**COPPICE AGROFORESTRY**
Resprout Silviculture for the 21st Century
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# Coppice Design Case Study

## Sovereign Hill Farm

Chester, MA
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## INTRODUCTION

As we muddle our way through the oil peak, into climate chaos, and towards whatever our future will bring, we need to examine new ideas and re-examine old ones, testing them on the ground to see how they might help us bring our best to that future. This case study is intended as a sketch of patterns and possibilities that test what we have learned so far about coppice and pollard systems against a particular piece of ground. It is based on the best available data and a small investment of time and energy, but in no way do we pretend to have all the information we need to make the ideas developed here successful. In fact, part of the point of doing this sketch is to help us identify the gaps in our knowledge and feel our way as far as we can into filling those gaps. We hope in that process to be of service to you, our case study clients, and pray we do not lead you astray.

With that in mind, it is important to note that, while plenty of experience with resprout silviculture exists in Europe with European species and our observations give us faith in the resprout ability of North American woody plants, we have little research or experience supporting the ability of most if not all of the North American species mentioned herein to be *managed* as coppice, and even less on their use as pollards. Few studies appear to have been done on these practices on this continent, and the studies we have found have limited utility for the kinds of practices we discuss here. We have learned much in working on this sketch, but we still have much to learn. In moving towards the ideas laid out below, proceed with caution and scale up at a reasonable pace. Test species, practices, and systems at small scale before committing large amounts of land, money and labor to this design scheme.

This report begins by elucidating some of the farmers' Goals, proceeds through a brief Site Analysis and Assessment, and then proposes several Design Schemes.

## DESIGN GOALS:

• The farm serves the community, providing:
  - An ideas, practices, and demonstration place.
  - A gene bank of plant species and livestock breeds.
  - Discussion around and access to information on multi-racial cross-generational social justice, healthy living, youth education…
• The farm provides food resilience (meat and milk for Kathrin and Joseph) and some meat animals and pelts for trade.
• The farm provides a space for very limited residential life coaching/farm learning/experience retreats.
  - 1 on 1 workshops.
  - On-farm work immersions.
  - Farm retreats.
  - "Day Bed Sessions" transformational farm retreats, perhaps…

**Desired coppice products/crafts, other planting/land use goals:**

• Leaf hay for winter fodder, summer snack fodder, summer emergency fodder.
• Possible interest in nut trees—nut trees over coppice?
• Main field remains open for haying.
• Herb production in coppice/pollard understory for the flower essence business.
• Provide shade for the animals.
• Provide kindling and firewood for the house:
  ~ Kindling: about 10 cf/year!?
  ~ Firewood: ½ woodshed/year: 9.5' x 5.75' x 7' = 382 cf/128 cf/cord = 3 cords.
  ~ Elegant design: easily transportable to livestock and easily accessed with existing truck trails.
• Poles for building construction: humanure processing at barn, shed construction, etc.
• Small poles: rebuild tomato trellises every couple years.
• They wish they had black locust somewhere other than where it currently grows—black locust an ideal species for them.
• Shiitake mushroom logs (20-24 4' lengths x 5 to 8" dia.) every 2-3 years.
• Joseph: A woodworker someday.
• Improve the meadow.
• Might expand pasture system someday—no intention at this time but set up so can.

• Poles of various sizes for garden structures and polewood construction as needed.

**Leaf hay needs:**
• Why leaf hay/tree fodder for the animals:
  - Leaf hay so healthy for them (parasites).
  - Existing abundance of trees here.
  - Diversity of management practices: something other than scything all day….
• Livestock needs:
  - Sheep: Cascade Farmstead sheep.
    ~ Had 20 sheep last summer. This winter: 5 ewes, 2 rams.
    ~ Sheep average 65 lbs each.
    ~ Sheep eat 2-3x more than goats.
    ~ Better than goats at keeping grass down; still have to mow sometimes because it grows so fast; but ran out of grass in August 2014.
    ~ Leaf hay could offer some summer supplement in hard years.
  - Goats: Kinder, dual meat and milk breed.
    ~ 3 bucks, 5 does. Probably never more than 6 does, 9 goats.
    ~ Their goats average 65-85 lbs/animal.
  - She is thinking of selling her sheep and having only goats. If all goats, then browse becomes more of a focus than grass production.
  - Winter feed needs:
    ~ They currently feed:
      - 500-750 30-40 lb bales of hay per winter;.
      - 8 goats, 12 sheep require about 1.5 40ish # bales/d = ± 60 lbs hay/d ÷ 20 animals = 3 lbs hay/animal/d.
    ~ During winter, most ewes and does will go from maintenance through gestation and into lactation, so the average dry matter intake (DMI) as a % of body weight (BW) for each life stage is a reasonable the number to use to estimate total DMI for the winter season. According to Schoenian, average DMI as % Body Weight from Maintenance through Lactation is 3%.[1]
    ~ Assume 80 lbs/animal; 80 lbs x 3% body weight = 2.4 lbs DM/animal/d. Growing lambs (DMI = 4.4%BW) in the 66# range need about 3# DM/d. *Assume 3# DM/animal/d for the sake of argument and to be conservative.*
    ~ 3# DM/animal/d x 180 d winter = 540# DM per animal per winter x 20 animals = 10,800# DM, or 5.4 tons DM.
    ~ Ideal protein content varies depending on life stage, but ranges from 9-14% Crude Protein for sheep; for milking goats, 14-18% CP.[2,3]
  - Summer feed needs:
    ~ Assume flock size 2x winter numbers.
    ~ 2 x 5.4 tons = 10.8 tons DM = 22,600 lbs.

## SITE ANALYSIS AND ASSESSMENT

**AREA:** Main field 7.6 acres, including barn, paddocks, hayfield, and some woods edges. Barn and fenced paddocks total about 3.0 acres, including some of the upper shady wood pasture. The hayfield north of the paddocks totals about 3.64 acres excluding all wooded areas except the center sloping scrubby patch.

### CLIMATE

**Precipitation:** Average annual: 58-61 inches per year.[4] Monthly averages are almost all over 4 inches per month in the datasets found; the most reputable dataset indicates 4.23 inches to 5.57 inches average monthly precipitation during the growing season.

→ Irrigation should not be necessary in most years. Still need to plan for greater variability in rainfall in the future, however.

**USDA hardiness zone:** 5b (-15° to -10°F)

**Arbor Day hardiness zone:** 6 (0° to -10° F)

**Frost-free days:** 150-165

**Prevailing Winds:** Data from the UMass Wind Energy Center[5] using an anemometer set on Gobble Mountain, 3.3 miles west of the site, indicates that winds prevail from the northwest, primarily, with northeasterlies also occurring frequently in spring.

→ This site, lying on an east-northeast-facing slope, should be well-protected from prevailing northwesterlies. This makes long-term pollards a more viable option, should they be considered, as there will be less wind-throw of weakly-connected pollard sprouts. However, storm winds (northeasterlies) could cause damage on an occasional basis. Ideally, if long term pollard rotations are used (more than five years or so), they should be in locations protected from nor'easters.

### LANDFORM

**Ecoregion:** 58e: Berkshire Transition zone of the Northeastern Highlands region.

*Physiography*: Hills and open low mountains, gently rounded to some steep slopes. Moderate gradient, bedrock, boulder, and cobble-bottomed streams. Some natural lakes and ponds, and a few large reservoirs.

*Surficial and bedrock geology*: Quaternary sandy loamy till, some ice-contact sand and gravel. Devonian schist, micaceous quartzite, quartz schist, calcareous granofels, quartzose marble, granite, and gneiss; Ordovician to Cambrian schist, gneiss, amphibolite, and marble; Precambrian gneiss and schist.

**Elevation:** 1,230 – 1,330 feet.

**Slope aspect(s):** East-northeast-facing.

**Soil types:** See Appendix 1 for a map and descriptions of the soils in the study area.

- The woods surrounding the main field are classed as Tunbridge-Lyman association, steep, extremely stony. We will focus on the soils in the field itself here, though.
- The entire open field and immediately adjacent woodland edges are classed as Tunbridge-Lyman complex, rocky soils. Tunbridge Lyman complex contains such an intricate mix of Tunbridge and Lyman soils that they could not be easily mapped as separate soil units. Tunbridge and Lyman soils account for approximately 83% of the area mapped as Tunbridge-Lyman complex. In addition, the Tunbridge Lyman complex includes four other soil types mixed into the area that constitute about 17% of the area, on average.

*Parent Materials:* Both Tunbridge and Lyman soils formed in loamy supraglacial till derived from either granite and gneiss, phyllite or mica schist. Till material usually contains mixed particle sizes, from silt and clay to boulder-sized, that have not been sorted by running water. This mixing of particle sizes means that the smaller particles fill the spaces between the larger particles, so the soils therefore tend to be dense and easily compacted to become a restrictive layer. However, since this till was "supraglacial" it was carried on top of the glacier, and so was not compacted by the ice, but deposited loosely as the ice melted. It will therefore more likely be able to transmit water and roots unless compacted by human activities.

*Depth to Bedrock, Restrictive Features, and Water Table:* Bedrock typically lies at 28-38 inches from the surface in Tunbridge soils and 18-28 inches in Lyman soils. No other restrictive features are commonly found in these soils. Water tables are usually more than 80 inches deep, within the bedrock.

→ The types of bedrock that likely lie under the site do not tend to be highly fractured rocks. This may limit the rooting ability of deep-rooted tree species.

→ The soil types explain why the field remains a field: the field's soils are less stony than the surroundings. The stonier areas now in woodland were released from agricultural use decades ago.

→ Shallow soils mean that shallow-rooted species will likely be most successful in most parts of this site, unless deep pockets of soil are found. This will probably limit the health and productivity of most nut trees.

→ Check the site to find the deepest soil pockets for tree planting, especially for nut trees. Gentler slopes, bottoms of steep slopes where they meet gentler slopes, as well as valley-ish areas, are the places where erosion will most likely have been least or where eroded soils would most likely be deposited over time.

**WATER:**

**Soil Hydrologic Groups:** Tunbridge soils: C (moderately high); Lyman soils: D (high). These are high runoff soils, meaning that they will produce large volumes of runoff fairly quickly in rain events. This is probably due mostly to the shallowness of the soils to bedrock.

**Available Water Storage in Soil Profile***:* Moderate in Tunbridge soils (about 6.1 inches), low in Lyman soils (about 3.4 inches). Again, probably due to the shallow-to-bedrock soils. The Tunbridge soils will hold moisture better in droughty periods, offering about 6 weeks of moisture for growing crops.

**Watersheds:** The watershed draining onto and through the field totals about 30 acres, of which just over 9 acres is the field itself. Much of the 24 acres or so above the field consists of slopes about as steep as the site, leading up to gentler slopes on a ridge top. The whole watershed has soils quite similar to those on the site itself: shallow to bedrock, high runoff, and moderate to low water storage capacity. However, Lyman Road, above the site, has ditches and likely diverts much of the runoff from above the site away from the field itself. The southern end of the field is likely drier than the central portion of the site due to the topography, which appears to concentrate runoff toward the middle and northern part of the field, if it can cross Lyman Road.

**Wet Spots:**

→ Given the geology, surficial geology, and soil profile, the site and its surroundings would appear to generate significant amounts of runoff in the wet seasons which will run downhill on or just below the surface. Locations where steep slopes bottom onto gentler slopes, and where the overall topography creates valleys that concentrate runoff, as in the middle of the north field, will likely have significant amounts of water at or near the surface in the wet seasons. Either avoid such areas for coppice plantings or plant wet tolerant species.

→ The shallow soils and moderate to low water storage capacity of the soils would indicate a tendency towards droughtiness, if rainfall shifts to a lower-than-normal pattern. Drought tolerant species would be a good idea.

→ Planting or swaling slightly off contour may assist in infiltrating runoff into the soil and storing it in what limited storage the soil has available, while also letting excess runoff move away from plantings and down the hill. Avoid swaling or planting strictly on contour to prevent water logging of plantings.

- Paddock 10 has a huge amount of water that comes out of the ground right at the edge of the existing tree stand. Paddock 9 is a bit wet there too. In spring, all the uphill pastures are wet to a certain extent.
- The downhill/east edge of paddocks 6 and 5 are tremendously wet.
- Lyman Road has a huge deep ditch on the uphill side, and culverts that just got installed in 2014 by a logger. Exact locations of those culverts unknown.
- The northeastern downhill corner of the north field is fairly wet.
- The lower edge of the north field may tend to be wet in general, probably wet early spring.

- The central steep slope probably has drainage tile through it.
- East and south of the central clump of ash trees lie some divots that would be perfect for ponds—alá Sepp Holzer. The topsoil from barn construction is stockpiled here, and could be smoothed out.
- At least one culvert dumps onto the north field from Lyman Road somewhere between the NW corner of the fenced paddocks and the clump of trees protruding into the field near the northwest corner of the north field.

**ACCESS & CIRCULATION:**

- Hay equipment access from Lyman Road to the north field goes through the opening at the very northwestern corner of the north field, an opening at the NW corner of the paddock system, and about 30' north of that.

→ Maintain at least two of these equipment access points.

- The very northwestern corner of the north field is also probably the driveway for a future house if a house ever gets built here. Do not block or plant along this corridor.
- A 4' gate leads uphill out of the paddock system right near the SW corner of paddock 13.

→ Perhaps a space to let animals out of paddocks into a coppice or pollard block let them browse or graze while fenced with electronet.

- Big barn is 36 x 66, hayloft above is 36' x 50' x avg. height 7' (2' knee wall, ±12' at peak) = ±12,600 cf storage. One can access the hayloft at the south end of the barn through second floor doors approximately six feet wide.
- Small barn down by house: 16' x 26' with a hayloft above it.

→ The small barn is highly inconvenient relative to livestock barn, but it could be emergency overflow fodder storage.

**VEGETATION:**

**Typical Regional Vegetation:** Mix of northern, transition, and central hardwoods-conifer forests. Northern hardwoods hemlock-white pine forest on dry to mesic mostly north facing slopes and ravines. Red oak-sugar maple transition forest on mesic mid-slopes with northern red oak, sugar maple, beech, black birch, and some white pine and hemlock. Oak-hemlock-white pine forest with white oak, chestnut oak, northern red oak, black birch, black cherry, and red maple, with some hemlock and white pine. Some ridge top pitch pine-scrub oak woodland with pitch pine, northern red oak, black oak, and scarlet oak. On stream slopes and terraces, red maple, silver maple, American elm, basswood, sugar maple, shagbark hickory, and black cherry. Many of these species resprout, and some, especially the maples, birch, elm, and basswood have some fodder potential.

**On-Site Vegetation**:
*Woodland Edges:*
• The trees in the woods and woodland edges around the field consist of mostly red oak, a lot of sugar maple and red maple, black cherry, a few hickories and a white pine or two. They are mostly too large to coppice at this point.
• Some smaller individual trees (12" or less) lie scattered among the bigger trees around the field that may be coppiceable or pollardable, but they have large amounts of shade from neighboring mature trees.
• Some 7-8" diameter trees stand in the woods in paddocks 9 & 10.
• Also have bittersweet and grapevines on edges of field, especially along northern stone wall, and knotweed along stone wall of northern boundary.
→ The utility of coppicing or pollarding the field edges is probably minimal, as scattered trees will be harder to care for and harvest from regularly.
→ Cutting the woods at the field edges will increase the area the farmer(s) must manage.

*Field Configuration:*
• The north hayfield has a number of zigzagging edges that are surely hard to manage when cutting hay.
• The central steep slope and disturbed area are difficult if not impossible to safely cut with a tractor.
• The Lyman Road edge of the north field between the fenced paddocks and the toe of trees sticking into the field to the north has a lot of bracken fern and goldenrod in it; bracken really taking over the last few years. There are also rocks in the field near that area.
→ These zigzags, steep slopes, and rocky bracken areas offer opportunities to establish coppice and pollard systems with minimal negative and some positive impact on hay harvesting.

*Pasture Paddocks:*
• The existing fenced grazing has no shade except in a few instances. The animals need shade to reduce summer stress. Some trees have already been planted to begin this process. These trees are all Ashworth honeylocust (thornless *Gleditsia triacanthos*; marked "H" on the plans in Appendices 3 & 4), except those between paddock 1 and SP5, which includes pear trees, Russian quince, blueberries, and perhaps sea buckthorn (marked "T" on the plans in Appendices 3 & 4).
→ Unfortunately, the data on honeylocust indicates that, while the foliage is high in protein and a decent fodder, the trees do not recover well from cutting and therefore do not have high potential for coppice or pollard systems. However, the number of studies on this is low, and the trees already existing are worth playing with to see

how they respond to management. We do not recommend planting more of this species though, at least for foliage fodder. The pods are another question, and could be useful as fodder themselves, which we assume is why they were planted. In this case, the trees will have to grow much larger to get maximum production than if they are pollarded, which will cast more shade on the pastures below and reduce the number of other trees that the space can hold.

→ Additional trees to shade the paddocks would be of great use in summer. Must be sure not to shade too much to reduce grass production, unless they let go of their sheep.

→ We could fence off a 10' swath in any of the 4 uphill or downhill pastures to protect trees that night be planted.

→ Filling in the uneven edges of the field with plantings will simplify hay land management while not reducing hay yield that much, and offer the opportunity to plant the highest value fodder species as well, perhaps with high value medicinal or other crops in the understory, out of reach of livestock.

→ The uneven field edges, unused corners, and steep slopes should be one focus of planting efforts for large-scale coppice and pollard production systems.

## SITE DESIGN

**Summary:**

• We offer below several design options for this site. Our overall intent is to keep the main portion of the north field open for haying while increasing fodder production for winter storage, providing summer snack forage, increasing summer shade, and decreasing winter wind stress on the livestock. Filling in the crenellated edges of the hay field and other difficult to mow areas with coppice and/or pollard blocks will minimize impact on hay yields while playing with a range of coppice and pollard systems to test them out. In addition, we propose planting some trees among the fenced pastures to improve summer shade conditions for the animals and offer more and increased diversity of forage for them. Summer fodder can be either for "snack" purposes or as a major fodder component during the growing season, but either configuration should also reduce wind speeds in winter.

• The sections below detail the concepts and specifics of each option. Some options can be mixed together, others are mutually exclusive. See Appendices 3 & 4 for the plans that show these options.

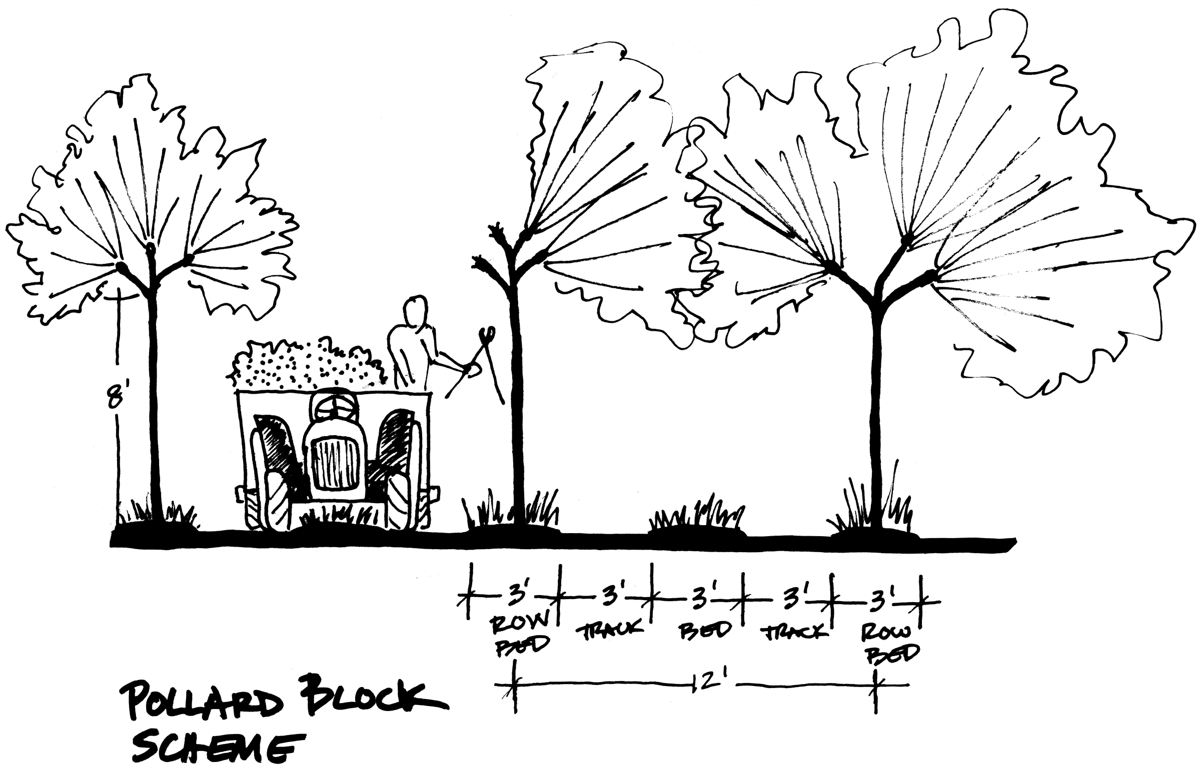
## Option 1: Winter Pollard Blocks (Blocks A, B, D, E, F; Appendix 3)

### Design Concept:

- On flatter ground, either near the top of the pasture along the western edge of the field or at the bottom edge of the main field, blocks of pollard rows grow on 10-12-foot centers. Pollarded at 8 feet and cut on a 3-year rotation, a pickup truck or wagon can pass under the pollard heads allowing a person to prune and stack leaf hay while standing in the truck. The space beneath offers shady conditions for growing medicinal herbs, or for brief summer grazing.

### Design Considerations:

- Historically, harvesting leaf hay has been a time-consuming and labor intensive process, involving climbing trees with ladders, dropping cut material onto the ground, picking that material up, carrying it to its drying and storage location, and stacking it to store and ferment it until use. Reducing labor in this process by simplifying harvest and transport seems critical to successful pollarding.
- Blocks E and F, along the upper, western edge of the north hayfield and the fenced pastures, have sufficiently flat topography for the use of a pickup truck or wagon as a roving elevated platform to harvest, stack, and transport the leaf hay. This should dramatically reduce the logistical effort involved while still keeping the pollard material out of the reach of livestock and deer while it grows.
- This design concept assumes leaf hay as the main product, with the potential for full shade herbal crops below, hence, close spacing of pollards to maximize leaf hay yield.
- Austad, Hamre, Rydgren, and Norderhaug have created the only study of pollard yields that offers data actually usable in design.[6] Sadly, the study only involved three trees of two species (two *Ulmus glabra* and one *Fraxinus excelsior*) over a period of five years in Norway, a climate and context very different from the Northeast. However, it is all we have to go on. Assuming similar yields from most species, we can estimate each pollard will yield 21 pounds of dry matter per year of its rotation, and that well-established pollards will attain a diameter of approximately 25 feet in a 5 year rotation. If we assume a 3-year rotation on young pollards, the diameters will be less. We're guessing that the trees can therefore be planted at 12-foot centers within the row and a minimum of 12 feet between rows, depending on the intended use of the understory. For this design concept, rows at 12 feet will form the standard.




• A large standard pickup truck is 6.5 feet high at its roof, with a bed 3.5 feet off the ground. Pollarding trees starting at 7-8 feet off the ground should allow a truck or tractor and wagon to fit under the pollard knuckles and main scaffold branches. Since tractors tend to exhaust upwards, a tractor and wagon will less likely contaminate the soil with exhaust. This will allow shady herb production beds between the tractor/wagon tires. This bed must be narrow enough to fit between the tractor, wagon, or truck tires.

**Design Details:**

• Table 1, below, provides the sizes, areas, numbers of rows and trees, and yield estimates for each pollard block. A few comments on each block follow.

• Comments re: the pollard blocks:

- Tall trees stand on three sides of Block A, including the south side. Therefore, to gain maximum photosynthesis, we need to lift the canopies off the ground to get more sun early in the crops' rotation. This supports the placement of pollards in this block. Block A appears to be somewhat wet, which might limit the species viable to plant there, and possibly the harvesting method.
- Block B is quite narrow, probably wet in spring, and fairly shaded, though it should get solid afternoon sun. Lifting canopies higher through pollarding should help gain more sun, but the utility of planting pollards here is somewhat

questionable. It may offer some interesting opportunities to play with varied species or styles of pruning however, and mimics a pattern seen in photographs from Norway where small stands of pollards lie tucked away on field edges such as this.

Table 1: Pollard block configurations and yield estimates for Option 1. The table assumes 12 feet between alleys, 12-foot spacing within rows, and 21 pounds of usable dry matter (DM) per year of rotation over a 3-year rotation (63 pounds per harvest per tree). Yields will likely vary: we have little data for these estimates.

| | **Block A** | **Block B** | **Block D** | **Block E** | **Block F** | **Total** |
|---|---|---|---|---|---|---|
| **Size, ft.:** | 120' x 55' | 190 x 25' | 100' x 90' | 260' x 55' | 175' x 35' | |
| **Area:** | 6,600 sf | 4,750 sf | 9,000 sf | 14,300 sf | 6,125 sf | 40,775 sf |
| **Number of Alley Rows:** | 11 rows | 2 rows | 8 rows | 5 rows | 4 rows | |
| **Length of Alleys:** | 55' | 190' | 100' | 260' | 175' | |
| **Trees/Row:** | 5 | 16-17 | 9 | 22-23 | 15 | |
| **Total No. Trees:** | 55 | 33 | 72 | 111 | 60 | 331 |
| **Trees Harvested/Yr:** | 18 | 11 | 24 | 37 | 20 | 110 |
| **Est. DM Yield/Yr, lbs.:** | 1,134 lbs. | 693 lbs. | 1,512 lbs. | 2,331 lbs. | 1,260 lbs. | 6,930 lbs |
| **% Winter Fodder Req.:** | 10% | 6% | 14% | 22% | 12% | 64% |

- Block D has the best sun of all the blocks and a mostly flat site except for the western/upper edge, where piles of topsoil from the barn construction are stockpiled. It should work well for harvesting pollards by truck or wagon. Rows should run whichever direction are optimal for tractor use in the hayfield as well as the pollard block, based on field observations, but probably on or close to contour.
- Block E, the largest of all the blocks, has good sun and a relatively flat site, making it work well for harvesting pollards by truck or wagon. Rows can easily run parallel to the field edge with good planning for tractor turning and hay equipment access at the south end. A culvert from Lyman Road dumps into this space, and should be considered when finalizing any planting or harvesting plans.
- Block F lies in the southwestern upper corner of the field, between the fenced pastures and Lyman Road at the corner of Sovereign Road. Rows can run parallel to the field edge. Shorter rows may facilitate vehicle movement through and around the pollard block. The block could be extended eastwards to cover or partially cover the fenced ring path if so desired.

• Possible species: For winter fodder, the most important fodder characteristics include: palatability, high digestibility, and metabolizable energy, as long as basic protein needs are met (10-14% protein should be fine). Data on these key factors is scarce as of yet, except for crude protein (See Appendix 2). The ability of the cut branches to hold their leaves is another very critical factor in making this system work, and we know little about this for North American species. Further research is needed before selecting from among the species below.

Table 2: Possible pollard block species.

| Blocks | First Choice Species | Other Possible Species |
|---|---|---|
| **A, B** | *Alnus rubra, Salix babylonica, Salix caprea, Salix fragilis, Salix nigra, Salix pentandra.* | *Alnus* spp., *Acer rubrum, Acer saccharinum, Betula allegheniensis.* |
| **D, E, F** | *Morus alba, Alnus rubra, Ulmus* spp. | *Populus* spp., *Robinia pseudoacacia, Sassafras albidum.* |

### OPTION 2: COPPICE BLOCKS (C, D, PERHAPS A, B; APPENDIX 4)

### Design Concept:

• Densely planted coppice stools grow on 6-foot centers in blocks where haying is either impossible or less practical. Cut at or just above the ground (depending on species planted), the species chosen for these blocks can produce animal fodder or mushroom logs, crafts, kindling or firewood, depending on the cutting rotation. The space beneath offers shady conditions that could be used for growing medicinal herbs, however the logistics of that may be prohibitive given the density of coppice stools.

### Design Considerations:

• The sloping ground of Block C makes harvesting pollards from wagons or pickup trucks untenable. Block D's rough ground could be problematic for wagon harvesting of pollards, though it is fixable. Block A may be too wet for truck or wagon use. Block B may be unsuited to significant pollard production as a result of wetness, though its shadiness nudges in that direction. The size of Blocks A and B mean that higher production might be gained from a closer spacing of trees compared to pollards. All these factors push towards coppice rather than pollards.
• Blocks C & D get the best sun of any of the blocks laid out on the site. Blocks A and B get less sun, and may be suited for coppice as they could be harvested when ready for various uses rather than having the animals depend on the fodder they might produce, when yields and rates of growth may suffer due to the shade.
• Generally speaking, coppice systems yield:
  - 0.9 – 1.8 tons/acre/year.[7] For the purposes of this case study we will use the low end of the yield spectrum: 0.9 tons/ac/yr.
  - 0.5 – 1 cords of wood/acre/year.[8] For the purposes of this study, we will assume 0.75 cords/ac/yr.
  - Yields of rods and poles probably vary by species, stool health and age, planting density, site quality, rotation length, etc. However:

~ In Britain, with 600 to 700 stools/acre (spacing approximately 8-8.5 feet), top quality hazel coppice on a 7-9 year rotation yields 10,000 to 12,000 rods/acre 10-15' long at each harvest, while poor quality hazel copses yield under 4,000 rods/acre.[9]

~ British sweet chestnut coppice at about 600 stools per acre on a 16-17 year rotation can yield 2,000-2,350 rods per acre.[10]

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**Design Details:**

- Table 3, below, provides details on the blocks and their potential yields of woody material by mass, by volume, and by the rod.
- Few of the potential blocks for coppice are ideal, in the sense that they are either wet, small, steep, narrow, or shaded by tall trees on several sides.
- Tall trees stand on three sides of Block A, including the south, though the site should get good afternoon sun. This block is also probably fairly wet. Yet, it is a good size (120' x 55'), and offers significant yield potential if it can be well utilized.
- Tall trees stand on two sides of Block B, including the south. The site is narrow (190' x 25') and probably at least seasonally wet. Coppice growing here will likely have "pistol-grip" bases, or lean into the field, but it may be useful as a place to test species for their survivability and growth rates.

Table 3: Coppice block configurations and woody material yield estimates for Option 2. The table assumes 6 feet between coppice stools. Yields estimates are *per year* except rods per harvest cycle: multiply by length of rotation to get yield per harvest. Rods/ harvest assumes good quality hazel coppice on a 7-9 year cycle and yields comparable to British conditions. Yields will likely vary: we have little data for these admittedly conservative estimates.

| | **Block A** | **Block B** | **Block C1** | **Block C2** | **Block D** | **Total** |
|---|---|---|---|---|---|---|
| **Size, feet:** | 120' x 55' | 190' x 25' | 200' x 30' | 55' x 30' | 100' x 90' | |
| **Area, square feet:** | 6,600 sf | 4,750 sf | 6,000 sf | 1,650 sf | 9,000 sf | 28,000 sf |
| **No. of Stools @ 6' spacing** | 184 | 132 | 167 | 46 | 250 | 779 |
| **Est. tons/block/yr** | 0.136 | 0.098 | 0.123 | 0.034 | 0.186 | 0.578 |
| **Est. pounds/block/yr** | 273 | 196 | 248 | 68 | 372 | 1,157 |
| **Est. cords/block/yr** | 0.11 | 0.08 | 0.10 | 0.03 | 0.15 | 0.48 |
| **Est. cords/block/15 yr cycle** | 1.65 | 1.20 | 1.50 | 0.45 | 2.25 | 7.68 |
| **Est. no. rods/7-9 yr cycle** | 1,515 | 1,090 | 1,377 | 378 | 2,066 | 6,426 |

- Block C is also narrow (200' x 30'), and stands on a steep slope that is practically unmowable. Block C1 is clear of other trees, while Block C2 contains an existing clump of tall, large diameter ash standards which shade the site and take up some space (55' x 30'). Both C1 and C2 could be planted with C2 becoming a coppice

with standards area, or only C1 could be planted, or C2 could be cleared of existing trees and then planted. The existing trees need to be evaluated from an arborist's perspective for their longevity (and emerald ash borer taken into account) before deciding one way or another. The trees' size makes them unlikely to sprout when cut. There may be seepage in this area that would limit species selection, and this should also be investigated further before moving ahead.
- Block D has few practical limitations on use as a coppice block, at least once some regrading is done, except the potential for the likely pistol-grip form of the sprouts on stools along the edges of the block.

- To provide the most flexibility in terms of products, alders (*Alnus* spp.) are probably the optimal species for the wetter areas (Blocks A, B, and perhaps C or parts of it). Alders provide a reasonable fuelwood in terms of heat value, and their high sapwood content makes them good mushroom logs. They also work well as fodder, and have craft uses, too. Willows would also work, especially if you thought basket making was in your future, though they are less valuable as firewood.
- For drier blocks (D, parts of C), hazels (*Corylus* spp.) would be good species to use for flexibility. Alders may also work here, especially Italian alder (*Alnus cordata*), which tolerates drier conditions than most other alders.

## OPTION 3: SUMMER SNACK & SHADE POLLARD WINDBREAKS (FENCED PASTURES; APPENDIX 3)

### Design Concept:

- Fodder pollards arrayed in dense rows along every-other existing east-west pasture fence provide shade for the animals in summer, windbreak effects in winter, and small but significant amounts of episodic to regular summer fodder that diversifies the stocks' diets, adds excitement to their day, and offers medicinal value. We suggest planting enough of these to offer significant supplemental nutrition in seasons when the grass runs out (e.g., drought years).

### Design Considerations:

- Currently the animals' only main shade lies in the stand of trees inside the fenced area of pastures 9 and 10.
- Thirteen young Ashworth honeylocusts already grow in various places throughout the paddocks. These are probably low value foliage fodder crop trees due to their reputed slow resprout behavior, but it will be useful to work with these trees and see how they behave to confirm or deny the literature that makes those claims.
- Species chosen will vary for different areas of the site. Carefully observe and consider wetter areas before choosing species.

• We assume all pollards will be kept to ±15-foot diameters in this design. This should allow for a 3 year rotation, perhaps longer. Larger diameter pollards are certainly possible, but will cast more shade and be more prone to wind damage, especially if they become overstood (their rotation extends too long before cutting).
• A windbreak with approximately 50% permeability yields a zone of maximum wind reduction 5x the windbreak height (5H) downwind. The windbreak density here will probably be lower than 50% due to the pollard configuration (no branches in the lower portion of the trunk), the deciduous nature of the pollards, and some getting cut every year. Hence multiple rows of pollards at most 5H apart if possible will assist the windbreak function. We assume here a pollard height of 15 feet.
• As a way to minimize shading, pollard windbreak rows will be planted along every-other east-west fence between paddocks. This may result in less than optimal windbreak function, but some windbreak is better than none. Pasture production is the more critical factor to consider in this design.

**Design Details:**
• The key windbreak zone is the first line of defense: the northern edge of the paddocks. Twelve 15' pollards will fit along the outside edge of the north paddock outer fence. A double row at this location may be advisable, with the second row along the edge of each of the northernmost paddocks.
• Five pollards planted on the fence between paddocks 5 & 6, and four between 7 & 9 would complement and fill in the windbreak already building with the honeylocusts planted in the corners of 5, 8, and 9. This second row of pollards is about 75 feet downwind of the first line. Assuming a 15' height for the pollards, this is 5H downwind.
• The third row would consist of the existing honeylocusts planted in paddock 3 (between 4 & 2), plus a row of 4 pollards planted between paddocks 10 & 11.
• The last row includes the existing fruit trees planted south of paddock 1 and a row of 6 pollards to be planted between paddocks12 & 13 and extending towards the barn. Each of these rows must stop well short of the barn to avoid getting dumped on by snow sliding off the barn roof in winter.
• Total pollards to be planted: 31; total existing honeylocusts used as windbreak: 11.
• Estimated fodder production from new pollards:
  - 31 pollards; 3 year rotation.
  - 10 trees harvested per year x 21# DM /yr x 3 yrs = 630 # DM per year.
  - ±3% of yearly summer need: snack food!
• Suggested species: Given that ewes and does will lactate in spring and summer and these are snack trees, we recommend a summer fodder protein content as high as possible. Species should also have been demonstrated to tolerate or adapt well to pollard management, or at least have some indications of such. In all cases,

significant further research will be needed to narrow the species palettes below to determine the best choices. Considerations include: tendency towards adventitious sprouting after cutting; tolerance of hard pruning; rate of regrowth; nutritional content, palatability, and digestibility of foliage over the course of the growing season; tree longevity under pollard management, and; leaf size, edibility, and persistence after autumn leaf drop (affects health of grass sward under the trees in autumn).

- In drier areas:
  - ~ First choice species (high crude protein content, known to pollard historically or has relatives that were pollarded historically): Morus alba, Ulmus minor, and Ulmus glabra.
  - ~ Second choice species: primarily because they root sucker: *Robinia pseudoacacia, Populus tremula, Populus alba, Populus tremuloides.*
  - ~ Third choice species: because while they have high protein content, we do not know if they will pollard well*: Betula allegheniensis, Acer saccharinum.*
- In wetter areas:
  - ~ *Alnus incana, Alnus glutinosa, Alnus rubra, Salix caprea, Salix babylonica, Salix fragilis, Salix pentandra.*

**OPTION 4: SUMMER SNACK & SHADE POLLARD SILVOPASTURE (APPENDIX 4)**

**Design Concept:**

• Fodder tree pollards scattered along the existing pasture fences provide shade for the animals in summer, some windbreak effects in winter, and episodic to regular summer fodder that diversifies the stocks' diets and adds excitement to their day as well as medicinal value. These large-crowned, but widely-spaced trees maximize pasture grass production rather than pollard production, improving the design's performance for sheep, while also spreading out the shade to enhance spreading of summer livestock travel patterns. The trees' high-bottom crowns allow sunlight under each crown to the grass below, but their locations and pruned stubs make climbing to harvest easier.

**Design Considerations:**

• Currently the animals' only main shade lies in the stand of trees inside the fenced area of pastures. The honeylocusts already planted will offer more as time goes on, but more shade than that is probably possible without significantly retarding grass growth in the pastures.[11, 12, 13, 14, 15, 16]

• The evidence we have indicates that the honeylocusts already planted will not regrow very rapidly once cut, so are unlikely to be able to be harvested on a rapid rotation.[17] However, they will offer fairly high protein fodder (average of studies we have found: 13.7% foliage crude protein, with a range of 10.9 – 17.7%). With their typically low crown density and small diameter compound leaves, they should not cast a lot of shade, nor cause problems with killing the pasture below after leaf drop. However, we probably should manage these trees on long rotations and harvest sections of each tree at a time, rather than the whole tree at a time, to provide them with the resiliency and energy they need to bounce back.

- To maximize sunlight on the pasture sward below the pollards, the pollards should be pruned to have canopies with high bottoms—at least 8-10 feet of clear stem to the bottom of their canopies. Accessing the pollards for harvest will therefore involve climbing the tree or a ladder or both. Pruning the lowest branches of the pollards as the trees grow in their early years should be done with forethought: the trees will need the energy the lower branches supply early in their lives, but ultimately they need to be cut off. Yet, cutting them with long stubs will make climbing the tree easier for you (and your goats!). Deliberate well before making these pruning choices!
- Large diameter crowns will offer the most shade for animals and the most windbreak effects en masse, while also giving the trees large crowns for you to draw from over the course of the years. We suggest that the trees should be pollarded piecemeal, not wholesale, once they are established; that is, only a section of a tree will be cut in any one year, and the trees will themselves have a rotation within their crowns, not just among the trees. This will give the trees consistent energy production to respond to the pollard cuts, preserve the desired windbreak and shade effects of the pollards en masse, and allow you to rotate your stock through the pastures during the growing season and serve them their snacks wherever they might be.
- Denser plantings of pollards are definitely possible, perhaps even without negatively effecting pasture yields, but this needs much more study and consideration than available here.

**Design Details:**

- Twenty-two 25-foot diameter pollards scatter across the fenced paddocks at wide spacing complement the existing honey locusts and give them room to grow.
- Estimated yields: 22 new pollards + 13 existing honeylocust, 21# production per year on each tree, but only 1/3 harvested in any year: 35 trees÷ 3 x 21# x 3 years = 735 lbs fodder per year. Still snack food!
- Denser silvopasture plantings are likely possible, with up to 40% shade perhaps not reducing grass production much if at all. Generally speaking, that might look like doubling the number of pollards and therefore the leaf hay production.
- Species choices would be similar to those outlined in Option 1.

### OPTION 5: NUT TREE-COPPICE-FODDER BLOCK

**Design Concept:**

- In the existing nut grove planted in 2011, just east and downhill of the fenced pastures, create a coppice with standards system with nut trees in the overstory and fodder coppice in the understory.

**Design Considerations:**

- The site already has: hazel, heartnut, black walnut-butternut-heartnut cross, black walnuts, planted hickories and pre-existing oaks.
- Get coppice fodder crops going under the nut trees for short rotation fodder.
- Already fenced on 3 sides.
- Use animals to get rid of blackberry? Protect existing trees and then put animals in every two weeks to eat blackberry sprouts.
- This idea arose late in the project, and we do not have time to explore it in detail at the moment. It certainly has some good points going for it, but also some challenges.

### OPTION 6: POLLARD HERB & HAY MEADOW OR NUT TREE-HAY-HERB ALLEYS

**Design Concept:**

- Widely-spaced pollards allow enough sunlight to reach the grass understory that the land can produce both hay and a leaf hay crops. The widely-spaced alleys of pollards, and the pollards widely spaced in each alley row, makes haying with equipment feasible and provide enough sunlight and air movement to dry the cut hay. The spaces between pollards within the alley rows are not easily hayed, however can provide space to grow sun-loving and part-shade tolerant herbs for medicinals production. Alternatively, the pollards could be replaced with nut trees, and the haying can help keep the site clear for harvesting nuts in the fall.
- This idea does not warrant further investigation for this site, as the hay land is probably of insufficient size to play with it. The farm also already has a labor shortage and the rows of herbs would increase labor demand.

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[1] Schoenian, Susan. 2003. "An introduction to feeding small ruminants." Small Ruminant Info Sheet. Clear Spring, Maryland: Sheep and Goat.com. http://www.sheepandgoat.com/articles/feedingsmallruminants.html, accessed January 15, 2015.

[2] Schoenian, Susan. 2003. "An introduction to feeding small ruminants." Small Ruminant Info Sheet. Clear Spring, Maryland: Sheep and Goat.com. http://www.sheepandgoat.com/articles/feedingsmallruminants.html, accessed January 15, 2015.

[3] http://www.milkproduction.com/Library/Scientific-articles/Other-milking-animals/Feeds-and-nutrition/, accessed March 15, 2015.

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[4] Western Regional Climate Center data, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ma1430, accessed February 12, 2015; http://www.usclimatedata.com/climate/chester/massachusetts/united-states/usma0084, accessed February 12, 2015.

[5] http://www.umass.edu/windenergy/resourcedata/Chester, accessed February 12, 2015.

[6] Austad, I., L.N. Hamre, K. Rydgren, and A. Norderhaug. 2003. "Production in wooded hay meadows." *Transactions on Ecology and the Environment,* 64: 1091-1101.

[7] Converted into US measurements from Evans, Julian. 1992. "Coppice Forestry: An Overview." In *Ecology and Management of Coppice Woodlands*, edited by G.P. Buckley, 18-27. New York: Chapman & Hall. 25.

[8] This is generally understood to be the standard Current Annual Increment or sustained yield of most forestlands in the Northeastern US.

[9] Tabor, Raymond. 1994. *Traditional Woodland Crafts.* London: B.T. Batsford Ltd. 155; Collins, E.J.T. 2004. "The Greenwood Crafts." In *Crafts in the English Countryside: Towards a Future,* edited by E.J.T. Collins, 75-146. West Yorkshire, England: Countryside Agency Publications. 100. Among others!

[10] Tabor, Raymond. 1994. *Traditional Woodland Crafts.* London: B.T. Batsford Ltd. 71, 155

[11] Garrett, H.E., M.S. Kerley, K.P. Ladyman, W.D. Walter, L.D. Godsey, J.W. Van Sambeek, and D.K. Brauer. 2004. Hardwood silvopasture management in North America. *Agroforestry Systems* 61:21-33.

[12] Feldhake, C.M., D.P. Belesky, and E.L. Mathias. 2008. "Forage production under and adjacent to *Robinia pseudoacacia* in Central Appalachia, West Virginia." In *Toward Agroforestry Design: An Ecological Approach*, S. Jose and A.M. Gordon, eds. Advances in Agroforestry, volume 4. Springer. 55-66.

[13] DeBruyne, S.A., C.M. Feldhake, J.A. Burger, and J.H. Filke. 2011. "Tree effects on forage growth and soil water in an Appalachian silvopasture." *Agroforestry Systems* (2011) 83:189-200.

[14] Feldhake, C.M. 2006. "Appalachian Silvopasture Research." *Temperate Agroforester* December 2006 No. 4. Columbia, MO: Association for Temperate Agroforestry. http://www.aftaweb.org/latest-newsletter/temporate-agroforester/96-2006-vol-14/december-no-4/79-appalachian-silvopasture-research.html, accessed February 9, 2015.

[15] Jose, S., A.R. Gillespie, and S.G. Pallardy. 2004. "Interspecific interactions in temperate agroforestry." *Agroforestry Systems* 61: 237-255. Cites several papers indicating increased forage quality under partial shade, depending on forage species (mostly cool season grasses).

[16] Lehmkuhler, Jeff. 2006. "Livestock performance and general considerations for cattle management in temperate silvopastoral systems." In Proceedings of the 60th Southern Pasture and Forage Crop Improvement Conference 2006, Auburn University, Auburn, Alabama, April 11-13, 2006. 26-34. Available at http://spfcic.tamu.edu/proceedings/2006/ SPFCIC%202006%20Proceedings.pdf, accessed February 9, 2015.

[17] Burner, D.M., D.H. Pote, and A. Ares. 2005. "Management effects on biomass and foliar nutritive value of *Robinia pseudoacacia* and *Gleditsia triacanthos* f. *inermis* in Arkansas, USA." *Agroforestry Systems* (2005) 65: 207–214.

## Custom Soil Resource Report
## Soil Map

## MAP LEGEND

**Area of Interest (AOI)**
- Area of Interest (AOI)

**Soils**
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

**Special Point Features**
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

**Water Features**
- Streams and Canals

**Transportation**
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

**Background**
- Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Hampden and Hampshire Counties, Massachusetts, Western Part
Survey Area Data: Version 10, Sep 19, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 28, 2011—May 12, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

# Map Unit Legend

| Hampden and Hampshire Counties, Massachusetts, Western Part (MA608) | | | |
|---|---|---|---|
| **Map Unit Symbol** | **Map Unit Name** | **Acres in AOI** | **Percent of AOI** |
| 122C | Tunbridge-Lyman complex, 8 to 15 percent slopes, rocky | 10.9 | 80.4% |
| 909E | Tunbridge-Lyman association, steep, extremely stony | 2.7 | 19.6% |
| **Totals for Area of Interest** | | **13.6** | **100.0%** |

# Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

# Hampden and Hampshire Counties, Massachusetts, Western Part

## 122C—Tunbridge-Lyman complex, 8 to 15 percent slopes, rocky

### Map Unit Setting

*National map unit symbol:* 2trpn
*Elevation:* 430 to 1,870 feet
*Mean annual precipitation:* 31 to 95 inches
*Mean annual air temperature:* 27 to 52 degrees F
*Frost-free period:* 60 to 160 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Tunbridge, rocky, and similar soils:* 50 percent
*Lyman, rocky, and similar soils:* 33 percent
*Minor components:* 17 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Tunbridge, Rocky

#### Setting

*Landform:* Mountains, hills
*Landform position (two-dimensional):* Shoulder, summit, backslope
*Landform position (three-dimensional):* Mountaintop, mountainflank, mountainbase, side slope, crest
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Loamy supraglacial till derived from granite and gneiss and/or loamy supraglacial till derived from phyllite and/or loamy supraglacial till derived from mica schist

#### Typical profile

*Oe - 0 to 3 inches:* moderately decomposed plant material
*Oa - 3 to 5 inches:* highly decomposed plant material
*E - 5 to 8 inches:* fine sandy loam
*Bhs - 8 to 11 inches:* fine sandy loam
*Bs - 11 to 26 inches:* fine sandy loam
*BC - 26 to 28 inches:* fine sandy loam
*R - 28 to 38 inches:* bedrock

#### Properties and qualities

*Slope:* 8 to 15 percent
*Depth to restrictive feature:* 20 to 40 inches to lithic bedrock
*Natural drainage class:* Well drained
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to high (0.00 to 14.03 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Moderate (about 6.1 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 3e
*Hydrologic Soil Group:* C

### Description of Lyman, Rocky

#### Setting

*Landform:* Mountains, hills
*Landform position (two-dimensional):* Backslope, summit, shoulder
*Landform position (three-dimensional):* Mountaintop, mountainflank, mountainbase, crest, side slope
*Down-slope shape:* Convex
*Across-slope shape:* Convex
*Parent material:* Loamy supraglacial till derived from granite and gneiss and/or loamy supraglacial till derived from phyllite and/or loamy supraglacial till derived from mica schist

#### Typical profile

*Oe - 0 to 1 inches:* moderately decomposed plant material
*A - 1 to 3 inches:* loam
*E - 3 to 5 inches:* fine sandy loam
*Bhs - 5 to 7 inches:* loam
*Bs1 - 7 to 11 inches:* loam
*Bs2 - 11 to 18 inches:* channery loam
*R - 18 to 28 inches:* bedrock

#### Properties and qualities

*Slope:* 8 to 15 percent
*Depth to restrictive feature:* 11 to 24 inches to lithic bedrock
*Natural drainage class:* Somewhat excessively drained
*Capacity of the most limiting layer to transmit water (Ksat):* Very low to high (0.00 to 14.03 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Low (about 3.4 inches)

#### Interpretive groups

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 4e
*Hydrologic Soil Group:* D

### Minor Components

#### Dixfield, rocky

*Percent of map unit:* 9 percent
*Landform:* Mountains, hills
*Landform position (two-dimensional):* Backslope, footslope
*Landform position (three-dimensional):* Mountainflank, mountainbase, mountaintop, side slope, crest
*Microfeatures of landform position:* Open depressions, closed depressions, closed depressions, open depressions
*Down-slope shape:* Concave
*Across-slope shape:* Concave

#### Cabot, rocky

*Percent of map unit:* 4 percent
*Landform:* Mountains, hills
*Landform position (two-dimensional):* Footslope, toeslope

*Landform position (three-dimensional):* Mountainbase, mountainflank, mountaintop, side slope, crest
*Microfeatures of landform position:* Open depressions, open depressions, closed depressions, closed depressions
*Down-slope shape:* Concave
*Across-slope shape:* Concave

**Berkshire, rocky**

*Percent of map unit:* 3 percent
*Landform:* Mountains, hills
*Landform position (two-dimensional):* Summit, shoulder, backslope
*Landform position (three-dimensional):* Mountainbase, mountainflank, mountaintop, side slope, crest
*Down-slope shape:* Convex
*Across-slope shape:* Convex

**Rock outcrop**

*Percent of map unit:* 1 percent
*Landform:* Mountains, hills
*Landform position (two-dimensional):* Backslope, shoulder, summit
*Landform position (three-dimensional):* Mountaintop, mountainflank, mountainbase, crest, side slope
*Microfeatures of landform position:* Rises, rises
*Down-slope shape:* Convex
*Across-slope shape:* Convex

## 909E—Tunbridge-Lyman association, steep, extremely stony

### Map Unit Setting

*National map unit symbol:* 99xt
*Elevation:* 10 to 2,500 feet
*Mean annual precipitation:* 35 to 48 inches
*Mean annual air temperature:* 39 to 45 degrees F
*Frost-free period:* 120 to 195 days
*Farmland classification:* Not prime farmland

### Map Unit Composition

*Tunbridge and similar soils:* 40 percent
*Lyman and similar soils:* 30 percent
*Minor components:* 30 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*

### Description of Tunbridge

**Setting**

*Landform:* Mountains, hills
*Landform position (two-dimensional):* Backslope, summit
*Landform position (three-dimensional):* Mountaintop, mountainflank, side slope, crest

*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Friable, moderately-deep coarse-loamy basal till derived from mica schist over mica schist

**Typical profile**
*H1 - 0 to 3 inches:* loam
*H2 - 3 to 14 inches:* loam
*H3 - 14 to 24 inches:* loam
*H4 - 24 to 28 inches:* unweathered bedrock

**Properties and qualities**
*Slope:* 15 to 45 percent
*Percent of area covered with surface fragments:* 9.0 percent
*Depth to restrictive feature:* 20 to 40 inches to lithic bedrock
*Natural drainage class:* Well drained
*Runoff class:* Medium
*Capacity of the most limiting layer to transmit water (Ksat):* Low to high (0.01 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None
*Available water storage in profile:* Low (about 3.4 inches)

**Interpretive groups**
*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* B

### Description of Lyman

**Setting**
*Landform:* Mountains, hills
*Landform position (two-dimensional):* Backslope, summit
*Landform position (three-dimensional):* Mountainflank, mountaintop, side slope, crest
*Down-slope shape:* Linear
*Across-slope shape:* Convex
*Parent material:* Friable, shallow loamy basal till derived from mica schist over mica schist

**Typical profile**
*H1 - 0 to 3 inches:* loam
*H2 - 3 to 19 inches:* fine sandy loam
*H3 - 19 to 23 inches:* unweathered bedrock

**Properties and qualities**
*Slope:* 15 to 45 percent
*Percent of area covered with surface fragments:* 9.0 percent
*Depth to restrictive feature:* 10 to 20 inches to lithic bedrock
*Natural drainage class:* Somewhat excessively drained
*Runoff class:* Medium
*Capacity of the most limiting layer to transmit water (Ksat):* Low to high (0.01 to 6.00 in/hr)
*Depth to water table:* More than 80 inches
*Frequency of flooding:* None
*Frequency of ponding:* None

*Available water storage in profile:* Low (about 3.4 inches)

**Interpretive groups**

*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 7s
*Hydrologic Soil Group:* D

### Minor Components

**Berkshire**

*Percent of map unit:* 25 percent

**Marlow**

*Percent of map unit:* 5 percent

**COPPICE AGROFORESTRY**
Resprout Silviculture for the 21st Century
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**Appendix 2: Crude protein content of leaves of selected woody plants, in Latin name order**, based on scientific papers published through 2012. Data may contain percent crude protein (% CP) content of samples taken at various times of year, including dead or senesced leaves taken off the ground in autumn. Some samples in the dataset may have included twigs or young green shoots, but for the most part such data was excluded. Data for species with average leaf crude protein below 9.0% not shown. *Please note* the number of studies (# Refs) for each species in the right-hand column: this table is highly preliminary and narrowly focused! We desperately need much more research and practical experience to enhance the depth and breadth of understanding here.

| ***Genus*** | ***species*** | **common name** | **Reported Leaf % CP Average** | **Reported Leaf % CP Low** | **Reported Leaf % CP High** | **# Refs** |
|---|---|---|---|---|---|---|
| *Acer* | *rubrum* | red maple | 11.4 | 2.7 | 12.8 | 6 |
| *Acer* | *saccharinum* | silver maple | 14.0 | 11.7 | 16.3 | 3 |
| *Acer* | *saccharum* | sugar maple | 12.5 | 7.8 | 28.8 | 4 |
| *Ailanthus* | *altissima* | tree-of-heaven | 18.2 | 10.5 | 27.2 | 2 |
| *Albizia* | *julibrissin* | mimosa | 19.3 | 16.8 | 23.8 | 3 |
| *Alnus* | *cordata* | Italian alder | 15.9 | 12.1 | 19.7 | 1 |
| *Alnus* | *glutinosa* | European black alder | 15.2 | 9.4 | 19.7 | 4 |
| *Alnus* | *incana* | European gray alder | 20.1 | 17.6 | 25.0 | 2 |
| *Alnus* | *rubra* | red alder | 14.2 | 12.7 | 15.6 | 2 |
| *Amelanchier* | *utahensis* | Utah serviceberry | 12.0 | 11.0 | 13.0 | 1 |
| *Amorpha* | *fruticosa* | false indigo | 18.2 | 12.5 | 19.7 | 5 |
| *Betula* | *allegheniensis* | yellow birch | 23.5 | 12.5 | 34.4 | 1 |
| *Betula* | *alnoides* | xi hua | 19.4 | | | 1 |
| *Betula* | *lenta* | black birch | 13.5 | | | 1 |
| *Betula* | *pendula* | European white birch | 19.3 | 16.9 | 23.0 | 2 |
| *Betula* | *pubescens* | downy birch | 15.4 | 17.6 | 13.2 | 2 |
| *Caragana* | *jubata* | shag-spine | 20.3 | | | 1 |
| *Caragana* | *korshinskii* | Korshinsk peashrub | 17.0 | 13.3 | 19.1 | 3 |
| *Caragana* | *microphylla* | litteleleaf peashrub | 16.8 | | | 1 |
| *Castanea* | *sativa* | European chestnut | 14.5 | 12.4 | 17.0 | 3 |
| *Celtis* | *occidentalis* | hackberry | 11.5 | 8.7 | 13.5 | 1 |
| *Cornus* | *stolonifera* | red-osier dogwood | 14.4 | 11.3 | 17.5 | 2 |
| *Corylus* | *avellana* | European filbert | 10.5 | 8.5 | 12.1 | 1 |
| *Corylus* | *cornuta* | beaked hazel | 13.8 | 12.4 | 14.6 | 1 |
| *Elaeagnus* | *angustifolia* | Russian olive | 18.0 | 11.1 | 25.0 | 6 |
| *Elaeagnus* | *umbellata* | autumn olive | 17.9 | 13.8 | 21.9 | 1 |
| *Fagus* | *grandifolia* | American beech | 11.6 | 10.8 | 12.3 | 1 |
| *Fagus* | *sylvatica* | European beech | 16.1 | 11.9 | 17.5 | 3 |
| *Fraxinus* | *americana* | white ash | 14.4 | | | 1 |
| *Fraxinus* | *pensylvanica* | green ash | 9.9 | | | 1 |

(continued)

Leaf crude protein content of selected woody species, *in Latin name order.*


| ***Genus*** | ***species*** | **common name** | **Reported Leaf % CP Average** | **Reported Leaf % CP Low** | **Reported Leaf % CP High** | **# Refs** |
|---|---|---|---|---|---|---|
| *Ginkgo* | *biloba* | ginkgo | 11.9 | | | 1 |
| *Gleditsia* | *triacanthos* | honeylocust | 13.7 | 10.9 | 17.7 | 6 |
| *Hippophae* | *rhamnoides* | seabuckthorn | 19.7 | 15.6 | 21.8 | 4 |
| *Liquidambar* | *styraciflua* | sweetgum | 10.9 | 9.0 | 16.9 | 3 |
| *Liriodendron* | *tulipifera* | tulip-tree | 12.4 | 7.9 | 16.8 | 5 |
| *Morella* | *cerifera* | southern bayberry | 13.1 | 9.5 | 16.0 | 1 |
| *Morus* | *alba* | white mulberry | 20.5 | 10.7 | 35.9 | 24 |
| *Populus* | *alba* | white poplar | 14.8 | 13.0 | 16.5 | 2 |
| *Populus* | *deltoides* | eastern cottonwood | 12.0 | 5.6 | 18.5 | 5 |
| *Populus* | *nigra* | black poplar | 13.7 | 11.3 | 19.7 | 4 |
| *Populus* | *tremula* | aspen | 18.5 | 12.8 | 27.7 | 4 |
| *Populus* | *tremuloides* | quaking aspen | 13.8 | 5.4 | 26.9 | 5 |
| *Quercus* | *alba* | white oak | 9.2 | 3.4 | 12.9 | 3 |
| *Quercus* | *nigra* | water oak | 13.0 | 10.3 | 19.1 | 1 |
| *Quercus* | *robur* | English oak | 14.7 | 11.5 | 18.2 | 2 |
| *Quercus* | *rubra* | red oak | 11.7 | 8.7 | 13.9 | 3 |
| *Quercus* | *stellata* | post oak | 12.3 | 12.1 | 12.4 | 1 |
| *Quercus* | *velutina* | black oak | 9.5 | 8.6 | 10.3 | 1 |
| *Quercus* | *virginiana* | live oak | 9.5 | 9.1 | 10.2 | 1 |
| *Robinia* | *pseudoacacia* | black locust | 19.8 | 11.9 | 27.3 | 23 |
| *Salix* | *babylonica* | weeping willow | 14.5 | 6.9 | 24.8 | 3 |
| *Salix* | *caprea* | goat willow | 18.8 | 16.5 | 22.3 | 2 |
| *Salix* | *fragilis* | crack willow | 15.5 | | | 1 |
| *Salix* | *humboldtiana* | Humboldt's willow | 12.7 | 6.9 | 18.4 | 1 |
| *Salix* | *nigra* | black willow | 10.5 | 8.3 | 13.3 | 2 |
| *Salix* | *pentandra* | laurel willow | 18.3 | | | 1 |
| *Salix* | *purpurea* | purpleosier willow | 23.7 | | | 1 |
| *Salix* | *udensis* | fantail willow | 9.9 | 8.2 | 11.4 | 1 |
| *Salix* | *viminalis* | basket willow | 18.3 | | | 1 |
| *Sassafras* | *albidum* | sassafras | 13.5 | 5.5 | 28.3 | 2 |
| *Sorbus* | *aucuparia* | rowan | 14.6 | 14.3 | 14.8 | 2 |
| *Ulmus* | *alata* | winged elm | 13.0 | 7.3 | 27.6 | 2 |
| *Ulmus* | *americana* | American elm | 12.6 | 4.8 | 16.3 | 3 |
| *Ulmus* | *crassifolia* | cedar elm | 10.9 | 8.7 | 12.1 | 1 |
| *Ulmus* | *glabra* | Scotch elm | 17.6 | | | 1 |
| *Ulmus* | *minor* | smooth-leaved elm | 15.0 | 12.1 | 19.7 | 2 |
| *Ulmus* | *rubra* | red elm | 9.9 | | | 1 |
| *Zanthoxylum* | *americana* | prickly ash | 17.2 | | | 1 |

### Winter Pollard Blocks

- Blocks of alley pollards: 12' alleys. Pollards 12' apart within rows.
- Pollarded at 8' for ease of harvest from truck or wagon.
- Cut in August/September for winter fodder storage.
- 3' wide beds in rows and in centers of alleys for herb production.
- Various blocks available; if all blocks used could produce up to 64% of winter fodder for 20 sheep and goats.

### Summer Snack Pollard Windbreaks

- Rows of pollards on 12' centers on every other east-west fenceline.
- Pollarded at 8' for ease of harvest from truck or wagon.
- Cut in growing season as snack fodder for fun and medicine.
- Possible double row at north edge of fenced pastures.
- Could provide about 3% of summer fodder for a large flock with minimal negative impact on grass production while providing shade to animals.


## Option 1: Winter Pollard Blocks & Option 3: Pollard Windbreaks

# Design Concept

## Sovereign Hill Farm

*Mark Krawczyk and Dave Jacke*
*January 17, 2015*
*Base map from Mass GIS Oliver.*
*Contour interval 3 m / 9.8 ft.*

N

1" = 100'

**Key:**

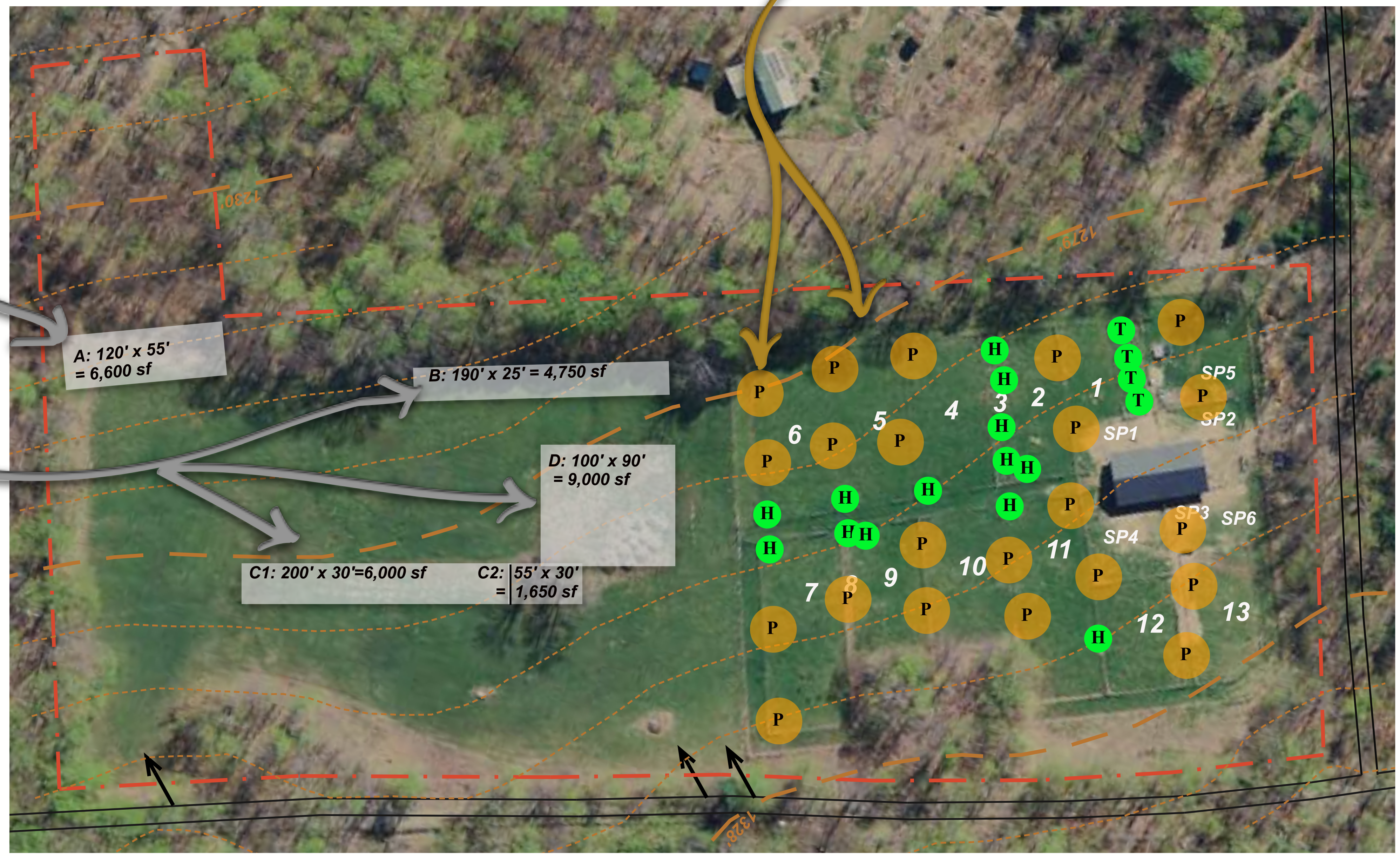
- H Existing honeylocust
- Haying equipment access point
- P Summer Snack Pollard/Windbreak

### Multifunctional Coppice Blocks

- Blocks of coppice stools on 6' centers with species that can serve as fodder, firewood, craft material, or mushroom logs.
- Use determines cutting rotation.
- Cut in dormant season unless for winter fodder storage.
- Could produce over 1,000 pounds of woody material per year, or about 1/2 cord of firewood per year (i.e., 7.5 cords in a 15 year rotation), or about 6,400 hazel rods in a 7-9 year cycle.

### Summer Snack Pollard Silvopasture

- Large diameter (24') pollards on fencelines provide shade, some windbreak, and forage.
- Pollarded at 8' or higher to provide a high canopy bottom for increased light to grass.
- Cut in growing season as snack fodder for fun and medicine.
- Careful pruning as trees grow could provide "built-in" ladders to climb trees for harvest.
- Could probably increase density of pollards with minimal negative impact on grass production while providing more shade to animals.




## Option 2: Coppice Blocks &
## Option 4: Summer Snack Pollard Silvopasture

# Design Concept

## Sovereign Hill Farm

*Mark Krawczyk and Dave Jacke*
*January 17, 2015*
*Base map from Mass GIS Oliver.*
*Contour interval 3 m / 9.8 ft.*
N
*1" = 100'*

**Key:**

- H Existing honeylocust
- Haying equipment access point
- P Summer Snack Silvopasture Pollards