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FINAL REPORT

Demonstrations of Silvopasture & Other Agroforestry Systems

Conservation Innovation Grant – NRCS Agreement 69-1106-17-56

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Table of Contents

Executive Summary

The Wilhelm Farm Conservation Innovation Grant to support demonstrations of silvopasture and other agroforestry systems was awarded and initiated on March 1, 2017. The project purpose is to demonstrate a mix of sustainable systems suitable for owners of small forest and farm holdings in Connecticut. These lands generally are viewed as financially marginal. The project goals were to:

- Invest in silvopasture and other sustainable farming systems
- Develop support demonstration materials, such as factsheets, web pages, and videos
- Open a collaborative demonstration farm to serve NRCS and other outreach needs.

The grant ended on September 30, 2019. This report documents results to date and expected continuing outcomes over the coming years. We accomplished several of our specific goals during the grant period, and additional goals will be met soon.

Invest in silvopasture

Our initial plan was to convert about 3 acres of brush, brambles and low value hardwoods to silvopasture. We added to our plan more brush covered areas and some marginal pasture, expanding the unit to seven acres of low-value landscape. We are using goats to help us convert this land. Once silvopasture – trees and forage – are well established, we will reconsider the mix of livestock.

Wilhelm Farm Factsheet 12, *Trees and Brush into Silvopasture: Low-Cost Guideline & Steps Using Goats*, describes our use of goats to convert brush into silvopasture. We are learning management of goats during the grazing season but need to expand our seasonal capacity over time. Mid-fall, goats will be sold because we have little grazing potential December through March. We may add beef cattle, pigs and poultry to the livestock mix in the future. The timing of these decisions will depend on how fast we learn to implement the goat operation and the business results and how fast we can clear the land to establish a mix of forage and desirable trees.

Invest in other agroforestry systems

We explored other agroforestry systems and the relationship of these systems to permaculture. We planted windbreaks for protection from drifting snow. Ann started two trial forest farming areas for ramps and fiddleheads, and she is experimenting with shiitake and other log-grown mushrooms. These activities are in early stages, so we cannot judge their impact on Wilhelm Farm.

We have forest riparian vegetation along the short stretch of Mountain Brook that crosses Wilhelm Farm. Our Factsheet 10, *Riparian Protection on Wilhelm Farm***,** outlines steps we will use to provide even better streambank protection. As we develop water courses to move surface and subsurface water flows from the silvopasture unit to storage ponds, we will install riparian vegetation to protect those areas from erosion.

We plan to use an alley cropping system to convert a steep hillside currently in hay production to alleys of nut trees and either a forage crop or berries. We may use a similar system around our center south pasture, which has wet margins with soils that could be dried with trees and other woody plants. Decisions on the specifics will be made as we gain experience and the longer-term climate trends become clearer.

Our experiences led us to invest more time and money into permaculture planning. The details are in the narrative of this report.

Develop support demonstration materials

We produced 15 Factsheets through our CIG project and seven video presentations with another video expected in the fall after our CIG project ends. Wilhelm Farm now has a strong social media presence with web pages that access all results from the CIG. The web pages also provide information on the Wilhelm Forest, birds and wildlife habitat, and other aspect the farm. The farm has a *Facebook* presence (182 followers), but *Instagram* is proving more popular (442 followers) because many of the farm activities and scenes present such strong visual storytelling.

Provide a collaborative demonstration farm

Wilhelm Farm has hosted a variety of tours and field days over the decades. We participated in Granby Farm Day this year and hosted events in 2014, 2016 and 2018, which highlighted our silvopasture and other agroforestry opportunities.

We will discuss the opportunities with other organizations who might use Wilhelm Farm as a demonstration site. Among the potential collaborators are the NRCS experts, UConn Cooperative Extension, CT service foresters, CT Forest and Parks Association, RC&D, local land trusts, CT Farm Bureau, CT NOFA, and UConn, Yale and other academic programs in resource management and applied ecology. We will continue developing agroforestry and permaculture technologies and sharing our successes (and failures) with others through outreach collaborations.

Learning from Results – Good and Bad

This report focuses on the project goals and positive results, but not everything worked as planned and the project team learned as much from what did not go well as from the successes. Among the most critical issues was an underestimation of the speed of brush regeneration, learning how to manage a larger goat herd for brush conversion, and starting from scratch with videography for project outreach.

As we gained experience with agroforestry systems and permaculture it became obvious that we had, in some cases, jumped to conclusions. We are developing diagnostic methods and decision-making frameworks to help understand small farm problems better and make decisions with based on improved understanding of causes (see Appendix D).

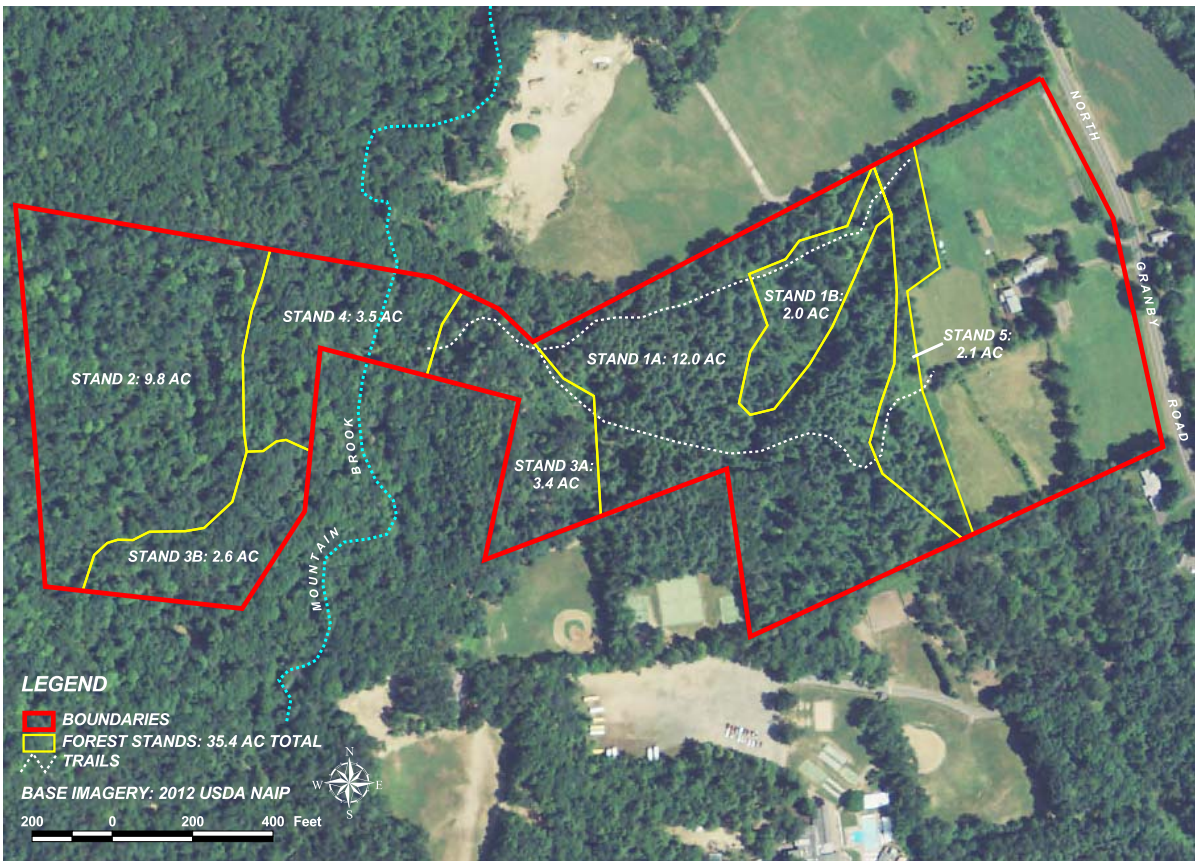
The narrative ends with a critical review of results, what was learned, and a look to the future of Wilhelm Farm considering the experiences and learning from the CIG project.

Project History

Family Ownership

Wilhelm Farm began in 1936 with the purchase of about 30 acres in North Granby. The land uses were a mix of hay, marginal pasture and some fruit trees and garden plots. Oscar Wilhelm and his two sons, Fred and Lloyd, planted pine trees, fenced pastures and developed a subsistence farming system that persisted through the turn of the 20th century. The family farm produced vegetables, milk, and meat. In 1962, Oscar and Marie passed away, and Fred and Edith Wilhelm acquired the farm. They raised 5 children and, with part-time help from others, provided significant amounts of food for the family and collaborators. Fred had earlier purchased an adjacent 15 acres of woods, which brought the total farm to its current 45.6 acres. Ann Wilhelm and Bill Bentley purchased the farm from Fred and Edith in 2003. Wilhelm Farm has been owned by one family for 83 years with some possibility of continuing into a fourth generation with Ann and Bill's sons, Russell and Rick Bentley.

An overview of 2014 land use on Wilhelm Farm provides a baseline for measuring what was accomplished through the CIG project**.**



This map shows Wilhelm Farm with forest stand boundaries in 2014, before the last timber harvest and our effort to create a silvopasture unit.

The land uses in 2014:

Farm & forest	Acres	Comments
Stand 2	9.80	Upland red oak, sugar maple & scrub pine
Stand 3B	2.60	Esker w/south slope; mixed hardwood in cove
Stand 4	3.50	Total 15.00 acres - west side of Mountain Brook
Stand 3 A	3.40	Esker & north slope mixed hardwoods & hemlock
Stand 1A&B	14.00	Predominantly eastern white pine
Stand 5	2.10	Initial core of silvopasture area
Total Forest	**35.40**	20.40 acres - east (farm) side of Mountain Brook
House, barns & garden	1.20	Raised beds w/intense soil management
Hayfields &pastures	9.00	2+ acres of wet pasture; 1.5 acres steep hayfield
Total Farm	**10.20**	May convert 1 acre to market garden; + raised beds
TOTAL	**45.60**	

Fred and Edith donated a conservation easement for the farm to the Granby Land Trust in 1992 with full support of their five offspring. In 1994, Fred had the first forest stewardship plan prepared by a professional forest consultant. The plan laid out clear goals for soil and water stewardship, habitat management for songbirds, and sustainable management of white pine and mixed hardwoods using group selection and natural regeneration. Revisions of the stewardship plan were done by Bill Bentley in 2004 and 2009.

The first timber sale was completed in 1997. Wilhelm Farm harvested timber three times from 1997 to 2014, removing over 450,000 board feet, 75% of which was white pine. Most of the harvested pine had been planted in 1936, but some timber was the result of natural reproduction. Future harvests will include natural pine or seedlings planted in 2014. We received a NRCS EQIP grant that provided partial support for a 2013 forest stewardship plan. A second EQIP grant partially supported the late summer 2014 mechanical clearing of brush and 2015 planting of white pine seedlings in an area where natural regeneration failed after the 2007 timber harvest.

Evolution of Silvopasture Plan

Several factors led us to silvopasture specifically and agroforestry more broadly. First, we were looking for ways to improve the productivity of our land. Second, our long-term vision was of an integrated farm and forest with a strong sense of permaculture. Third, Wilhelm Farm historically had livestock as critical components of the family farm, and we were looking for practical ways to reintegrate animals into the overall operation. In addition, Wilhelm Farm had hosted tours and other outreach activities serving landowners of small farms and forests for over 80 years, so an expanded outreach role contributes to an important NRCS mission.

Planning and implementation of the 2014 timber harvest encouraged Bill and Ann to rethink the longer term uses of the wooded area east of Mountain Brook. Continued management of white pine/mixed hardwoods made sense on 15.5 acres, but there were over 3 acres of woods with low productivity, often wet soils and prone to brush invasion. As we studied the soils map, it became clear that this area was not suitable for white pine or quality hardwoods.

We began exploration of converting these acres to silvopasture. Vivian Felton, NRCS District Conservationist in the Windsor office, suggested applying for a Conservation Innovation Grant. She noted that Connecticut NRCS did not have demonstrations of silvopasture specifically or

agroforestry more generally, so we could fill an agency gap while learning how to better manage our landscape.

CIG Application focused on Silvopasture, Agroforestry and Climate Change

We started with a land-use goal: *Invest in silvopasture and other sustainable farming systems* and added outreach goals: The innovations were investing in silvopasture and other agroforestry technologies, developing of social media for Wilhelm Farm's outreach purposes (e.g., webpages, Facebook, Instagram), and creating demonstration videos. While there were many illustrations of using these tools for outreach in general, few examples existed that were useful for Connecticut rural landowners interested in combining grass and trees on marginal soils. A CIG was awarded beginning March 1, 2017 through September 30, 2019.

Before we began thinking about agroforestry and permaculture, we had concluded that our long-term farm plans must withstand climate change. We gathered information about the impact of greater weather variability on agriculture and forests in Connecticut and southern New England. Our review suggested that agroforestry systems would be useful in alleviating damage from climate change. The benefits include:[1]

- Agroforestry utilizes solar energy more efficiently than monoculture systems because different heights, leaf shapes and alignments capture more energy for photosynthesis
- Mixed species systems often lead to reduced insect pests and associated diseases
- Agroforestry provides more diverse farm household economies and stimulates rural economies, leading to more stability and lower risks by producing multiple products

Audiences and their Information Needs

We began our CIG project by developing a sense of the audience for small-scale land-use. As we explored the literature and spoke with colleagues, it became clear that our audience included several groups, some of which fell outside our expectations. After looking at various studies and statistics, one question about our potential audience rose to the surface: *are there 24,000 farm and forest ownerships in Connecticut, or are there six times that number?*

The numbers are interesting. Using Forest Service and Agriculture Census data, there are about 24,000 landowners in rural Connecticut. There are a few large farm ownerships, and many in the 1 to 50 acre size. Overall 6,000 families own 436,539 farm acres, with an average farm size of 73 acres, and a median of 22 acres. The Connecticut 2012 USDA Agriculture Census statistics are:

Acres	Number
1-9	1,768
10-49	2,403
50-179	1,317
180-499	379
500-999	67
1,000 and more	43

[1] See references, but especially Gough, et al, 2019 for estimates of primary production in complex forests.

But with a large percentage of our own farm being wooded, a situation common in Southern New England, we wanted to look at forest ownership numbers as well.

Studies report that 17,000 families and individuals own nearly 600,000 acres of Connecticut forest, all in 10 acre or larger holdings. Connecticut has 34% of its forest ownerships in properties greater than 10 acres, the size the Forest Service uses for ownership assessment. However, and vital to our interests, Mary Tyrell and Brett Butler expanded the usual Forest Inventory measure to count owners from 1 to 9 acres (in addition to the usual Forest Service standard of 10 or more acres[2]). This acreage measure added another 300,000 acres and 122,000 owners and made a total of 139,000 forest owners in Connecticut[3]. Additionally, almost all these ownerships are families (however structured legally). These small forest ownership categories developed by Butler and Tyrell began to shape our thinking about Connecticut landowner audiences.[4] While similar research has not been done focused on farm ownership, data suggests similar patterns exist.

There are a few large acreage, productive farms in Connecticut, but most are less than 50 acres, and almost a third are 9 acres or less. Forest ownerships in the 1-9 acre size constitute nearly 90% of Connecticut forest ownerships. These small properties are not suitable for most commercial agriculture practices or industrial wood production but could be candidates for agroforestry systems. We believe that these many small farm and forest owners are prime candidates for information about agroforestry and permaculture, practices that would easily fit their ownership scale and goals, and could ultimately provide value benefits to the owners. And our research suggests that our potential audience is at least 124,000 landowners, which is considerably larger than the 24,000 we identified at the time our proposal was submitted.

The usefulness of these small ownership categories becomes more obvious when reviewing the data on rural land holdings. For example, Connecticut rural landownership in parcels of 1 or more acres is 5,977 farm owners[5], and 138,800 forest owners[6]. The forest units of 1 to 9 acres make up 88% of the owners (34% of Connecticut's forestland), and when expanded to include owners with 10 to 24 acres (16% of the state's forestland), the figure rises to almost 95%. Farms in the 1 to 9 acre size are 30% of the total owners (but only 2% of the state's farmland), and when expanded to 49 acres (13% more of the total farmland) the figure rises to 70% of all farm ownerships. These statistics further bear out how numerous, and important, small farm and forest ownerships are in Connecticut.

Amenity Values

We believe our target audiences include the *Rural Retreat*, *Back to the Land Folks* and some of the *Non-Resident Owners*. The common threads between the first two groups are goals of

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[2] See references for Butler and Tyrell for details. Their 2012 to 2016 research provides an in-depth understanding of Connecticut's small rural landownerships.

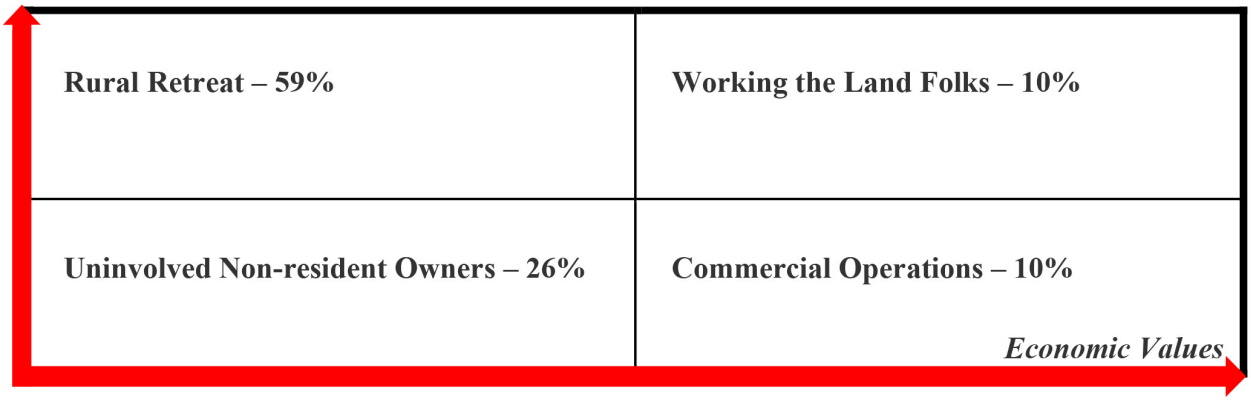
[3] Using the USDA agricultural census one acre standard

[4] We attended a workshop on social marketing to family forest owners sponsored by the CT Forest & Park Association (CFPA) workshop February 24, 2017, on targeted marketing to small Farm & Forest landowners. Emma Kravet, CFPA Education Director, and Lindsay White, a graduate student working for Yale's Sustainable Family Forest Initiative, were the workshop leaders.

[5] USDA Agricultural Census 2012

[6] Understanding Connecticut Woodland Owners, Mary L. Tyrell, Yale School of Forestry • March 2015

sustainability and working with their ecosystems. While non-resident owners are irritants to most extension and outreach professionals, in Connecticut these owners often live close to their properties and work on them regularly.[7] As a result, they often share the values of the other two target audiences. The total number of rural Connecticut landowners with 9 acres or less parcels is over 124,000 and most of these are non-commercial. Mary Tyrell estimated that the Rural Retreat group is the largest forest ownership category in Connecticut – 59%.



Categorization of Audiences for Wilhelm Farm CIG Results (With Percentage of CT Forest Owners Noted)

Commercial owners are generally not interested in silvopasture or agroforestry, but they often are concerned with sustainability. The Connecticut landscape, except for the valleys, is generally not prime cropland soil, so ways of increasing productivity may be of interest to a few commercial owners on their lower productivity soils.

Each audience needs a broad view of how agroforestry systems work, and case examples that make the idea concrete. The demonstration farm, factsheets, webpage and videos are means for delivering this information to an array of rural Connecticut landowners.

Summarizing our observations on our audiences:

1. The majority are not looking for immediate cash flows or profits.
2. Environmental & amenity values are important to owners.
3. All small ownerships face uncertain futures because of climate change with more volatile weather patterns and rapid change in political, social & economic contexts
4. Wilhelm Farm is typical of Connecticut small farm and forest owners
5. Our demonstrations are focused on sustainability and resilience within a diverse set of family goals

[7] This point was made to Bill Bentley by Brett Butler in a conversation early in the CIG grant

Accomplishments and Results

The area planned for silvopasture grew from under 3 acres to about 7 acres. This area includes wet pastures planted with hybrid poplar to be hydraulic pumps that store and transpire water, the former barn and chicken yards, and a path/watercourse that connects the main unit to the barns and yard. Conversion of the low-quality woods and brush is far from complete, but progress demonstrates that the system works and that a new livestock operation can be based on this area.

Two other agroforestry systems were developed: trials with forest farming of mushroom, ramps and fiddlehead ferns, and windbreaks to reduce snow drifts. Riparian systems will be used along Mountain Brook and proposed water channels to move surface and subsurface water on front quarter of the farm. We also have plans to use alley cropping to reduce actual and potential soil erosion on slopes now used for hay production. Another result is initial development of a permaculture strategy for Wilhelm Farm.

Silvopasture Systems Emerge

In 2013, Wilhelm Farm obtained an EQIP grant from NRCS to update our previous forest stewardship plan. Ian Branson, a CT and NRCS certified forester, was retained to prepare the plan and developed a harvest plan, including soliciting bids from private logging and lumber firms. During the planning process, ideas developed for replanting pine in a 1.7 acre area where regeneration failed following the 2007 timber harvest. Brush had taken over the area. Mechanical brush removal was required before pine seedlings could be planted. Another area of 2.1 acres was identified with very dense brush, hardwoods and pines of marginal value, and often wet soils that are distinct from the adjacent high productivity pine soils. Additional scattered brush sites were identified. These brush conversion areas led to a second EQIP grant to mechanically remove brush on 7 acres and replant 4 acres to white pine.

A vision of an integrated silvopasture unit emerged. An area of wet pastures with similar marginal soils was added to the marginal woodlands, a strip of brush along an old watercourse and cattle path, and the former barn and chicken yards. This unit encompasses about 7 acres. The vegetation management strategies vary over the area. The most difficult area is the brushy marginal woodlands where the focus is on reducing brush and reseeding to pasture grasses. Over time, more low-value trees will be removed and some oaks either tended (natural seedlings) or planted. Eventually, we will re-space trees to be more evenly distributed in the unit, while retaining some thickets of pine and hemlock to protect livestock from fall and winter wind and summer heat.

The barn and chicken yards and cow path/water course are now largely clear of low woody vegetation. With some expansion of the barn yard, we hope to have an area close to the barn for some winter grazing and outdoor space for animals during winter days of reasonable weather.

The goats are demonstrating their ability to clear brush in spots where equipment cannot be used.

We planted hybrid poplar on the wettest pasture to be hydraulic pumps that store and transpire water. It is too early to validate that the practice works, but our seedling establishment success encourages more planting. The trees can be used for cut-and-carry fodder (poplar leaves have high protein content), small poles or biomass for energy.

Other Agroforestry Systems

We are also exploring the four other major agroforestry systems.

Windbreaks/live snow fence – We designed and planted live snow fences. The heavy winter snows come from the north because of the prevailing winter weather patterns, which are reinforced by a gorge a half mile north of Wilhelm Farm. One windbreak will reduce the snow flying over the garage and house, accumulating at the garage entrance and front door. The other prevents major drifts on the east-west driveway, especially at the bottom where it is difficult to enter the drive from North Granby Road.

Forest Farming – We have been growing mushrooms for several years, mainly Shiitake, and are experimenting with several other varieties as part of learning about forest farming. Ann has had success with oyster mushroom and with straw mushrooms following harvest of asparagus late each spring. In 2018, Ann installed a trial of ramps and fiddle heads on the alluvial soil to the east of Mountain Brook. The results to date are not positive. The area was covered by water very late into spring 2019 and it receives little direct sunlight in the heart of summer. However, we will monitor for another year or two.

She installed a second trial in 2019 on the southwest slope of an esker to the west of Mountain Brook. Dr. Jim Chamberlain, the Forest Service expert on forest farming, advised her to select a site with more sun and better drainage, which guided her search and choice. For more information, see Factsheet 13, *Forest Farming on Wilhelm Farm*.

Riparian Management – Our only current riparian zone is a short distance along Mountain Brook. Our plans for improving management of this zone are described in Factsheet 11. We will develop a riparian zone along the ditches and channels required to move surface and subsurface water from the upper silvopasture unit to storage near the future market garden area.

Alley Cropping – We do not have an example of ally cropping on site, but we plan to use alley cropping to help stop soil erosion on a steep slope that has been hayed for 100 years or more.

The steep slope in the south hayfield will be converted to an alley cropping system with alternate nut-tree alleys and forage or berry alleys. Forage is the preferred alternative, but the feasibility depends on identifying haying equipment that can operate in narrow alleys. In addition, we will use a modified alley cropping system on the wet periphery of our center south pasture

Permaculture Strategy[8]

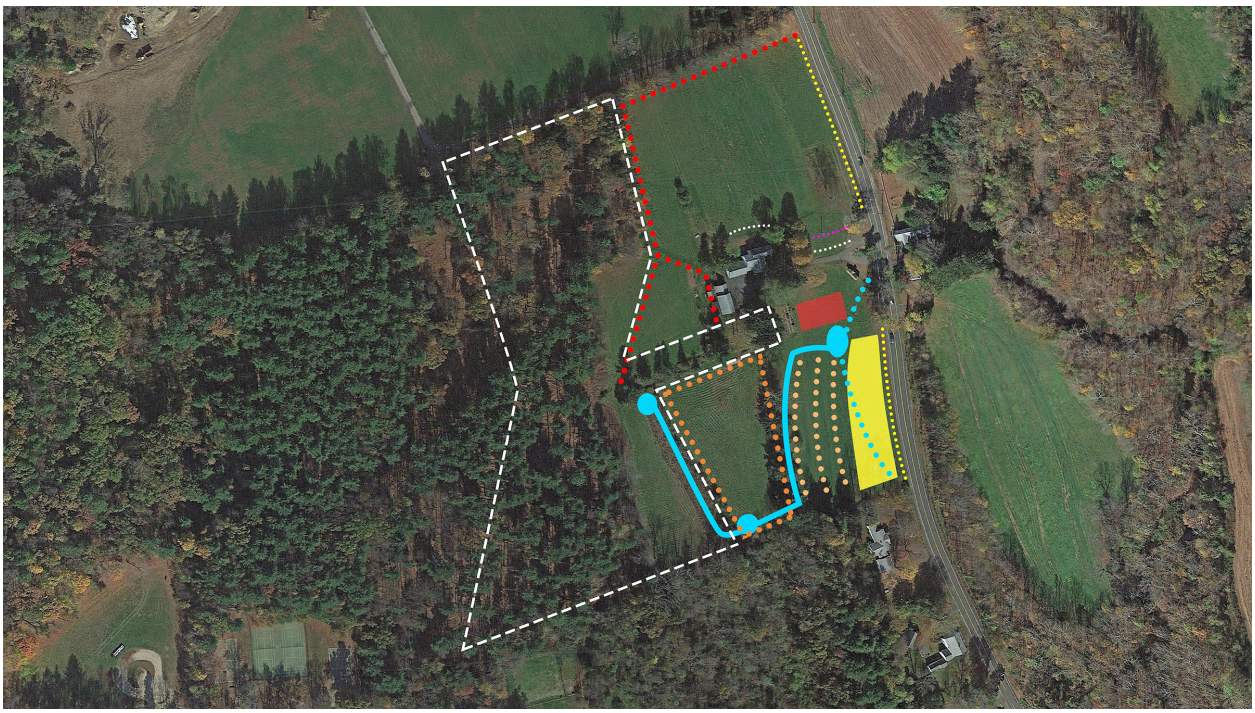
As we learned more about our farm and the potential of agroforestry systems to improve value productivity, we appreciated permaculture as a strategic goal. We have perennial vegetation on 97% of our working landscape, so in an important sense we are already there.

The landscape we purchased in 2003, however, reflected of its history from 1936, when Oscar and Marie Wilhelm purchased the farm, back to the original settlement of Granby in the 1700s.

[8] We have read many articles and books about permaculture over the years and talked with several experts during our CIG project, including Vivian Felten, Connor Stedman, Kip Kolesinsksas and Sven Pihl. Our current thinking and planning has drawn freely on all our sources. We recommend Jono Neiger's *The Permaculture Promise* to anyone looking for a useful manual that is based on science and experience (see Reference Appendix).

For example, the back 15 acres, which has steep granitic outcrops, was partially logged but never fully cleared and only lightly grazed. The high-quality oak and sugar maple trees on this area are a result of that history. The pine and mixed hardwoods on the east side of Mountain Brook was marginal pasture in 1936 with a few large grandmother pine trees scattered over 21 acres. Oscar and his sons planted over 15 acres of eastern white pine, which created a pine/mixed hardwood stand. The hayfields included some of the wet pastureland in the early years but have been concentrated on the dryer landscape for the past 35+ years. The home garden was moved from time to time, but the area was always replanted to hayfield after the garden was moved.

Our tentative permaculture plan for the eastern edge of the farm is illustrated below.



The Permaculture Plan*: the dashed white line is the silvopasture area; yellow dots are pollinator strips; blue designates proposed channels and ponds for water moving off silvopasture area; orange dots are alley cropping trees (both around edge of pasture, and in contour lines); the new market garden is shown in yellow; windbreaks are shown in small white dots, and flowers in magenta dots; road & trail into back of farm is indicated in red*

We will refine this plan as we move forward in 2020 with help from private consultants and public agency professionals.

Livestock Enterprise Plan

20 to 40 years ago, Wilhelm Farm had several livestock enterprises – a dairy cow or two, some beef cattle, a couple of pigs for the spring through fall, and chickens for eggs and stewing. These were dropped one by one as Fred and Edith aged. Owning goats year-around since 2017 stimulated a rethinking a livestock enterprise.

We need goats on site from May until October to browse the brush that is key to converting our landscape to a true silvopasture system. We do not want to carry more than 2-3 goats over winter because of the cost of hay and grain and the effort of clearing manure regularly. One alternative would be to buy kids each spring and then sell them for meat each fall.

Another, which is still in the development stage, is to buy some females and several kids from the nearby Sweet Pea goat dairy. The does could be either dry or still nursing a kid or two. Additional kids would be purchased as they are weened. In the fall, Sweet Pea Dairy could purchase back any does it wants to add to the coming year's dairy herd. We would select the 2-3 we'd retain, and the rest would be sold to slaughter. Because we have large Caribbean and Muslim populations in the Greater Hartford area, there is a steady demand for goat meat. This would create a sensible, sustainable livestock enterprise that could adjust to annual brush grazing needs.

We will add range chickens to the mix, refencing the barn yards. We may add pigs to root out browsed brush, but this alternative depends on our success in converting brush to grass with browsing, seasonal mowing and herbicide without rooting out brush roots.

Other Wilhelm Farm Enterprises

Ann is producing specialty crops, like rhubarb, herbs, ramps and mushrooms, plus asparagus, heirloom tomatoes and various peppers and eggplants. This enterprise could be expanded to a renewed full-fledged market gardening, but that will require hiring help or a partnership.

Our other commercial enterprise is timber production. We can harvest pine every 8 to 12 years and oak, sugar maple, black birch and other hardwoods every 20 to 25 years. The cash-flows from timber harvests are reinvested into the farm. The 2014 timber harvest was, for example, the initial funding source for our transformation into silvopasture.

In addition to the three commercial activities, we manage our forest habitat to encourage migratory songbirds. Since our first harvests in 1996/97, we have seen a significant increase in both number of birds and number of species. The multiage, multi-height stands provide more habitat niches. While not desired in many respects, dense brush, especially multiflora rose, provides cover for many species during egg and hatching periods. Our work with Audubon and Forest Service project *Forests for the Birds* estimates over 45 species in residence during a part or all the summer. A visual inventory this spring by Michael Bentley affirms that number.[9]

An additional non-profit enterprise is service to our community and state as a demonstration farm. We will continue to work closely with NRCS, UConn cooperative extension, DEEP service forestry, Farm Bureau, and other outreach organizations for tours, factsheets and videos.

[9] See WilhelmFarm.org//images-from-the-farm/ May Birds 2019

Family Values Guiding Management

Our project will encourage a holistic perspective in decision making. Looking at your farm as-a-whole allows effective integration of goals like *Natural Resources Stewardship*, *Family and Community Values* and *Financial Perspectives*.[10]

All values cannot be collapsed into dollars or present net worth estimates. Making tradeoffs explicit between dollars and other values is essential for small farm and forest ownerships. Research by Dr. Brett Butler (2016) and his team on family forest ownerships reveals an array of desired values:

1. Amenity values are the dominant reasons for owning 10 acres or more:
    - Beauty, wildlife, nature, legacy, privacy and water are cited by 50% or more of owners as important or very important
    - Family, hunting and recreation are important to very important for 40 to 50% of the respondents.
    - Long-term Investment is an important purpose for 40% or more of the owners and even more so for those who own 10 acres of more of the forested acreage, which is 66% of the total Connecticut forested area. Timber, firewood, and non-timber forest products – utilitarian values – are far less important.

2. Butler, *et al* (2016, p. 646) observes, *Owners tend to be active on their land, but most are not engaged in traditional forestry programs. Program effectiveness will likely increase with more explicit incorporation of amenity-oriented ownership objectives, increased emphasis on intergenerational transfer of land, and a focus on traditionally overlooked owners, such as females.*

Integration of goals is a desirable step to help family forest owners make more sophisticated and socially responsive decisions. While the literature with regards to small farm owners is less rich, we observe considerable evidence that similar values hold

A short case study of the Wilhelm Farm farmstand 1990–2012 illustrated the tradeoffs between time and money. Ann and Bill were married in late 1990, Russell was born in 1992 and Ricky in 1995. During the 22 years of market garden and farmstand operation, we benefitted from:

Trade-offs among values

- Reduced income, but also reduced expenses
- Tax advantages

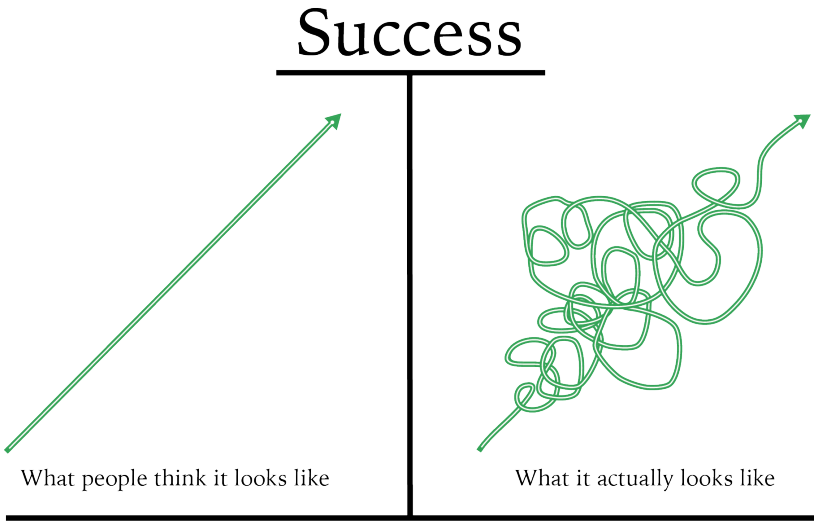
Intangibles–critical to our audiences

In summary, operating the market garden and farm stand netted at least $31,000 a year in savings and other benefits. Salary opportunities in this period for Ann were about $35,000 after taxes, so we attributed about $4,000 annually to intangibles.[11]

[10] See Factsheet 9, *A Household Economics View of Small Farm & Forest Ownerships.*

A second, more complex case study illustrates choices among 6 land uses on Wilhelm Farm using financial, social and ecological criteria to rate the alternatives. The case study demonstrates that the measures are not limited to quantitative estimates, but can include a variety of qualitative measures, even plus (+) and minus (-). We also summarized the alternatives in terms of our vision for Wilhelm Farm, which will enhance our relationships with our children, extended family, community, and professional colleagues, and they, in turn, will broaden and deepen our vision over time.

Results that Did Not Come Out So Well



Some truths are much more obvious at project end than when we developed our CIG proposal. Between Ann and Bill, we had professional and scientific training in animal science and forestry, and we both had practical experience with animals, trees and even some agroforestry. We were not experienced with the specifics of brush and goat management in southern New England, and we did not have any experience with making videos – scripting, shooting, and editing. Our handicaps were reduced by many wonderful people, some on our team and many others in organizations interested in the problems that we were addressing. A summary of what did not work as planned, however, makes what we are learning clear and may help others interested in silvopasture and other agroforestry systems

Brush Control – Our greatest failure was not understanding how fast the mechanically mowed brush would resprout from the roots. Efficiency in equipment use and cost dictated doing 7.1 acres at one time, well before we planned how to maintain control of vegetative cover. We did plant 2,000 pine seedlings on all areas where regeneration did not occur following our 2007 timber harvest. The survival rate was excellent – over 95% – and the seedlings generally have

[11] See Factsheet 9, *A Household Economics Perspective on Small Farm and Forest Ownership,* for more details on this and next more complex case study.

grown in height rapidly after a year or two focused on root growth. The most spectacular growth is in open areas, but even in the partial shade of brush overstory most of the pine seedlings are growing reasonably well and will overtop the brush in a few years.

Where we are converting to grass or grass/tree vegetation, however, we were not able to keep the brush under control. We did not have the capacity to use mechanical control. The silvopasture area is rocky and has large logging slash from the 2014 harvest. Our diesel tractor and brush hog cannot operate in this terrain.

We had decided against using broad cast applications of Roundup because of possible environmental effects and we wanted the option of moving eventually to organic certification.

Three successive summers of high rainfall and warmer weather were quite favorable for brush growth (and, on the positive side, tree growth). The rapid invasion and spread of Asian Bittersweet in the past 5 years compounds our brush problem. This invasive makes broadcast application of herbicide a more desirable alternative because it would kill root systems, which prevents brush from resprouting.

Appendix D – Diagnostics and Decisions, lays out a process for systematically looking at land use problems like our wet pastures and woods to ascertain likely causes and potential solutions.

Scale of Goat Management for Brush Control – Our successes with goats for brush control are real. We did not, however, estimate how many goats would be needed to effectively control brush on 3 to 4 acres in 2 or 3 summer seasons. Once we recognized the problem, we also were realistic about the scale of operation we could handle. Time is our limiting factor, which will continue because Ann is fully employed off-farm. Our planning for the future goat livestock operation will focus on the appropriate scale for anticipated labor availability year by year.

A livestock business model is emerging, and we will increase of our scale each year. Once cleared, goats will be able to maintain control of the brush.

Videography – We recognized from our earliest planning that we needed strong support for our visual strategy for communicating results. Hanna Lindeyer, who had grown up in Granby and was a recent graduate from Pratt Institute, was working in video for some New York City firms. She agreed to work with us. Michael Bentley, who has expertise in graphic design, video and sound editing and production, also joined our team. Hanna had to drop off the team after about a year, but we have several hours of video footage that can be used in future projects.

Factsheets – We are pleased with our 15 Factsheets. Some factsheets should be rewritten with current results over the coming couple of years. Factsheet 4, *Biophysical Metrics for Agroforestry: Measures & Uses of Simple, Inexpensive Information to Guide Management*, needs a complete rework and reissue. The proposed line-intercept design is solid, but it was not possible to implement. The rapid growth of brush in the center of the silvopasture unit made it impossible to measure along set line intercepts because we could not move through the vegetation in a straight line with a tape measure. After we have brush removed mechanically again, we can reinstall permanent line intercepts. In the meantime, we are exploring use of a drone with a camera in fall 2019 or winter 2020.

Where Does Wilhelm Farm Go from Here?

The future for Wilhelm farm over the next few years is set by the results of our CIG project. We will continue to develop a goat livestock operation, and Ann will apply for grants to partially fund developing a working model of meat and female goat production, working with Sweet Pea Dairy. If successful, Wilhelm Farm will add a viable new enterprise and contribute to the success of another farm in Granby.

Bill will develop a plan for reducing the brush to a level manageable by a goat herd of the size Ann concludes is optimal for her livestock enterprise. The plan will include mechanical removal of the above ground stems followed by repeated follow-up spot spraying. The mechanical step requires use of an external service because neither our DR Field machine or our tractor with brush hog can operate in this area of rocks and large logging debris. The mechanical removal should occur after major above-ground growth (roughly July 15 to August 1). Herbicides that translocate to roots and kills them works best after this date because the plant is building starch storage in its roots for growth the next spring.

We will continue to plan and implement our permaculture strategy. The critical next step is to develop detailed plans for managing and storing surface and subsurface water flowing off the silvopasture unit. At least one more consulting session will be scheduled with Conner Stedman, AppleSeed Permaculture, Inc., to follow up on the broad plan developed earlier. Another session with Kip Kolesinskas, Connecticut Land Conservation Council, may also be scheduled to help us better understand our soil resources and water management.

Specialty vegetable crops will be a continuing enterprise, probably expanding as Ann moves into retirement. If a suitable partner is identified, the raised beds can be extended down the slope and the new market garden are be established and made operational. Mushroom production will require improved management of sunlight and moisture in our logyard. If we have successes with growing ramps and/or fiddleheads, long-term investments will be necessary to establish patches that can be harvested sustainably.

The forest enterprise needs reshaping to reflect relationships with other Wilhelm Farm enterprises. The oak and sugar maple management on the western 15 acres of woods will be modified as needed to provide appropriate space and light for ramp and fiddlehead production. An ongoing source of small red oak logs for mushroom production will be developed by periodically thinning the woods, but that requires protection and spacing of natural regeneration as it develops.

We will explore the potential of producing florist cut branches and greens as a byproduct from the forest. We have several expanses of ferns as forest succession occurs, and other floristic species may be identified as well.

Protection from invasives is an ongoing issue. Multiflora rose and Japanese barbury will be continuing problems, but probably managed with shade as the tree canopy closes with mechanical removal of small patches. The most difficult problem is Asian bittersweet. It is pervasive and spread by birds that eat the berries. It can regenerate in partial shade, climbs trees, and will kill even tall oaks and pines by smothering if left unchecked. Because it has no natural enemies in the Northeast US, it will profoundly change northeastern forests. We are mechanically removing stalks that are climbing our commercial trees, and we will collaborate

with the Connecticut Agricultural Experiment Station on potential research using biological controls.

At present, we do not have serious insect or disease problems, but we monitor for signs of gypsy moth, white pine weevil, pine blister rust and other diseases that may develop with changing climate.

Appendix A – Factsheets

Factsheet No. 1: *A Summary of Agroforestry Systems for Connecticut and New England*

Factsheet No. 2: *Considering Silvopasture Systems in Connecticut and Southern New England*

Factsheet No. 3: *Wet Pasture into Silvopasture: Guidelines & Steps using Hybrid Poplar*

Factsheet No. 4: *Biophysical Metrics for Agroforestry – Measures & Uses of Simple, Inexpensive Information to Guide Management*

Factsheet No. 5: *Trees as an investment*

Factsheet No. 6: *Timber Prices and Price Projections for Southern New England*

Factsheet No. 7: *Forest investments – Wilhelm Farm Examples*

Factsheet No. 8: *Windbreaks on Wilhelm Farm*

Factsheet No. 9: *A Household Economics Perspective on Small Farm and Forest Ownership*

Factsheet No. 10: *Riparian Protection on Wilhelm Farm*

Factsheet No. 11: *Potential Impacts of Climate Change on Southern New England Farms and Forests*

Factsheet No. 12: *Trees and Brush into Silvopasture: Low-Cost Guideline & Steps Using Goats*

Factsheet No. 13: *Forest Farming on Wilhelm Farm*

Factsheet No. 14: *Alley Cropping Plans for Wilhelm Farm*

Factsheet No. 15: *Permaculture and Landscape Design – Wilhelm Farm Case Study*

All the Factsheets can be viewed on the Wilhelm Farm webpage, *wilhelmfarm.com*

Appendix B – Videos

Videos and PowerPoint slides developed as part of Wilhelm Farm CIG, available via wilhelmfarm.com:

Lessons Learned from CIG Project: Demonstrations of Silvopasture & Other Agroforestry Systems – An Interview with Ann and Bill and Ann to summarize this project (to be released in late fall 2019).

The Evolution of Permaculture Design on Wilhelm Farm – A graphic tour of the evolution of our thinking.

Why Goats? – This is the most important video of this series from a practical viewpoint.

The View from Oscar Wilhelm's Farm – A presentation made to the Yale Forest Forum on 28 March 2019. Topics include the history of Wilhelm Farm, the NRCS Conservation Innovation Grant, potential Connecticut audiences, and plans for the farm.

Silvopasture for Family Farms – Presenting ideas about how silvopasture and other agroforestry practices might fit into forest and farm ownerships in Connecticut and southern New England.

Wilhelm Farm Through Time & Space – Seeing the farm and its place in the landscape using historical and current aerial views.

Barn Fields and Trees – An introduction to the Demonstration Farm Project.

Wilhelm Farm Slide Show – A presentation outlining the history of the farm and our stewardship of the land, as well as our plans.

Videos from Other Sources:

Managing Our Connecticut Forests – University of Connecticut forestry extension video covering forest management issues (converted from tape – now available via wilhelmfarm.com)

Introduction to Agroforestry – University of Wisconsin, available via youtube.com/channel/UCLNtxoX1cwQruNoOoDVCc1w

What is Agroforestry? – Available via youtube.com/watch?v=MZ6No1mL1QM

Agroforestry Practices – Alley Cropping, University of Missouri, available via youtube.com/watch?v=b8Kwb5yInPM

The Appalachian Beginning Forest Farmer Coalition – Available via youtube.com/user/exforestfarming

National Agroforestry Center – Available via fs.usda.gov/nac/ & nrcs.usda.gov/wps/portal/nrcs/main/national/nac/

World Agroforestry Center – Accessible via worldagroforestrycentre.org/

youtube.com/channel/UCLNtxoX1cwQruNoOoDVCc1w

A web search for agroforestry videos will lead landowners to subjects that fit their information needs.

Appendix C – Budget vs. Expenditures
(March 1, 2017 through September 30, 2019)

NRCS line items	***$ Budget***	***$ Expenses***	***$ Variance***
Travel	500.00	500.00	0
Material & Supplies	4,000.00	4,000.00	0
Other Costs	28,600.00	28,600.00	0
NRCS Totals	**33,100.00**	**33,100.00**	0
Wilhelm Farm match line items	***$ Budget***	***$ Expenses***	***$ Overage***
Salaries	28,400.00	65,961.14	37,521.14
Travel & other costs	4,800.00	9,039.11	3,056.57
Wilhelm Farm Totals	**33,200.00**	**75,000.25**	**41,800.25**
CIG Project Total	**66,300.00**	**108,100.25**	**41,800.25**

The Federal grant funds awarded by NRCS ($33,100.00) were fully expended. Wilhelm Farm agreed to a match of $33,200.00 in time and cash. It matched this amount, plus $41,800.25, a 126% overage.

Appendix D – Diagnostics and Decisions

Diagnostics and Decisions[12]

Agroforestry systems are quite adaptable and multifaceted, but they are not the solution to all problems. Before deciding that an agroforestry system is ***the solution*** to a specific problem, the landowner must concisely identify the problem. We use a problem taxonomy that helps select the proper structure to use in framing how to reach a solution:

- **Symptoms** – what is causing unwanted or unexpected symptoms?
- **Decisionmaking** – given an understanding of what is causing symptoms, what are the alternatives for alleviating the symptoms?
- **Action Planning** – given a decision, what steps are necessary to implement the selected solution?

Action Planning is a relatively simple identification of the steps necessary to implement a project in a rational order, assigning responsibility (who) and setting a date for completion. The level of detail is set by the project, and very complex plans are possible where the expected results justify the effort. Plans provide a framework for following up – how are we doing on implementing the planned project?

Decisionmaking – Some examples developed during our CIG /project are:

1. ***How do we Increase Specialty Crops Based on our Forest Resources?*** A goal of Wilhelm Farm is to produce specialty crops that have a strong market demand. Ann has grown mushrooms, mainly shiitake, for many years. She is experimenting with other varieties and would like to increase her forest-based crops. Forest Farming of ramps and fiddlehead ferns are two alternatives she is exploring with field trials. This example illustrates a decision problem – clear goal expressed in terms of physical yield and cash flow. How do we get there? The results are described in Factsheet No. 13: ***Forest Farming on Wilhelm Farm***.

2. ***How do we reduce Drifting Snow limiting accessibility to driveway and garage?*** Snow drifts during Nor'easters from the north hayfield presented another decision problem. Snow accumulates on the north side of the house and garage and drifts over the garage blocking the entrances. More serious drifts accumulate on the bottom of the driveway, sometimes making it impossible to enter from the highway and drive up to the house.

   The solution is a choice among different forms of snow fence. A barrier causes drifting snow to drop and accumulate on the ground before the garage or the driveway. For years,

[12] See Miller, Shinn and Bentley, *Rural resource managers: problem solving tools for the long term*, in the references for the processes of developing and testing hypotheses about causes and how to link values expressed as criteria with alternatives to make decisions. The perspective of these authors and many others was shaped by Kepner and Tregoe, *The rational manager* (see references).

Fred Wilhelm set up old-fashioned wood-slatted snow fences each fall north of the driveway. The fences wore out and were not replaced because they were heavy and difficult to handle without strong, young helpers. We used plastic show fence for a few years, but strong blizzard winds frequently blew the fence apart. Windbreaks are often used in the upper Midwest as living snow fences to prevent drifts across roads and highways. We read the literature, and worked with Dr. David Miller, a professor emeritus at University of Connecticut who specializes in meteorology, including use of windbreaks around farms. The solution and design of red cedar hedges is described in Factsheet No. 8: ***Windbreaks on Wilhelm Farm*.**

3. ***How do we manage our Riparian Zone?*** We can look at the history of the nearby east branch of Salmon Brook to understand the causal forces of changes in the riparian environment. Salmon Brook significantly changed course following a year of bad flooding, and this also significantly altered the riparian zone around the brook. We have alternatives to implement when the steam banks show signs of erosion. See Factsheet No. 10: ***Riparian Protection on Wilhelm Farm*.**

   In the future, we probably will move water from the silvopasture area to the future market garden, which will create new riparian areas. Managed riparian vegetation will be needed to protect the bank of the water channels. In a similar vein, alley cropping is an obvious choice among alternatives for stopping erosion on the steep hayfield.

Causal Analysis. Many complex problems start with a question: ***what is causing this symptom?***

The initial prompt for our CIG project provides a good example of complexity in cause and effect. Causal Analysis should be dealt with before alternative solutions are evaluated in a decision process. Through much of our project, we labeled the central problems as the ***Silvopasture Problem*.**

Our problem was first identified by the heavy brush growth in the eastern unit of our woods that were dominated by white pine and oak. Our reconnaissance identified two areas where brush dominated:

- 1.7 acres where we experienced pine regeneration failure following the 2007 timber harvest.[13]
- 2.1 acres where brush and low-value hardwoods dominated and an adjacent 0.7 acres on a different soil type but with similar brush vegetation.

The perceived problem was initially dense brush growth, but what caused this growth?

[13] The failure caused by a poor cone production year and little viable pine seed to germinate in 2008. This was a decision problem. The soil type is a high productivity site for white pine and red oak, so we solved this problem by planting pine seedlings in 2015 following mechanical removal of the brush. We understood the cause and the solution because mechanically clearing the brush and planting pine seedlings was a standard and obvious decision.

The real problem is *Wet soils* and *low value productivity.* This problem was first identified on 2.1 acres with low-value hardwoods and heavy brush adjacent to our high productivity pine and oak stand. As we studied the soil characteristics and similar problems on adjacent woodlands and pasturelands, it became clear that the common symptom was wet soils through the spring and often much of the summer. The vegetation on the almost 7 acres of wet soils includes (1) grass with lots of sedge and Carex, (2) black birch and red maple of generally poor form, and (3) tall, dense brush with native species (e.g., grape, black raspberries, and poison ivy) and invasives (e.g., multiflora rose, Japanese Barberry, and increasingly Asian bittersweet).

The causes of these productive farm soils being so wet is elusive. Fred Wilhelm thought that the area became wetter after High Meadow built a large graveled parking lot about 4 decades ago. That may be true, but the drainage ditch and tiles installed in the center pasture by Oscar Wilhelm in the 1930s document that the area has been seasonally wet for over 80 years.

The high soil moisture contributes to low pH, low cation exchange capacity and other traits that degrade the soil productivity from that predicted by the NRCS soil types. Alternative solutions include soil drainage, moving surface water off site, fertilization and soil amendments, changing the vegetation in ways that reduce the problems or, most likely, a mix of these alternatives.

Three soil types are found in these wet areas, and all are rated as prime farmland and two are rated farmland of statewide importance. The soils are 15% of the land available Wilhelm Farm for agricultural and forest production, so correcting this problem will improve the total value productivity of the farm.

The wet soils are indicated in blue. The dark blue outlines the original silvopasture unit. Map developed by Michael Bentley using NRCS soils map for Wilhelm Farm.

The three soil types occupy 15% of Wilhelm Farm's operating area, which is why we focused on new uses that would make this area more value productive:

Map unit name	Rating	Acres in AOI	Percent of AOI
12 Raypol silt loam	Farmland of statewide importance	1.1	2.4%
23 Sudbury sandy loam, 0 to 5 percent slopes	All areas are prime farmland	5.1	11.1%
37C Manchester gravelly sandy loam, 3 to 15 percent slopes	Farmland of statewide importance	0.7	1.5%

If one starts with "how to make woods and pastures on wet, poor soils more economically productive," silvopasture is not necessarily the obvious solution. A review of the NRCS soil maps and the detailed soil tests we had Logan Labs do for the silvopasture area and adjacent fields identifies three important facts:

1. NRCS describes the soil in the silvopasture area (including the grassy southwest pasture (with hybrid poplar on downhill east edge) and an adjacent wooded area by High Meadow as "All areas are prime farmland" and another adjacent area as "Farmland of statewide importance." Clearly this is not the case on the Wilhelm Farm sites.
2. All three areas are very wet as snow season ends and can stay wet all summer if precipitation is high in June and July (which was true in 2019, 2018 and 2017).
3. Several measures indicate poor soil productivity –
    - Relatively low exchange (cation) capacity compared to the hayfield and garden soils, which means they are more prone to acidity than would otherwise be the case.
    - Lower pH – 5.7 compared to 6.3/6.4 (and pH is logarithmic, so the 0.6 difference is 10 times more important than the arithmetic difference).
    - Very low in phosphorous (root growth depends on P), low in calcium (needs lime, which also will bring up pH), need standard NPK fertilizer regularly

The NRCS classifications, however, point to a much higher potential if the excess moisture can be removed and soil fertility enhanced with lime and NKP. We are designing a set of ditches, channels and small ponds that would move surface and subsurface water off-site. The next steps will involve further discussions with Connor Stedman and Kip Kolesinskas, a civil engineer, and a specialist in constructing the require ditches and ponds. Once a workable design is at hand, we will have to assess the benefit values compared to the costs.

Appendix E – References

Over the course of proposal preparation and implementation of our CIG grant, we read many articles and books. This is a list of the most important in terms of our thinking and understanding. In the body of the narrative, we use the (author, date) system for citations with a few footnotes.

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