A CASE STUDY

Advancing On-Farm Application of Silvopasture Technologies at Dickinson College Farm
Boiling Springs, PA

Photo: Emily Bowie

A Northeast SARE Partnership Grant Project
April 2016

Compiled by: Tracey Coulter, Agroforestry Coordinator, DCNR Bureau of Forestry; Jenn Halpin, Farm Manager and Noah Burchard, Farm Apprentice, Dickinson College Farm; Susan Parry, State Grassland Conservationist, USDA/NRCS

Partners:

Table of Contents

I. Introduction

A. What is Silvopasture?

Agroforestry is the intentional integration of trees with crop and/or animal production systems to create economic, environmental, and social benefits. There are five key agroforestry practices, including windbreaks or living fences that buffer field, farmstead, and livestock; riparian and upland buffers, which act as sponges and filters to protect water quality; silvopastoral systems that combine trees, livestock, and forages; alley cropping that integrates annual or perennial crops with high-value trees and shrubs; and forest farming where agricultural products are grown under a managed forest canopy.

For this project, we focused on silvopastoral systems only. Silvopasture results from one of two approaches: 1) integrating livestock into an existing forested area, and 2) introducing timber crops onto existing pasture land. All silvopastoral systems have three management components: trees, forages, and livestock. With silvopasture, the landowner must understand each of the three components and how they interact in order to be successful.

B. Project Background

Presently, many landowners utilize their wooded areas for passive forest grazing, e.g. providing shade in summer and overwintering for shelter, which is detrimental to the forest and contributes little forage towards sustaining a herd. In contrast, silvopasturing of woodlands that are currently being mismanaged has the potential to increase the forested land under management for wood production while increasing available pasture area. Silvopasturing is an opportunity to integrate wooded areas within the overall farm operation, resulting in greater incentive for good stewardship through more deliberate and efficient land use.

Our project goal is to develop case studies on two demonstration sites highlighting technical considerations when establishing and implementing silvopasture in both an open pasture situation and a forest ecosystem. The silvopasture system on the Dickinson College Farm (DCF) was developed thanks to partner support and assistance through a Northeast SARE grant, with additional funding provided through the Chesapeake Bay Forestry Program.

Management is the key to the success of silvopasture areas, but producers currently lack the information and decision support tools needed to implement the practices in the most effective manner possible. Thus, the project aims to address knowledge gaps regarding management of forest and grazing lands together to achieve a level of farm diversification, therefore investing in the future of the farm.

Project Management Team:

✓Coordinator, Susan Parry - State Grassland Conservationist, USDA-NRCS;
Email: susan.parry@pa.usda.gov

✓Tracey Coulter - Agroforestry Coordinator, PA DCNR, Bureau of Forestry; Email: trcoulter@pa.gov

✓Jennifer Halpin - Director, Dickinson College Farm; Email: halpinj@dickinson.edu

✓Duane Hertzler - Treasurer, PA Forage and Grazing Lands Conservation Coalition;
Email: glcipa@gmail.com

✓Dan Ludwig - Grazing Specialist, USDA-NRCS; Email: daniel.ludwig@pa.usda.gov

✓Melissa Rubano - Support Animal Scientist; Email: melissa.rubano@pa.usda.gov

✓Kathy Soder - Research Animal Scientist, USDA-ARS; Email: kathy.soder@ars.usda.gov

✓Suzette Truax, USDA-NRCS; Email: suzette.truax@pa.usda.gov

C. Dickinson College Farm Background

The Dickinson College Farm (DCF) is a 180-acre working farm located in the town of Boiling Springs in South Central Pennsylvania. Dickinson's farm is not only an educational resource, but also provides produce to the college's dining hall, CSA members, and community members through a farmers market in Carlisle, PA. DCF is presently USDA-certified organic and Animal Welfare Approved. Although vegetable production accounts for most of the farm's revenue, much of its land is pasture devoted to rotational grazing for small flocks of sheep, laying hens and broilers, and is home to a small herd of Angus cattle. Agroecological theories and practices are integrated into DCF's operations to create an ecosystem that is self-supporting and is largely not dependent on synthetic inputs. The managers of DCF strive to integrate student workers into the many layers of farming to provide a hands-on learning experience. Adjoined to DCF is a premier trout stream – the Yellow Breeches, a tributary of the Susquehanna. Its central location, commitment to outreach, innovation and education, and the combination of plant and animal crops, made Dickinson College Farm an ideal choice for a project demonstration site. Moreover, DCF's participation in this project aligned well with its strong commitment to education and sustainability.

Learn more about DCF at: http://blogs.dickinson.edu/farm/

II. Establishing Silvopasture

A. Open Pasture Scenario

1. Design Considerations

After discussing potential planting designs (Fig. 1), the project team decided to widely space the new trees in rows, since DCF's pasture area is limited.

Figure 1. Silvopasture Layout Options (Brantly 2013).

2. Tree Selection and Planting

The project team, along with DCG, discussed potential tree species to plant into the existing pasture; the following benefits were considered a priority:

~ Attracts pollinators, providing benefits to the nearby vegetable and fruit crops on the farm
~ Provides a food source for livestock and people (although the farm does not intend to invest time in harvesting this food source)
~ Allows filtered light to pass through the canopy, providing a light shade for the livestock while allowing the forage to continue to thrive

After considering trees native to Pennsylvania that provided these benefits, DCF ordered 71 trees from Shichtel's Nursery in upstate New York, amounting to $5,285 (see Table 1).

Table I. Initial Trees Selected with Corresponding Cost.

Species	Quantity	Cost
Robinia pseudo. Purple Robe	15	$1,140
Gleditsia tricanthos vars. Inermis /Halka Shademaster	15	$1,050
Cladastris kentuckea	10	$970
Malus 'Harvest Gold'	8	$520
Malus x 'Red Jewel'	8	$520
Quercus rubra	5	$380
Catalpa speciosa	5	$355
Tilia americana Legend	5	$350

All trees were planted in the Fall of 2013 by volunteers and staff at DCF, then irrigated by hand periodically for about one month. Due to the fact that irrigating by hand is a relatively labor-intensive method, it was discontinued in the fall as there became adequate rainfall levels.

3. Tree Protection

a. Fencing with Electric Netting

To protect newly planted trees from damage caused by livestock eating foliage and rubbing against the bark, DCF initially fenced off the trees with portable electric netting whenever livestock grazed nearby.

Weaknesses with this method include:

-Very time-consuming

-Unreliable in inclement weather: Electric net fencing can slack or completely collapse under snowfall or heavy rain, leaving trees vulnerable. After DCF's fencing collapsed under snowfall in the Winter of 2014, sheep destroyed 8 of the farm's new trees.

Strengths of this method include:

-Economical: DCF had several fences it could use for this method, and was able to reuse the fences for other purposes after it transitioned to using other tree protection methods.

b. Tree Cages

In 2015, DCF decided to more permanently enclose each individual tree for improved protection, using cages. The new tree cages consisted of metal fencing wrapped around three T-posts per tree, secured with zip-ties. A spacing of the T-posts of approximately 6 feet from the tree and 6-8 feet from each other minimized the potential for damage from the largest livestock type on the farm, Angus cattle.

Weaknesses with this method were:

-Time-consuming and labor intensive: Each tree cage took roughly 20 minutes to establish for a group of 3 workers. DCF found that it could efficiently establish the cages with people working in groups of 3, while other methods of protecting the trees can be efficiently completed with only one worker.

-Vulnerable to livestock damage: The cages were too weak to withstand the strength of the cattle. Calves bent the bottom of the cages, which were set a few inches above the ground, and forced their way inside. Moreover, the cages were bent inwards as cattle rubbed against the sides, leaving the trees insufficiently protected. Due to the vulnerability of trees as the cages were damaged, two of DCF's trees died and will be replaced in the future.

Strengths of this method of protection were:

-Potentially a time-saver in the long run: If cages are constructed to provide adequate tree protection, they can save a significant amount of time in the long run by eliminating the need to set up additional temporary fencing every time livestock are moved.

-Effective at protecting trees from sheep damage: Even trees in relatively weak cages should not need additional protection from sheep. DCF has not needed to fence sheep out of the rows of tree cages.

-Resourceful: After the trees have grown and the cages are no longer needed, T-posts can be reused for various purposes on a farm.

Fencing with Electric Wire

Next, DCF decided to protect its trees by using a single line of electric wire to fence cattle out of tree cage rows in paddocks being actively grazed. DCF currently sets up electric wire around tree cage rows and connects it to an electrified cattle fence running along the edges of its pasture, essentially blocking off the cattle from thin strips of pasture where the trees are located in each paddock.

Weaknesses with this method include:

-Time-consuming: A significant amount of time is added to moving cattle to each new paddock, as 1-3 rows of trees may be need to be fenced off in any given paddock of the farm.

-Wasteful of some areas of pasture: Since cattle cannot graze the forage within the tree rows that are fenced off, this pasture is essentially wasted and requires additional mowing. Sometimes when DCF staff prepares to move the cattle to a new paddock, it first opens up the tree rows, allowing the cattle to briefly graze forage there before moving on.

-Slightly costly: This method requires DCF to have a relatively large number of posts and reels of electric wire.

Strengths with this method include:

-Effective at protecting the trees in combination with the tree cages: No trees have died since DCF started using this method. Although a single line of electric wire has proven ineffective at keeping calves out of the tree rows, the calves are more occupied with the untouched forage than the cages. The temporary fencing is vulnerable to occasionally falling slack if a post falls over, but in these instances the tree cages have provided adequate protection until the fencing is set back up.

c. Tree Protection Moving Forward

Although the combination of temporary electric wire fencing and tree cages successfully protected DCF's trees from livestock damage, the farm decided to consider other protection methods that would save time in the long run. For a more permanent solution, DCF considered the following options and their respective weaknesses and strengths:

- Electrifying each tree cage: Very effective protection, yet expensive and requires a relatively extensive underground wiring system.
- Strengthening each tree cage with three additional T-posts (six total per cage): T-posts can be reused for other purposes in the future. Note: Dickinson tested this method by adding T-posts to one tree cage in a paddock, and not fencing it off with the other trees, and this method proved effective at protecting the tree from livestock damage.
- Wrapping strands of barbed wire around each cage: Potential for similar effectiveness of protection as electricity, and a less time-consuming option.

~ *Additional Note: After learning that wrapping barbed wire around the cages complied with the standards for Animal Welfare Approved, the project team decided to implement this method for protection. In October 2014, DCF tested a row of 5 tree cages to see whether barbed wire wrapped on the cages would provide adequate protection from cattle, without temporary electric wire fencing. Two strands of barbed wire were wrapped tightly around each individual cage, roughly at chest and waist height. After several days of grazing cattle in the paddock, these 5 trees were left undamaged. One of the cages, which had already been weakened before DCF started using electric wire, sustained additional, minor damage. The project team plans to test barbed wire on additional trees in DCF's pasture. Currently, it seems that cages wrapped with barbed wire will adequately protect the trees from cattle damage.

d. Protection from Rodents, Browsers, and Competing Vegetation

The trees that DCF received from Shictel's Nursery were larger than mere saplings, at 1.5 inches in diameter. Thus, DCF did not need to protect the new trees from rodent and browser damage with tree tubes.

To protect its trees from competing vegetation, DCF decided not to spray herbicides, but rather spread a thick mulch layer of wood chips around each tree. Moreover, the farm's tree cages were spaced several inches from the ground, with the hope that any weeds that grew through the mulch could be cut back with weed wackers. However, the weeds could only be partially removed with weed wackers, since the cage sides were set several feet from the tree. Therefore, farm workers resorted to climbing inside the cages to cut tall weeds out with pruners, a somewhat time-consuming process. DCF realizes that climbing inside the cages will become more difficult with the addition of barbed wire.

B. Woodland Scenario

In addition to creating a silvopasture system in existing pasture, the project team established silvopasture in a one-half-acre area of a woodlot at DCF. The project team's primary goal for this plot was to provide shade for cattle, control undesirable and invasive plant species, as well as provide desirable forage for livestock and to improve soil health. DCF has little interest in harvesting timber products, but could possibly consider hardwood harvest, mushroom production, or other options for the area in the future.

Photo: Emily Bowie

1. Basal Assessment and Canopy Clearing

To establish an ideal wooded silvopasture system, the project team needed to remove some trees from the plot. A basal assessment, a process that examines the surface area of tree trunks 4.5 feet above the ground, revealed that the plot had a basal area of roughly 82%, exceeding the optimal 60% for growth of forage grasses. An arborist from Dickinson College, along with the project team and a service forester from the Pennsylvania Department of Conservation and Natural Resources (DCNR), conducted a mini-training at DCF's woodlot in November 2013 to familiarize everyone with the methodology for removal selection. Eleven trees in total were marked for removal, based on factors such as overall tree quality and the spacing of trees throughout the plot. The selected trees were removed from the plot in the Winter of 2013, and are currently being used on the farm for firewood.

2. Site Preparation, Seeding and Maintenance

In the Fall of 2014, the woodlot was limed in preparation for seeding the area with a pasture mix, which was purchased from King's Agriseed. Since the difficult terrain in the woodlot was not conducive for using equipment, the area was limed by hand, a time-consuming process that would be difficult for larger plots. Due to labor costs, the project team decided to merely apply 500 of the optimal 1,000 pounds of lime to prepare the woodlot. Later, in early Spring 2015, the project team seeded the area.

The project team faced several challenges with managing the forage within the woodlot area, which already had various invasive plants growing. Although the team hoped to use DCF's cattle to graze down and/or stomp out the invasives, the cattle largely rejected these plants for food. Thus, spot herbicide treatments were used in the area, but the plot still has some undesirable vegetation growing among its forage.

3. Monitoring Protocols and Data Collection

To evaluate the strengths and weaknesses of the woodlot experiment, the project team closely monitored the woodlot from 2013-14, collecting data on soil compaction and moisture, soil quality, botanical composition, and forage quality. To strengthen the data collection processes, the project team divided the woodlot into a northern and southern section using temporary fencing, and developed several monitoring protocols for the plot.

a. Soil Compaction and Moisture

The project team initially attempted to measure soil compaction using bulk density soil samples. However, the results were inconclusive due to the excessively rocky soil of DCF's woodlot, and subsequently they developed an alternative method for measuring compaction, in which soil penetrometer readings were taken monthly throughout the DCF grazing season. Three transects were established through the woodlot, and penetrometer readings were only taken along these transects. Furthermore, soil moisture was measured at 3-5 points along each transect with a probe to help determine whether penetrometer readings should be taken. The optimal average soil moisture for accurate penetrometer readings is 22-25%, and penetrometer readings were taken when soil moisture was relatively close to this optimal range (average soil moisture readings ranged from 18-46% on days when penetrometer readings were collected). Ten penetrometer readings were taken along each transect per measurement. Measurements were collected from April to August 2013, and did not reveal significant trends.

b. Soil Quality

To monitor soil quality, fifteen 6'' deep soil cores were collected using a step-in soil corer in spring 2013. The cores were then composited and sent to Ag Analytic for soil quality analysis, revealing various facets of the woodlot's soil, including that it featured a strong organic matter content of over 9%, and a pH of 5.9. Although the woodlot's soil is somewhat more acidic than desired (considering that a pH of 6-7 is optimal for cattle pastures), slightly acidic soil is not unusual for forestland in Pennsylvania.

c. Botanical Composition

Meanwhile, grab samples of forage were collected for quality analyses three times during the grazing season, coinciding with times that the cows were given access to the woodlot. Furthermore, the botanical composition of the woodlot's forage was assessed in randomly selected samples of the understory several times in 2013-2014, and categorized as grass, legumes, rocks, weeds, litter, or bare ground. Samples were taken by tossing a frame, 0.25 square meters in size, randomly for 20 points in the woodlot. Rocks, weeds, litter, and bare areas decreased in 2014 from the previous year, while the abundance of grass and legumes improved during this span. Specifically, grass increased from an average of 1% of the woodlot's forage in 2013 to 9.4% in 2014, while legumes grew to roughly 5% of the woodlot's forage in 2014 after being nearly absent in the previous year. However, forage samples revealed that weeds and litter still comprised approximately three-quarters of the forage in 2014. Overall, botanical composition in the woodlot has progressed over time from being dominated with chickweed to consisting of more desirable forage for Angus cattle.

Example of a sample taken for botanical composition analysis (Aug. 2014). Photo: Emily Bowie

d. Forage Quality

Forage quality was also analyzed from samples taken in May-September of 2013. Samples were taken by randomly tossing a frame up to 10 times in the woodlot, clipping forage within the frame to the ground and stopping once enough forage was collected for an appropriate sample size for analysis. The clipped forage was compiled in a cloth bag inside a cooler and weighed, and then weighed again after drying the sample in a 55 degree Celsius oven for 24 hours. Afterwards, the samples were ground at a size of 1mm and sent to Dairy One for analysis.

Although data collection was paused after 2014, the project team observed further increases of grass in 2015. Currently, a sizable portion of the woodlot's forage is palatable for the cattle, but overall, the woodlot benefits the cattle primarily as an ideal location for shade rather than productive forage.

III. Project Accomplishments

A. Timeline - Notable Developments at DCF: Open Pasture and Woodlot

1. Open Pasture

<u>2013</u>

- Tree species were selected in summer then planted in the fall by volunteers and DCF staff. After discussing possible planting designs, the project team decided to widely space the new trees in rows, since DCF's pasture area is limited. See Table 1 for the list of tree species planted at DCF.
- The project team decided to use portable, electric net fencing to protect new trees from livestock. Materials were purchased and installed.
- Introductory video was begun, completed and released between 2013 and 2014.

<u>2014</u>

- DCF's portable electric net fencing collapsed under the weight of snow, and the farm's flock of sheep effectively killed 8 new trees in the pasture. These trees were replaced in the fall.
- The project team decided to transition to creating tree cages to protect trees from livestock damage.
- Field day/pasture walk held with up to 35 attendees; presentations by project team and full discussion conducted regarding the project including methodologies and current status, results thus far as well as practical challenges and benefits of each management scenario.
- Preliminary discussions and some footage for final technical video conducted.

<u>2015</u>

- DCF staff finished creating tree cages in the winter. In the spring, these cages were damaged by the farm's cattle rubbing against them. The cattle effectively killed 2 trees after their respective cages failed. The project team plans to replace these trees soon.
- The project team started using temporary electric wire fencing in combination with the tree cages to protect trees from cattle.
- Technical tour took place post-grazing, including discussions regarding management adaptations and needed activities for 2016.
- In October, the project team tested a row of 5 tree cages to see whether barbed wire wrapped on the cages would provide adequate protection from cattle, without using temporary electric wire fencing. Since only one of the cages experienced any damage during this experiment, the team plans to test barbed wire on additional cages in the future.

<u>2016</u>

- Continued visual monitoring and assessment per animal impact was completed throughout the 2015-2016 grazing season.
- Technical tour took place pre-grazing, including discussions regarding final management adaptations for both plots and needed materials for tree protection.
- Additional footage, interviews and materials collected for final project products, including case study, technical document and final video.

2. Woodlot

2013

- A team of 2 staff each from DCF, Agriculture Research Service (ARS), Natural Resources Conservation Service (NRCS), and DCNR met to establish possible protocols to be used in observing and monitoring the DCF site. Later in the spring, the study design was finalized and monitoring of the woodlot began. Monthly monitoring per study design was completed from April-November of 2013.
- Bulk density soil samples were taken at the woodlot per the original work plan; however, the results were inconclusive for measuring soil compaction. After realizing the limitations of the bulk density measurement for determining compaction in the woodlot's excessively rocky soil, an alternative monitoring method using a soil penetrometer was used.
- Introductory video was begun, completed and released between 2013 and 2014.

2014

- The project team, a DCNR service forester, and Dickinson College's arborist collaborated on a training session with the group on basal assessment methods in the winter. A basal assessment of the woodlot resulted in the group selecting 11 trees for removal. These trees were removed in the spring and stored at DCF for firewood.
- Dickinson College's arborist used targeted herbicide application on invasive species that were challenging to control in the woodlot.
- Monitoring, conducted from April-November of the previous year, continued.
- DCF applied 500 pounds of lime to the woodlot in preparation for seeding pasture mix (fall).

2015

- The woodlot was seeded by hand with a pasture mix, purchased from King's Agriseed (spring).
- Visual monitoring by DCF and limited animal access provided through the grazing season.
- Technical tour took place post-grazing, including discussions regarding management adaptations and needed activities for 2016.
- Continued visual monitoring and assessment per animal impact was completed throughout the grazing season.

2016

- Technical tour took place pre-grazing, including discussions regarding final management adaptations for both plots and needed materials for tree protection.
- Additional footage, interviews and materials collected for final project products, including case study, technical document and final video.

B. Lessons Learned

The case study of silvopasture at DCF is largely educational, providing opportunity for other farmers in Pennsylvania and the surrounding region to learn from the weaknesses and strengths of various strategies implemented by the project team, and for farmers to successfully develop their own silvopasture systems with the guidance of organizations, such as NRCS.

Some important takeaways from this project include:

* Overall, creating silvopasture in existing, open pasture resulted in less labor costs for DCF than establishing pasture in an existing woodlot.
* Creating durable tree cages is an effective method to protect new trees from livestock damage and can save time in the long run.
* Collaboration between parties in implementing silvopasture, such as farmers and foresters, can yield creative and effective solutions to inevitable challenges.
* Farmers may consider alternative methods to tree protection that reduce labor and financial costs, by creating natural barriers (i.e. by surrounding newly planted trees with plants such as Woody Hawthorne). Likewise, farmers may consider planting trees very resilient to livestock damage, requiring minimal to no protection for adequate yields. On the other hand, farmers may consider planting trees that are relatively inexpensive, and may provide minimal to no protection for the trees from livestock damage, with the expectation that some trees will die.

References

Advancing On-Farm Understanding and Application of Silvopasture Technologies in Pennsylvania: What is Silovpasture? Bowie, Emily. Northeast Sustainable Agriculture Research & Education, 2014.

Agroforestry Notes: From a Pasture to a Silvopasture System. Robinson, James L., and Terry Clason. USDA National Agroforestry Center, 2000.

Considerations for Establishing and Managing Silvopastures. Fike, John H., Alicia L. Buergler, James A. Burger, and Robert L. Kallenbach. Plant Management Network International, 2004.

"Data Collection and Analysis for Silvopasture at DCF." Rubano, Melissa. Phone Interview. 2015.

NESARE Silvopasture Project Field Day, Boiling Springs, PA. Northeast Sustainable Agriculture Research & Education, 20 Oct. 2015.

"Perspectives of the Dickinson College Farm Concerning Experiences with Silvopasture." Halpin, Jenn. Personal Interview. 2015.

"Silvopasture." Training Manual for Applied Agroforestry Practices. University of Missouri Center for Agroforestry, 2013.

Silvopasturing in the Northeast: An Introduction to Opportunities and Strategies for Integrating Livestock in Private Woodlands. Chedzoy, Brett J., and Peter J. Smallidge. Cornell University Cooperative Extension. Plant Management Network International, 2011.

Working Trees Info: What Is Silvopasture? Brantly, Sid. USDA National Agroforestry Center, 2013.