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Agroforestry at Wright-Locke Farm

Master Plan Design Report

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Master Plan Overview

Project Purpose & Contributions

Based on conversations with members of the Wright-Locke Farm Conservancy, Farm staff, Conservation Commission members, and community members, and on the April 2017 Community Design Charrette, the following primary goals for an Agroforestry Master Planning process were identified:

1. *Increase Community Connections to Wright-Locke Farm*
   a. *Educational Opportunities*

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   b. *Exploration & Enjoyment*
   c. *Knowledge & Understanding of Living Systems*
2. *Intensify perennial agricultural production across the property, to grow more food for the community while providing an economic return to the farm*
3. *Optimally use, sustain, and regenerate the natural resources (agricultural, wild, and in-between) of the farm property*

In addition to these main property-wide organizing goals, several larger purposes can be identified that locate Wright-Locke Farm's endeavor to transform its land use in several larger systems:

Bolstering the Pollinator Ecology of Winchester

Globally, both native and introduced agricultural pollinator populations are in precipitous decline due to chemical stressors, habitat loss, and climate change. The enhancement of growing season-wide pollinator resources across Wright-Locke Farm will have substantial positive effects not only on insect-pollinated agricultural crops and trees on the farm, but on the viability of farms and wild food webs across all of Winchester and the surrounding towns.

Connecting Families to Food Sources & Systems in the Boston Suburbs

A century ago, the Boston suburbs provided nearly all of the city's vegetables and fruits in near-year-round growing systems using market gardens, orchards, and greenhouses in every town. Today, WLF is the last remaining working farm in Winchester and one of the few in the surrounding area. In addition to the loss of farm biodiversity and local food access, there also has been a loss of direct relationship with food source and communities of life. Wright-Locke Farm has the potential to continue to create a cultural shift in the relationship between families in the region and the land under their feet. The adoption of innovative agricultural and agroforestry practices can both enhance opportunities for these connections and connect local families' hands, minds, and imaginations to the larger global project of revitalizing food systems that Wright-Locke Farm is part of.

Building Farm and Community Resilience for Climate Change

Climate change is disrupting lives, communities, and ecosystems worldwide and will continue to do so with increasing severity for the foreseeable future. Brittle, monocultural, non-redundant systems will not have the flexibility or capability to adapt to these rapid changes. Increasing the diversity and perenniality of food production, land use, forest management, and species of life present at Wright-Locke will help the property become more of a biological and agricultural "Ark" and refuge in the face of unknown future conditions for people, crops, and wildlife alike.

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Project Phasing & Overall Costing Estimates

The full implementation of the systems detailed in this Master Plan and Design Report will take many years and significant capital investments. Based on Wright-Locke's current priorities and resources, we recommend the following top priorities for initial investment in the coming one to two years (2018-19):

Please Note: Capital Expenditure estimates are based on an $850/day labor rate for a three-person (one foreman and two planters) planting crew. Actual labor costs may be higher or lower depending on contractors employed and use of volunteers. See Plant Costings spreadsheet for more details and to enter actual labor costs once numbers are known.

1. Silvopasture Establishment (Increase in Grazing Area & Initiating Productive Woodland Use). *CapEx Estimate: $16,000-18,000 (large majority is fencing)*
2. Diversified Grazing/Pollinator Orchard Establishment (Beginning Multi-Year Investment in Tree Fruits). *CapEx Estimate: $7000-9000*
3. Mushroom Log Production Yard (Cash Flow Agroforestry Crop & Usage for Thinned Small-Diameter Trees). *CapEx Estimate: $2000-3000.*
4. Permanent Pasture Restoration & Fodder Strip Establishment (Restoration of Critical Grazing Area). *CapEx Estimate: $3500-4500.*

As time and resources permit in 2018-2019, the following conservation-oriented projects can also be undertaken, for which additional public or philanthropic funding may be available:

5. Bioswale Establishment & Plantings. *CapEx Estimate: $4000-5000.*
6. Wetland Pollinator Plantings & Multistrata Forest Gardens. *CapEx Estimate: $4500-5500.*

As the previously established systems mature and volunteer and staff roles grow to include their management, maintenance, and ongoing improvement over time, the next phase of project emphasis in the following 2019–21 years can then include:

7. Fodder Windbreak Establishment. *CapEx Estimate: $3500-4000.*
8. Chestnut Orchard & Foraging Trail Establishment. *CapEx Estimate: $4500-5000.*
9. Enhancing Structural Complexity Forestry & Stand Improvements. (No costing estimate possible)

Now, the Design Report will explore each recommended system at Wright-Locke Farm with detailed recommendations for implementation and management.

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Fodder Windbreaks

Windbreaks can serve several important purposes at Wright-Locke Farm: reducing wind and dehydration stress on annual and perennial crops; increasing livestock health; reducing snow drifting in winter across roadways; and increasing habitability of the farm for workers and visitors. Field crops under the protection of windbreaks have shown an average of 10-15% increase in yields, with as high as 50% yield increases on very windy sites.

Recommended Species

Mulberry, *Morus spp.*, is a fast-growing, fruiting tree that produces one of the highest-nutrient and highest-protein leaves for animal fodder. It coppices readily and regrows vigorously from browsing. Mulberry is the primary (and in many regions, only) food for the Silkworm, and is the basis for silk industries around the world. Many Mulberries were planted in Massachusetts during attempts to establish silk mills here in the 1800's. Mulberry leaves and branches are also a favorite food of goats and sheep.

Basswood, *Tilia americana*, is an edible-leaf tree that coppices well and provides important bee forage during its May-June flowering peak. Its young fresh leaves in April and May are a wonderful salad vegetable, while its flowers are a delicious and calming herbal tea.

Willow, *Salix spp. (i.e., S. exigua)*, is a fast-growing multi-stemmed shrub that regrows very vigorously from coppicing or browsing. Its leaves and young branches are a favorite forage of goats and sheep, providing anti-inflammatory medicine as well as a high-nutrient food.

Nannyberry, *Viburnum lentago*, is a beautiful edible fruiting shrub that offers migratory birds valuable forage on their way south in the fall, as well as vibrant fall foliage and stem/fruit colors.

Winterberry, *Ilex verticilata,* is a highly ornamental shrub that offers a key forage resource for late fall migrants and winter residents.

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General Windbreak Planting Principles

- Multiple layers of trees (perpendicular to the prevailing winds) increase the windbreak's effectiveness.
- Height of the windbreak is one of the most important factors in its effectiveness. Windbreaks will meaningfully slow wind speeds downwind for a distance of 10-15x the height of the trees. They will also slow wind speeds upwind for 1-4x the windbreak height. A 30' windbreak will help provide wind protection for 300-450' downwind and 30-120' upwind.
- If resources and time allow, planting at 2-3 times suggested spacing will allow for faster establishment of the windbreak and fuller wind protection. Trees can be thinned to select the most genetically fit individuals for your site conditions between age 8-15.

Installation

- Flag trial layout with landscaping flags spacing trees 8' apart.
- If resources are available, we recommend double-planting (planting at twice eventual tree density with all species) and then thinning by 50% when trees are 8-15 years of age. This will allow for faster establishment of windbreak height and wind shielding benefits for the leeward fields.
- Plant, compost, and water according to the specification for Woody Perennials in Appendix A.
- If trees are planted within ten days of April 15th they will generally not need to be watered during their first establishment year, unless there is significant drought.

Management

- These trees should require little to no management once planted. We recommend maintaining deer protection (tree tubes) until trees are over 6' high with well developed branches above that height, and winter rodent protection (hardware cloth) until outer bark develops texture and thickness.
- In drought conditions during establishment years, if plants show visible water stress (wilting), water 10 gallons per plant per week until rains resume.
- Mulberry, Basswood, and Willow can be harvested as a tree fodder for goat and sheep forage during the growing season. This can be done as a pollard (cutting above a certain height, which we would recommend as 4-5' for ease of harvest), a coppice (cutting to ground level), or as pruning individual branches. Guidelines for cutting tree fodder:
    - Avoid cutting more than 1/3 of the total biomass of these trees as fodder per year to retain windbreak function and allow for adequate regrowth;

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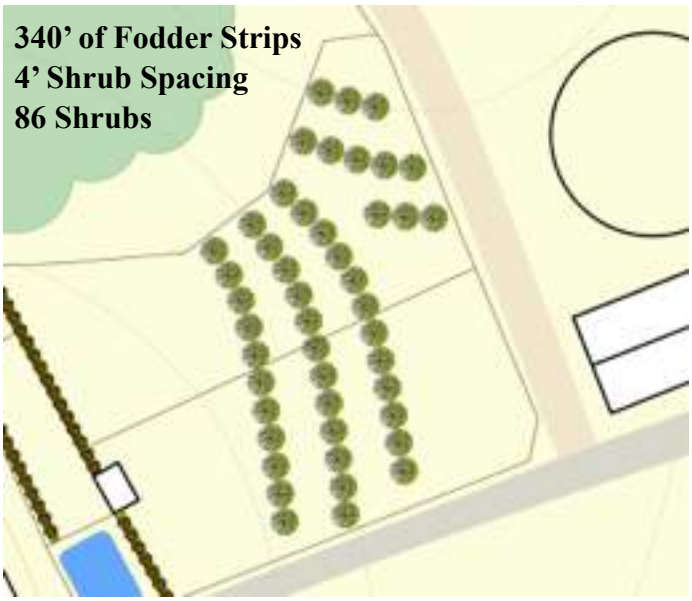
- Distribute fodder removal in an even pattern across the windbreak (for instance, pruning 1/3 of each tree's biomass; or 2/3rds of every other tree pollarded; or every 3rd tree coppiced to ground level).



Goat Fodder Strips

The current permanent goat pasture at Wright-Locke Farm provides excellent goat visibility for visitors and accessibility for farm staff, but has suffered significant degradation and erosion, particularly on its steepest upper slopes. Among other recommended strategies (in particular, expansion of available goat and sheep forage through the establishment of silvopastures), woody fodder strips can play a role in the restoration of this pasture and its return to eventual ongoing productive use. Due to the ongoing disturbance and control offered by livestock on this site, and due to the limited suite of vigorously resprouting shrub species adapted to dry sites, we are recommending a mixture of both native and non-native species for this system.

Woody fodder plants provide benefits to both pastures and livestock, and particularly significantly to goats. Goats evolved in forested mountain regions of southwest Asia, and their physiology is best adapted to a diet composed of at least 50% woody browse plants by weight. Planting woody forage components in goat pastures serves multiple functions, including:

- More optimal nutrition for goats
- Reducing parasite loads through less low grazing (many goat parasites are transmitted in the lowest 3 inches of forage above ground surface) and the inclusion of pharmaceutical woody forage plants
- Shade access for goats, reducing heat stress
- Slope stabilization & erosion reduction on steep sites
- Nitrogen fixation, contributing to pasture health and soil fertility
- Increased wildlife habitat value of goat pastures for a greater diversity of birds and insects.

Recommended Species

Grey Dogwood, *Cornus foemina,* is a native thicket-forming shrub of dry fields and hillsides. It forms colonies through root suckering and regrows well from browsing.

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Leadplant, *Amorpha canescens*, is a nitrogen-fixing shrub native to the prairie regions of North America. It is considered an excellent livestock forage and offers abundant bee forage during its July flowering peak. Its nitrogen fixing improves soil fertility conditions for adjacent plants.

Goji, *Lycium barbarum*, is a vigorous edible-leaf and edible-fruiting shrub whose dried fruits are a common food in east Asia and in increasing use as a health food item in North America.

Bristly Locust, *Robinia hispida*, is a nitrogen-fixing shrub native to the southern United States. Its early summer flowers offer bee forage and its nitrogen fixing improves soil fertility conditions for adjacent plants.

Installation

- Exclude all livestock from 50% of pasture through fencing for 1-2 years while fodder shrubs establish. Guarding of forage trees and shrubs is of great importance, as goats will exfoliate and girdle trees and shrubs until they are large enough to regrow from and withstand their browsing. If goats are reintroduced into a pasture area before fodder shrubs are well established, the shrub rows must be carefully guarded with tree tubes, hardware cloth, or row-length fencing until they are large enough to grow above browse height and/or established enough to resprout from browsing.
- Measure contour lines across pasture in the livestock-excluded 50% using an “A-Frame” level or water level.
- Dig narrow swales following these contour lines to capture overland water and sediment moving downslope, and to provide sites richer in water and soil resources for shrub establishment. Swales should be ~1’ wide and 1’ deep. The downhill berm of the swale can be additionally retained by creating 3-5” high fencing using small-diameter brush bundles (1/4” diameter woody stems w/ minimal branching) and living willow stakes for additional woody plant establishment.
- Plant, compost, and water according to the specification for Woody Perennials in Appendix A.
- If trees are planted within ten days of April 15th they will generally not need to be watered during their first establishment year, unless there is significant drought. However, on this drier and lower soil fertility site additional watering may be needed during the establishment year.
- Regenerate pasture forages by reseeding grasses and clovers into bare areas of soil. Cover these seeded areas with a light layer of shredded mulch to minimize erosion and seed loss.
- Once grass is regenerated and fodder shrubs are established, exclude livestock from the other 50% of the permanent pasture and repeat the above steps to continue the established contour swales and plantings across the slope.

Additional Goat Management Recommendations

Goats face particular challenges in the Northeast US from parasite exposure. The following management practices will help to reduce potential goat parasite loads at Wright-Locke Farm, therefore

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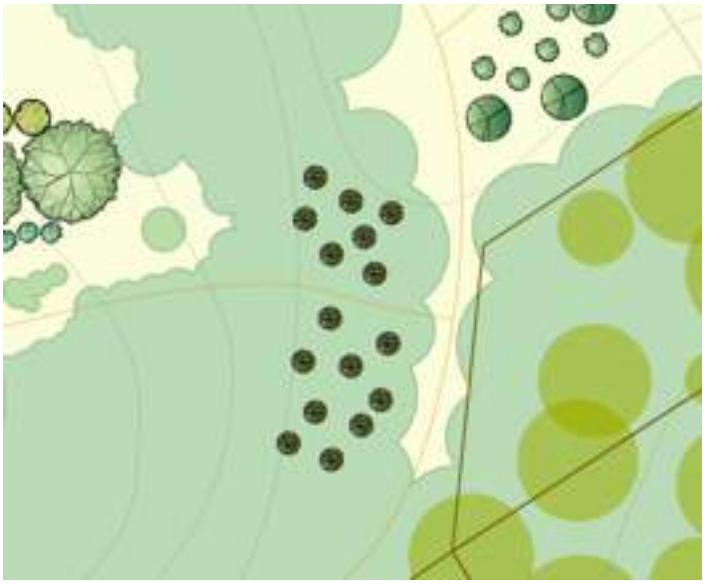
increasing animal health and reducing the potential need for expensive and environmentally harmful chemical and pharmaceutical controls. Note that it is not generally possible to fully eliminate parasite issues through grazing practices alone.

- Never graze goat pasture plants to below 3" above soil level if at all possible. Parasite larvae live in water droplets on pasture plants and are much more common in the lowest 3" of forage.
- Do not graze goats on wet pastures if at all possible.
- Provide goats with as much woody browse and/or high-growing herbaceous forages as possible.
- Establish internal pasture divisions through fencing, and rotate goats frequently with as much rest time for pastures as possible. 3-6 months rest between goat grazing is ideal for interrupting parasite cycles (3 months during the growing season or 6 months over the dormant season).
- If possible, practice multi-species grazing. Few goat parasites are transmissible to other animal species. Grazing with chickens in particular in between goat rotations will help significantly in interrupting parasite reproduction. Note that some goat parasites are shared with sheep and as such including sheep in a multi-species rotation with goats, while beneficial for forages, will not in and of itself address parasite issues that may be present.
- Avoid stocking more than 5 goats per acre.
- If feeding supplementally, use feed troughs wherever possible rather than spreading feed on the ground.
- Protect feed troughs, water sources, and any salt feeders from manure contamination.

Coppice Hillside Plantings

The dry hillside above and to the immediate West of Wright-Locke Farm's pond includes a section of young, small-diameter shrubs and regenerating trees along one of the main footpaths leading up to the open hilltop site. This young regenerating stand can be transitioned through a combination of interplanting and managing existing vegetation into a productive coppice stand yielding multiple farm products. Production from this stand can include 1-2 year leaf fodders for goat forage, 3-6 year polewood for light farm production, and 10-15 year small sawlogs for mushroom production.



Existing Species to Retain and Release

Red Maple, *Acer rubrum*.
Red Oak, *Quercus rubra*
White Oak, *Quercus alba*

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Black Birch, *Betula lenta*
Shagbark Hickory, *Carya ovata*

Species to Add
Mulberry, *Morus rubra*

Species to Remove
Staghorn Sumac, *Rhus typhina*
White Pine, *Pinus strobus*
Other early-succession species without coppice or timber value

Implementation
- Within existing vegetation, fell individuals and clusters of "species to remove" during summer months.
- Plant individuals of "species to add" to replace clusters of removed species, particularly Sumac stands. Allow newly planted individuals at least 3-4 years to develop prior to coppicing them for the first time.
- Choose vigorously growing individuals of retained and planted species to initiate coppicing.
- For a given coppice resource (i.e., animal fodders; polewood; mushroom logs), avoid removing more each year than a fraction of the overall resource approximately equal to one divided by the regrowth time in years of the resource. For instance, if polewood species take 3-6 years to reach useable diameter, no more than 1/3 to 1/6th of the polewood resource should be coppiced in any given year.

Coppice Guidelines
- Clear out all leaves and other debris around the base of the chosen coppice stool (single or multi-stemmed individual to be felled).
- Cut and clear away any dead or dying stems.
- Progressively cut each stem starting with the most accessible sections and working in to the center of the stool. Ideally one cut should be made about 1-2 inches above where the branch grows out of the stool. That cut should be angled some 15 to 20 degrees from horizontal with the lowest point facing outwards from the center of the stool.
- In some cases it maybe necessary to make a first cut higher and then trim back as above.
- Fell all poles in one direction for easy bundling and removal.

Wet Site Pollinator & Food Plantings

Wet-soil sites surrounding the spring-fed pond at Wright-Locke Farm are currently working to buffer the pond with their existing vegetation, but they also remain underutilized spaces that are being increasingly colonized by introduced woody species. These spaces have the potential to be lightly managed as a

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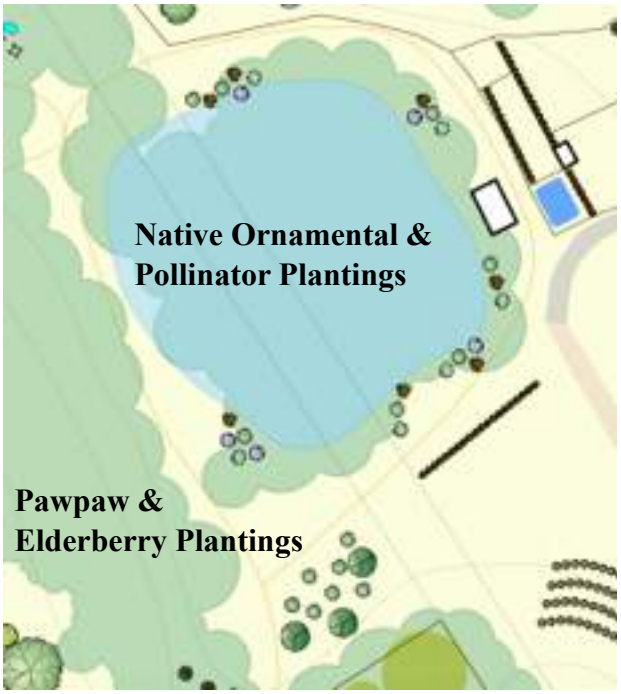

productive "Zone 4" area of the farm that still lies easily accessible to visitors and staff. So as to preserve the natural diversity and feel of the wetland edge ecosystem, and so as to avoid adding production row systems West of the farm boundary pipeline, these plantings are wild-simulated additions to existing landscapes rather than intensive production systems. Their primary function is to add wildlife food and habitat, with secondary functions of offering the farm ornamental, edible, and medicinal crops to add beauty and diversity to the farm stand and other outlets.

Recommended Species

Pawpaw, *Asimina triloba,* is a remarkable native understory fruit tree producing large (up to 1 lb) fruits with delicious custard-like flesh. It is also the sole food resource for the Zebra Swallowtail butterfly. Pawpaw plantings will expand gradually over time to form thickets and groves through belowground root suckering.

Elderberry, *Sambucus canadensis*, is a native wetland and riparian shrub producing large quantities of flowers and fruits, each of which have both edible and medicinal uses. Elderberry is easily propagated through vegetative cuttings and is a major component of many agriculturally productive buffer systems in New England. Its immune-boosting fruits in particular have value-added markets as medicinal syrups, tinctures, and other preparations.

Red-Osier Dogwood*, Cornus sericea*, is a native wetland shrub whose red stems are highly ornamental and are traditional basketry materials for indigenous people across North America. Red-Osier Dogwood is traditionally coppiced to produce long, straight, unbranching regrowth for material use, and it is easily propagated through vegetative cuttings. Both its dormant season stems and its striking white fruit displays are valued ornamentals in floral displays and as stand-alone products.

Arrowwood, *Viburnum dentatum*, is a native wetland and riparian shrub whose stems are traditional basketry and arrow shaft materials for indigenous peoples of the Northeast. Arrowwood stands are traditionally coppiced to produce long, straight, unbranching regrowth for material use. Its high-nutrient and high-fat fruits are an important food source for pre-migratory songbirds.

Highbush Cranberry, *Viburnum trilobum*, is a native wetland shrub whose fruits are rich in Vitamin C and are a traditional women's menstrual medicine as well as a valuable late fall forage for late-migrating

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and winter resident birds. Its flowers, fall foliage, and fruit displays are all considered highly ornamental and it is easily propagated through vegetative cuttings.

Buttonbush, *Cephalanthus occidentalis*, is a native wetland shrub whose white flower displays produce important nectar forage for bees and hummingbirds. It is highly tolerant of wet soils.

See full Costings spreadsheet for additional plant species recommendations for these plantings.

Implementation

- Survey areas within existing vegetation to be planted and measure the space available for planting.
- Order the appropriate number of trees and shrubs to fill the chosen areaa. We recommend planting at 50% or less of typical agricultural production density, to allow for the natural biodiversity of the site to persist and be enhanced by the addition of native shrubs and trees. See Costings spreadsheet for species, quantity, and sourcing recommendations.
- Plant trees and shrubs as per the specifications for woody perennials in Appendix A.
- Trees and shrubs will need protection from deer until growing robustly above browse height. Tree tubes will likely be the most appropriate and cost effective way to protect newly planted trees and shrubs. See a full description of tree tubes in Appendix A.
- Additional area can be covered and establishment costs can be reduced through propagating certain shrubs (in particular red-osier dogwood, arrowwood, highbush cranberry, and elderberry) vegetatively:
  - Visit mature individuals of chosen species from this list (between March-May or Sept-Oct is best).
  - Use hand pruners to take straight 10-14” cuttings of 1-2 year old growth stems. Cuttings should be branch-free and 1/2 to 3/4 inch in diameter.
  - Pound or press these cuttings into the ground throughout the buffer planting area, so that at least 6” of their length is belowground.
  - Cuttings will root directly from stem into soil.

Management

- If trees and shrubs are planted in the early spring (after ground thaw but before canopy leafout) they will require little to no watering in the establishment phase.
- This is a very low maintenance system. Most shrubs and trees will not require any pruning or fertilization. Harvest flowers (elderberry) and fruits (elderberry, highbush blueberry, pawpaw, and others) as you see fit while being careful to not over-compact or disturb wet soils.
- Once woody plants are well established and their lowest branches reach above 6’, remove the tree tube from each shrub or tree. This is an essential step, and ensures that the shrub or tree does not grow into or around the tube. This will typically be required in year 3-7 depending on the growth rate of the shrub or tree.

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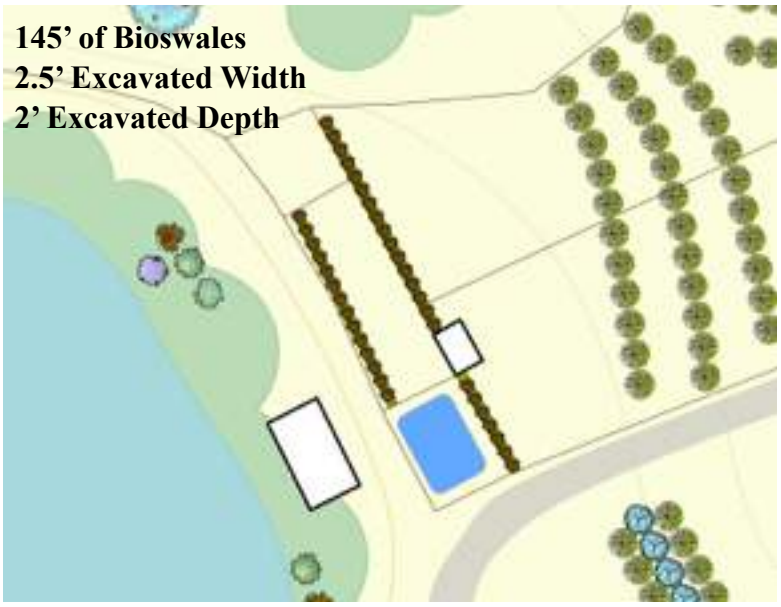
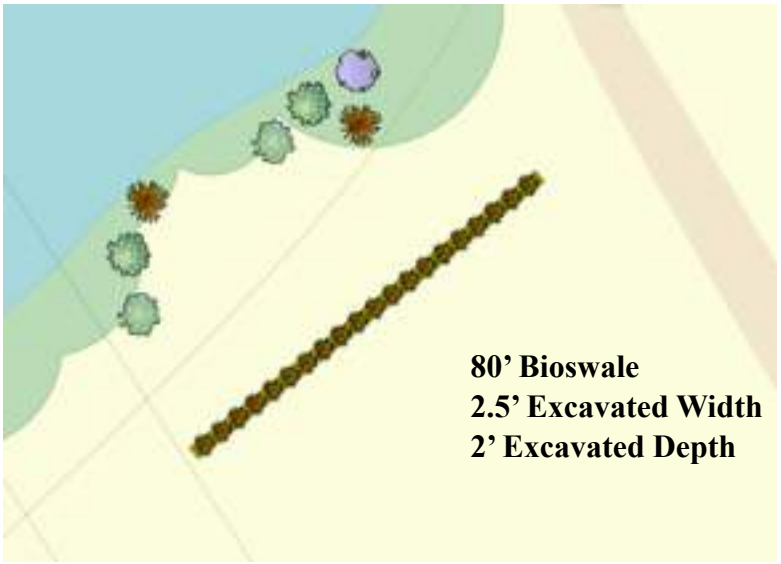
Bioswales



Bioswales are modified rain gardens - shallow depressions in the landscape that act as infiltration basins. Through high-organic soil and a diversity of plants that tolerate both wet and dry conditions, and can make use of captured excess nutrient runoff, they allow rainwater and surface runoff to slowly percolate into the soil and be converted into plants rather than enter wetlands or waterways. Bioswales and rain gardens are increasingly in use across the US to increase water infiltration and reduce surface runoff, as well as to provide native pollinator habitat. In this design, the placement of the Bioswales will capture nutrient runoff from livestock-active areas during high-rain events and wet seasons, thus helping to reduce pond nitrification and preserve water quality.

Installation

- Stake out the area of the bioswale with flagging. Ensure that no digging will interfere with any existing buried power or phone/cable lines.
- Excavate approximately 2' deep and 2.5' wide across the flagged area, with gradually sloping basin walls. Save the top 12" of soil for re-mixing.
- Mix the top 12" of soil with 1/3 as much volume of compost (creating a 2/3 soil, 1/3 compost mixture)
- Use a water level and hand tools to create a flat, level bottom to the bioswale basin.
- Aerate the bottom of the excavated basin through forking or light mechanical tillage (i.e. shallow rototilling)
- Replace the soil-compost mixture and spread evenly across the basin floor, leaving approximately 6" between the top of the new soil surface and the rain garden walls. Make sure the new



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soil surface is even and level (use water level to check as needed)
- Use as much of the remaining excavated soil as necessary to increase the width and depth of the berm on the downhill side. Firmly compact the berm as layers of soil are added. Leave a "slot" open at the original soil surface level as a drainage spillway away from animal-used and other runoff-heavy areas. Compact this spillway and line with small stones to avoid erosion in high rain events.
- Any excess soil can be used to create berms elsewhere on the farm, or mixed with additional compost for raised beds.
- IMPORTANT: avoid soil compaction in the rain garden basin once it's been excavated! No mechanical implements after basin floor aeration, and tread lightly while planting.
- Plant the bioswale! Install plants according to the recommended Herbaceous Plant Establishment Guidelines in Appendix A. Suggested plant list can be found in Planting Costs Spreadsheet.
- Plant in three zones (see Installation Costs Spreadsheet for recommendations):
    - ZONE 1 - Wet-tolerant plants (center of bioswale)
    - ZONE 2 - Intermediate-tolerant plants, including annuals (around center)
    - ZONE 3 - Dry-tolerant plants (around edges)

Maintenance

Bioswales are very low-maintenance once planted. You may wish to further edge the swale with pavers or other stones to delineate the space and allow for easier access. Occasional light weeding is generally all the maintenance needed, in addition to replacing any plants that perform poorly in the new conditions. Major flood events may alter the soil profile of the swale and require re-grading and/or maintaining of the berm wall. Annuals employed such as sorghum and sunflowers must be re-planted each year and will benefit from being planted as starts rather than direct seeded.

Recommended Resources
- *Rainwater Harvesting for Drylands and Beyond, Vol's 1 & 2* - Brad Lancaster
- "Native Plants for Rain Gardens" - New York Flora Association - http://www.nyflora.org/files/8913/6672/0378/2011_-_Vol._22_2.pdf

Mushroom Cultivation

Cultivation of mushrooms on hardwood logs is the oldest method of growing mushrooms, and most closely imitates the emergence of fungi in natural ecosystems. Oyster mushrooms and others can be grown on a variety of media other than hardwood, including paper and straw. Wood chips can be utilized

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as a growing medium for Winecap Stropharia. Mushrooms can be eaten fresh, dried, or used in medicinal preparations. The location recommended for mushroom cultivation at Wright-Locke Farm offers convenient relative location to other food production activities and easy inclusion in the visitor experience.

Interconnections

Management of Wright-Locke Farm's forested acreage can yield nearly all materials needed for mushroom cultivation. Thinning young stands of hardwood saplings from will yield wood chips for mulch bed production and logs for plug or totem inoculation. Production of mulch straw through small-scale grain production can serve the additional function of straw inoculation. Dunking basins for mushroom logs can be dug in cultivation areas to provide periodic log submersion. Spent woodchips and straw can be added to compost to provide fungal inoculation, while spent logs can be used to construct raised bed borders or returned to complete their decomposition in the forest floor.

Please Note: Mushroom spawn cultivation is a precise science requiring sterile materials to ensure single strain mushroom spawn, so that no unwanted inedible mycelia mix with the edible strains. In the absence of an onsite lab that can support this level of precision, we strongly recommend purchasing spawn from a trusted supplier (see below).

Mulch Bed Production

Implementation

Mulch Bed Inoculation

- Procure spawn in Spring for a Spring inoculation. Winecap Stropharia mushrooms are a delicious beginner's mushroom to work with in this methodology.
- Prepare a bed that will remain in shade for a good part of the day. The media that is most appropriate for spawn consists of two thirds wood chip mulch (from hardwood trees only) and one third compost mixed together.

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- This bed can be prepared in a number of ways, from beginning with a sheet mulched bed and building a layer with the appropriate wood chip and compost composition, to removing sod and applying the compost/wood chip mixture on top of fresh soil.
- Sprinkle spawn on top of the medium as per the instructions included with the spawn.
- Cover with another layer of the wood chip and compost mixture.
- Water the bed fully upon completion.

Management

Log Inoculation

- Soak mushroom logs for 24 hours every 6-8 weeks during growing season, to stimulate fruiting. It's convenient to have a large vessel for soaking available right next to your logs to minimize carrying.
- Logs can also be left to fruit naturally according to fluctuations in rain and humidity, but will not produce nearly as many fruiting bodies.

Mulch Bed Inoculation

- Maintain consistent moisture in the bed by checking 2-3x/week, especially during hot weather. Water as needed to keep bed moist like a wrung-out sponge.
- Mushrooms should begin to fruit between the late summer after a spring inoculation, and the following spring.
- Re-inoculate with new spawn in future years if production diminishes significantly.

Recommended References & Resources

- *Farming the Woods*, Ken Mudge & Steve Gabriel
- *Mycelium Running,* Paul Stamets.
- Fungi Perfectii, www.fungi.com
- Mushroom Spore Source: www.fieldforest.net

Shiitake Log Production

Cultivation of mushrooms on hardwood logs is the oldest method of growing mushrooms, and most closely imitates the emergence of fungi in natural ecosystems. Mushrooms can be eaten fresh, dried, or used in medicinal preparations.

Implementation

Log Inoculation

- In spring or fall, procure recently-cut hardwood logs of manageable size. If you plan to soak logs, err on the small side for manageability when saturated. Use oaks and maples for shiitake, poplars, box elder and other softer hard woods for oysters.
- Drill holes a couple inches deep into logs
- Insert spawn from shiitake or oyster mushrooms into holes

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- Seal holes with wax
- Stack logs in a shady area

Management

- Soak mushroom logs for 24 hours every 6-8 weeks during growing season, to stimulate fruiting. It's convenient to have a dunking basin or large vessel for soaking available right next to your logs to minimize carrying.
- Logs can also be left to fruit naturally according to fluctuations in rain and humidity, but will not produce nearly as many fruiting bodies.

Recommended References & Resources

- *Farming the Woods*, Ken Mudge & Steve Gabriel
- *Mycelium Running*, Paul Stamets
- Fungi Perfecti, www.fungi.com
- Field & Forest, www.fieldforest.net (excellent spore source)
- "Best Management Practices for Log-Based Shiitake Cultivation in the Northeastern United States." Northeast SARE. http://www.nesare.org/Dig-Deeper/Useful-resources/Northeast-guides-and-books/Shiitake-Mushrooms

Silvopasture Orchard

Mixed-species, diversified orchards can reduce the impacts of tree fruit pests and diseases without the use of petro-chemical pesticides, herbicides and fungicides used in commercial mono-crop orchards. They also can experience improved pollination and fruit set over mono crops if nectary-producing understory plants are in use, and produce a wider range of yields and uses than the production of a single fruit crop. Animals can be integrated as a grazing component of the orchard, reducing or eliminating the need for moving and producing additional yield from the overall system. There are five layers to the proposed multi-strata production orchard system at Wright-Locke Farm: overstory honeylocust standards, mid story fruit trees, understory multifunctional shrubs, understory herbaceous support plants, and livestock forages (existing pasture) between tree rows.

Although the primary function of this system is fruit production, an important secondary function is additional grazing acreage for sheep and goats on the farm. As such, it is important to note that when converting a pasture to silvopasture through tree plantings, a few scattered trees within the pasture do not constitute an effective silvopasture. Without enough continual shade, livestock impacts on soil and trees are concentrated on and around those few individuals. Therefore, it is important that:

a) Enough trees must be planted, as in this design, that they distribute the shade resource relatively evenly in rows or scattered throughout the pasture area,

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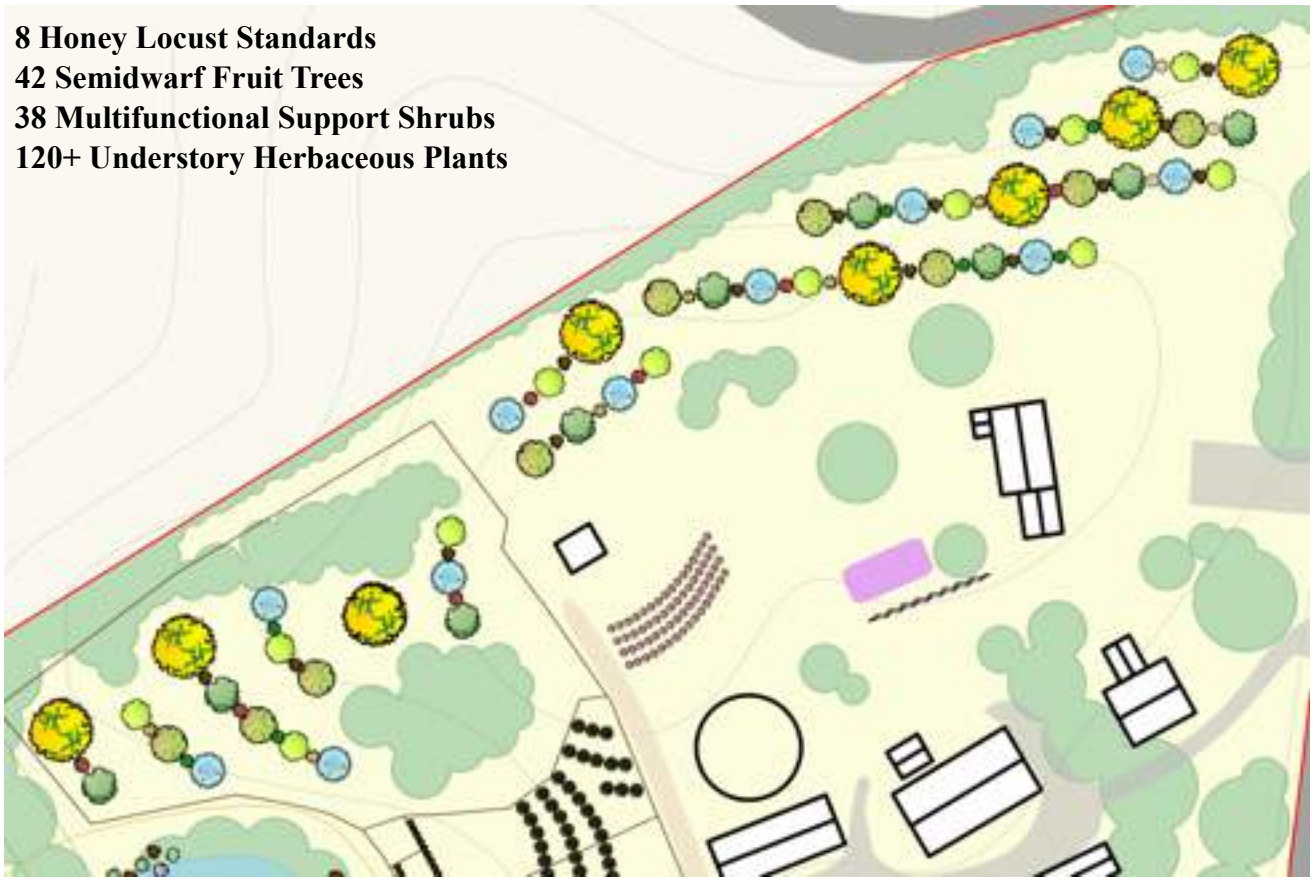

b) The entire orchard be established within 1-2 seasons so that the shade resource grows and develops evenly across the pasture, and,

c) Those trees are then protected from animal impacts through stem guards and/or fencing until they are large enough to withstand those impacts on their own. In this system, we strongly recommend grazing with moveable electric fence in between rows of trees until such time that the trees and intermediate plantings are all well established and tree bark is thick enough that goats will avoid debarking.

Implementation

- Order trees as guided by attached Plant Costings spreadsheet. Order or produce sufficient compost and mulch as indicated on "Silvopasture Orchard" tab.
- Flag orchard layout with landscaping flags. Measuring contours may help guide layout, however, this orchard is not laid out on exact contours for consistent row width and ease of access and grazing. Semidwarf fruit trees are spaced 25' apart within rows; honeylocust standards are 35' from each neighboring fruit tree. Rows are spaced 35' apart. This is a slightly wider spacing than traditional semidwarf orchards to allow for grazing and easy visitor exploration.

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- Plant, compost, mulch and water according to the specification for Woody Perennials in Appendix A. Note that layout of tree species is intentional to reduce cross-tree pest exposure - no two trees of the same species are adjacent to each other.
- If trees are planted within ten days of April 15th they will generally not need to be watered during their first establishment year, unless there is significant drought.
- Protect individual trees from winter vole damage - at least 3' tree guards for snow season, sunk 2-4 inches into ground.
- Plant herbaceous support species with each tree, such as:
  - Common comfrey, *Symphytum officinalis*
  - Yarrow, *Achillea millefolium*
  - Bush Clover, *Lespedeza virginica* (2-3') or *L. capitata* (4-5')
  - Wild Indigo, *Baptisia australis*
  - Wild Senna, *Senna hebacarpa*
- Herbaceous support species planting: up to 3-4 plants per tree, planted evenly spaced surrounding tree, 3' from trunk. *Important to note:* these herbaceous support species are an option for you to consider either at initial implementation or as time goes on. They benefit the orchard significantly through attracting beneficial insects, fixing nitrogen, and other nutrient cycling benefits, but can be a more expensive element of establishment as many of the best understory support species do not have easy wholesale sources and pricing. *We recommend a phased approach* where, in the years leading up to orchard establishment, you develop nursery stock through propagating support perennials growing on the farm. This stock will reduce costs of planting support guilds for the full orchard, and allow you to start with a few plants per tree and add over time.

Management

- Training for tree architecture is the most important aspect of management during the years before trees begin to bear.
- In year one or two begin to train trees by choosing three to five framework branches and one central leader, in a "modified central leader" pruning pattern. For peaches, we recommend a different pruning style: choose 3-5 radial framework branches with no central leader ("open crown" pruning). See Lee Reich's *The Pruning Book,* Michael Philip's *The Holistic Orchard*, and/or consult a local orchardist for more details on pruning methods.
- Train framework branches to grow at an ~60 degree angle with the trunk (or "one third" of the 180 degree space from vertically up to vertically down). Use clothespins, weights and stakes with ropes to train branches if needed.
- Prune accordingly as you choose your central leader and 5 framework branches. Prune trees when trees are dormant in the winter months.
- Develop a farm philosophy and strategy for working with orchard pest management. See Michael Phillip's *The Holistic Orchard* in particular for help in developing your approach.
- Once trees begin to bear harvesting crates and orchard ladders will become important tools for the farm to acquire.

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- As trees mature, prune gradually to diminish the framework branches on each tree to four, and then eventually to no more than three.

Recommended References & Resources

- *The Holistic Orchard* - Michael Phillips
- *The Pruning Book* - Lee Reich
- FEDCO Trees, www.fedcotrees.com – order online by early March
- Felco - for pruning shears and saws - http://www.felcostore.com/
- Cummins Nursery - http://cumminsnursery.com/
- Premier 1 - Fencing Supplier - www.premier1supplies.com

Agroforestry & Land Use on Forested Sites

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Stands 1 & 2 - Multistrata Forest Gardens

Multistrata forest gardens offer the opportunity to practice an ancient and complex form of agroforestry management, where full sun, part shade, and full shade crops coexist in a multi-layer production system. These systems feature high species diversity in a small space and often blend wild and native biodiversity with more managed food or medicine production species. Forest gardens are also living laboratories for practicing polyculture cultivation techniques, which can then be applied in simpler broader-scale ways in diversified orchard and other tree crop farming systems. At Wright-Locke Farm, two sites in close proximity to each other offer ideal conditions for development into multi strata systems: an upland site that can be integrated into forest silvopasture systems; and a low site that can be converted to production of wetland crops and occasionally grazed during the driest times of year.

There are two areas with promising characteristics for development into multi strata forest gardens - an upland site at the Southeast corner of the property's forested acreage, and a wetter lowland site along the southern east-west footpath connecting the farm to neighborhoods and conservations lands beyond. Both can be integrated into the silvopasture grazing rotation in this area of the property (see "Stands 1 & 3 - Silvopasture" below) while being developed for foraging potential when not in use by animals.

Multistrata Conversion Sequence

- Clearing. In congruence with the Silvopasture conversion sequence described below, approximately 50% of the current canopy area of the multi-strata sites should be thinned. Felled trees can be converted to firewood for use on the farm and brush should be piled rather than distributed to allow for greater understory development. Unless individuals are crowding each other, all Black Walnuts and Apples should be retained in these areas.
- Planting. New mid story and understory vegetation can be added into these sites in congruence with the arrangement shown in the final design and species listed in the Plant Costings

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spreadsheet. Plant, compost, mulch and water according to the specification for Woody Perennials and Herbaceous Perennials in Appendix A.

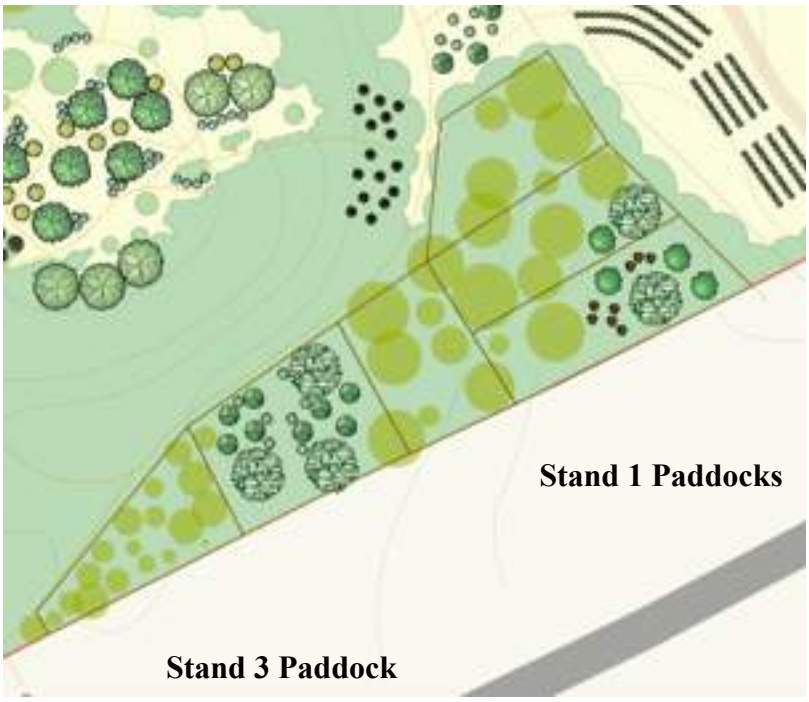
- Guarding. New trees and shrubs will require substantial guarding from goat and sheep browse during their establishment years. We recommend either a) excluding livestock from direct contact with or access to new plantings through temporary fencing, or b) erecting galvanized wire cages 2' out from the stem of each newly added woody plant.

Management

The main management process for multi-strata systems is managing tree regeneration entering the site. Both the dry-site and the wet-site multi strata systems can be periodically grazed to help accomplish this vegetation management. The dry-site multi strata area can be grazed lightly as new shrubs are established, as long as they are adequately guarded from browse. The wet-site multi strata area can be grazed when the ground is at its driest during the growing year to minimize animal exposure to parasites.

Stands 1 & 3 - Woodland Silvopasture

Silvopasture is a forest grazing system that dates back many thousands of years. The ecological analogue of silvopasture is the role large grazing animals have historically played in forest, woodland, and savanna ecosystems worldwide. The presence of these animals (such as elk and buffalo historically in North America, and elk, wild boars, and wild ancestors of cattle in Europe historically) diversifies woodland habitats through the animals' grazing and trampling disturbance, while dispersing seeds and opening areas for new species of trees to regenerate and establish.



Silvopasture grazes livestock under partial tree cover. In general, a tree canopy must be 40% open or more to allow enough sunlight to reach the forest floor for the growth of grasses, legumes, and other forage plants. Three components of a silvopasture system must be managed together in an integrated way: trees, forages/pasture, and animals. Though silvopasture is complex, it is currently one of the best-studied and best-documented agroforestry systems appropriate for the Northeast. The work of a small group of agroforestry practitioners, including Brett Chedzoy, Steve

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Gabriel, and Peter Smallidge of Cornell Cooperative Extension, Joseph Orifice of Paul Smith's College, and Eliza Greenman of the Greenhorns, has significantly expanded the knowledge and practice of silvopasture in our region over the past decade. Silvopasture is also widely practiced, and promoted by USDA, in other regions of the US (particularly the Southeast and the Rocky Mountain West)

Benefits from silvopasture include:

- Year-round shade access for grazing animals, which reduces heat stress and therefore increases animal health.
- Diversified diet for animals from mast (fruit and nuts) and a diversified set of understory forages (in certain silvopasture systems).
- Co-production of timber, fruit, and/or nuts from overstory trees, along with understory forage production.
- Improved production of certain forages (cool season grasses and some legumes) which perform optimally under light/dappled shade.
- Control of expansive/dispersive plant species through repeated grazing.
- Soil building in woodland/savanna areas through rotational grazing and manuring from livestock.
- Habitat for woodland and savanna-utilizing game animals (such as Wild Turkeys) and migratory songbirds (such as Prairie Warblers).

Silvopasture is an intensive management system, and can have negative impacts on trees, soil, and biodiversity if not managed well. For example, livestock in the Northeast have often historically been permitted to graze in the woods through permanent fencing beyond the pasture's edge. This "animals in the woods" approach reduces heat stress and provides a diverse environment for livestock, but it does not necessarily meet goals of forest health and sustainability. The lack of management of either the forest overstory or understory led to the absence of high-quality forages for the livestock in the woods, while the use of fixed-paddock systems made soil compaction and erosion likely, along with damage to trees and impacts on forest regeneration.

Overall, detrimental affects of silvopasture if not managed well can include:

- Soil compaction and erosion, if forages are not well established or livestock are not rotated frequently enough.
- Concentration of animal impact on one or or a few shade trees, if the system includes too few trees in each paddock.
- Reduction in successful tree regeneration, if forages are not well established or livestock are not rotated frequently enough.
- Re-closure of forest canopy and loss of forages, if too few livestock are grazed or woodland is not periodically re-thinned and maintained.

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Stand 1 at Wright-Locke Farm is a young, regenerating stand on gently sloping land. The stand is dominated by Boxelder and Buckthorn, both early-succession trees without present or future timber value. As discussed in "Stand 1 & 2 - Multistrata Forest Gardens", the Southeast corner of Stand 1 features larger trees including maturing Black Walnuts and wild Apples. Excluding the Black Walnut inclusion, Stand 1 overall has a Basal Area[1] of 86.5 ft^2/ac:

Stand 1 Species (without Black Walnut inclusion)	**BA Per Species (ft^2/ac)**	
Boxelder	27.5	
Buckthorn	20.5	
Black Cherry	10.5	
Red Maple	8.0	
Norway Maple	6.5	
White Ash	4.5	
Apple	3.0	
Eastern Juniper	2.0	
American Elm	2.0	
Staghorn Sumac	1.0	
Mulberry	1.0	
	86.5	**Total BA**

Stand 3 is a similarly young and regenerating stand to Stand 1, on a small elevated strip of land between the Southern footpath of the property and neighbors' properties to the South. It is dominated by Black Cherry and Red Oak regeneration, both species with significant future timber value. Stand 3 has a Basal Area of 71.5 ft^2/ac:

Stand 3 Species	**BA Per Species (ft^2/ac)**	
Black Cherry	25.5	
Red Oak	24.0	
Eastern Juniper	9.5	
Buckthorn	4.0	
White Ash	3.5	
White Oak	2.0	
Staghorn Sumac	2.0	
Shagbark Hickory	1.0	
	71.5	**Total BA**

Overview of Silvopasture Conversion

Forest stands can be relatively easily converted to silvopasture through careful forest management. The stand must be thinned sufficiently to allow enough sunlight for a forage mix to establish in the understory. The balance between favoring timber growth and forage growth can be delicate - too dense a stand, and forages will be shaded out, whereas too open a stand, and trees will lose their straight boles, become more vulnerable to wind damage, and decline in timber value. The range of forest stand basal

[1] Basal area is a measurement of stand density, incorporating both tree stem density and tree diameter. It is expressed in square feet per acre.

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area that allows for both timber production and forage health is between 35 and 65 ft^2/ac. Closer to 35 ft^2/ac emphasizes rapid forage establishment; closer to 65 ft^2/ac emphasizes tree growth and timber production. Above 65-70 ft^2/ac of basal area, forages will not grow in the understory.

This range of retained basal area integrated well with retention shelterwood silivicultural systems, in which a thinned canopy of overstory trees are retained after a timber harvest to shelter the regenerating cohort of trees below. In the case of silvopasture, the understory being sheltered is both forest regeneration and pasture forage establishment. Over a longer time frame, silvopasture allows for two high-value forms of economic production on a single site.

Stand Prescription: Clearing Stage

For silvopasture areas that attempt to emphasize co-production marketable timber along with forages, a final Basal Area of 50-65 ft^2/ac is recommended. For silvopasture areas that are de-emphasizing timber production in favor of faster and more complete forage establishment, as low as 35-40 ft^2/ac is acceptable.

In this case at Wright-Locke Farm, the primary objective informing the silvopasture conversion is the opening of new grazing acreage on the property and the productive multi-strata use of low-timber-value forest stands, rather than the intensive production of future timber stems. Therefore, this prescription recommends thinning to 35-40 ft^2/ac to encourage the most rapid forage establishment and growth.

To achieve this, we prescribe the following for the clearing stage of silvopasture conversion within Stands 1 and 3, in paddock-by-paddock phases within the stand as appropriate.

Stand 1 & 3 Prescription

Both Stands

1. *Remove all Buckthorn and Norway Maple.* Buckthorn is an introduced species present throughout the WLF property. It casts heavy understory shade and is not a helpful component of a silvopasture system. Norway Maple is an introduced species with occurrence in a few areas of the WLF property. It is allelopathic to surrounding plants and spreads vigorously through seed production. Many of the removed trees of both species will resprout; however, this coppicing action can be controlled through adequate goat and sheep grazing.
2. *Remove all Black Cherry.* Though Black Cherry is a valuable and beautiful hardwood and wildlife food source, its wilted leaves present a toxicity risk to grazing livestock. If Cherry timber or other wood products are desired for construction or other projects on the farm, well-formed Black Cherries elsewhere on the property can be found. The removed trees here can be converted to firewood with choice pieces preserved for their spoon or bowl carving value.

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3. *Retain all Walnuts, Hickories, White Oaks, Junipers, Mulberries, and feral Apples in the stand*. These mast producing species will provide excellent supplemental mast feed for grazing animals, foraging people, and wildlife.
4. *Retain all living Elms and Ashes*. These species are under stress from introduced pests (Emerald Ash Borer) and diseases (Dutch Elm Disease). It is a regional conservation priority to retain a wide diversity of genetics of these species in wild stands so that the genetics most resistant to these stressors can be found and have the opportunity to reproduce.
5. *Retain a Diversity of Ages for Stand Regeneration.* Including a diversity of understory, sapling, and seedling trees in addition to the retained canopy will ensure that the tree component of the system will continue to grow and regenerate over time.

Stand 1 Specific

6. *Remove 50% of Boxelder*. Boxelder is a beautiful species associated with disturbed sites and riparian forests in New England. It has a short lifespan and a low, arcing growth habit, and as such is not a species to emphasize in the future canopy development of a silvopasture stand. However, the remaining 50% of Boxelder in Stand 1 will provide good partial shade conditions while the longer-term canopy trees (Ash, Elm, Red Maple) develop further.

Stand 3 Specific

7. *Remove 33% of Red Oak*. In thinning the Red Oak component of Stand 3 to achieve the sun conditions associated with a 35-40 ft^2/ac, remove less well-formed individuals (subdominant, crooked, and/or showing partial dieback) so that those that remain will mature into a well-formed canopy for this silvopasture in the future.

Felled trees and cleared shrubs need to be removed from the site for forages to establish. They can be converted to an on-farm resource for animal bedding and mulch through chipping. They also can be milled into timbers if large enough, or split into cordwood for on-farm fuel. Most if not all individuals removed from stands 1 and 3 will be too small-diameter for timber milling, and many will lack straight 16’ sawlog boles.

Fencing

For the rotation of animals between the 5 woodland paddocks indicated, we recommend establishing permanent fencing using on-climb woven wire fence on wooden posts.

Height: 4 ft. above ground
Linear Feet: 2070’
Materials: 4’ tall 2”x4” non-climb woven wire, 6’ tall t-posts

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Gate Number: 6
Gate Type: Livestock gate
Gate Height: 4'
Gate Width: 1-4' & 1-10'

Each paddock will require:

—Gates to adjacent paddock and/or to adjacent pasture or trail system.
—Water trough secured to permanent post (may be frequently overturned otherwise!)

Stand Prescription: Forage Establishment Stage

After an area of the stand has been thinned and cleared to increase sun access, the next stage of silvopasture conversion is the establishment of understory forage crops. The eventual forage mixture will be a combination of a) naturally occurring herbaceous vegetation that establish in the newly cleared understory, and b) newly seeded forages. Adding forage through seeding is essential to develop a robust grazing sward, ensure full soil cover with vegetation to prevent erosion, and outcompete undesirable shrubs re-entering the site. The following steps are recommended to establish additional understory forage crops.

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Silvopasture Seed Mix - 30 lbs

Common	Scientific	Cost Per Lb ($)	# Pounds	Price ($)	Source	Link	Notes
Grasses	*Poaceeae*						
Upland Bentgrass	*Agrostis perennans*	24	1	24	Roundstone Seed	roundstoneseed.com/native-grasses/180-upland-bent-grass.html	
Orchard Grass	*Dactylis glomerata*	2.71	8	21.68	Roundstone Seed	roundstoneseed.com/naturalized-grasses/149-orchard-grass.html	
Canada Wild Rye	*Elymus canadensis*	14	2	28	Roundstone Seed	roundstoneseed.com/native-grasses/98-canada-wild-rye.html	
Virginia Wild Rye	*Elymus virginicus*	12	2	24	Prairie Moon	prairiemoon.com/seeds/grasses-sedges-rushes/elymus-virginicus-virginia-wild-rye.html	
Tall Fescue	*Festuca arundinacea*	1.25	8	10	Roundstone Seed	roundstoneseed.com/naturalized-grasses/146-fescue.html	
Eastern Gama Grass	*Tripsacum dactyloides*	20.50	1	20.5	Roundstone Seed	roundstoneseed.com/native-grasses/111-eastern-gamma-grass.html	
Legumes	*Fabaceae*						
Partridge Pea	*Chamaecrista fasciculata*	30	1	30	Prairie Moon	prairiemoon.com/seeds/wildflowers-forbs/chamaecrista-fasciculata-partridge-pea.html	
White Clover	*Trifolium repens*	7.80	7	54.6	American Meadows	americanmeadows.com/grass-and-groundcover-seeds/dutch-white-clover-seeds	
Totals			30	212.78			

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1. Soil Bed Preparation

Seed germination will be highest with bare mineral soil available as a seed bed. There are three options for preparing the seed bed:

—Livestock trampling (running pigs through to the point of bare soil exposed)
—Hand raking
—Mechanical disturbance (dragging/raking behind light tractor)

For this scale stand, we recommend hand raking and/or livestock trampling to expose a mineral soil bed.

2. Seeding & Trampling

Forages ideal for silvopasture are listed below, followed by a recommended 30lb seed mix for the 1.2 acre total silvopasture site (20lb/acre plus 25% surplus for reseeding) with sourcing and pricing for each component.

Initial seed establishment density is recommended at 20 lb/acre, or 24 lbs total for the 1.2 acre site, with 6 lbs left over for re-seeding as needed. Disperse seeds by hand (slow) or with a hand seed spreader (requires a piece of equipment, but much faster).

Seed either in fall before snow, or early spring after snowmelt but before vegetative growth begins. After seeding each paddock, running animals through for 1-2 days will trample seeds into the ground and maximize germination rates.

Optional Alternative: *Bale Seeding*

An alternative to hand seeding that employs animal power is bale seeding. To bale seed, acquire hay bales cut from a hayfield or pasture containing good forage species (minimizing "weed" species such as Dock and Thistle, and maximizing grasses and legumes). After fencing is established and canopy thinning has taken place, unroll bales on the forest floor in late fall or late winter and send in livestock to feed on the hay. The seed component of the hay will be dispersed, mulched by the hay remnants, and fertilized by animal manure. Hand seeding can then be employed the following growing season to fill in gaps in germination.

3. Monitoring Germination

Once seed germination begins in spring, observe the plot 1-2 times per week to monitor germination density. Note areas that may be germinating less completely than others.

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4. Weeding

As the forage mix establishes, walk through the site every 1-2 weeks and hand-weed undesirable woody plants that may be establishing (ex: Buckthorn; Honeysuckle; Poison Ivy with excellent hand & body protection).

5. Reseeding (As Needed)

Seed additionally in areas where germination has been substantially lighter than average across the plot. If the entire plot is germinating weakly or patchily in the spring, repeat steps 1-3 in the fall for the entire plot. Continue to patch-seed from here where needed until full grass/legume sward is established.

The ultimate outcome of silvopasture conversion is the establishment of an open woodland environment with a mixed understory including:

—Grasses
—Legumes
—Naturally occurring wildflowers, herbs, and shrubs
—Forest regeneration (tree seedlings)

All 4 of these elements are desirable and important for the silvopasture system moving forward. The effects of grazing on each one will need to be monitored and evaluated. Grazing frequency/intensity, reseeding, weeding, and guarding or planting trees can all be adjusted or utilized if one of more of these understory elements appears in danger of being grazed out of the system.

In particular, it is important that once the silvopasture is establish, each paddock is consistently grazed 2-3 times each year. Periodic disturbance and manuring from grazing animals, followed by at least 20-30 days of rest, are necessary inputs to sustainably manage a silvopasture. Periodic thinning will also be necessary as tree crown widths expand to shut out important sunlight. Forest products - cordwood, polewood, and potentially small saw timber - will become available over time through this cyclical thinning.

Recommended Silvopasture Management Practices

- *Observe & Interact*. The most important principle of silvopasture management is ensuring frequent enough rotations and adequate rest time so that the pasture component can continue to develop and regenerate. Too infrequent of rotations, and the pasture component will be degraded by overgrazing and rooting/digging; too short of rest time, and the same will occur in slow motion over the course of the season. To do this, it is necessary to closely observe the behavior of the sheep and goats making use of the silvopastures, and their affects on vegetation and soil in the grazing paddocks. Especially

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in the early years of establishing the silvopasture, daily visits are recommended while animals are grazing, to observe their affects and notice adjustments needed in the system.

- *Rotations.* In general, allow sheep and goats to graze for no more than 4-6 days per paddock.
- *Paddock Size*. Paddocks should be no more than 200 feet across in any dimension, to ensure concentrated enough grazing to prevent forest seedlings from shading out grass growth. See associated maps for recommended paddock layout.
- *Rest Periods.* Rest each paddock for at least 3 months after animals have grazed it to interrupt parasite cycles and allow for the grass sward to fully regrow.
- *Stocking Rates*. Based on paddock size, rotation length, rest periods, and likely pasture quality on this site, WLF's animals will be able to spend approximately 30% of their grazing time during the grass growing season (May 1 - November 1) in the silvopasture paddocks. This is reflected in the following rotation:

Exact lengths will depend on grass growth and observations of grazing impacts. Greater stocking rates and/or longer residence times should be possible in the future as the silvopasture develops and forage yields increase. For now, we do not recommend stocking more than 15 goats or sheep in a silvopasture paddock at any given time, and do not recommend exceeding 6 days residence time in a paddock until higher levels of grass production are observed and more grazing is possible. See "Pasture Rotations" later in the Design Report for more on grazing systems, pasture quality, and stocking rates.

Silvopasture Paddock #	Residence Time
1	4-6 days, 2x per year
2	4-6 days, 2x per year
3	4-6 days, 2x per year
4	4-6 days, 2x per year
5	4-6 days, 2x per year
Elsewhere on the farm	120-140 days total during season

- *Thinning.* As the forest canopy closes from the clearing, it will be necessary to further thin the silvopasture to maintain light conditions. After the initial clearing to establish, light thinning may be needed every 3-5 years to maintain the system. In general, canopy cover should be maintained at 30-45%, or stand density at 35-50 ft^2/acre of basal area. When thinning, remove the least desirable trees for future timber and firewood production, and leave the best-formed ones with the greatest growth potential and/or greatest contribution to mast resources as supplemental feed.
- *Sapling Protection.* In each paddock, observe the pattern of tree regeneration (i.e., growth of saplings in understory). If tree regeneration is spotty or absent, choose a handful of well-formed saplings (1-3" in diameter) in each paddock and guard them from animal browsing with fencing.
- *Evaluation.* We recommend that you consult with AppleSeed Permaculture 1-2 years into the project to evaluate the development and ecological health of your silvopasture system, to recommend any needed adjustments, and to answer any questions arising in your management.

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Other Ecological Considerations for Silvopasture

It is important to recognize that even well-managed, rotationally grazed forest-to-silvopasture systems represent a significant alteration of forest ecosystems. Wildlife habitat quality for forest interior bird, mammal, and invertebrate species may drop; understory plant composition will change and may grow less diverse; and the system may contribute to forest fragmentation and introduction of expansive species deeper into forest interiors.

As a result, woodlands should primarily be converted to silvopasture at the edge of existing pasture or cropland (as in Stand 1 at WLF), in existing small forest fragments (as in Stand 3), or as a component of a larger-scale forest management plan that takes fragmentation and habitat conservation into account. Forest stands that have previously been impacted by unmanaged livestock grazing, poor timber harvesting practices, and/or introduced species - all common in woodlands at agricultural edges - may be the best candidates for silvopasture conversion, as these sites may benefit ecologically as well as economically. Any forest sites with rare plants, sensitive soils, unusual natural communities, and/or critical habitat features (such as seeps or vernal pools) should not be converted to silvopasture.

Additional Silvopasturing Resources

- "**Silvopasturing in the Northeast."** Brett Chedzoy and Peter Smallidge. Cornell University Cooperative Extension. 2011. Available free at http://www2.dnr.cornell.edu/ext/info/pubs/MapleAgrofor/Silvopasturing3-3-2011.pdf.
- **Agroforestry Notes, No.'s 8, 9, 18, 22, & 26.** Various authors. USDA Forest Service. 1997-2003. Available free at http://nac.unl.edu/agroforestrynotes.htm.
- ***Silvopasture: Integrating Trees, Animals and Forages in a Farm Ecosystem.*** Steve Gabriel. 2018 (forthcoming). *Will be the first comprehensive practitioner's treatment of temperate climate silvopasture.*
- **Northeast Silvopasture Ning.** http://silvopasture.ning.com/ *Free, open-access social network of silvopasture practitioners in the Northeast, dedicated to information sharing and developing best management practices.*

Stands 4 & 5 - Maturing, Rocky Hardwoods

These beautiful stands lie at the outskirts of the property managed by Wright-Locke Farm. They contain many of the oldest and largest tree individuals on the property, including

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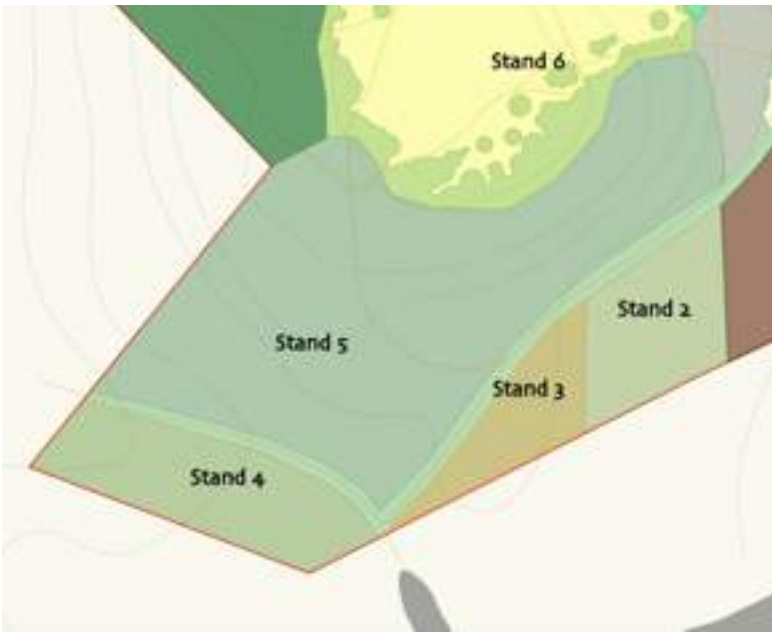

many very large White Oak and Red Oak individuals as well as large Shagbark Hickories in places. Much of Stand 5 is extremely rocky and steep, impassible by vehicles and difficult to traverse on foot off of established trails. Due to these characteristics, we recommend no management on these sites, allowing old-growth characteristics to continue to develop though natural processes. We do recommend monitoring the stand for oak regeneration and considering:

a) releasing sapling-size oak regeneration by thinning adjacent trees that are not oaks or are poorly formed oaks, and/or,
b) protecting seedling-size oak regeneration from deer browse through "brush fencing" (bunching brush and branches around small oak seedlings to allow them to gain height protected from deer),

in support of the successful regeneration of this dry oak forest natural community into the future.

Stand 6 - Chestnut Orchard & Foraging Trails

The American Chestnut was a keystone perennial food crop across eastern North America until the introduced Chestnut Blight reduced it to near extinction in the early 20th Century. Now, the use of Chinese and other Eurasian chestnuts, as well as new blight resistant hybrid American chestnuts, are making this once-abundant perennial starch and protein producer a viable crop again. Historically chestnuts were used in both savory and sweet dishes, and often ground into flour for breads, cookies, cakes and more. Today chestnuts are an excellent and special addition to CSA shares and farmers' market sales, and provide the opportunity for many value-added products.

The former orchard hilltop of Wright-Locke Farm offers ideal site conditions for chestnuts, which are tolerant of drier and shallow-to-bedrock sites than most traditional orchard fruit species. It is also an ideal site for a suite of coastal New England-adapted dry-site fruiting shrubs which could complement and augment the wild food resources already present on the hilltop, while replacing the buckthorn-dominated forest regrowth present with a managed landscape of foraging trails. The central block of young Buckthorn and other tree regeneration offers the area of the hilltop with the best soil development and opportunity to convert to a different land use regime.

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Additional agroforestry opportunities with nut tree species offer themselves on this hilltop. The block of Shagbark Hickory seedlings to the south of the Buckthorn thicket offers another site for developing nut production systems, through grafting Northern Pecan scion wood onto wild Hickory seedlings to prepare for longer and warmer growing seasons in the climate-changing years to come. The stand of developing Red Oak sawtimber offers the opportunity to thin and coppice these trees for mushroom log production elsewhere on the farm.

Conversion Sequence

- When chestnuts are ready to plant, clear the central block of buckthorns and other young regenerating trees to open light conditions for chestnut establishment.
- Plant trees and shrubs as per the Woody Plant Establishment Guidelines in Appendix A.
- As regular irrigation will be impossible during the growing season on this site, considering using an ATV or other cart system to transport water tanks up the hill to water the trees well at time of planting. This system could be extended to any drought periods that the farm may experience if the new plantings are in need of moisture.
- We strongly recommend using 5-6' tree tubes when planting chestnuts on this site due to its distance from the farm core and exposure to deer and other wildlife pressures. Smaller tree tubes can be utilized for single-stem shrub species being planted. Multi-stem shrubs (such as any Running Juneberry and Lowbush Blueberry) can be guarded with hardware cloth cages for their initial years of establishment.

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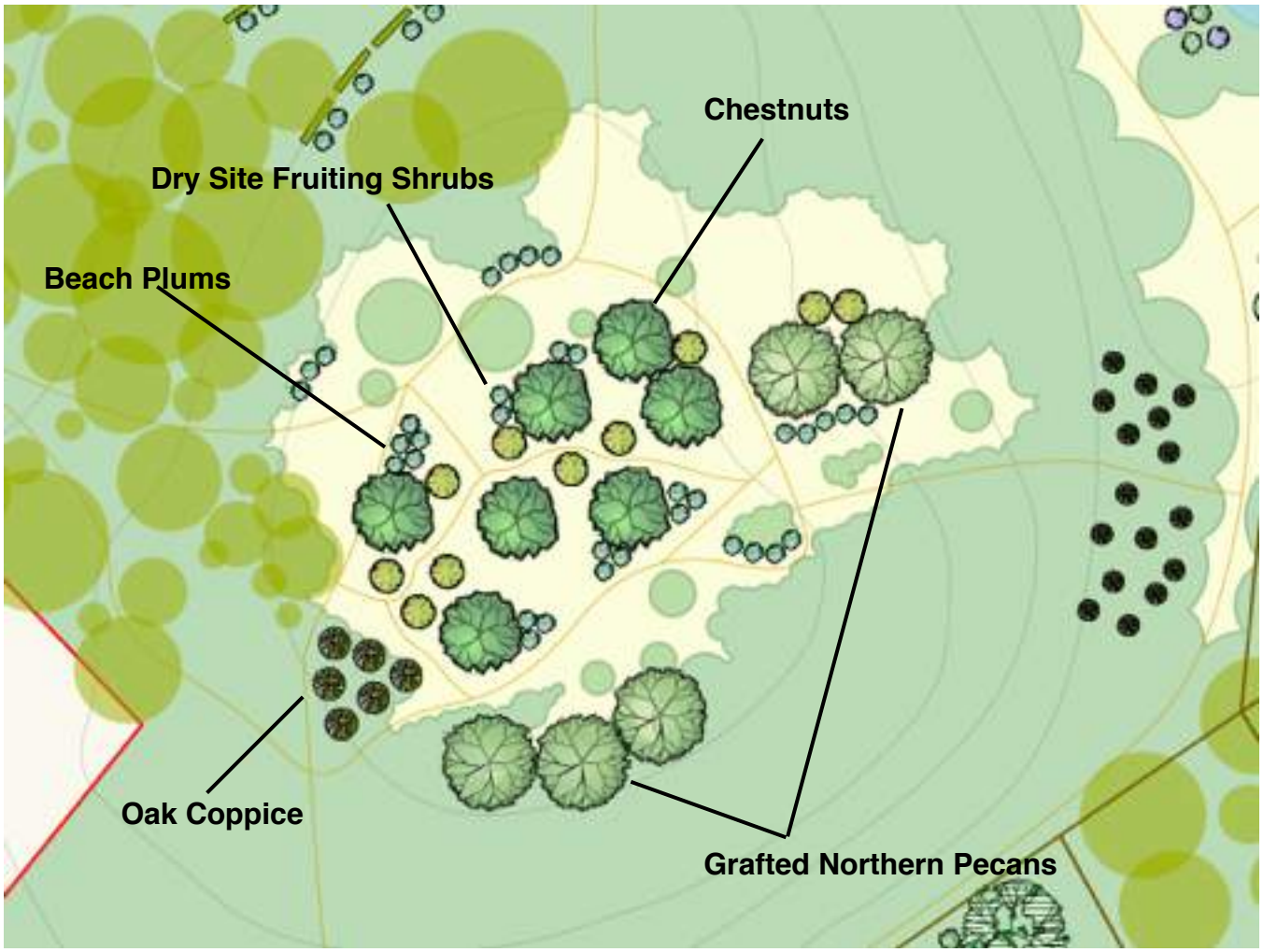

- Begin to lay out and utilize new foraging trails that wind across the hilltop and allow for easy maintenance (and future harvest!) visits to the new plantings.

Management

- The greatest threat to young nut trees is the potential of rodent damage in the winter. After each fresh snow stamp around the base of each tree as per the rodent protection specifications in Appendix A.
- The cleared buckthorns and other woody species currently regenerating on the hilltop will continue to reassert themselves for some years to come after initial clearing. These can be controlled with periodic goat browsing visits to the hilltop, as long as portable electric fencing is used under the watchful eye of a shepherd and the planted trees and shrubs are sufficiently guarded from goat browse. If it is not possible to utilize goats for this clearing, they will need to be mowed by scythe or other brush cutting tool twice per growing season until their root energy reserves have been exhausted.

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- For the best currently available guide to holistic orchard management, please see Michael Phillips' *The Holistic Orchard.* Though the pest management of chestnuts is very different than for chestnuts, many other orchard management principles and activities are the same. Key management activities include training young trees, winter and summer pruning, fertilizing through applications of compost, mineral amendments, and/or foliar sprays, grazing with livestock to interrupt pest life cycles, and harvest. We also recommend Martin Crawford's *How To Grow Your Own Nuts.*

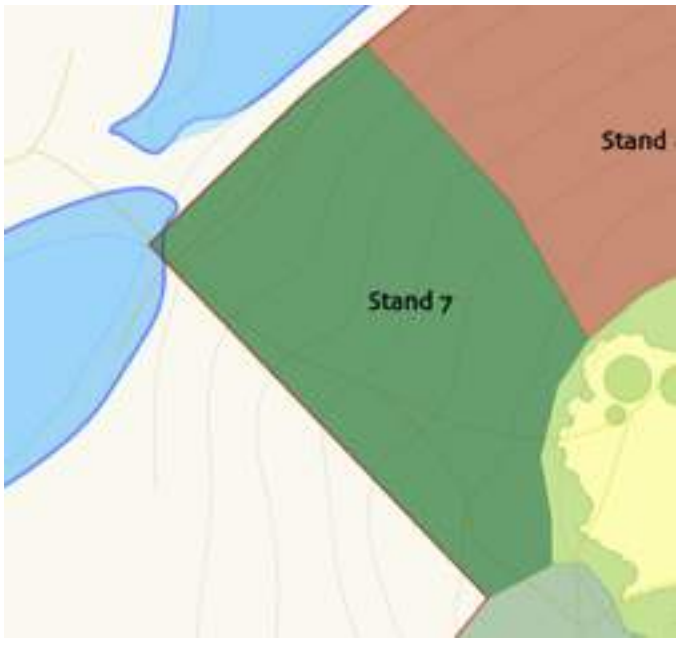
Recommended References & Resources

- *The Holistic Orchard* - Michael Phillips
- *The Pruning Book* - Lee Reich
- *A Guide to Nut Tree Culture in North America* - Dennis Fulbright
- *How to Grow Your Own Nuts,* Martin Crawford

Stand 7 - Enhancing Structural Complexity

This interesting but remote stand on the property contains a diverse mixture of intermediate-aged trees, including some larger individuals and widespread understory regeneration. Dominant species include Red and White Oaks, Shagbark Hickory, White Pine, Juniper, and Grey Birch. Pitch and Red Pines are also present, totaling four species of evergreen coniferous trees present here. The site is dry and sandy but not excessively rocky. It is navigable on foot without difficulty and would be a viable area to practice timber management on the property. Given its small size (1.2 acres), timber management should be for speciality projects on the farm rather than for commercial sale.

The stand displays an interesting structure, with multiple age classes present from overstory "standards" to maturing saw timbers to small sawtimber and polewood sized regeneration. Young groupings of oaks could be thinned or cleared for mushroom log production. Small patch cuts or smaller group selections could produce millable timber while opening the forest for new regeneration to enter. The stand is adjacent to several walking trails, so off-trail sites and/or uneven-aged management (single tree selection) may be considered for public relations and aesthetic purposes.



If Wright-Locke Farm does seek to expand its land management practices into responsible forest and timber management in the future, this

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stand would be one place to experiment. In particular, the stand's structure lends itself to an emerging approach to regenerative forest management known as Enhancing Structural Complexity (ESC). ESC mimics the processes through which old-growth forests form to remove timber products from forest lands while significantly increasing their structural diversity, presence of high-diameter individuals, and occurrence of coarse woody debris on the forest floor. It is significantly more carbon-storing than traditional forestry approaches and in some cases can approach the carbon storage rates of natural forests while still producing timber harvests and enhancing forest biodiversity. While the full ESC silvicultural system is complex and has only been fully described in the academic forest management literature to date, some of its key components which could be implemented at Wright-Locke include:

- Girdling medium to large sized, but poorly formed trees, to increase snags and release better-formed individuals,
- Felling and leaving some low-timber value trees on the forest floor as coarse woody debris,
- Identifying "release trees" to develop into large-diameter individuals, and harvesting clusters or individuals adjacent to these release trees.
- Crown release (removing trees on 2-4 sides) for the largest individuals in the stand to encourage their continued growth in size.
- Removing timber trees of variable diameters and in variable groupings (from single tree to small group selection), but retaining the largest and best-formed individuals throughout.

Stand 8 - Oak-Blueberry Woodlands

This North-facing stand is dominated by Red and Black Oaks, with numerous large-diameter individuals and a striking open understory and viewlines running through the stand. White Pine and Shagbark Hickory are also present in the stand, and the understory contains moderately well dispersed Oak regeneration as well as wild Highbush Blueberry. There are areas of erosion and soil loss occurring in the stand, particularly on the upper slope of the stand adjacent to the

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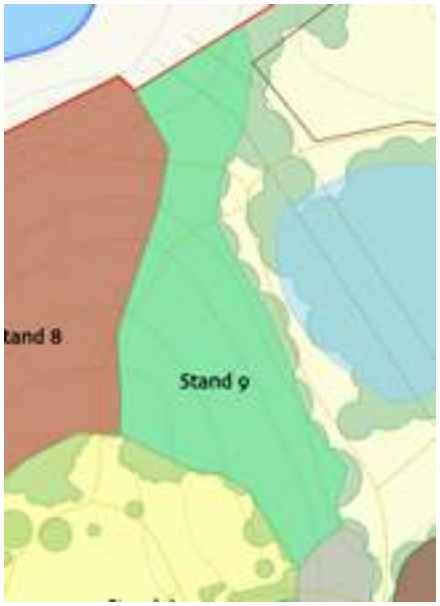
property's open hilltop.

We recommend utilizing Enhancing Structural Complexity techniques to release and continue to support the growth and health of the largest-diameter individuals in this stand. Choose 2-3 smaller trees surrounding each large-diameter (over 18" diameter at 4' of height off ground level) tree to fell. This "thinning from below" will encourage the further development of the largest trees' iconic size and mast production, as well as yielding timber products (from sawlog size trees), mushroom logs (from small sawlog size), firewood (from misshapen, small sawlog sized, or polewood size), and/or coarse woody debris for the forest floor.

In addition, we recommend mitigating erosion and creating opportunities for low-impact exploration of this interesting oak woodland environment using brush swales. Lay polewood size felled trees and coarse to fine woody brush down in bundles parallel to the contour lines of the stand. These bundles can be held in place through stakes fashioned from polewood and driven into the ground on the downslope side of the "swales". Above these swales, additional wild food resources can be planted, such as Highbush Blueberry and Huckleberry. These measures will slow the erosion of this dry slope and allow for people to access the understory fruit without creating further heavy soil disturbance, while the thinning from below treatment will encourage those understory fruits to produce more heavily with increased light.

Stand 9 - Buffer Slope



This young, mostly even-aged stand sits on a steep, non-rocky East-facing slope between the open brushy hilltop and the farm's pond. The stand forms an important visual buffer between those two focal areas on the property and along a widely used footpath on the West side of the pond. Dominant species here include Red and Black Oaks, White Pine, Juniper, and some Red Maple regeneration beginning to enter the understory. Trees are polewood to small sawtimber sized. We recommend a no-management strategy here to allow the stand to mature through natural growth and mortality, and to preserve the forested slope buffer between the main upland and lowland areas of the property.

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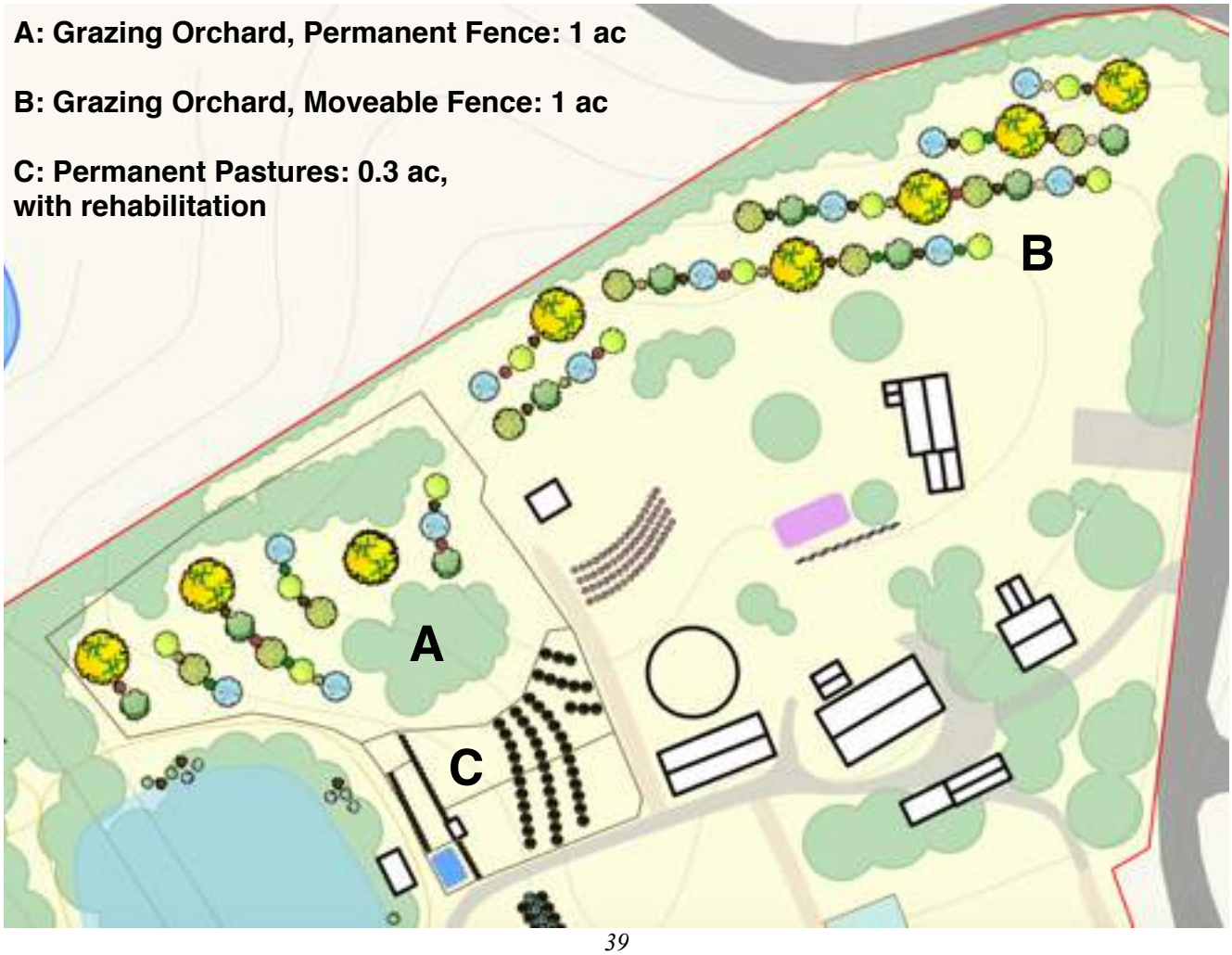
Pasture Rotations

Rotational grazing is one of the most powerful tools for long-term, sustainable meat or milk enterprise production and maintenance of pasture health and productivity. With proper landscape assessment, appropriate species and breed selection, quality stocking and rotation planning, careful observation of weather, pasture vegetation, and animal behavior, and well-timed rotations, planned grazing can rapidly regenerate pasture and rangeland. It can rebuild topsoil lost to overgrazing, compaction, and other forms of land degradation, while maintaining grassland biodiversity, sequestering atmospheric carbon in pasture lands (up to 1 ton carbon stored / acre / year is possible in many temperate climate pastures), and providing for greater animal health and nutrition than would be possible in a fixed-lot operation and . Planned grazing is necessary for silvopasture systems to function and remain productive long-term, and can also be used for land clearing and invasive species control purposes.

Opportunities for grazing exist on multiple sites across Wright-Locke Farm:



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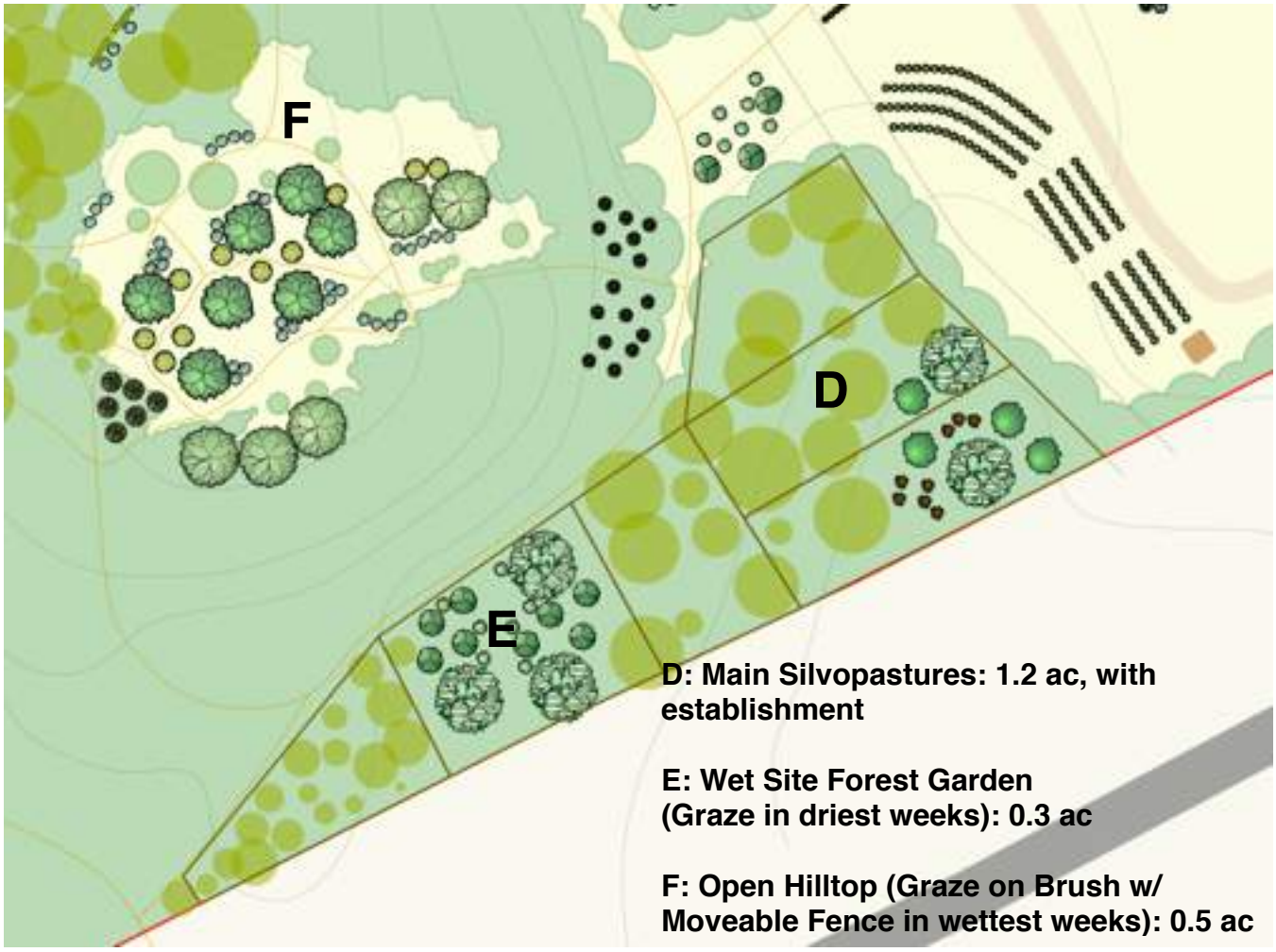

These areas total 3.8 acres of primary pasture (once all sites fully restored or established) and 0.8 acres of marginal woody pasture on wet and dry sites without a developed grass sward.

The greatest potential increases in grazing area at Wright-Locke Farm derive from:

A) Establishing new pasture areas (Grazing Orchard outside of current permanent fencing, Forest Silvopastures)
B) Increasing forage quality in the current permanent pasture through restoration, and in the future silvopastures through forage and site development.

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Under current conditions with initial silvopasture establishment, animal residence time should be distributed approximately as follows:

Pasture	Acreage	Forage Value Estimate	Acreage Equivalent	Full Stocking Rate - # of Adult Goats/Sheep	Total Foraging Days in Grazing Year At Full Stocking	Total Foraging Animal-Days (For Goats & Sheep)
Current Permanent	0.3	0.5	0.15		10	136.5
Grazing Orchard	2	0.8	1.6		106	1446.9
Forest Silvopastures	1.2	0.6	0.72		48	655.2
Dry Hilltop	0.5	0.4	0.2		12	163.8
Wet Forest Garden	0.3	0.2	0.06		4	54.6
TOTAL	**4.3**		**2.73**	**13.65**	**180**	**2457**

These totals can be supplemented with tree fodders produced by the multiple coppice and fodder systems planned for Wright-Locke, and months of the year without grass growth must be fed by hay. Animals should not be hay-fed at length in silvopastures due to likely debarking damage to tree roots, though sheep may be temporarily housed and hay-fed in silvopastures in the winter when the ground is completely frozen.

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With restoration and quality increases in the primary grazing areas, the potential future pasture quality on the farm could be closer to the following:

Pasture	Acreage	Potential Future Forage Value Estimate	Acreage Equivalent	Full Stocking Rate - # of Adult Goats/Sheep	Total Foraging Days in Grazing Year At Full Stocking	Total Foraging Animal-Days (For Goats & Sheep)
Current Permanent	0.3	1.0	0.3		16	265.6
Grazing Orchard	2	0.9	1.8		98	1626.8
Forest Silvopastures	1.2	0.8	0.96		52	863.2
Dry Hilltop	0.5	0.4	0.2		11	182.6
Wet Forest Garden	0.3	0.2	0.06		3	49.8
TOTAL	**4.3**		**3.32**	**16.6**	**180**	**2988**

These stocking rates and grazing days can act as a management objective for the farm's grazing system.

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Appendix A: Perennial Establishment Specifications

Herbaceous Perennial Planting Guidelines

Planting & Seeding Conditions

Seeding dates:
April 15 - June 15
September 1 - October 15

Planting dates:
April 1 - July 15
October 1 - November 15

(For bale seeding / frost seeding:)
November 15 - December 30
February 15 - March 15

Do not install grass seed when wind velocity exceed 5mph.

Herbaceous Perennial Planting Instructions - General

- Procure pot-grown (PG) or root-cutting (RC) plant material according to size scheduled on Installation Budget.
- Excavate planting hole by hand (NOT with a mechanical auger) as follows:
  - PG - 2.0 times the width of the pot; only as deep as necessary to allow herbaceous perennial plant collar to sit at undisturbed ground level.
  - RC - 1.5 times the width of root cutting; 2-4 inches deep.
- Set plant in planting hole so that the plant is completely vertical and so the top of the soil root ball is level with at undisturbed ground level.
- Pack excavated soil with fingers and hands around the soil root ball.
- Apply 1.0 - 2.5 gallons of Finished Compost evenly across the top soil root ball and backfilled hole, taking care to keep compost 2-4 inches away from all sides of plant stem.
- Apply 2.5 - 5.0 gallons of specified mulch evenly across the top of the backfilled hole and compost, taking care to keep mulch 2-4 inches away from all sides of plant stem
- Water plant immediately with 2.5 - 5.0 gallons of water.

Woody Perennial Planting Guidelines

Woody Perennial Planting Instructions - General

- Procure bare-root (BR) or pot-grown (PG) plant material according to size scheduled on Installation Budget.
- Excavate planting hole by hand (NOT with a mechanical auger) as follows:

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  - BR - 1.5 times the width of the maximum diameter of horizontally-stretched roots; only as deep as necessary to allow woody plant root collar to sit at undisturbed ground level or up to 1 inch above undisturbed ground level.
  - PG - 2.0 times the width of the pot; only as deep as necessary to allow woody plant root collar to sit at undisturbed ground level or up to 1 inch above undisturbed ground level.
  - Any sod removed shall be placed grass-down on the downhill side if ground is sloped or evenly spaced in a ring if ground is flat.
- Set plant in planting hole so that the main stem or trunk of the plant is completely vertical and so the plant root collar is level with at undisturbed ground level or up to 1 inch above undisturbed ground level.
- Backfill planting hole with excavated soil in the same order in which the soil horizons were excavated. DO NOT add compost or fertilizer into the hole.
- Pack soil with fingers, hands, and feet until compacted enough to hold plant upright on its own. DO NOT stake plants upright. If soil is excessively dry, water soil into the hole halfway through the backfilling process.
- Apply 2.5 - 5.0 gallons of Finished Compost evenly across the top of the backfilled hole, taking care to keep compost 4-6 inches away from all sides of plant root collar.
- Apply 5.0 - 15.0 gallons of specified mulch evenly across the top of the backfilled hole and compost, taking care to keep mulch 4-6 inches away from all sides of plant root collar.
- Water plant immediately with 5.0 - 10.0 gallons of water.

Tree Protection Techniques

Perimeter Deer Fencing

- **Posts:** 4" x 4" in by 12 feet long square locust line posts OR 4-6” by 12 feet red cedar round posts, spaced at 18 to 20 feet or closer if necessary to avoid rocks or other landscape features.
- **Braces:** Corner and end posts will be 5”x 5” x 14 feet long instead of 12 feet long. Next to each corner post install a 10 or 12 foot brace so that the first 2 posts will be 10 or 12 feet apart and have a diagonal brace wire to support these two posts. For heavy gates, use 6” to 6” by 12 feet long gate posts.
- **Wire:** Bekaert Galvanized fixed knot hi- tensile deer fence (in black color). This wire is 75" high and has 17 horizontal line wires and it has 6" vertical stay wire spacing in order to deter some smaller animals. The spacing is also graduated from smaller at the bottom with a 3" x 6" block to a 6" x 7" block on the top.
- **Gates:** Use 8 foot tall gates of 16 gauge high tensile galvanized steel tubing with 2" x 4" wire mesh welded on to them.

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Tubex Tree Tubes
Some trees will be planted outside of deer fenced areas. Individually protecting trees with a tubex tree tube is a cost effective way to protect young trees from deer browse which can kill the tree.

- **Tubex:** We are finding that 6 ft. tall tubes are necessary in heavy deer pressure areas. They can be purchased from Wilson Forestry Supply. For lower deer pressure areas, 5 ft. tall tubex tubes can be purchased from Oikos Tree Crops.
- **Stakes:** Many materials will work as stakes as long as they can be pounded into the ground. The longest lasting and most cost effective stakes PVC. Metal U-posts are also long lasting. Wooden stakes often rot but may be a locally available resource.

Rodent Protection
Subterranean rodent activity during the winter can be the biggest threat to the survival of newly planted trees next to deer. They like to eat the roots and will sometimes chew right through the base of the trunk disconnecting the top of the tree from its roots. There are a number of precautions that can be taken to prevent this:

- **Hardware Cloth:** Each orchard tree or berry shrub that is inside a deer fence but not protected with a tree tube will do well to get a 6”-12” tall ring of hardware cloth protection at the base. Rolls of hardware cloth are available at all hardware stores. We’ve found the plastic coated hardware cloth to be much easier to work with. Cut to size using tin snips and fasten around the base of each tree or shrub. Work the base into the soil to be sure you are providing sufficient protection. Hardware cloth can be removed once tree is well established and less vulnerable.
- **Fall Mowing:** One final mowing before winter arrives will reduce rodent meadow habitat to discourage them from making a winter home in your orchard.
- **Winter Stomping:** Upon the arrival of a fresh snow and wintertime walk through the orchard will do wonders in preventing rodent damage. Stomp around the base of each tree to compact the snow to the ground leaving little to no air space for easy rodent travel between the snow and the ground.