Biophysical Metrics for Agroforestry

Measures & Uses of Simple, Inexpensive Information to Guide Management

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You cannot manage systems that you cannot measure!

Management is the setting of goals and measuring progress towards them!

These brief statements focus our attention on why biophysical metrics of agroforestry is important for farm owners. Measurements confirm that we are accomplishing what we want when managing vegetation – or tell us we are going in the wrong direction

The metrics for agroforestry are the same as for sustainable agriculture or sustainable forestry, but the focus is on different details. Our starting point always is the important goal of sustainability. We use definition of sustainability that is different than a stable target. The general perception is that sustainability is a state that landowners achieve after not being sustainable. Our perspective is one of dynamics: ***are the changes in a positive direction or are they negative?***

This perspective follows the definitions of conservation and depletion posed by Professor Siegfried von Ciriacy-Wantrup.[1] Wantrup described conservation as the shifting of natural resource use toward the future rather than toward a specific measurable state. Correspondingly, depletion is the shifting of use toward the present. Following this logic, sustainability is measured by a shift that moves resource management and use toward the future. A perpetual state of sustainability is not measurable but shifts or changes are.

Agroforestry is a set of land-use technologies that are promoted as being more sustainable than the forestry and agricultural practices that they replace. Our approach is to test the hypothesis of improvement in sustainability: does an agroforestry practice shift resource use toward the future? Monitoring progress toward sustainability is the purpose of agroforestry metrics.

Silvopasture metrics

We favor simple metrics that can be repeated with reliability. Some metrics may use a complete survey of the property or management unit, but in general sampling is both cheaper and more effective.[2]

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[1] Ciriacy-Wantrup's central ideas are presented in *Resource conservation: economics and policies,* published in 1952 by the University of California Press; see especially Ch. 4. *Meaning of Conservation*. [Copies can be downloaded for a fee; a copy is available from the UCONN Babbidge Library, Dewey Stacks - Level B - 333.72 C496]

[2] See Launchbaugh, Karen. 2011. *Principles of Vegetation Measurement & Assessment and Ecological Monitoring & Analysis.* This is an on-line course by the University of Idaho - http://www.webpages.uidaho.edu/veg_measure/ and is ab excellent course on vegetative measures and sampling.

No. 4, March 2018, in factsheet series produced with NRCS Conservation Innovation Grant 69-1106-17-56

Our initial project application is on our silvopasture unit because that is the largest area we are converting to agroforestry. We later discuss metrics for alley cropping, forest farming, riparian protection and windbreaks. Additional guides will be provided in future factsheets for each of these agroforestry technologies.

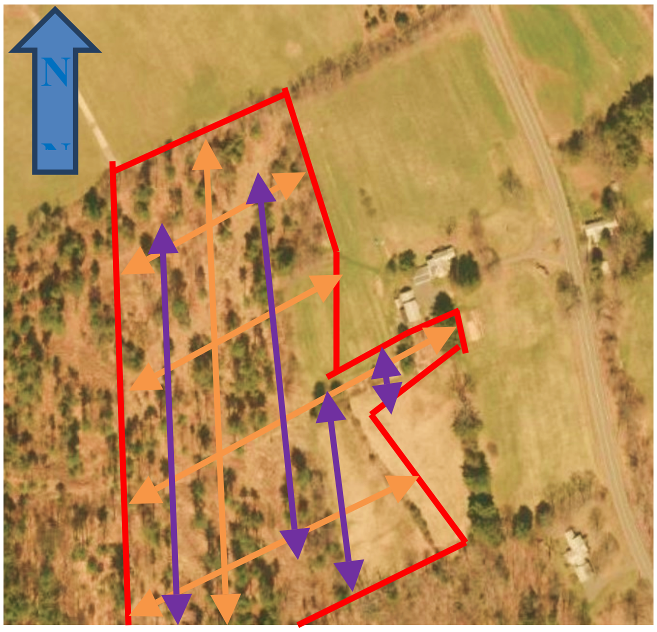

Figure 1. Map of Wilhelm Farm Silvopasture Unit

We favor line intercept samples in silvopasture. They are simple to establish and measure reliably, and the methodology has been refined by previous research in pasture, range and wildlife management. On Wilhelm Farm, we established a set of six permanent line intercepts though the silvopasture unit. The longest goes roughly north/south across the unit, and four others go east/west (see Figure 1). Annually, we will measure the vegetation along each intercept, looking for changes in percentage ground cover, canopy cover, species (at least in broad vegetative terms like trees, brush, grass, sedge, etc.).

The permanent measurement framework (**orange lines**) is amplified by additional temporary transects (purple lines). These help us ascertain that our estimates of change are reliable.

We measure lineal feet of key indicators along each transect, including;

- **Bare soil** – soil exposed to water and/or wind erosion.
- **Wet soil** – seasonally wet in late spring, summer and/or early fall
- **Perennial vegetation**
    - Grass
    - Sedge and rushes
    - Flowering herbs, weeds
    - Brush (multiflora rose, berry/brambles, wild grape, Japanese barbury, laurel, etc.)
    - Trees (white pine, hemlock, red and white oak, red and sugar maple, birch, etc.)
- **Crown Cover (shade from canopy)**

We are looking for trends in the balance between perennial and annual vegetation and between woody plants (especially trees) and perennial grasses. The percentage in brush and other invasives is critical to progress on conversion to a stable silvopasture unit where plant competition is managed by grazing intensity and livestock rotation patterns. A primary determinant of forage production by grass species is the amount area where of direct sunlight hits the ground during the daylight hours.

Preliminary estimates of the permanent intercepts by measuring lineal feet yield the following percentage estimates for 2,150 feet of intercept sample:

Bare soil	**Wet soils**	**Grass**	**Quality Forage**	**Sedge & Rushes**	**Trees**	**Brush**	**Shade**
1.5%	19.0%	12.0%	2.2%	2.5%	17.1%	40.6%	60.1%

We will add temporary plots for detailed measurement of specific grass and herbacious species (purple lines on map). For example, later we could install 1-square foot or 1-square meter plots for assessing grass and other forage plants and monitoring soil traits more precisely.[3] The plots could be temporary and located randomly along our transects. A few could be located permanently, which would provide stronger trend data.

We will update our measures monthly in 2018 as we learn from our results, posting our latest metrics online in May 2018 (http://WilhelmFarm.com). Our data sheet for the permanent and temporary transects is:

Transect	**Bare soil**	**Wet soils**	**Grass**	**Quality Forage**	**Sedge**	**Trees**	**Brush**	**Shade**
Lineal Feet								
#1 – N/S								
#2 – E/W								
#3 – E/W								
#4 – E/W								
#5 – E/W								
Total								
%								
Temp 1								
Temp 2								
Temp 3								
Temp 4								
Temp total								
%								

[3] A rigid metal circle encompassing 1ft^2 or 1M^2 is used by pasture and range agronomists with a systematic random interval to locate the sample center points.

The trees in silvopasture systems require additional measurements if timber and carbon storage are values that guide management. Measuring tree diameter (at 4.5 feet) and tree height enable the landowner to estimate timber volume and metric tons of carbon stored. While 100% of the trees could be measured in some small areas, sampling is more efficient and more accurate even on a small agroforestry project like our 5 acres of silvopasture.

Sampling can be done on plots where each plot represents a known percentage of the total area. This is common in several methods for measuring timber or grass forage, two common interests in agroforestry. For trees and related vegetation, 1/20th acre plots are often used because they we also easy to locate with systematic random sample. If tree basal area or timber volume estimates are the focus, variable plots can be incorporated into fixed plot designs. We will measure tree diameter and height of each sampled tree and use this data to estimate tree volume.[4]

In our silvopasture unit, we are using a mix of permanent plots and temporary random variable plot samples. In part, our reason for this design is that we are moving toward grouping our trees in small groves rather than having them located uniformly over the unit. The overall target is 20% shade coverage by trees and no shade by brush. Tree groves better serve the livestock needs for summer shade and protection from storms during the late fall to early spring months. Permanent plots allow us to monitor the attributes of the trees in terms of growth, timber yield, and carbon storage.

The storage of carbon in trees is important because it is for longer periods of time than other perennial vegetation. We are interested in annual changes. Tree carbon storage calculations will be based on stored woody biomass per acre; changes each year are determined by net growth.[5]

In a supplement to this Factsheet, we will summarize all the biophysical data for our silvopasture unit at the end of the 2018 growing season (roughly October 15). The supplement will also explain the variability of each measure and how to interpret the statistical reliability. This release will be repeated each October.

Metrics for Other Agroforestry Systems

Alley Cropping – We think a similar line intersect sampling method will work. The alley will be laid out for maximum solar radiation on the crops – north by northeast to south by southwest in the case of North Granby CT. A sample grid of north/south and east/west will allow measurement of the same data used in silvopasture, but more finely focused in the crops in question.

Forest Farming – Our experience so far suggests the appropriate measures that are like our vegetable garden areas: seed germination, survival percentage and various stages of crop development, and yields. The specifics will be included in a future factsheet on forest farming and a future factsheet on mushroom cultivation under the forest canopy.

Riparian Protection – The crucial measure are soil erosion and degradation of stream banks. In the factsheet on Riparian Protection, we will illustrate with our stream-side example, and amplify

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[4] Zobrist, Kevin W., Donald P. Hanley, Amy T. Grotta, and Chris Schnepf. 2012. Basic Forest Inventory Techniques for Family Forest Owners. A Pacific Northwest Extension Publication PNW 630. Washington State University. 68 p. http://cru.cahe.wsu.edu/CEPublications/PNW630/PNW630.pdf

[5] A Factsheet, ***Agroforestry and Carbon Sequestration***, is scheduled for early summer 2018.

with a review of the rich literature available from NRCS, Forest Service, and land grant university sources.

Windbreaks – Our current and likely future windbreaks serve three purposes:

1. Preventing snow drifts on our driveway and other farm lanes;
2. Reducing the impact of cold north winds on home heating; and
3. Protecting garden areas from wind and snow damage.

Each windbreak purpose requires different metrics, which are best developed in contact of solving specific problems. We will demonstrate using some Wilhelm Farm problems in a forthcoming factsheet.