Quantifying Nutritional Value and Best Practices for Woody Fodder Management in Ruminant Grazing Systems

Progress report for FNE19-930

Project Type: Farmer
Funds awarded in 2019: $14,920.00
Projected End Date: 12/31/2021
Grant Recipient: Wellspring Forest Farm
Region: Northeast
State: New York
Project Leader:

Steve Gabriel
Cornell University / Wellspring Forest Farm

Project Information

Project Objectives:

This project seeks to develop an applied management guide for utilizing tree fodders with two main components; (1) results of multi-year farm research collecting consistent forage analysis for six species of common woody plants and trees that are persistent in northeast farm landscape, and (2) a literature review and profile for the six species.

Research will establish a baseline nutritive quality values for the tree/shrub species, accounting for seasonal variation and site characteristics (Year 1). In addition to this qualitative analysis to gain an appreciation for food value in various woody plants, our experience and observations can offer insight around questions on how to integrate tree fodder into a grazing system.

This research will coincide with a literature review of each species and any relevant data on nutritive quality from forage analysis, to compare these figures with the data we collect.

The project results will offer farmers the opportunity to improve on-farm productivity and reduce feed costs, which could result in an increase in farm income from grazing operations. Valuing woody vegetation in the farm landscape also increases grazing resilience in extreme climate conditions, and offers immense opportunities to value woody plants in a range of resource conservation efforts compatible with rotational grazing, from riparian buffers to windbreaks to nutrient runoff capture.

Introduction:

Woody trees and shrubs offer farmers better utilization of farmland, high-quality feed sources during drought and excessive rain conditions, and the development of silvopasture systems that are among the best at carbon sequestration. While there is a long history utilizing woody plant fodders in Europe, South America, New

Zealand, Japan, and other global regions, very few farmers are familiar with approaches to successful management.

Many farms have lands covered in both native and non-native shrubs, including species such as willow, poplar, black locust, honeysuckle, buckthorn, privet, autumn olive, and others. These species offer resiliency in extreme conditions when compared to traditional pasture grasses and forbs. Literature suggests that some of these species also have substantial food value, which offer implications for several management approaches at the farm scale.

Since the practice of using such plants as animal fodder is novel in the US, we started with pulling relevant data on nutrition from a range of research literature from around the world. At best, this data suggests the species worth focusing our attention on. The problem lies in that available data is
neither from the Northeast US region, nor does it specifically compare relevant species closely over several seasons or offer details about the changes in nutrition within the growing cycle. Trees and shrubs collect sunlight and materials from the soil, and depending on the time of year, more or less
of the compounds are available in the leafy material.

If farmers know that plants have food value to their animals, they will seek more opportunities to include them in grazing plans, knowing better WHAT to feed their animals. If we know the changes in nutrition over time, farmers can better know WHEN to feed these materials to livestock. While simple forage analysis techniques can offer this data, the ability to consistently sample is cost-prohibitive on a farm-by-farm basis.

Description of farm operation:

Wellspring Forest Farm is a 50-acre agroforestry inspired farm in the Finger Lakes region of New York. The farm is co-owned and operated by Elizabeth and Steve Gabriel and we've been in commercial production since 2011 including gourmet mushrooms, maple syrup, duck eggs, pastured lamb, and elderberry extract. We also have a yurt onsite that we rent during the summer. Our farm is as much an example of production as it is an educational site for people to learn. We offer courses onsite and online, and publish articles and host webinars to teach others about agroforestry and the potential benefits to farms and homesteads. We currently farm part time, with 1 - 2 seasonal hires.

Cooperators

- Mahra Parian (Researcher)

  interbrookfarm@gmail.com

  farm help 2019

  NY 13045

  (607) 391-2660 (office)

- Fay Benson, Fay

  afb3@cornell.edu

  Cornell Cooperative Extension (1862 Land Grant)

60 Central Ave Room 105
Cortland

Research

Materials and methods:

RESEARCH QUESTIONS

What are base nutritive values and how do they vary over the season?

In the first season, we collected leaf samples to establish a baseline read on the nutrition in the fodder of selected species, looking to see if we note changes in composition as the season progresses. While the original proposal had planned to compare grazed vs. ungrazed specimens in the second year, the sheer volume of leaf material needed for samples to the lab did not permit this. Instead, we determined it was worthwhile to collect a second year of nutritional data and look for any differences given the seasonal changes (2019 was a more normal year while 2020 was abnormally dry for most of the season)

What literature and resources exists to support management and harvesting of woody species for tree fodder?

In addition to our on site investigations, we completed a literature review for each species to develop a species profile including history, range, and any documented uses. Each species profile will be compiled into a guidebook along with background on tree fodder use and a list of future research questions given our analysis of this initial dataset.

FORAGE SAMPLING PROCEDURE: YEAR 1

1. Complete baseline assessment: We recorded the location of specimens for the 6 species on google earth (See figure 1) using a handheld GPS unit.
2. Starting in late June when trees are leafed out, each sample will be collected every 2 - 3 weeks, filling a gallon zip lock bag with material. The trees will be randomly sampled and the leaf material mixed together to develop a representative sample.
3. Samples were dropped off at DairyOne Labs in Ithaca, NY for forage analysis, including: % Dry Matter, % CrudeProtein, Acid Detergent Fiber, Lignin, Starch, DM, CP, SP, ADF, aNDF, NFC, fat, ash,TDN, NEl, NEm, NEg. Results was entered into a spreadsheet and the process repeated every two weeks until end of October, completing a total of 8 samples.

LITERATURE REVIEW PROCEDURE (YEAR 2)

1. Both the project lead and hired farm labor will engage in a review of relevant literature, through google scholar, internet searchers, conversations with scholars and practitioners, and access to the NYS Agricultural Library collection. Searches will seek to find information on global use and history of the six species, as well as any research that specifically offers data around use as fodder.
2. Resources will be annotated and compiled using Zotero. A short summary will be written for each resource and compiled into the narrative for each plant

profile in the guidebook.

3. The finished results will be available via the referenced narrative in the guidebook, along with the Zotero research guide published online with free and open access.

Research results and discussion:

During the 2019 season, we successfully collected 8 samples of the 6 species, for a total of 48 sample data sets from 6/24, 7/11, 8/2, 8/19, 9/4, 9/23, 10/4, and 10/25. We waited until late June for the first sample because we wanted to have all species leafed out, but realize in retrospect that samples should have started sooner since may species leaf out far earlier (black locust is very late). We began baseline sampling in 2020 earilier in June to account for this. The latest sample in October was also not very relevant as tree fodder quality was low or non exisistant. We adjusted to start sampling earlier in 2020 and decided to stick to a biweekly schedule to gather more accurate data.

In 2020, we documented 12 samples of the 6 species, for a total of 72 sample data sets from 6/4, 6/15, 6/24, 7/6, 7/16, 7/27, 8/6 8/17, 8/27, 9/7, 9/17, and 10/5. This growing season was abnormally dry for much of the sample timeframe, which might bear some impact on results.

Figure 1 shows the location of sample sites, which were shifted to be closer to the barn and central part of the farm, since multiple people we doing sample collecting. Because of the volume of leaves needed per sample per species, it was not feasible to keep samples separate per tree or continue to harvest from the same few trees each time as we had originally written into the grant. By combining samples from multiple plants we also got a representative sample of the quality of leaf fodder in the landscape which more accurately reflects the browse experience were the sheep to harvest it. We collected a random sampling from a block of trees and mixed the sample to get a broad representation of the leaf forage available in the landscape for grazing animals. Sampling included plucking leaves, stuffing them into zip lock bags, labeling, and then storing in the fridge until they could be dropped at the lab.

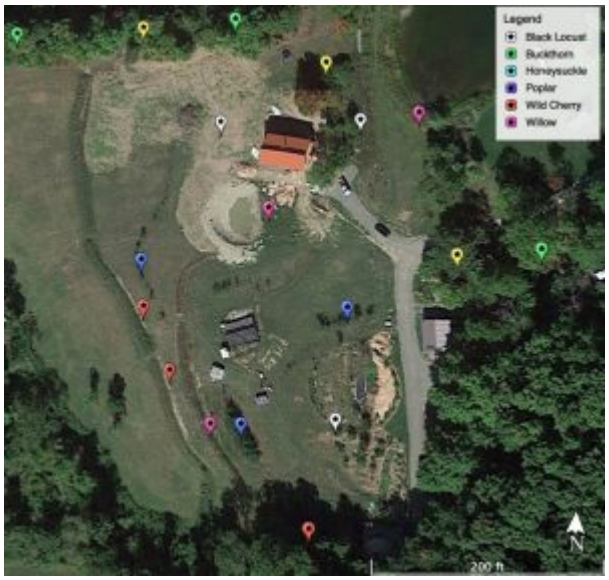

Figure 1: Sampling locations at Wellspring Forest Farm

Results:

The results below reflect our initial analysis from 2020 data. As of January, 2021 we have compiled our data from 2021 and are actively working to analyze the data alone, and in comparison to 2020. We expect the full analysis along with the guidebook to be completed by April 1, 2021 and made available in the final report as well as published to our website.

Average Values 2020

Table 1 below shows the average values for each species over the season during 2020. Also included are datasets from DairyOne aggregated database with pasture forage values based on hundreds of samples.

Species	% Crude Protein	%ADF	%NDF	%TDN	Relative Feed Value
Black Locust	23.61	18.7	32.89	66.5	227.75
Buckthorn	18.35	14.58	41.05	67.63	272.13
Honeysuckle	12.71	20.04	39.99	65.38	196.63
Poplar	14.99	22.55	35.73	64.25	182.38
Wild Cherry	13.84	17.49	39.56	64.25	211.5
Willow	15.63	21.49	37.78	65	200.25
Legume Pasture	*26.23*	*27.75*	*35.96*	*66.26*	*192.59*
Grass Pasture	*15.79*	*35.65*	*60.89*	*60.68*	*98.72*

Table 1: Average values of measured tree leaf fodder compared to pasture data, 2020

Notable are the high protein value offered by Black Locust and Buckthorn, with indicators of energy and digest ability (ADF and NDF) ranking them with the more nutritious forages available. Even with these standouts, all the tree fodders offer solid CP and NDF values keeping with guidelines for various life stages of grazing ruminants. (Table 2). A score of 100 in relative feed value corresponds with high quality alfalfa hay, with fresh leaf offering better values close to fresh legume pasture across the board.

	NDF	CP
General	under 70%	more than 8%
Reproduction	under 50%	10 - 12%
Growth	30 - 40 %	16 - 18%
Lactation	under 55%	12 - 14%

Table 2: Recommended NDF and CP values for various ruminant life stages.

Source: Ball, D.M., M. Collins, G.D. Lacefield, N.P. Martin, D.A. Mertens, K.E. Olson,

D.H. Putnam,D.J. Undersander, and M.W. Wolf. 2001. Understanding Forage Quality.American Farm Bureau Federation Publication 1-01, Park Ridge, IL

One claim often made about woody browse are the increase in nutrients animals gain from consuming the plants. It follows that woody species in our study this year certainly offered better values for some macro (Table 3) and micro (Table 4) nutrients, mostly notably:

Calcium: Buckthorn and Honeysuckle

Magnesium: Honeysuckle and Willow

Potassium: Buckthorn

Iron: Buckthorn and Honeysuckle

Zinc: Poplar and Willow

Manganese: Wild Cherry

Molybdenum: Honeysuckle

In particular of note are the two oft hated “invasive” species, Buckthorn and Honeysuckle, which demonstrate excellent nutrients available for several categories where traditional forage is lacking.

Species	Calcium %	Phosphorus %	Magnesium %	Potassium %	Sodium %
Black Locust	1.29	0.23	0.15	1.43	0.02
Buckthorn	2.92	0.21	0.29	2.46	0.01
Honeysuckle	2.5	0.18	0.33	1.69	0.01
Poplar	1.71	0.2	0.22	1.52	0
Wild Cherry	2.17	0.19	0.24	1.25	0.01
Willow	2.13	0.23	0.34	1.14	0.01
Legume Pasture	*1.21*	*0.38*	*0.26*	*1.79*	*0.027*
Grass Pasture	*0.5*	*0.31*	*0.14*	*0.93*	*0*

Table 3: Average values for Macro elements

Species	Iron (ppm)	Zinc (ppm)	Copper (ppm)	Manganese (ppm)	Molybenum (ppm)
Black Locust	86	33.88	9.88	93.88	0.64
Buckthorn	153.63	18.88	7.25	78.13	2.03
Honeysuckle	184.88	22.88	7.5	70.25	12.08

Poplar	70	135.63	8.38	98.63	0.8
Wild Cherry	100.5	21.75	8.38	226.38	0.78
Willow	93.88	180.25	6.5	155.88	0.79
Legume Pasture	*206.86*	*50.94*	*5.89*	*18.03*	*2.09*
Grass Pasture	*0*	*0*	*4.76*	*7.76*	*0*

Table 4: Average values for Micro elements

Change in Values over the Season (2020)

Knowing that on average, tree fodders offer some nutritive value with specific species offering elevated CP, macro and micro nutrient levels, our next goal was to determine what values, if any, fluctuated during the course of a growing season. We first charted the changes in CP, ADF, and NDF over the season.

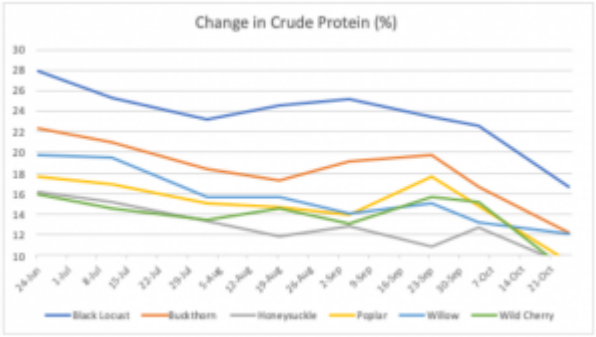

Figure 2: Change in Crude Protein % in 2019 for six species

As seen on the graph for crude protein (Figure 1) values tend to lesson over the course of the season, regardless of fodder species. From this perspective, feeding or harvesting tree fodder earlier in the season would be more beneficial. In this case, higher numbers indicate more growth on the animal. Specifically, the CP refers to the content of a feed sample that contains a mixture of true proteins, amino acids, nitrates, and other nitrogen sources.

Another measure of forage quality is acid detergent fiber (ADF), a measure of the forage components that are least digestible by livestock, mostly cellulose and lignin. As ADF increases, digestibility decreases, which results in less available energy. In other words, lower values of ADF indicate more energy for the animals. The fodder species sampled together had the lowest values in the mid summer months (early Aug - early Sept).

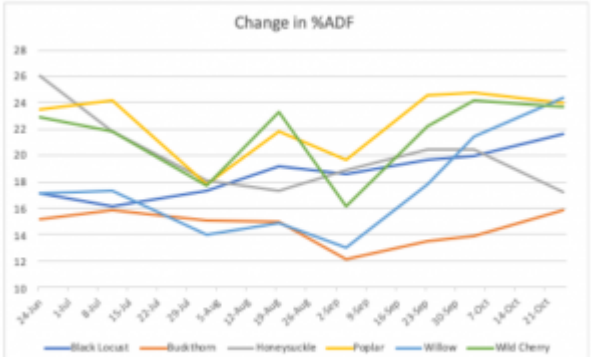

Figure 3: Change in Crude ADF % in 2019 for six species

Complementary to measuring ADF is the neutral detergent fiber (NDF), which accounts for the structural components of the plant cell walls and is a predictor of voluntary intake since it provides fill for the rumen. In general, low NDF values are desired. This dataset indicated that late summer (end of september) had the lowest NDF values, though some species also experienced a dip in the last weeks of August, as well.

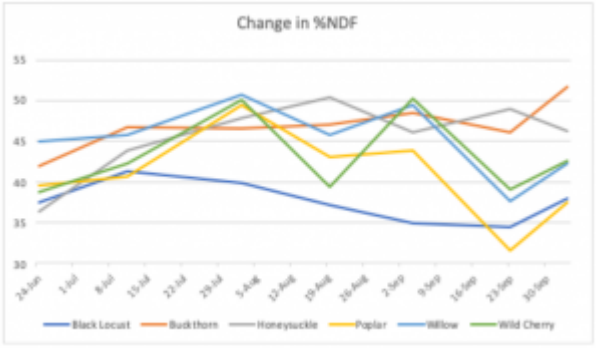

Figure 4: Change in Crude NDF % in 2019 for six species

Next, looking at the subset of species that produced exceptional figures for macro and micro nutrients, there are some subtle trends but the patterns fluctuate and also seem species dependent. We chose three macro (calcium, magnesium, potassium) and three micro nutrients (iron, zinc, manganese) that the tree fodders sampled offered notable values when compared to pasture forages.

For Calcium, values were highest for Buckthorn and Honeysuckle, which trended toward greater accumulation toward the latter end of the season:

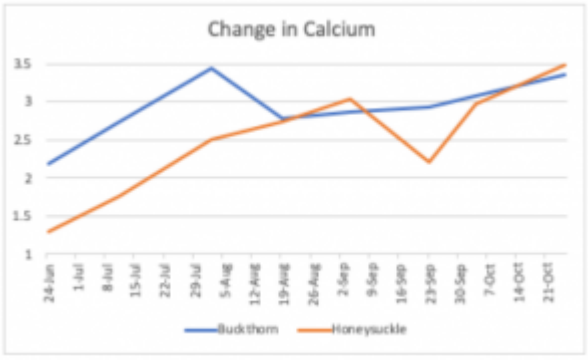

Figure 5: Change in Calcium % for top tree fodder species

Magnesium is best supplied by Willow and Honeysuckle, who saw higher values later in the season as a general trend:

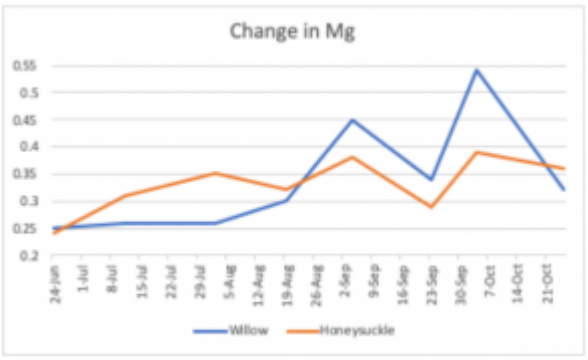

Figure 6: Change in Magnesium % for top tree fodder species

With Potassium, both Buckthorn and Black Locust provide good sources, both having more moderate changes which may not affect timing as much as other nutrients.

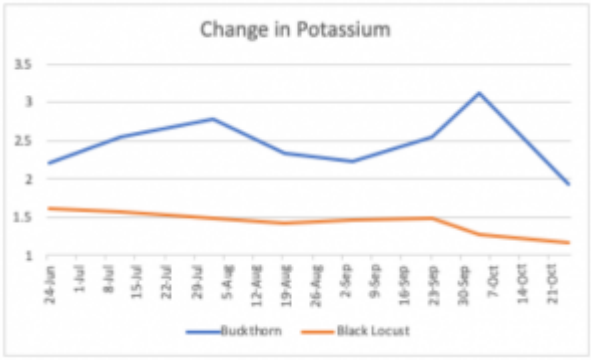

Figure 7: Change in Potassium % for top tree fodder species

The values expressed for Iron in Buckthorn and Honeysuckle appeared very opposite, with Honeysuckle experiencing higher values in the earlier part of the season, while Buckthorn saw a spike at the end.

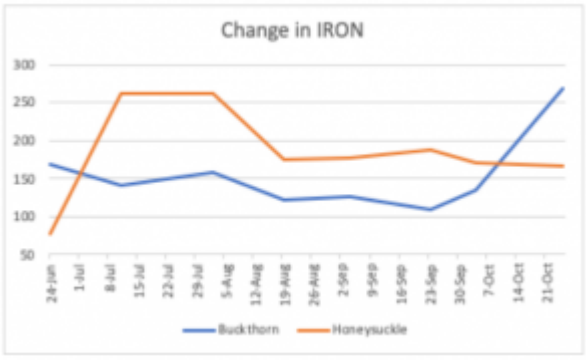

Figure 8: Change in Iron (ppm) for top tree fodder species

For Zinc, both Poplar and Willow are good accumulators, and values go up as the season progresses.

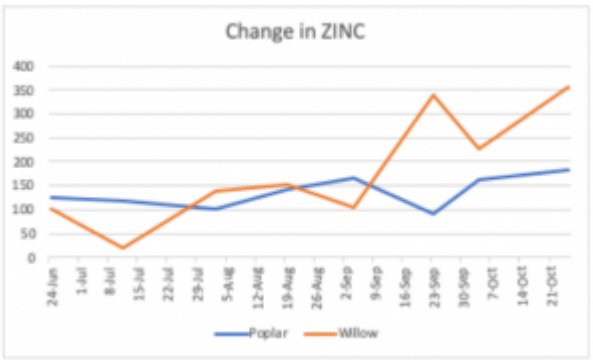

Figure 9: Change in Zinc (ppm) for top tree fodder species

And for Manganese, a similar trend with values highest at the end of the season for Willow and Wild Cherry.

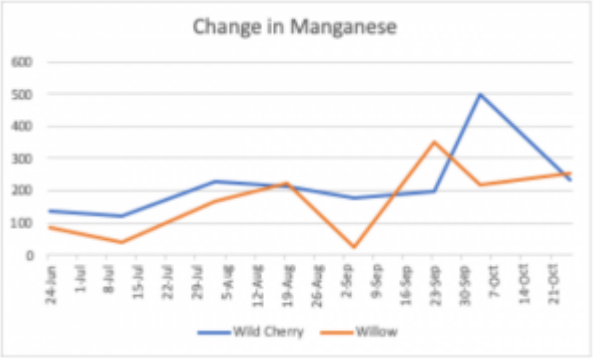

Figure 10: Change in Manganese (ppm) for top tree fodder species

Summary

The important take home from this season is that nutritional values in forages are complex, and harvesting is likely a tradeoff where doing so in one part of the season offers both advantages and disadvantages. Rather than attempt any conclusion, at this point is makes most sense to identify some patterns and trends than we might seek to test in the coming season to further define. In any case, it will be necessary to describe best practices on a species by species basis, depending on the most valuable aspects of the forage nutrition we want to capture.

Assuming the goal is to maximize nutritional benefit, we can begin to summarize each species in the following way. This is, not a conclusion, but a starting point for possible further analysis.

Black Locust is highest valued for its high crude protein content which declines over the season, as well as values for Potassium (little change during the season) and Manganese highest in early July but also spiking in early Sept and Oct, with lowest values of ADF and NDF from early August through early September. Early September, overall, looks to be the best timing to maximize benefit based on this dataset.

Buckthorn offers a good crude protein content, along with elevated levels of Potassium, Calcium, and Iron, which are highest in the latter end of the season (early October) while NDF and ADF are lowest in September and Crude protein really drops toward the last week of September. So, early to mid September into early October is possibly best timing-wise, though protein levels are lower then.

Honeysuckle offers a great source of Calcium and Magnesium which is highest toward the end of the season, and Iron which appeared highest in July. Not a clear best time, might depend on the value placed on the different nutrients. It appears substantially larger amongst the sample species in Iron, which might make it prioritized for this offering.

Poplar provides good levels of Calcium, Zinc, and Manganese. While the calcium is greater in the end, the levels of Zine and Manganese appear relatively dispersed through the season, though since its contribution as far a calcium is not as significant as other species, it might suggest this one is good for anytime in the growing season.

Wild Cherry’s contributions are Manganese and Calcium, both of which improve toward the later part of the season, which suggests greater benefit, though this foliage doesn’t stand out substantially in comparison with the others, and so it may not matter as much. It’s pretty low value.

Willow is a nutrient sink, offering good values for Calcium, Magnesim, zine, and Manganses, all trending toward the later part of the season, peaking around late September/early October as the best time to harvest.

To be clear, we offer the above summary as an attempt to hone in on some of the optimal windows, there is almost certainly benefit to feeding any of these forages to livestock at any time of the season. The logistics of rotating animals and providing access to these forages will likely override the perfection of being able to offer a tree fodder in a specific window of time, at least as farmers in the US just start the process of adopting tree fodders into their managed grazing systems.

After year one, it makes most sense to look at all the data from a “trend” or pattern analysis, where we seek to see something emerging. After we make changes in the coming season and collect a second dataset, more clear evidence should emerge to clarify where a more detailed statistical analysis would offer benefit.

Research conclusions:

Expected to be available April, 2021

Participation Summary

2 Farmers participating in research

Education & Outreach Activities and Participation Summary

5 Consultations

1 Curricula, factsheets or educational tools

1 On-farm demonstrations

3 Online trainings

8 Webinars / talks / presentations

PARTICIPATION SUMMARY:

100 Farmers

25 Number of agricultural educator or service providers reached through education and outreach activities

Education/outreach description:

We have reached a wide audience with several events during this grant cycle. Our farm hosted an online course in February 2020 in partnership with the National Organic Skillnet (Ireland) and September 2020 in partnership with the practical Farmers of Iowa, with a total of 107 students enrolled over the two offerings. As part of the courses we engaged in five consultations with farmers around silvopasture opportunities for their site. We also engaged in public presentations with Food Animal Concerns Trust (Oct 26, Nov 2, Nov 9 2020) on silvopasture and woody fodders and the species studied in this were discussed in all of them. We presented twice for the Ecological Farmers Association of Ontario conference in December 2020 and for the Vermont Grassfed Conference in January 2021. The SARE reporting site has been featured since January 2020 on our SilvopastureBook.com website.

Sustainable Agriculture Research & Education US Department of Agriculture

This site is maintained by SARE Outreach for the SARE program and is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award No. 2019-38640-29881. SARE Outreach operates under cooperative agreements with the University of Maryland to develop and disseminate information about sustainable agriculture. USDA is an equal opportunity provider and employer.