factor?

**Final Project / Oral Presentation**  
**'The Final Feast'**  
**December 1, 2022**

The final project in this course is practice for evaluating and implementing NTFP value-added products or new ideas that create a stream of revenue for a household. Once again, everyone is asked to imagine themselves as the owner of an imaginary forest farm, but with a goal of discovering new plants to add into our farms/gardens, and a value-added product is the motivation. Each group will wildcraft, forage, or shop for available plant material and create a value-added product from that plant. Pies and sweets are great!! We will be sharing these “projects” with each other on the last day of class!

If you choose to shop for something, please confirm it’s something that ***could*** be wildcrafted in this region if one was inclined. The point is to test the waters with plants appropriate for growing in the Ithaca area, so if you make orange juice, it won’t mean much in our larger conversation on *temperate climate forest farming*.

**Foraging:**

Foraging is a fantastic way to understand ourselves as part of the “natural world” and the plants that we might want to bring into our imaginary forest farms or forest gardens. It’s testing the waters in the forest before committing to big design plans on your own property. Forest gardens and forest farms can be more effective if we can view each plant in its favorite location before we attempt to grow them into our own spaces. After all, forest farming and forest gardening is ‘farming as a forest’.

Forage for NTFPs locally or during travels throughout the semester. Any plants or plant material collected between now and December is appropriate. Everyone should create a product for sharing on the final day of class with the foraged plant material. Feel free to experiment. The presentation could be anything from a wreath fashioned from boughs, or moosewood clothespins, or even miniature trees for model train displays made from *Lycopodium*.

Hopefully, we will all create some interesting products that might inspire our future selves to add a new plant into our forest farm. Feel free to make pies, jams, or teas to share as well. Have fun with this, the final day is simply sharing what you have created and exploring what different plants we might incorporate into our forest farms. This time is for sharing and stories. Bring food, drink, and friends if you’re inclined.

*\*\*\* It is perfectly acceptable to forage in the urban environment if this is something people are curious about. But some urban environments grow plants that are not suitable for consumption (please ask Ken, Chad, Steve, or Tom if you’re not sure).*

**PLANTS TO FORAGE ??? :**

1. hickories and pecans
2. walnuts
3. paw paws
4. staghorn sumac
5. persimmons
6. Jerusalem artichoke
7. apios
8. wild grapes
9. wapato
10. common barberry
11. spice bush
12. hackberry
13. hobblebush
14. acorns
15. nannyberry
16. chestnuts
17. hawthorns
18. kousa dogwood
19. cornelian cherry
20. highbush cranberry
21. various roots (ginseng, cohosh, bloodroot, ramp seeds, etc.; collected at the Arnot on our trip)
22. cornus mas
23. conifer cones, roots
24. peaches/stone fruit
25. wintergreen

If you have read this far, congratulations. Be the first person to email me and receive a bag of shiitake mushrooms.  
(ccc289@cornell.edu)

Also, keep reading. There is a schedule on the next page.

Revised 8/18/22

**WEEKLY ACTIVITIES, READINGS, AND ASSIGNMENTS FOR FALL 2021**

Date	Activity / Location	Presenter	Assignment/ Attendance (% final grade)	Required Reading
Aug. 25, 2022	Introduction to Forest Farming  Meet at KPL 170 classroom  View nursery plants/ Potting activity?  Overview of MacDaniels Nut Grove (walk to MNG)	Ken Mudge via Zoom, Chad Cully, Tom Whitlow, Steve Morreale	5% - attendance	Text, Chapter 1, What is Forest Farming
Sept 1, 2022	Forest Nursery Production, (Propagation, and production systems).  @ KPL 170 & walk to MNG	Chad Cully	5% - attendance	Text Chapter 7, A Nursery in the Forest
Saturday, Sept 3, 2022	TBD – optional workday @ MNG	-	-	-
Sept 8, 2022	Design Practicum: Art, design, botanic gardens, and horticulture in agroforestry  @ Cornell Botanic Gardens - Nevin Welcome Center	Emily Detrick & Chad Cully	5% - attendance	Text, Chapter 10, Designing and Managing a Forest Farm & Skim: Chapter 3, Mimicking the Eastern Forest in a Changing Climate
Saturday, Sept 11, 2022	Ort Family Farm Open House, Watkin Glen *** <u>optional, no credit, no transportation</u> ***	Ort Family	-	<a href="https://ortfamilyfarm.com/">https://ortfamilyfarm.com/</a>
Sept 15, 2022	Mushrooms! With Carl Whitaker! And Emma!  @ MNG & McGowan Woodlot???	Carl Whitaker & Emma	5% - attendance	If you go Hunting for Wild Mushrooms.... P147
Saturday, Sept 17, 2022	TBD – optional workday @ MNG	-	-	-
Sept 22, 2022	Field Trip 1  Hawk Meadow Farm (depart @ 1:30)	Steve Sierigk	Journal 1- 3% + 5% attendance	Text Ch 10, Designing and managing a forest farm  <a href="https://www.hawkmeadowfarm.com/">https://www.hawkmeadowfarm.com/</a>

Date	Activity / Location	Presenter	Assignment/ Attendance (% final grade)	Required Reading
Saturday, Sept 24 <sup>th</sup> , 2022	TBD – optional workday @ MNG	-	-	-
Sept 29, 2022	Forest Cultivation of Mushrooms @ MNG	Ken Mudge	5% - attendance	Text Ch 5, Forest Cultivation of Mushrooms
Saturday, Oct 1, 2022	Workday w Kirsti Sullivan and Master Naturalists (grad students required – optional for undergrads) @ MNG	Kirsti Sullivan and Chad Cully	-	-
Oct 6, 2022	Non-Timber Forest Crops I - Crop fact sheet and economic/cultural uses presentations. @ MNG	Chad Cully & MNG students	5% - attendance <b>+Group Project/Crop Fact Sheets Due Oct 6</b>	Text Ch 4, Food from the forest (Getting a Yield, Plant Selection, Criteria)
Oct 13, 2022	Non-Timber Forest Crops II - Crop fact sheet and economic/cultural uses presentations. @ MNG	Chad Cully & MNG students	5% - attendance <b>+Group Project/Crop Fact Sheets Due Oct 6</b>	Text Ch 4, Food from the forest (Fruits for the Forest Farm)
Saturday, Oct 15, 2022	Saturday Field Trip (2) <ul style="list-style-type: none"> <li>sugar bush</li> <li>deer management</li> <li>ramps, ginseng</li> <li>slash walls</li> </ul> @ Arnot Forest - depart from Fernow Hall @ 9AM, and return to Fernow by 5pm	A.Wightman, S. Morreale, K. Mudge, Chad Cully, Bob Beyfuss	5% - attendance <b>+Group Project/Crop Fact Sheets Due Oct 6</b>	Text Ch 4, Food from the forest (Tree syrups, ramps)
Oct 20, 2022	Non-Timber Forest Crops III - Crop fact sheet and economic/cultural use presentations. Medicinals and other NTFPs @ MNG	Chad Cully & MNG students	5% - attendance	Text Ch 4, Food from the forest (Nuts for the Forest Farm)

<b>Date</b>	<b>Activity / Location</b>	<b>Presenter</b>	<b>Assignment/ Attendance (% final grade)</b>	<b>Required Reading</b>
Oct 27, 2022	Riparian buffers and site management  @ MNG	Tom Whitlow	Journal 2 - 3% + 5% attendance	-
Nov 3, 2022	Tree ID walk, seed collection, seed storage, stratification, and cleaning  @ the Cornell Arboretum and Botanic Gardens	Dan Weitoish – Cornell Botanic Gardens Arborist & Chad Cully	5%	Text Ch 4, Food from the forest (Nuts for the Forest Farm)
Nov 10, 2022	Aaron W. Maple Lecture and value-added maple products  @ KPL classroom	Aaron Wightman & friends	5%	Text Ch 4, Food from the forest (Tree syrups)
Nov 17, 2022	TBA – optional, attendance not mandatory	TBD	5%	-
Nov 24, 2022	November Holiday	-	-	-
Dec 1, 2022	Forest feast  @ KPL classroom	Student presentations	Journal 3- 3% + 5% attendance and 5% Forest Feast Presentation	
	Journals		9%	
	Group Project/Crop Fact Sheets Due Oct 6		11%	
	Forest Feast Presentations Due Dec 1		5%	
	Course participation Student knowledge gain and attendance		75%	

*Starting from Scratch:  
The Plants*



**Plant Installations at the MacDaniels Nut Grove of Cornell University  
and Blue Rock Station in Ohio**

*The original plantings at 812 Dayton Avenue are the source of the plant material prepared for the MacDaniels Nut Grove and Blue Rock Station. Those plants were established in 2016 and continue to be a source of seeds or cuttings. Unless otherwise noted, 812 Dayton Ave is the source of the material.*

**Plant name, uses:**

Actaea racemosa, abortifacient, analgesic, antirheumatic, cough medicine, dermatological aid, diuretic, pediatric aid (sedative), native, biodiversity, *legion*...

Apios americana – see page 46

\*Aralia racemosa - native, biodiversity, conservation, pollinator plant, *too many uses to list...legion*

\*Asimina triloba - fruit, biodiversity, native

\*Baptisia tinctoria - native, biodiversity, conservation, pollinator plant, cathartic, antiemetic, gynecological aid, toothache, liver aid, dyes, *legion*...

Betula lenta - native, biodiversity, wintergreen, tree sap, pollinator plant

Calycanthus floridus - native, biodiversity, dermatological aid, emetic, poison, pediatric aid (sores and hives), urinary aid, eye medicine, spice

\*Castanea spp - hybrid chestnuts, food

\*Cephalanthus occidentalis - pollinator plant, native, biodiversity, headaches, antidiarrheal

\*Diospyros virginiana - small fruit, biodiversity, native

\*Gymnocladus dioicus - native, biodiversity, coffee substitute

Gynostemma pentaphyllum - adaptogenic herb, similar uses to ginseng (could take pressure off the native ginseng plants if grown/harvested locally)

\*Juglans ailantifolia var. cordiformis - nuts

*Lindera benzoin* - spice, native, biodiversity, fevers, abortifacient, blood medicine, cold remedy, respiratory aid, pulmonary aid, analgesic, induce sweating, *legion*...

*Lonicera caerulea* - small fruit

\**Myrica pensylvanica* - biodiversity, spice, tea, cultural use (typically Portuguese immigrants), candles, blood medicine, emetic, kidney aid

*Ocimum africanum* - From Richo Cech @ <https://blog.strictlymedicalseeds.com/tulsi-holy-basil-type-comparisons/>: “Temperate tulsi (AKA: “Holy Basil,” *Ocimum africanum*) was introduced by the now-defunct Abundant Life Seed Foundation. The plant has been grown successfully as a quick summer annual and is well-loved by American gardeners. The aroma is tutti-frutti, the plant bolts fast to flower, it magnetizes bees and is the only basil I know of that readily self-seeds from seed dropped the year before.”

*Prunus persica* - fruit, pollinator plant

*Prunus pumila v besseyi* - small fruit, biodiversity, pollinator plant

*Ribes × nidigrolaria* - small fruit

*Ribes uva-crispa* - small fruit

*Rubus fruticosus 'Triple Crown'* - small fruit

*Rudbeckia laciniata* - spring green, dietary aid, burns, biodiversity, pollinator plant, native

*Sambucus canadensis (York and John's)* - various immune boosting medicines, flu remedies, fruit, conservation, biodiversity, pollinator plant, native, *legion*...

*Spirea virginiana* - conservation, biodiversity (federally threatened), native

\**Taxodium distichum* - biodiversity, timber

\* Indicates a seed collected from a Northern Kentucky or Cincinnati park, arboretum, cemetery, or natural area.

*Apios americana* Medik.



C. Chad Cully  
March 2021

***a) Plant habits, info***

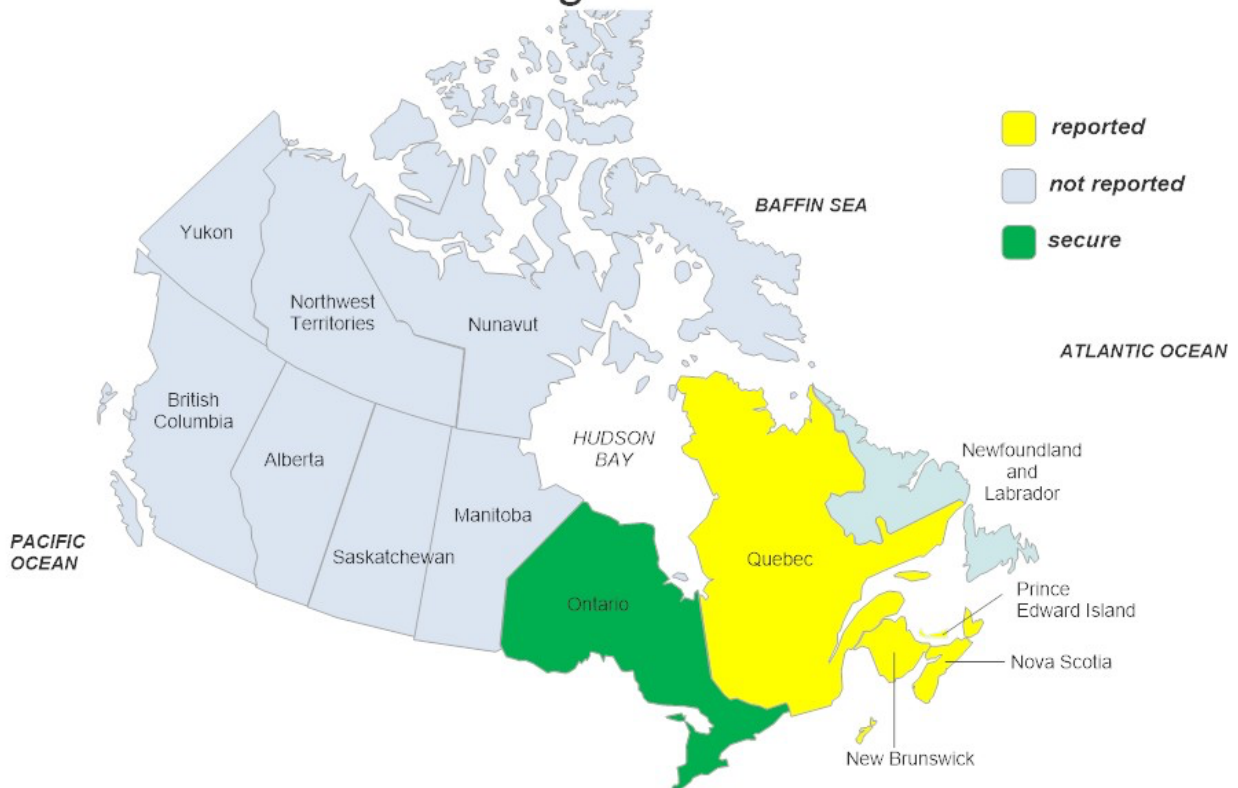
Common name: apios, tekëneipën, Lenape (Lenape 2021); eepiikanita, Miami (King 2003); hopniss, hapniss, groundnut, wild potato, American sweet potato bean, ground bean, wild bean, Dakota peas, [wild bean: *inage-tanenu-na*; wild potato: *ako-hl tanehi*; Cherokee (Perry 1974)]

Plant type: Herbaceous perennial vine

Family: Fabaceae/Leguminosae

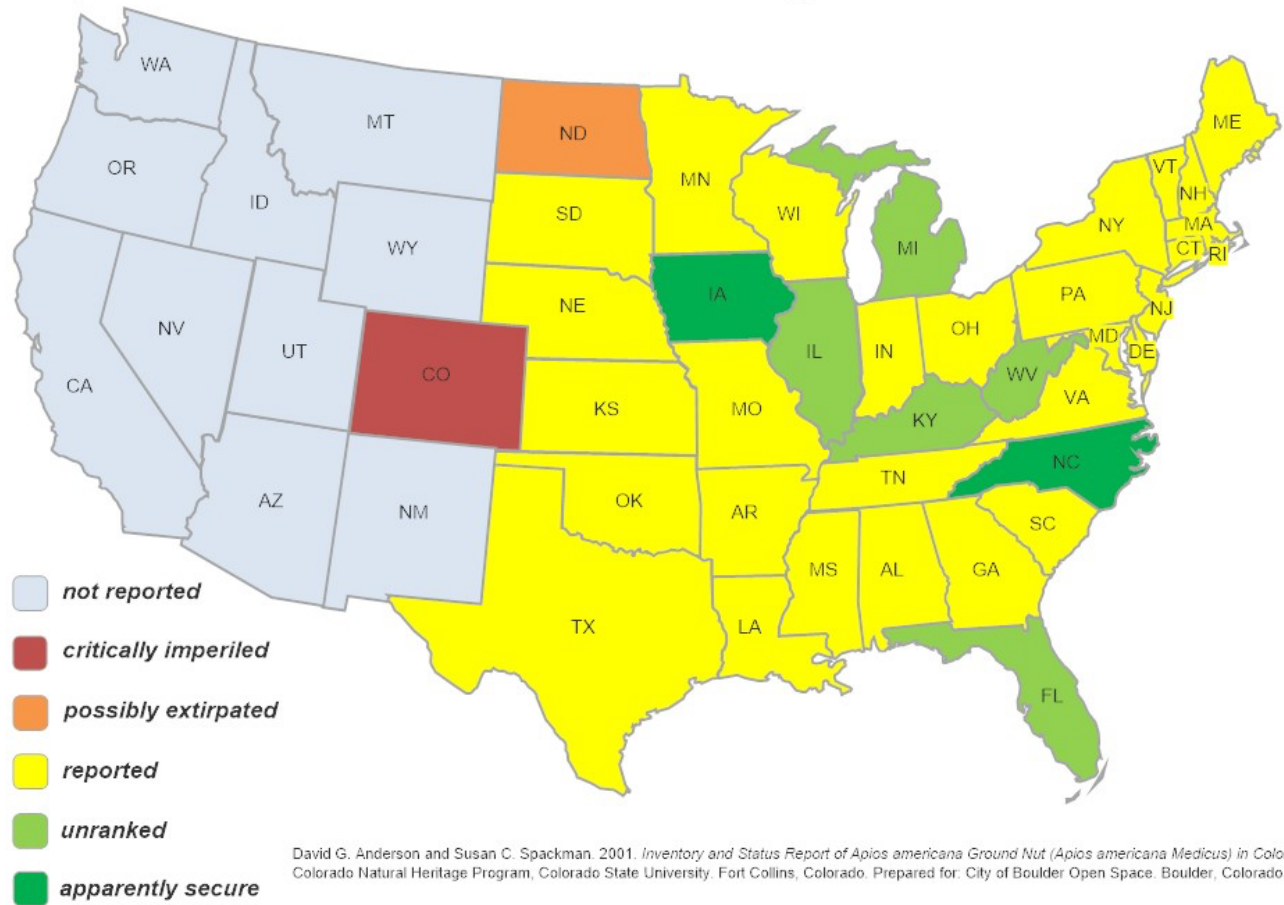
Native range/distribution: Eastern North America, prefers wet meadows, low thickets, banks of streams and ponds, sloughs, moist prairie ravines, and moist soils in woodlands (Stevens 2006)

## *Apios americana* Medik. native range in Canada



David G. Anderson and Susan C. Spackman. 2001. *Inventory and Status Report of Apios americana Ground Nut (Apios americana Medicus) in Colorado*. Colorado Natural Heritage Program, Colorado State University. Fort Collins, Colorado. Prepared for: City of Boulder Open Space. Boulder, Colorado.

## *Apios americana* Medik. native range in the United States



Height/spread: 1-10 ft. tall vine, 24 in. spread.

Bloom time/color: July-October in Eastern North America, red-violet-maroon.

Sun: Medium to full sun or dappled shade.

Water: Medium to wet soil.

Maintenance: Low maintenance, can become aggressive.

Suggested use: Agroforestry, non-timber forest product, agriculture, common gardens, fragrance gardens, native plant, restoration, nitrogen fixing, specimen plant, pollinator, horticultural therapy.

Flower: Lightly fragrant, red-violet-maroon. Useful in teas.

Fruit: Cylindrical ‘bean-pods’ about 3” x 3”, green to yellow-green pods contain maroon colored and edible seeds can be used like pinto beans (Perry 1974). Although it may be possible to harvest both tubers and seed from stands of *Apios*; there is some evidence that tuber production decreases as production of seed increases (Reynolds 1988). Self-incompatibility can also be an issue, so spacing out compatible lines can help increase open pollination and pod set. Additionally, pod set per hand pollination is low (Reynolds 1988).

Tolerate: Will tolerate some shade, some drought, deer browsing, and periodically wet soil.

Pollinators: Members of *Halictidae* (Halictid or sweat bees), *Megachile* (leafcutter, resin, and mortar bees), and *Apis mellifera* (Breauneau and Anderson 1994). Breauneau and Anderson (1994) also indicate that only *Megachile* can ‘trip’ the flowers. *Bombus terrestris* (bumblebee) is also a common visitor to *apios* flowers. Interestingly, *Megachilidae sculpturalis*, the giant resin bee from east Asia, pollinates *Apios priceana*, which is both native and federally threatened (Stevens 2019).

Foliage: Alternate and compound leaves, pinnate; with 3, 5, or 7 leaflets. Lancelolate and obvate leaflets with smooth margins. The leaflets are from 1.5”-2.5” long and .75”-2” wide. Leaflets are dark green on top, and the bottom side is lighter green. Venation is pinnate. All parts of the foliage can be slightly pubescent. When broken, the foliage can contain a milky sap. *Amphicarpaea bracteata*, is confused with *apios*, but the hog peanut has only 3 much smaller leaflets, which are spaced far apart by comparison, never 5 or 7 leaflets, and its flowers are light pink to white. Lakota botanists indicate that the green tops of the plant are edible and called “blo hu” (Black Elk 1998).

### **b) General history, cultural, and indigenous uses**

*Apios americana* is native to Eastern North America, from Florida to Ontario; by consequence, it has a history that is closely associated with First Nations and Native U.S. Americans. In 1939 Gretchen Beardsley wrote about ‘goundnuts’ that were used by all Native Americans that we’re in the range of the plant. Her accounts begin in 1602. Beardsley then

specifically cites that the Pilgrims ate them in the spring of 1623, when supplies were very low (Beardsley 1939). It's no surprise then, that Daniel Moerman listed numerous accounts of Indigenous Americans utilizing *Apios americana*, and a great variety of preparations of the starchy tubers and the seeds as a source of protein. (For a more complete explanation of traditional preparations and uses of *Apios americana*, see Beardsley 1939 and Moerman 1998).

A personal account of *Apios americana*, is given by Buffalo Bird Woman in 1917. She writes:

*"We Hidatsas believe that our tribe once lived under the waters of Devil's Lake. Some hunters discovered the root of a vine growing downward; and climbing it, they found themselves on the surface of the earth. Others followed them, until half the tribe had escaped; but the vine broke under the weight of a pregnant woman, leaving the rest prisoners. A part of our tribe are therefore still beneath the lake.*

*My father, Small Ankle, going, when a young man, on a war party, visited Devil's Lake. "Beneath the waves," he said, "I heard a faint drumming, as of drums in a big dance." This story is true; for Sioux, who now live at Devil's Lake, have also heard this drumming.*

*Those of my people who escaped from the lake, built villages nearby. These were of earth lodges, such as my tribe built until very recent years; two such earth lodges are still standing on this reservation.*

*The site where an earth lodge has stood is marked by an earthen ring, rising about what was once the hard trampled floor. There are many such earthen rings on the shores of Devil's Lake, showing that, as tradition says, our villages stood there. There were three of these villages, my father said, who several times visited the sites.*

*Near the villages, the people made gardens; and in these they planted ground beans and wild potatoes, from seed brought with them from their home under the water. These vegetables we do not cultivate now; but we do gather them in the fall, in the woods along the Missouri where they grow wild. They are good eating"*

Buffalo Bird Woman explains further:

*"I do not know when my people stopped planting ground beans and wild potatoes; but ground beans are hard to dig, and the people, anyway, liked the new kinds of beans better."*

*"Whether the ground beans and wild potatoes of the Missouri bottoms are descended from the seed planted by the villagers at Devil's Lake, I do not know."*

(Buffalo Bird Woman and Wilson 1917)

More recently, Samuel Thayer has become a great source of information regarding apios. Thayer, at the time he published his book, 'A Forager's Harvest', in 2006, had been foraging and working with apios for over 15 years. In that book (Thayer 2006), Mr. Thayer carefully details a variety of ways that a person might want to prepare and eat, what he calls, hopeniss, the Lenape word for 'potato'. His recipes span a range of uses from flour to tacos. He calls it a regular feature of his home cooking and estimates he has eaten hundreds of pounds of the tubers. Interestingly, this all comes with a caveat from Thayer. He recalls that through the years he has offered apios to guests in his home or workshops, frequently, and about 5 people have had what he terms, 'an allergic response'.

Thayer goes on:

*"Five out of a few hundred is a high rate of allergy, but it doesn't tell the whole story. Four of the allergic/intolerant individuals had eaten the plant on multiple occasions previously with no ill effect. After the initial adverse reaction, these individuals were extremely sensitive to hopeniss – even in very small quantities".*

(Thayer 2006)

Thayer's account could be alarming to anyone presently using this food, but he adds some additional ideas: First, he offers, it may just be that some people are predisposed, and cannot tolerate something concentrated in the tubers, and maybe Indigenous Americans have lived alongside this plant long enough to develop a tolerance, for which; Europeans have none. Another theory Thayer illustrates is more complex and worthy of greater investigation.

*"What also seems possible is that the Native Americans who ate this plant simply knew something about it that we do not – some nuances of its harvest and preparation that were not recorded or not understood by European ethnographers.*

*I suspect that there is some substance found in all hopeniss, but which is more concentrated in older tubers or those that grow in waterlogged soil. Perhaps the body initially reacts to this higher concentration of our mystery substance; once sensitized, however, it will not tolerate any amount of it. To play it safe, and to test this hypothesis, I now only harvest, eat,*

*and serve new tubers from dry soil. Hopefully, feedback from readers can shed some light on this issue.”*

(Thayer 2006)

Other farmers have developed methods that may offer another angle on this topic. In Japan, on the Shimokita peninsula, where apios is grown commercially; after harvest its exposed to extreme cold for prolonged periods, of about two months (November to January), around -10c (14f). The method is called “kanzarashi” and increases the sugar content of the plant (*UMAI MONO AOMORI* 2019). Although the Japanese methods are meant to increase the quality of the product, innovations like this and Thayer’s reimagining will result in a recapture of *Apios americana* both culturally and scientifically.

In present day, apios is being grown for commercial markets in Japan and South Korea. It appears that *Apios americana* was mysteriously introduced to the northern Tohoku District around 1895. A farmer named Hoshikawa began using the plant to relieve fatigue and for postnatal medication, and he eventually began cultivating apios. Somehow, the tubers became popular in the area, and it’s still grown for restaurants and markets, especially in Tottori, Akita, and Miyagi (Hoshikawa 1994). Hopniss powder is being used as a more healthful sausage binder in South Korea (김정미, 이미희, 박미란, 이종숙 2018), the flowers are used to make tea in Japan (Amazon), noodles in South Korea (Seyeon Na 2018), and tacos in Wisconsin (Thayer 2006); however, there remains no active market in North America for one of America’s more storied native plants.

### **c) Plant guilds**

Apios prefers to grow with other plants. Although it can ramble along the ground amongst grasses, it prefers to climb up the stalks of plants like goldenrod (*Solidago* sp), cow parsnip (*Heracleum* sp), and jewelweed (*Impatiens* sp) (Dean 2013). Joe Pye weed (*Eutrochium* sp), iron

weed (*Vernonia sp*), and sochan (*Rudbeckia laciniata*) are also common apios trellises. Hopniss prefers moist soils but will tolerate some drought. When it is well established it can become moderately difficult to control. Cranberry farmers in Wisconsin spray it with herbicide to control the spread (Dean 2013). Thayer calls apios a ‘twin’ to Jerusalem artichokes (*Helianthus sp*) and they’ve been spotted growing up the stalks of elderflower shrubs (*Sambucus sp*) (Dean 2013).

#### **d) Economic value**

International markets are not new to apios. The groundnut has been grown in Japan for about 130 years, and currently, apios is being grown in Korea as well. Both countries have at least small markets for apios, as a novel health promoting food. In Asia, apios is being used as a binder in sausage (김정미, 이미희, 박미란, 이종숙 2018), to make noodles (Seyeon Na 2018), as a salty snack with alcohol, to extend the shelf life of gluten free bread (Ito 2019), to relieve fatigue (Hoshikawa 1994); to make cookies, donuts, and bread; and as an alternative tuber in various cuisines, where they are commonly steamed, baked, and fried (Yangchen 2016).

Apios tubers are about 11-14% protein on a dry weight basis; twice the protein content of potatoes, rich in iron and phosphorus, and five times the calcium content of taros (Yangchen 2016). Various studies have shown apios tubers may be effective at reducing blood pressure, alleviating lung inflammation, curing chronic constipation, obesity, diabetes, and had positive effects treating disorders before and after childbirth (Iwai 2006) (Sohn 2015).

Domestically, I have spotted about a dozen plant nurseries selling the tubers for planting. The prices will average about \$2 per tuber, if ebay and Etsy prices are excluded. But if Etsy and ebay numbers *are* included, the average online tuber price is somewhere around \$4.50 per tuber. Also, nurseries will sell potted plants. A quart pot will run around 10\$ and a nursery trade one gallon should cost about 15 or 20\$. Nurseries might explore apios as a potted plant for local

markets, but for mail orders, apios will be a welcome addition for nursery owners that are concerned about the high costs of growing medium and shipping.

***Tubers:***

Norton's Naturals: \$1.50 per tuber  
Sow True Seed/Utopian Seed Project: 1oz = \$10 and 2oz = \$13.95  
Interwoven Permaculture Farm: 10 tubers = \$10 and 100 tubers = \$160  
Sand Mountain Herbs: 1000 tubers = \$769.95  
500 tubers = \$399.95  
100 tubers = \$89.95  
25 tubers = \$25.95  
10 tubers = \$14.95  
B&T World Plants (UK): one tuber = 24 Euros  
Korean Online Grocery \$13.97 per kg of Korean grown *Apios*  
Oikos: 4 'Carolina tubers' = \$14.95  
4 'Cluster' tubers = \$11.20  
ebay: \$3 to \$20 per tuber  
Etsy: \$1.25 to \$14.95 per tuber

***Potted plants:***

Wild Ridge Plants: quart pot = \$10  
Brushwood Nursery: true one gallon pot = \$30  
Camp Creek Nursery: quart pot = \$9.95  
trade one gallon = \$14.95

Wildcrafting of apios is certainly possible where populations are strong; Tamara Dean has written about harvesting large bounties of apios from Wisconsin riverbanks (Dean 2013). Sadly, the unadulterated tubers are not likely to be valuable in our current markets. Still, due to strong growth habits of apios, the abundance of potential value-added uses, and health benefits; apios has enormous potential for industrious households or small farms. In North America, growers of apios can focus on using it as a solidly producing nursery crop, with good potential to expand into value-added markets, specialty grocery, and restaurant settings. Farmers and woodlot owners in groundnut friendly states could experiment with apios in woods cultivation, wild simulation, or a forest nursery (dappled shade-sun).

***e) Laws and policy***

Apios is relatively common within its native range in the eastern U.S. and Canada: listed as “globally secure” (G5) by the Association for Biodiversity Information (Anderson 2001). In Colorado apios is classified “critically imperiled” (S1) by the Colorado Natural Heritage Program (Anderson 2001). Elsewhere, apios is not known to be threatened; therefore, not classified as

sensitive by any federal agency. Furthermore, institutions like the Kansas Natural Heritage Inventory, the Nebraska Natural Heritage Program, and the South Dakota Natural Heritage Data Base note apios to be common enough to be left untracked (Anderson 2001).

**f) Conclusions, recommendations, growing**

Although apios is not widely known, and not thought to be threatened, it should be included in future NTFP style management plans. Novel species like Japanese knotweed could take away habitat from plants like *Apios americana*, and updated information about the species distribution and abundance of apios is needed to determine the fate of this plant, as it competes for space with novel plants. Field trials and research plots should be ongoing in order to understand the usefulness of apios as a nitrogen fixing plant, pasture forage plant, cover crop, or in various agroforestry or conventional row-cropping systems (breeding programs could help advance apios a useful food crop). Of course, if not already in attendance, apios would be a welcome and unique way to add biodiversity into botanic gardens or native preservation areas.

Large scale agroforestry operations or farms could plant and harvest apios in about the same way as sweet potatoes. Because apios is nitrogen fixing, it could be incorporated as a cover crop or partner plant for other native perennials like elderflower or Jerusalem artichoke. At least one study noted the use of native legumes as cover crops, including *Apios americana*, to be ‘a promising direction of future research for newer cover crops in harsh conditions’ (Schartz 1999). Farmers like Gabe Brown and Jon Stika love encouraging farmers to try their own cover crop mixes, to find what works. Brown believes that daikon radish left in the ground with a cover mix, helps to create pore space and stronger communities of micro-organisms. Nitrogen fixing apios certainly has a place in this conversation, and other farmers might be interested to buy seed for their own cover mixes, if it’s proven to promote healthy soils and higher yields.

Even small groundnuts that are harvested can produce long strings of tubers, in the first season. Though the large tubers will usually produce more. In the very early spring, or late winter, small pots might be used to start tubers growing in a warm basement or greenhouse. In 10 or 12 weeks, these tubers can be potted up for a nursery, moved onto an agroforestry plot or other agricultural setting, or sold as young plants in bulk. A very small nursery could produce several hundred apios plants with little effort. As the popularity of native plants and pollinator gardens continues to increase, horticulturists and conservationists should consider easy to grow natives like apios.

Small and medium scale land managers might use raised beds, or even large pots, and mix apios with another tuber producing plant like *sunchokes*, a native plant, that would act as a trellis for the groundnuts. Because apios will perform with medium light, it should be considered into non-timber-forest-product management plans, that require plants in lower light conditions; especially under somewhat open forest canopies, in unused riparian areas, dappled shade, or along forest edges, for example. Apios can be obtained from any of the previously mentioned growers and expanded into a segment of a nursery business, in just a few seasons, and with much less input, compared to other nursery plants.

To overcome the limitation of rates of adoption, all the above methods should be considered. Collaboration between governments, seed companies, extension agencies, and farmers will be needed. Once information from field trials and population data has been collected, that information could be translated into practical data for farmers, small woodlot owners, conservationists, or land managers. Ultimately, markets need to be developed. Providing incentives for restoration, conservation of native plants, or culturally significant plants; could stimulate markets for apios in anything from animal feed mixes, to landscaping, or restaurants.

## **g) References**

김정미, 이미희, 박미란, 이종숙. 2018. Application filed by 대구과학대학교 산학협력단. *Apios sausage and manufacturing method thereof*. South Korea patent KR101856449B1, application granted 2018-05-10. <https://patents.google.com/patent/KR101856449B1/en>

Amazon.com. c1996-2021. Seattle, Washington. [accessed February 2021.] *Japanese Tea Shop Yamaneen Apios floral tea*. [https://www.amazon.com/-/es/Tienda-japonesa-Yamaneen-floral-paquetes/dp/B06XSVSY73?language=en\\_US&th=1](https://www.amazon.com/-/es/Tienda-japonesa-Yamaneen-floral-paquetes/dp/B06XSVSY73?language=en_US&th=1)

Anderson, David G; and Spackman, Susan C. 2001. Inventory and Status Report of *Apios americana* Ground Nut (*Apios americana* Medicus) in Colorado. Colorado Natural Heritage Program, Colorado State University. Fort Collins, Colorado. Prepared for: City of Boulder Open Space. Boulder, Colorado.

Beardsley, G. 1939. *The groundnut as used by the Indians of Eastern North America*. Michigan Academy of Science, Arts, and Letters Paper 25: 507-515. University of Michigan Press. Ann Arbor, Michigan.

Black Elk, Linda S. and Flying By, Wilbur. 1998. *Culturally Important Plants of the Lakota*. Sitting Bull College. Fort Yates, North Dakota.

Bruneau, Anne and Gregory J. Anderson. 1994. *To bee or not to bee?: the pollination biology of Apios americana*. Plant Systematics and Evolution, March 1994. DOI:10.1007/BF00985913

Buffalo Bird Woman and Wilson, Gilbert. 1917. *Agriculture of the Hidatsa Indians: An Indian Interpretation*. University of Minnesota. Reprint in 1987. *Buffalo Bird Woman's Garden, Agriculture of the Hidatsa Indians*. Minnesota Historical Society Press. St. Paul, Minnesota.

Dean, Tamara. 2013. "[Stalking the Wild Groundnut](#)". *Orion Magazine*. Retrieved 01 March 2021.

Hoshikawa, Kiyochika and Juliarni. 1994. *The Growth of Apios (Apios americana Medikus) a New Crop, Under Field Conditions\**. Faculty of Agriculture, Tohoku University. Sendai, Japan.

Ito, Seiko and Arai, Eiko. 2019. *Improvement of gluten-free steamed bread quality by partial substitution of rice flour with powder of Apios americana tuber*. School of Food and Nutritional Sciences, University of Shizuoka. Shizuoka, Japan. Science Direct and Elsevier. DOI: 10.1016/j.foodchem.2020.127977

Iwai, Kuniyoshi and Matsue, Hajima. 2006. *Ingestion of Apios americana Medikus tuber suppresses blood pressure and improves plasma lipids in spontaneously hypertensive rats*. Department of Life Sciences, Graduate School of Health Sciences, Aomori University of Health and Welfare. Aomori, Japan. Science Direct, 2007.

Kawamura, Jin; Miura, Emi; Kawakishi, Ken; Kitamura, Tsutomu; Moriga, Yae; Norikura, Toshino; Matsue, Hajime; Iwai, Kuniyoshi. 2015. *Investigation of the Safety and Antihyperglycemic Effect of Apios americana Flower Intake as a Food Material in Normal Diabetic Mice*. Japanese Society for Food Science and Technology. DOI: 10.3136/fstr.21.453

King, Brian C. 2003. *The Ethnobotany of the Miami Tribe*, p20-21. Honors Program Thesis, Miami University. Oxford, Ohio.

*Lenape Talking Dictionary*. c2021. Delaware Tribe of Indians: Bartlesville, OK; [accessed February 2021.]  
<https://www.talk-lenape.org/>

Moerman, Daniel E. 1998. *Native American Ethnobotany* p77. Timber Press. Portland, Oregon.

Perry, Myra Jean. 1974. *Food Use of Wild Plants by Cherokee Indians*, p46. Master's Thesis, University of Tennessee-Knoxville. Knoxville, Tennessee. [https://trace.tennessee.edu/utk\\_gradthes/1048/](https://trace.tennessee.edu/utk_gradthes/1048/)

Reynolds, Berthal D; Blackmon, William J; Wells, Merlyn H; Constantin, Roysell. 1988. *Progress in Domesticating Apios americana*. Department of Horticulture, Louisiana Agricultural Experiment Station, LSU Agricultural Center. Baton Rouge, Louisiana.

Schartz, Rita J. and Janke, Rhonda R. 1999. *Evaluation of Native Legumes for use as Cover Crops*. Journal of Sustainable Agriculture, 15:2-3, 45-59, DOI 10.1300/J064v15n02\_06

Seyeon Na and Ki Hyeon Sim. 2018. *Antioxidant Activities and Quality Characteristics of Noodle with Added Apios (Apios americana Medikus) Cultivated in Korea*. Sookmyung Women's University, Seoul, Korea. The Korean Journal of Food and Nutrition, Vol. 31 No. 6, 844-857. DOI: doi.org/10.9799/ksfan.2018.31.6.844

Sohn, Sung-Hwa; Sang-Yeon Lee, Jun Cui, Ho Hee Jang, Tae-Hoon Kang, Jong-Keun Kim, In-Kyoung, Deuk-Ki Lee, Seulgi Choi, Il-Sub Yoon, Ji-Woo Chung, and Jae-Hwan Nam. 2015. *Apios americana Medik Extract Alleviates Lung Inflammation in Influenza Virus H1N1 – and Endotoxin-Induced Acute Lung Injury*. The Korean Society for Microbiology and Biotechnology, Republic of Korea. DOI: 10.4014/jmb.1508.08017

Stevens, Kristen C; Cameron, Jack; and Ellis, James. 2019. *Giant Resin Bee Megachile sculpturalis (Smith) (Insecta: Hymenoptera: Megachilidae)*. Entomology and Nematology Department, University of Florida/IFAS Extension. Gainesville, Florida.

Stevens, Michelle. 2006. *Plant Guide, Apios americana Medik*. USDA, NRCS, National Plant Data Center.

Thayer, Samuel. 2006. *A Forager's Harvest* p234-245. A Forager's Harvest Press. Birchwood, Wisconsin.

*UMAI MONO AOMORI*. c2019. Aomori Prefectural Government: Nagashimi, Aomori City, Aomori, Japan. [accessed February 2021.]  
<https://www.umai-aomori.com/products/vegetables/shimokita-apos-americana/>

Yangchen, Hanyu; Belamkar, Vikas; Cannon, Steven B; and Jane, Jay-lin. 2016. *Characterization and development mechanism of Apios americana tuber starch*. Departments of Food Science and Interdepartmental Genetics, Iowa State University; USDA – Agricultural Research Service, Corn Insects and Crop Genetics Research Unit, and Department of Agronomy, Iowa State University. Ames, Iowa, USA.

*Starting from Scratch:  
Conclusions and Recommendations*



### ***Conclusions and Recommendations:***

As humanity tumbles wildly into the future, with climate breakdown on the horizon, we need every tool at our disposal. No project is too small or too simple, everything is on the table at this point. We are entering an “all bets are off” type of scenario. Small and medium scale private landowners need to be enlisted to help and they need to be incentivized to do so. In urban areas, every tiny scrap of land matters when we’re dealing with excessive heat, particulate matter, atmospheric carbon, and nutrients in stormwater.

Forest gardens and forest farms won’t solve the problem alone, but neither will any solution that we are currently proposing. A huge hurdle going forward, will be changing hearts and minds. Collectively, we view ourselves as something other than ‘nature’. We mostly believe that we live outside of its systems, and we will pay the price if we continue to believe this is true. Humanity is capable of more. We can move beyond “sustainability” and begin to understand ourselves as part of the trees and oceans. But to change hearts and minds, we need to put in the work that we’ve neglected to do.

Agroforestry is an opportunity to reclaim what was lost, and to show ourselves what is possible; to show ourselves how we are a part of something bigger than humanity. I’ve found, in my own work, that food forests are places that inspire people in ways that seem not possible. It’s not just the sugar that comes from maple trees, there is a connection that we all make that goes much deeper, and using that connection in food forests to inspire other natural climate solutions is important work. It *can* change hearts and minds and it can build bridges.

We also need to arrive at some numbers. We don’t yet know exactly what plants can do in this type of system. Trialing a variety of food or medicine producing plants in the forest shade will help us understand what is possible. Developing these experiments in different regions and different soils will help a great deal as well, so that first-time users get it right on the first attempt. Small

farms and families also need to maintain streams of income, or the trend will die. Exploration of new NTFPs and value-added products is an evolving conversation that includes history, culture, and politics. It's no simple task.

In terms of planning, or forest farming strategies, the practice seems to outperform the research. I've had some difficulty finding comprehensive lists of plants that will tolerate black walnuts and had similar experiences with staghorn sumac. Towering black walnut trees punctuate the canopy of the MacDaniels Nut Grove, and I would love to have a clearer idea about how forest farms can work with these native trees instead of excluding them from projects. Fully describing design strategies down to every detail could help a lot of people on this journey. A focus could be made on agroforestry's relationship to things like stormwater management, walnut toxicity, carbon offsets, nutrient runoff, landscape architecture, biodiversity, or urban heat islands, for example.

There is also a very real and massive problem of plant material. Where can aspiring agroforesters get affordable plant material and advice? Plant nurseries offer everything first time homeowners need to landscape a property with an English garden and grass-centric approach, but where can an agroforester go? More research on shade tolerant plants that produce food or have cultural significance can help nurseries to choose things for their customers to be successful, locally. Small farms or urban homesteads could also become producers of seedling trees destined for much bigger agroforestry production. Teaching low-tech and home-scale propagation of various agroforestry plants could be a turning point.

Finally, making work like this accessible to all who are interested, probably gives humanity the best chance. Outreach and extension that speak to these methods would be the most practical way of moving the needle. I think of agroforestry as a tool and I wonder how we can best use that tool, and what kind of history humans have with these tools, plants, and systems. If everyone has the tools, we stand a better chance.