A Closer Look to Guide Farm Use of Tree/Shrub Silages: Per-Species & Ensilement Analyses for Safe, Nutritious Rationing, plus Replicable Trial Results

Final report for FNE24-083

Project Type: Farmer
Funds awarded in 2024: $29,725.00
Projected End Date: 02/28/2026
Grant Recipient: 3 Streams Farm
Region: Northeast
State: Maine
Project Leader:

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3 Streams Farm & Belfst Blueberry Cooperative

Project Information

Summary:

These hand-stripped leaf-silages, fed 12/20/21, preceded machine-separation in 2022-'23 to produce similar-quality leaf-silages in greater quantity.

We wanted to:

- Understand nutrition underlying 2023 animal enthusiasm about our SARE FNE22-013 field-edge tree/shrub leaf-silages, plus explore additional tree/shrub species including some deemed “invasive;”
- Explore why my animals limit their consumption of regionally abundant Red (and Sugar) Maple leaves, and contribute data to limited scientific understanding of toxicities present in maple species plus Staghorn Sumac; and
- Delineate safe use of wild Cherry species with regard to cyanide (HCN) levels - Black Cherry in particular grows substantially along field edges, and was a livestock top choice in FNE22-013.

Dairy One Forage Laboratory (Ithaca, NY) completed nutritional analyses on 102 leaf-samples of 20 tree, 11 shrub and 1 vine species, including 25 matched fresh/ensiled sample-pairs to look at nutritional changes when ensiled. We ordered quantification of Soluble Protein (SP) and Rumen-Degradable Protein (RDP), with partial success (many of those tests failed), and Wayne Zeller, US Dairy Forage Research Center (Madison, WI), screened 30 species of our leaf-samples for relative Condensed Tannin (CT) levels, plus has 9 more species to do (this work is outside of the commitments in our proposal). SP, RDP and CT levels give clues about ruminant digestive utilization of protein, with CT increasing utilization from all feedstuffs by as much as 25%.

High energy and low fiber traits of tree leaves were confirmed: our leaf-silage averaged 120% of the Water Soluble Carbohydrate % of Dry Matter level (WSC, % DM) of Dairy One average grass-silage, with more than twice as much Non-Fiber Carbohdrates (NFC, % DM) overall (NFC includes WSC).

Harvest-date comparisons were confounded by differing quality of 3 sites harvested consecutively (see 2 “Harvest-date” spreadsheets under “Results”). Earlier-harvested 2025 samples did show the expected trend of higher protein and lower energy % of DM than later-harvested 2022-’24 samples, with less pronounced difference in levels as fed (versus DM).

We had Dairy One analyse 4 long-fermented (>1 yr) leaf-silage samples for 6 acids normal to grass and corn silages, as follow-up to 2019 short (<1 yr) Fermentation Profiles which found almost none (see “Fermentation” spreadsheet under “Results”). Those acids did appear.

We ordered analyses of fats (Fat Ether Extract = Fat EE) and Ash, in order to obtain accurate NFC figures; average leaf-silage Fat content was 147% of the average Dairy One grass silage figure, and averaged 111% of levels in matched fresh leaf-samples (see “All” and ”Paired” spreadsheets under “Results”). Cutin and wax leaf coatings are an unknown portion of this, and are said to be indigestible.

Our new website is launched, built of colorful downloadable PDFS, so that I Shana can update them myself, off-line on browse walks. I added annotations to items on the “Tree Fodder & Climate Resources” page, and the “Farm Research” page has a Table of Contents, to find a short exhibit for each study easily. Links to reports, data sheets, presentations and articles are included for each study. The old website remains up and functional as well, for now. We await feedback from users.

Since start of this project 22 months ago, I’ve given 17 presentations at 9 event venues, and tabled twice. Venues beyond Maine were NOFA MA “Go Nuts” on-line agroforestry discussion series, Vermont Farm to Plate on-line, a NY agricultural educators’ Agroforestry Group x 2 on-line, and the international Short Rotation Woody Crops Conference at University of Missouri Center for Agroforestry in person.

A second Poor Proles Almanac podcast interview, this time about results of these SARE projects, has aired, (I dread to hear from listeners: I was late and stressed, so caused Andy to be short of time). Links to both segments of the first are posted on the websites below.

See the new https://3streamsfarm.wixsite.com/3streamsfarm , or the old https://3streamsfarmbelfastme.blogspot.com , for various presentation recordings and slide PDFs with full text.

CONTENTS (PDF under "Informatiion Products" at end of report has numbered pages)

Project Objectives:

This Project enabled us to seize an opportunity for analyses of SARE FNE22-013's vast tree/shrub-leaf-silage sample-bank collected/frozen in 2023, plus obtain additional leaf-samples for diverse forage analyses at 6 laboratories, to bridge an informational gap that has been slowing livestock farmers from productive use of woody perennial forages, when weather challenges limit grass-forage harvests.

We:

1. Broadened analyses of nutrition, ensilement and digestibility to 32 tree/shrub/vine species including 7 deemed "invasive," for generalizable findings on change from ensilement, plus per-species info sought by Northeastern farmers;

2. Broadened toxin testing to 3 cherry and 4 maple species plus Sumac, exploring Black Cherry harvest dates, wiltedness, and ensilement time-periods, to shed new light on farmer and livestock risk in using maple/cherry abundance along field edges;

3. Obtained analyses of one sample per leaf-silage barrel fed during our winter

goat/steer intake/milking trial, more than meeting academic standards for triplicate samples per 9 species fed (and samples ordered by dates fed are available, to correlate with frozen milk samples for further study);

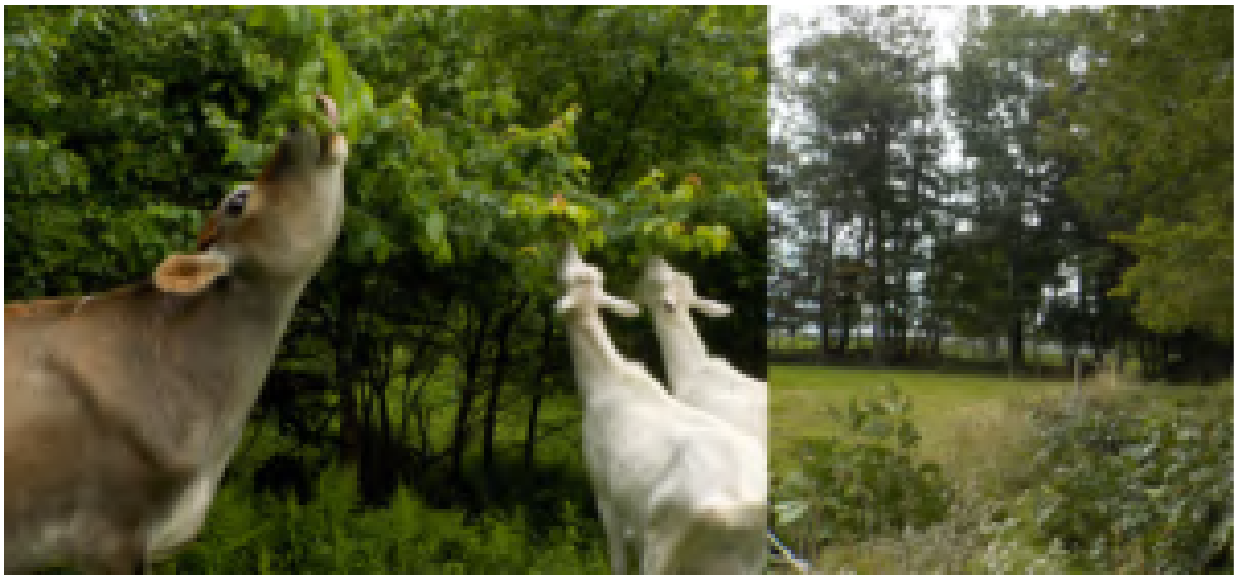
4. Re-created our website, and updated and used our listserve, to streamline dissemination of woody forage information.

Northeastern farmers now have guidance to effectively supplement ruminant rations with alternative on-farm forages.

Introduction:

Northeastern farmers' climate risks around grass-based forage continue. In 2023, water-logged fields caused a first-harvest hay-scramble in mid-August. Nutritional quality of such late first-cut is poor, and second-cut was low in volume. Grass baleage provided to Meadowsweet Farm was also cut late; farmer Eliot VanPeski said the condition of his grass-fed cattle was diminished, due to poor baleage quality.

Cattle browse-lines are evident on field-edge trees of most Northeastern dairy farms. Tech Advisor Karl Hallen observed in his past herd that his highest-performing cattle were doing most of that browsing; Fred Provenza stated that ruminants perform better across the board with access to woody browse (5/21/20 webinar hosted by Didi Pershouse). Tree/shrub leaf-silage can extend both known and (humanly) unknown benefits into ruminant winter diets.



My herd trimming a browse-line, & Holstein browse-line at Faithful Venture Farm

Our weather-resilient SARE FNE 22-013 harvest of field-edge trees and shrubs started as soon as Doak's Machine finished upgrades on the Chain-Flail Leaf-Separator prototype in late June, and yielded slowly but plentifully. Cutting with hand-held power-tools, and stripping leaves with this machine prototype (created by current Tech Advisor Karl Hallen) which is 90% quicker than traditional hand-stripping, we produced 2,500+ gallons of tree/shrub leaf silage (70 of 60-70 planned barrels) in only 1,000 lineal feet of field edges (our proposal identified 5,700 LFT for potential harvest).

Late June 2023 Leaf-harvest at MOFGA with the Chain-Flail Leaf-Separator

Cattle generlly eat 12% Dry Matter (DM) of woody browse, sheep 20% and goats 60% (Lindsay Whistance, 12/10/21 Silvopasture webinar hosted by Steve Gabriel, Wellspring Forest Farm); my steer Angelo in SARE FNE22-013, with unlimited access to that low-quality 2023 late-cut hay, consistently chose tree/shrub leaf-silage as 33% DM of his (grain-free, forage only) diet across three separate 11-day periods of one 2 hour offering-period/day. Angelo kicked up his heels to gallop to it (he only trotted quickly for the alternate-period offerings of 2nd-cut hay); I did not weigh him, but he outgrew draft tack and looked great all winter.

Angelo skipped to this White Ash leaf-silage, and Black Cherry, Red Oak, and Honeysuckle were also fvorites, during the 2023-'24 FNE22-013 winter trial.

Positive livestock palatability responses from SARE FNE18-897 (Hanson 2020[a]) and VTGF Mini-Grant nutritional results (Hanson 2020[b]) preceded SARE FNE22-013 (Hanson 2025), which added data on HOW MUCH my steer and goats will eat, and on whether leaf-silage can support milk production (it does). The SARE 24-083 upon which we report overlapped that study, using fresh and ensiled leaf-samples taken during FNE22-013 harvests and winter livestock trials, plus additional new leaf-sampling, to explore nutritional levels (more thoroughly than in previous VTGF study), nutritional changes when ensiled, cherry-leaf cyanide (HCN) toxin levels when fresh, ensiled or dried, and little-known toxicities present in maple species.

Freshly separated Box Elder, sometimes toxic, & Norway Maple, always safe and tasty.

This project enlisted my past SARE FNE18-897 intern Emily MacGibeny to support positive change in our web presence, where I can now make more efficient and organized updates, so that farmers can better access this new information plus other resources on use of tree/shrub forages.

A summary of each of our farm studies is on the "Farm Research" page of the new website. Emily MacGibeny's hand and arms are featured in this frame :) Thank you, Emily, for BOTH the old and the new websites!

I went beyond committed testing, laboriously packing leaves into bags and containers for additional nutritional tests with some on my own dime (I got curious), and packing numerous samples for Wayne Zeller, US Dairy Forage Research Center (Steve Gabriel attested to the time this takes, in his SARE FNE 19-930 report, Gabriel 2022)). Wayne is working on a monumental task in a context of diminished lab assistance, to isolate, purify and identify Condensed Tannins (CT) from 26 species with comparative CT levels above or equal to “5” (on a 1 to 10 scale, with Birdsfoot Trefoil reference at “6”), plus up to 9 more of our species if they screen to have similarly high levels. Perhaps farmers will no longer need bioengineered tannin-producing white clover and alfalfa, once our more traditional woody sources

are understood.

Wayne Zeller's Condensed Tannin screening, April 2024, his photo, used with permission

Scott Radke, toxicologist at Iowa State University Veterinary Diagnostic Laboratory, continues to go beyond ordered Cyanide testing as I write this report, to find references which might shed light on our surprising data, and repeat tests with extreme results. Everyone that I became linked to through this study has shared a steep learning curve, while addressing the multi-faceted knowledge gap.

Along with data on printable spreadsheet pdfs (see “Results” section), I am reporting noteworthy trends, remaining limitations of our data-set, and new insights plus unanswered queries, for both farmers harvesting and rationing leaf-silages, and researchers interested in benefits to ruminants.

As yet, other farmers do not have leaf-separator machines, but some are proceeding to use tree/shrub forages fresh, dried, chipped or hand-stripped. They have been eager for the information I’ve brought to presentations; that information is updated and more completely offered herein. It’s already helping these smallest most flexible and adventuresome farmers accurately and safely improve winter diets of their herds.

Two years of immersion in data have increased my own awareness of laboratory-based understanding of ruminant digestion and needs, and further defined gaps that remain in my understanding (and some in that of other researchers). I watch my animals closer than ever, for clues about their clearer knowledge. I strive to improve how I feed my herd. There are wonderful results on some samples that my animals entirely refused, but then on certain days certain animals seek bits of those, for benefits prohibitively expensive and elusive to deduce in a laboratory.

I look forward to continuing collaborations with Wolfe’s Neck Center and Liberation Farms, where herdspeople have upped woody forage use (with maybe an extra spark from me). Karl Hallen, Tech Advisor for this Project and creator of the Leaf-Separator) continues to make plans and seek funding to develop methodology of leaf-harvest within willow biomass harvest; our ongoing contact has strengthened his own motivations. Jon Thomas Jr. and his father now have my Leaf-Separator at the Thomas Bandsaw Mills shop for winter upgrades, including less tangly cylindrical (rather than square) flail rotors plus many practical changes offered by Jon Jr. – the last bit of pay I receive from this grant (amidst reimbursements) will go to good use.

I hope our collaborative efforts will support long-term increases in vertical farm-scape diversity - trees with useful accessible canopies, pleasantly moderating farm temperatures, winds and rain. I hope also that tree-based industries soon find added-value encouragement of new forage-streams, that can strengthen sustainable, renewable land practices.

Ernst Zurcher's slide, Colloque Trognes 2018, & David Dellas drawing

CITATIONS:

Gabriel, S (2022). SARE FNE19-930 Final Report: Quantifying Nutritionl Level and Best Practices for Woody Fodder Management in Ruminant Grazing Systems. Accessed 10/28/24.

Hanson, S. (2020[a]). SARE FNE18-897 Final Report: Tree Leaf Fodder for Livestock; Transitioning Farm Woodlots to "Air Meadow" for Climate Resilience. Accessed 10/18/24. https://projects.sare.org/project-reports/fne18-897/

Hanson, S. (2020[b]). Vermont Grass-Farmers Network (VTGFN) Mini-Grant Final Report: Lab Nutritional Analysis of Ensiled Tree Leaves and Ensiled Chipped Leafy Branches, with Dried (non-ensiled) Comparisons, plus Average Grass Fodder Comparison, and Relation to Animal Responses. Accessed 10/18/24. https://drive.google.com/file/d/1c3TVSuGlmnJTmmpE_QngslewRG_F2Dme/view

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Whistance, Lindsay. Farming, Animals and Trees. In Tree Fodder Virtual Seminar webinar hosted by Steve Gabriel, Wellspring Forest Farm, December 10, 2021.

Accessed 1/20/25. https://www.youtube.com/watch?v=hCJYKhOZt58&list=PL3dng73x0WAQKUQKFWM12Ky2DkHgub7rt&index=4

Pershouse, Didi & Provenza, Fred (2020). Nourishment: Learning from the Nutritional Wisdom of Grazing Animals. Webinar "Mini-Course" 5/21/20, hosted by Land & Leadership Institute.

Description of farm operation:

I farm full-time at 3 Streams Farm (my home since 2000) and Belfast Blueberry Cooperative (mountain land purchased in 2018) bringing (7 right now) dairy goats and a steer both places. My intimate involvement with trees started with professional orchard pruning in 1983. After 8 years of goat observations, I started working with tree fodders as a primary focus in 2011, presenting internationally at 2iem Colloque Trognes in 2018.

Since then I've been a dedicated farmer-researcher, thinking deeply about next steps as I wander with animals, rake blueberries, or pursue other mind-free tasks. My SARE FNE18-897 and 2019 VTGF projects broke ground on storage, palatability, and nutrition of Northeastern US tree leaves, and subsequent SARE FNE22-013 funded the Chain-Flail Leaf-Separator prototype, imagined by me and made by Karl Hallen (Tech Advisor for FNE24-083 to which this report pertains). That project and machine enabled production of enough leaf-silage for a 60-day home livestock trial with my very willing steer and 10 goats, plus three shorter trials at other farms, and was the source of most (but not all) samples tested for this overlapping, ongoing FNE24-083 project.

3 Streams Farm provides goats' milk from 100% fresh greenery of woodland and pasture, to seasonal subscribers. Belfast Blueberry Cooperative provides fresh-market wholesale and PYO "No Spray since 2018" blueberries each late July-August. I am physically sustained by milk and blueberries, and rarely shop; combined gross is $12-$15,000.

Cooperators

- Karl Hallen - Technical Advisor

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  Agricultural/Forestry consultant, Researcher

  Farm, forest and fiddlehead consulting (Other)

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- Emily MacGibeny

  Web-Savy Intern

Research

Materials and methods:

1. **We broadened analyses of nutrition, ensilement and digestibility to 20 tree, 11 shrub, and 1 vine species including 7 blacklisted as "invasives**:"

We sent 1 or more fresh-frozen of each species, and one or more ensiled sample of most species, of machine- or hand-separated

tree leaves:

American Beech, American Basswood, American Elm, Apple, Big-toothed Aspen, Quaking Aspen, Black Cherry, Pin Cherry, Black Locust, Box Elder, Gray Birch, Yellow Birch, Green Ash, White Ash, Hybrid (Crack/White) Willow, Norway Maple, Red Maple, Rock Maple, Striped Maple, Red Oak,

and shrub leaves (plus one vine):

Arrowwood, Autumn Olive, Bittersweet, European Buckthorn, Glossy (aka Smooth) Buckthorn, Honeysuckle, Leatherwood, Multi-flora Rose, Pagoda Dogwood, Speckled Alder, Staghorn Sumac, Winterberry,

to DairyOne for:

- "Ration Balancer" analysis which includes Moisture Content (MC), Dry Matter (DM), Crude Protein (CP), Soluble Protein (SP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Non-Fiber Carbohydrates (NFC), Total Dietary Nutrition (TDN), Net Energy for Lactation (NEL), Net Energy for Maintenance (NEM), Net Energy for Growth (NEG), Relative Feed Value (RFV) and 11 minerals,

  or:

- "Basic" analysis which is same as above but with no minerals (nor SP but we added SP below), for one of the samples in each pair, as minerals don't change much from fresh to ensiled,

We learned partway through that previous Relative Feed Value (RFV) and Non-Fiber Carbohydrate (NFC) figures were inaccurate due to lab categorizing of samples as grass forages; these were missing when Dairy One started correctly categorizing. So mid-stream I started ordering/paying for Fat EE and Ash add-ons in order for Dairy One to compute accurate NFC results (NFC though listed in initial package is included for grass forages only, as they use average known grass Fat and Ash figures).

RFV is a computation from Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF); Dairy One sent me a calculator spreadsheet containing the formula, and I replaced missing RFV figures despite that the formula is specific to grass forages. I left these questionable figures on the "ALL" sheet, but took them off the "PAIRS" sheet.

- Add-on measurements of Water-Soluble Carbohydrates (WSC), Soluble Protein (SP) when not included, Rumen-Degradable Protein (RDP), and Ph.

Dairy One gently requested for us to stop ordering Soluble Protein % DM (SP) and Rumen-Degradable Protein % DM (RDP) tests, because in many, the required liquid preparation gelled up and clogged their filter.

For each ensiled sample, we also obtained analysis of

- Ammonia.

For 4 samples ensiled more than 1 year, we obtained

- Fermentation Profiles*

**as follow-up to information from my 2020 VTGF Mini-Grant report on first-winter leaf-silages, of very low or zero amounts of the usual 6 acids found in grass and corn silages. These acids did appear with longer ensilement.*

We:

a. Charted data per 32 species;

b. Computed mean and range of each nutritional measurement across per-species avegares of 10 most prevalent species;

****See bottom of "Nutritionl Data from All"spreadsheet, in the Results section ***)*

c. Computed mean and range of changes in each nutritional measurement from fresh to ensiled, across species;

****See top of "Paired Fresh & Ensiled" spreadsheet, in the Results section.****

d. Re-grouped Fresh/Ensiled Pairs into 3 harvest-date categories. Computed mean and range of changes in each nutritional measurement from fresh to ensiled, per date category, to look at effects of length of period ensiled (but even these changes are affected by date-related differences in initial fresh leaf carbohydrates especially). I also compiled fresh and ensiled data separately per date-period, on same sheet, to look for date differences attributable to leaf development of fresh samples, and to allow others to puzzle over the complete data-set.

On separate spreadsheet, I re-grouped selected data of 3 species having multiple harvest-dates, into 3 harvest date-periods. I noted trends of change for each nutritional measurement as leaves matured and changed, while length of remaining warm weather-period supporting fermentation decreased.

Both of the above harvest-date category spreadsheets looking simultaneously at these two factors can help farmers to think about their choice of dates to harvest/ensile leaves, but do not offer conclusive results due to differing richness of our 3 sites, with each site harvested at a different point in the growing season.

Differences in average harvest dates of 2022-'23 versus 2025 sets of matched fresh/ensiled pairs provide another glimpse of harvest date effects.

****See "Fresh/Ensiled Pairs Comparing 3 Date Categories" spreadsheet, "Selected*

Leaf-samples Comparing 3 Date Categories" spreadsheet, & 1st 2 pages of "Dairy One 2023-2025 data comparing PAIRED FRESH & ENSILED leaf-samples, Final"

*spreadsheet (inc my comment at top of 2nd page), all under "Results."****

e. Discussed protein availability in light of CP, SP, RDP, & Ammonia measurements, including change from ensiling, plus considered probable increase in utilization due to Condensed Tannin levels. (*See Protein discussion under "Results.")*

****Find links to all (printable PDF) charts in the "Results" section.****

2. **We broadened toxin testing with ensiled comparisons**.

We used existing fresh-frozen/ensiled sample-pairs (for immediate March 2024 results), plus harvested, leaf-separated by machine or by hand, packed new

samples, & obtained laboratory analyses for:

a. Cyanide (HCN, also known as Prussic Acid) in 22 cherry leaf-samples:

- 6/27/23 Black Cherry (MOFGA), 1 Fresh/1 Ensiled 120 days;
- 6/29/23 Pin Cherry (MOFGA), 1 Fresh/1 Ensiled 120 days;
- 10/11-12/23 coppiced Black Cherry (Wentworth Way, Y Knot Farm), left out 24 hrs on a gray day, 1 Fresh/1 Ensiled 30 days;
- May 21, 2024 Black Cherry (Y Knot Farm mature tree), Fresh;
- June 3, 2025 Black Cherry (Y Knot Farm mature tree), 1 fresh & 1 dried;
- 1 fresh sample July 13, 2025 Choke Cherry (Harriman Rd., Swanville, ME), Fresh;
- July 3, 2025 Black Cherry (3 Streams Farm small pollard thicket) selecting leaves from new growth only, 4 samples: Fresh, Ensiled 30 days, Ensiled 60 days and Ensiled 90 days;
- July 3, 2025 Black Cherry (3 Streams Farm small pollard thicket) selecting leaves from new growth only, Wilted 4 hrs (new growth portions left out mid-day in full sun, before hand-stripping leaves), 4 samples: Fresh, Ensiled 30 days, Ensiled 60 days and Ensiled 90 days;
- July 3, 2025 Black Cherry (3 Streams Farm small pollard thicket) selecting leaves from new growth only, Wilted 24 hrs (new growth portions left out mid-day in full sun, then brought into the house for rest of wilting-period before hand-stripping leaves), 4 samples: Fresh, Ensiled 30 days, Ensiled 60 days and Ensiled 90 days.

We summarized findings, with inclusion of 2022 sample-pair tested within FNE22-013, & made recommendations/warnings for use of fresh, ensiled or dried cherry leaves.

I collected a 12-sample set of Y Knot Farm Black Cherry in 2024, but double zip-lock bags of ensiled leaves leaked air and molded (unlike previously purchased zip-lock bags used to ensile late-season leaves for nutritional testing). So I packed all 2025 samples excepting the Dried sample in plastic jars with foam lid-liners. All 2025 samples were frozen until October FedEx Overnight sending.

b. Gallic Acid and Ellagic Acid both free & hydrolyzed* quantitative levels, Hypoglycines A and B, plus homologues Methylenecyclpropylglycine (MCPrG) and γ-glutamyl-MCPrG comparative levels, in 3fresh replicates (similarly aged, with similar sunlight, but differing locations) each, of 5 species:

Red Maple, Rock (Sugar) Maple, Norway Maple, Box Elder, and Staghorn Sumac.

We:

- Compared toxin levels between above species,
- Explored relationship to ruminant intake data from SARE FNE22-013 livestock trials plus additional sampling/feeding observations in 2024-'25,
- Searched literature on this obscure subject, turning up info on potential ruminant digestive benefits from Gallic and Ellagic Acids, and an absence of info on toxic thresholds (especially in light of multiple toxins per species, and most of our data being relative levels versus absolute quantities).

Due to misunderstanding of listed gallotannin lab-service at UC Davis, which is non-quantitative and only on horse urine, we re-allocated funds for 3x greater expense of higher-tech analyses at MU Metabolomics Center. There, Director Zhentian Lei advised me to include Ellagic Acid (EA), and to use triplicate sampling (so we let go of including less abundant Striped Maple, and let go of ensiled comparisons, due to expense). I had already added the Hypoglycins and homologues due to their presence in Box Elder and maple literature.

**11 of 15 free Gallic Acid (GA) figures are much higher than hydrolyzed figures. Zhentian Lei had advised that hydrolization would yield data on Total level, but afterwards responded that some Free GA must have evaporated during hydrolysis. (2 Free Ellagic Acid (EA) figures were also higher than hydrolyzed figures).*

****See "Maple, Box Elder & Sumac Toxins" group of files under "Results."****

We summarized our data and literature-based information, plus my memory of comments of farmers who use these 5 species, and my own animals' use or rejections including provision of off-farm Box Elder and Staghorn Sumac in 2025, to give some idea of forage usability.

These toxins are said to increase throughout the season. Our "straw-payer" at University of Missouri Center for Agroforestry expressed unwillingness to wait; hence our rather early June 24-25, 2024 sampling dates. (MU Metabolomics Center can only directly serve those with university and other official research organization accounts.)

****See 2 "Maple, Box Elder & Sumac Toxins" files under "Results," for charts and graphs created by Dr. Zhentian Lei, MU Metabolomics Center; I've made minor additions and one correction. ****

3. **We obtained 1 nutritional analysis per each tree/shrub-species layer or full barrel/bucket of leaf-silage (Black Cherry, Gray Birch, Honeysuckle, Quaking Aspen, Big-Toothed Aspen, Red Maple, Red Oak, White Ash, Green ash)** fed during our 66 day winter SARE FNE22-013 goat/steer trial (which measured dietary intake and milk yield), **plus obtained analyses on each other ensiled date-batch of those species, and on other less abundant tree/shrub species** fed before or after that trial plus fed within trials at Y Knot and Faithful Venture Farms.

We took 3 lbs per numbered barrel fed, drawn from near top, middle and bottom of each barrel, then mixed/bagged/froze 2x1 qt and 2x tiny- bag (2"x3") samples. We drew/packed/froze lesser amounts from each bucket fed. We sent 1 or more sample/harvest-date/tree or shrub species for DairyOne analyses including:

- "Ration Balancer" analysis which includes Moisture Content (MC), Dry Matter

(DM), Crude Protein (CP), Soluble Protein (SP), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Non-Fiber Carbohydrates (NFC), Total Dietary Nutrition (TDN), Net Energy for Lactation (NEL), Net Energy for Maintenance (NEM), Net Energy for Growth (NEG), Relative Feed Value (RFV) and 11 minerals, and

- Add-on measurements of Water-Soluble Carbohydrates (WSC), Soluble Protein (SP) when not already included, Rumen-Degradable Protein (RDP), Ammonia, and Ph.

We charted, examined and are reporting:

a. Mean of each nutritional measurement per tree/shrub species;

b. Relationships between animal intake and nutritional measurements per tree/shrub species;

c. Nutritional comparison of these (mostly) 2023 leaf-silages to Dairy One average grass-hay and grass-silage figures 2004-2024, and to 2 samples of 2023 hay (from 2 sources), that we fed out during the 3 Streams Farm trial. (S*ee "All" spreadsheet under "Results.")*

Based upon this nutritional and toxin data, standard nutritional requirements, and Animal Intake data from FNE22-013 3 Streams Trial, we:

- Are offering supplemental leaf-silage rationing impressions per ruminant species, with discussion of gaps still missing for full understanding of these complex forages; and

- Have described harvest developments that must occur in order for this clearly valuable forage to become feasibly usable on a broad scale.

4. **Updated, improved and used our website, "tree fodder" listserve, and network of livestock farm-related organizations,** to streamline provision of this critical alternative forage data, augmenting in-person presentations at farmer events.

- Emily MacGibeny created a new 3streamsfarm.wixsite.org/3streamsfarm website built of pdf windows and download buttons, so I Shana can keep and update each page as a pdf of a Libre Office Presentation, enabling me to do that work on browse wanders off-line, with full control of color backgrounds and content organization. We added recently-dated tree fodder resources, and pertinent links (to updated spreadsheets, photos etc) in summaries of each of my research studies.

- Emily went through my Google Drive and deleted duplicate files plus files I'd unintentionally uploaded, and then organized into folders, with room to spare for future Resource additions. Previously my Google Drive was hitting full storage capacity, preventing me from posting links to new resources on our website.

- Emily MacGibeny went through our Tree Fodder listserve, adding the last few years of contacts from my paper notes from presentations and phone calls plus from saved emails. I remain unable to send emails to this listserve myself (my Proton enail does not have have listserve enabled, and the gmail we use for that has invisible black buttons on my black screen). I soon will have another new

resident who is likely to have that skill. Emily sent out notifications of presentations at key moments, during this Project.

Research results and discussion:

2 1/2 Barrels of White Ash harvested September 10, 2023. barrels of leaf-silage stored outdoors, & UME Intern Megan Smith's photo of fall 2022 Black Cherry, still tasty and nutritious at winter feed-out over one year later

NUTRITIONAL ANALYSES

Dairy One (Ithaca, NY) completed **nutritional analyses on 102 leaf-samples** of 20 tree, 11 shrub and 1 vine species. I organized results by species (except for one European Buckthorn sample paired with a same-day, same- site Smooth Buckthorn sample for comparison), with fresh-frozen versus ensiled paired samples listed at top of each species-specific list, and following samples generally organized consecutively by harvest-date. A later-season date = shorter ensilement; we froze most ensiled samples during 2023-’24 winter feed-out, including those harvested in fall of 2022 when our Leaf-Separator machine first arrived (therefore the 2022 barrels and buckets had the longest ensilement period, with a few warm-enough fall weeks plus one full summer).

Our **Species averages** of each nutritional measure use ensiled samples only, for consistency, and are only computed when multiple ensiled samples of a species were tested; we tested just one fresh sample for most species, and fresh/ensiled paired samples repeat the same batch. Averages are below species-specific lists containing multiple batches, and averages of 10 most abundant species are also compiled and averaged across species on the last 2 pages..

Dairy One NUTRITIONAL DATA from ALL 2022-'25 LEAF-SAMPLES (For compilation of 10 most abundant species averages, go to END) (pdf formatted to print on legal-sized, landscape-oriented paper**.)**

Previous Northeastern nutritional data on tree and shrub leaves was scarse, and nonexistent for ensiled leaves; our results are therefore highly useful despite sampling limitations. My caveots describing limitations follow:

These results are specific to Waldo County, Maine, and most samples came from just 3 SARE FNE22-013 harvest-sites, with varying and sometimes low numbers of samples per species. That harvest, which produced most of our samples, was aimed at yield per lineal feet of field edge, labor-time measurements, and provision of many barrels-full for livestock trials in that project. We tested one fresh and one

ensiled sample from each species that we came upon (we missed sampling a few), and tested one sample from each barrel, bucket or date-batch later once ensiled. Quaking Aspen averages for instance represent multiple samples from one stand only which produced many barrels – on retrospect I have regrets about our 3 Streams Farm Trial per-barrel test allocation decision, which left limited funds to test other species, harvest dates or sites.

We did not plan nor commit to a broad randomized sampling design for regionally generalizable results, as that would have taken dedicated driving and sample-packing time beyond our budget and availability; rather our project utilized the “bird in hand” of leaves already harvested, with just a small number of samples added to fill out our species list.

Validity of comparisons of species averages is limited by differing site qualities and differing harvest date-windows at the sites. The Leaf-Separator machine farm-trailer base required slow transport-speed, so was parked at sites consecutively with just one return-trip to Y Knot Farm. (As I write this report, Jon Thomas Jr., Thomas Bandsaw Mills, is squaring/aligning the frame and wheels of that farm-trailer base to handle normal road speeds, in future!)

Dry Matter (DM) across all individual samples 2022-2025 including trees and shrubs both fresh and ensiled averaged 40%.12 (mostly fresh) shrub samples added in 2024 and 2025 (close to half of our 26 total shrub samples) had a much earlier average harvest date than did 2022-’23 samples; earlier sampling dates seem to correlate with lower DM, and pulled our average DM down from previous calculations.Lowest among these were 6/3/25 fresh Pagoda Dogwood with 20.6% DM, and 7/31/25 fresh European Buckthorn, shaded by mature trees in a stream flood zone, with 20.8% DM. Our (mostly MOFGA-site ensiled) Honeysuckle samples ranged 25-55% DM, with unclear date correlation. Tree samples ranged less than that within species, but just as widely across all species. 10 tree-leaf samples (of 86) had DM above 50%; 6/26/23 Box Elder (the only Box Elder sample we used for nutritional testing) had the lowest %DM of our tree samples, with 23% DM fresh and 22% DM ensiled.

DM content affects how much one must harvest, to meet needs of one’s animals. Traditional harvests of pollarded trees in Europe occurred during late summer into fall, when DM is high, and tree carbohydrate stocks are also high (carbohydrates are needed for tree recovery and health, as well as for forage value). Here are my laborious DM and Harvest Date computations, to make sense out of our less than consistent data sets (which as stated above were aimed at bulk harvest versus sampling):

% DM & HARVEST DATE AVERAGES OF FRESH & ENSILED LEAF-SAMPLE GROUPS, inc. TREES VS SHRUBS

All Leaf Samples (some species over-represented, more tree samples ensiled, more shrub samples fresh, shrubs earlier ave harvest date than trees)

	All 2022-'25	All 2022-'24	'22-'25 Fresh	'22-'24 Fresh	'22-'23 Fresh	'22-'25 Ensiled	2022-'23 Ens
Ave %DM	39.92	40.94	38.37	38.60	40.41	41.51	42.12
Ave Harvest Date (with disregard to yr)	08/08/23	08/14/23	07/30/23	08/11/23	08/22/23	08/14/23	08/15/23

Paired Samples (1 pair per species excepting 2 of W Ash)

	All pairs	Tree pairs	Shrub pairs
Ave %DM (fr+ens)	38.73	39.96	34.84
Ave Harvest Date (with disregard to yr)	08/11/23	08/13/23	07/30/23

(Pairs Continued)	2022-'23 Fresh	2025 Fresh	2022-'23 Ensiled	2025 Ensiled
Ave %DM	40.41	33.53	38.28	33.15
Ave Harvest Date (with disregard to yr)	08/22/23	06/17/25	08/22/23	06/17/25

10 most abundant Ensiled species used for Ave of species averages (but now computed across indiv samples)

	All 10 Species	9 Tree species	1 Shrub species (Honeysuckle)
Ave %DM	42.7	43.2	38.16
Ave Harvest Date (with disregard to yr)	08/09/23	08/14/23	07/03/23

% DM & Harvest Date Aves of Leaf-Sample Groups (<-- pdf link, in case above screenshot is not clear)

Protein: Crude Protein (CP %DM) levels in our leaf-silages were respectable, falling between those of the 1st- and 2nd-cut hay we had that winter. Both 1st- and 2nd-cut hays were cut in late August, due to 2023 wet June and July; the bulk of our leaf-silages were harvested late June through July, and then a lesser number of barrels late September through to October 12th. Early cuts of both grass and tree matter are known to have higher protein levels as % of DM, than later cuts. Yet I wondered t owaht degree higher moisture/lower DM at earlier dates accounted for this difference.

2025 harvest-dates were 6/3 to 7/7 with a mid-June average date, an earlier range than 2022-'23 6/25 to 10/6 dates with mid-August average. Because DM and fiber were lower in these earlier-dated 2025 samples (by 6-7% & 5-8% respectively), I computed protein levels AS FED, below: This showed that difference in %DM protein levels between these sample-groups does not change how much volume animals must eat to get their protein. AS FED, the protein-levels differ little.

PROTEINS AS FED & FIBER AS FED	% DM	Cr P %DM	CP % as fed	Adj CP %DM	Adj CP % as fed	Sol P % DM	SP % as fed	Deg P % DM	Deg P % as fed	ADF % as fed	NDF % as fed
2022-2023 Fresh aves	40.41	12.52	5.06			1.45	0.59	3.53	1.43	23.44	16.22
2025 Fresh aves	33.53	14.50	4.86			2.19	0.73	6.44	2.16	8.89	10.83
2022-2025 Fresh aves	39.26	12.85	5.03			1.57	0.61	4.01	1.55	9.80	15.25
2022-2023 Ensiled aves	38.28	13.23	5.06	8.32	3.18	1.95	0.75	3.37	1.29	10.77	16.30
2025 Ensiled aves	33.15	16.23	5.38	12.93	4.28					6.85	10.31
2022-2025 Ensiled aves	37.43	13.73	5.12	9.08	3.40					10.12	15.30

Proteins & Fiber AS FED, comparing yrs differing in ave harvest-date, from p.2 of Dairy One 2023-2025 data comparing PAIRED FRESH & ENSILED leaf-samples

Acid Detergent Insoluble Protein (ADICP) levels in my 2019 leaf analyses had indicated limited protein availability (as do our new results). We therefore ordered quantification of Soluble Protein %CP (SP) and Rumen-Degradable Protein %CP (RDP), to gain more clues about protein utilization. In many of these tests, the

required liquid preparation gelled up and clogged the lab's filter. After the first large batches of samples yielded much but not all requested data, I gave in to Dairy One's gentle suggestion for us to stop ordering SP and RDP tests.

We have complete SP and RDP data for all samples of 16 species (out of 26). SP and RDP tests failures happened on all 5 Red Oak samples, and on fresh/ensiled sample-pairs of American Elm, Norway Maple, and Smooth Buckthorn, such that we have no measurements for these 4 species. Either SP or RDP failed on 4 out of 5 Honeysuckle samples; RDP failed on 4 out of 7 Quaking Aspen samples, 1 of 6 White Ash samples, and 3 of 11 Black Cherry samples. All of the first 3 SP tests and 2 of the first 3 RDP tests failed on Gray Birch, such that we have no SP and only one (curiously high) RDP result on Gray Birch; Red Maple had this problem for 3 of 6 SP and 4 of 6 RDP tests.

To compare actual quantities in the feed, I computed SP %DM and RDP %DM for both leaf- and grass-forages. Average SP %DM levels in our Black Cherry and Green Ash samples were highest among our tree samples (2.75 and 2.73 %DM respectively), slightly surpassing the level in our 1st-cut hay; certain samples of White Ash, Quaking Aspen, Basswood and Box Elder had similar levels. RDP levels were also highest in Cherry and Green Ash, but lower than that of the 1st-cut hay.

Our three Autumn Olive samples surpassed all other tree and shrub species, with CP ranging from 21 to 26.4 %DM, SP ranging from 4.8 to 9.5 %DM, and RDP ranging from 10.5 to 17.7 %DM. For comparison, Dairy One average grass hay has 11 %DM CP, 3.7 %DM SP and 7.2 %DM RDP, and average grass silage has 15.5 %DM CP, 8.2 %DM SP and 10.9 %DM RDP. Among the few shrubs with complete protein tests, a 6/3/25 Pagoda Dogwood sample also had respectable protein levels.

Jaime Garzon,UME Cooperative Extension Forage Specialist, uses a practical guideline that WSC to CP ratio should fall between .4 and 1.5 in silage, for digestive balance. Of that CP, he says SP should be 30-40%. Our average Black Cherry silage falls well within that WSC/CP range at .65, but with SP at only 20% of CP. Our Green Ash ratio is .575 with SP at 22%. Our 2 lowest-protein Autumn Olive samples come closest, with average WSC/CP ratio at .45 and SP averaging 25.5%. (We unfortunately did not obtain a WSC level to do this math on the much higher-protein early-harvested sample.)

Condensed Tannins (CT) in our leaves are likely to be increasing protein utilization of all feedstuffs consumed by as much as 25%, according to Wayne Zeller's ongoing work on our leaves (described below) combined with studies of cattle performance when fed other sources of CT. CT at 3% DM is optimal; more is anti-nutritional and antifeedant. Our levels are similar to those in Birdsfoot Trefoil (BFT); high-CT BFT fed as 60% of dietary DM to dairy cattle falls well below the anti-nutritional level, and increased digestive efficiency and milk production (Hymes-Fecht et al. 2013).

PDF, Birdsfoot Trefoil Silage increases Production of Lactating Cows, Hymes-Fecht et al. 2013

According to MOFGA Grounds Director and farmer Jason Tessier, Tessier farm, many grass-based farmers in Maine like himself make early wrapped baleage, and/or grass silage in a bunker. These early cuts have a surplus of protein, making energy versus protein the limiting nutritional component on such farms. See discussion of high NFC and WSC in our leaf-silage, below (past the Fiber discussion).

Quality of Protein: Tech Advisor Karl Hallen had a thought as we edited this report: Amino Acid profiles of grass forages do not fully meet Amino Acid needs of animals; perhaps woody forages might have more complete protein. We looked and found little info on Amino acids in Northeasatern leaf-species. Mulberry leaves in China DO have a more complete array of Amino Acids than does grass (Jiang & Nie

2015, cited in Mulberry FeedValue - Trees for Graziers).

Acid Detergent & Neutral Detergent Fiber (ADF and NDF) % of DM, averaged across averages of our 10 most abundant species of leaf-silage with August 9th average harvest-date, were respectively 70% and 66% of Dairy One averages of levels found in grass silage. Ensiled samples of matched (fresh/ensiled) pairs that were harvested in 2025 had earlier average harvest-date of June 17th, and had only 56% and 54% of ADF and NDF levels in grass silage (plus had more shrubs/less trees but that has less effect on %DM than does date).

Our leaf-silage leans somewhat toward the "concentrate" end of forages; low fiber correlates with high energy (see NFC, Fat EE and NE discussions below). In our SARE FNE22-013 trial, when 10 goats and a steer ate 55% and 33% (respectively) of their diets as leaf-silage (in a 100% forage diet, leaf-silage plus poor quality 2023 1st-cut hay), animals were satiated with 97% of the total lbs. DM that they ate when given 2nd-cut hay in place of that leaf-silage proportion. Strangely, this percentage of less DM intake with leaf-silage is the same for the steer and goats, despite that the goats were eating a much greater proportion of leaf-silage. What need was the steer meeting with his 33% leaf-silage diet, that allowed him to eat less DM? (Or is that difference simply accounted for by higher moisture in the leaf-silage than in hay? That seems unlikely to me.)

Leaf-silage or 2nd-cut hay were only offered once per day for 2 hours. If I'd had enough to offer a second such free-choice meal-period per day of leaf-silage, I suspect that they might have eaten that much again (but that would bring goats above capacity – very wide and giving more milk?).

If the steer ate twice as much leaf-silage, he would be eating 67% of his lbs. DM as leaf-silage, and would probably be satiated with 86% of the total lbs. DM that he ate when given 2nd-cut hay once per day and no leaf-silage. This level of leaf intake for a bovine would be far above modern expectations (Lindsay Whistance says cattle choose 12% of their diet as woody forages: Whistance 2018), yet up until the mid 1700s European cattle were indeed wintered on more leaves than grass, with 100% leaf cattle-diets in winter a probable reality for thousands of years, in earlier historic times.

Non-Fiber Carbohydrates (NFC): At 38.8% of DM average across 10 most abundant leaf-silage species' averages, our leaf-silage had well over twice the NFC of Dairy One average grass-silage (at NFC 16.8% DM), and surpassed average grass-silage level of

Water-Soluble Carbohydrates (WSC), the most quickly digested component of NFC: WSC in our 10 most abundant leaf-silages averaged about 10% DM; Dairy One grass silage average is 8% DM.

Such concentrated energy means that leaf-silage can support reduced use of off-farm-sourced concentrates, particularly when other dietary components compensate for lower protein levels, or if the leaf-silage is Autumn Olive, or some other higher-protein species.

Fat Ether Extract (Fat EE) level in our leaf-silages averaged 6% DM, or 150% of that in average Dairy One grass-silage.

Hauge, Garmo & Austad (in Austad & Hauge 2014) wrote (my English notes from the Norwegian – thank you to Yvonne Taylor, past Black Locust Farm farmer, for translating to me a few years ago) :

"The fat content is high in leaves (5 – 7% DM), as compared to grass (1 – 3%). The

reason is that the leaves have a thick, protective layer. This layer serves as a defense against parasites, and reduces water loss as a result of transpiration in the plants. The outermost part (cuticle) is built from a cutin and wax that doesn't have any nutritional value. Leaves from birch often have a higher content of fat than leaves from willow, vier, or, aspen, and rowan. The least fat content is found in elm, ash, linden, and hazel. Like in grass and clover (trifolium species) it is linolensyren [Linolenic acid, ALA] that is most prevalent in leaves (35 – 45% of total fatty acids) (Garmo 2012)."

In light of this, our leaves should have around 2.4% DM Alpha-Linolenic Acid.

Ensiled leaves consistently had more fat than fresh leaves (averaging 111% of fresh DM level, or 106% of fresh level As Fed). See "Nutritional Changes from Fresh to Ensiled" below.

Yulica Santos Ortega identified hundreds of lipids in our goats' milk with and without tree/shrub leaf-silage, during the SARE FNE22-013 3 Streams Farm trial. (I would love to know more about health effects of those lipids on us milk drinkers – Yulica said the lipids are "all good.") Yulica wanted to look at leaves eaten, but then moved to an all-consuming new job at University of Virginia. I have leaf-silage samples frozen, tallied by dates fed, in which to identify leaf lipids (to match our known lipids in milk samples, more milk samples are also frozen). Such further research might detail benefits of high leaf Fat content to animals.

Fats in ruminant diets increase digestive efficiency and decrease methane production, with no ill effects on digestion of up to 6-7% Fat in DM of diets (Hassan et al. 2020). It intrigues me that these optimum levels cited match content in our leaves; as usual, thousands of years of ruminant consumption of leaves can't be very wrong. :)

Metabolizable Energy (ME) signifies how much energy is available to animals for all bodily functions, and is used to compute Net Energy figures below.

Net Energy (NEL, NEM and NEG) across averages of our 10 most abundant species of leaf-silage averaged scores of .66 for NELactation, .64 for NEMaintenance, and .38 for NEGrowth. These were higher than levels in either of our hay samples or in Dairy One-tested average grass hay (across better years than 2023). Our NE figures even surpassed those of average Dairy one-tested grass silage levels (.58, .59 & .33). Our leaf-silage .66 NEL fell squarely halfway between Dairy One's NEL averages for grass silage and corn silage! The steer Angelo, who was 2 years old and growing, skipped to his leaf-silage offerings. Despite NEM still being low in his forage-only diet (though better with the leaf-silage), he seemed to grow fine – perhaps the Condensed Tannin magnification of protein utilization (see Protein discussion above) helped.

Minerals varied widely in our leaf-silages, as did those in my 2019 samples*, with a trend of higher levels of key elements than in grass forages. (*2020 testing thanks to a Vt Grass Farmers Network Mini-Grant; that report, Hanson 2020[b], linked here & fully referenced in "Introduction" above, includes a more in-depth look at mineral levels in leaves and livestock needs.)

Calcium was high in our leaf-silage species-averages, ranging from similar DM levels to both our hay samples, to almost 3x as much as in the hay. Across our 10 species-averages, Calcium DM level averaged to be 1.75% of that in average Dairy One-tested grass silage. I suspect that my lactating goats (and possibly my growing steer as well) preferentially choose forages that are high in calcium.

Zinc was especially high in both Aspen species, with DM levels in the two ensiled Y Knot Farm Big-toothed Aspen samples averaging 273.5 ppm, and 5 of 6 ensiled

MOFGA Quaking Aspen samples averaging 143.2 ppm (6 of 6 samples averaged 126.7, but I am tempted to discredit the sample with 28 ppm, harvested amidst all those samples from one stand of trees). Across our 10 species-averages, Zinc averaged 74.6 ppm, just about twice the 37.8 ppm average level in Dairy One-tested grass silage.

During our SARE FNE22-013 trial, I did not feed animals any ensiled rockweed that I harvest (into barrels, from rocks along the shore of Penobscott Bay at low tide) and usually offer intermittently. That seaweed and a salt block (which I did provide during our trial) are my animals' only mineral supplementations, excepting dirt that especially the steer eats from upturned tree root-masses (no such root-masses were present in their Winter Trial paddock). I have at times in past tried offering mineral mixes to my goats, but they showed no interest, perhaps because of their high browse and tree matter diet.

If rations include a broad species-range of leaf-silage, free-choice intake of mineral supplements may decrease, or such suplements may become unnecessary.

Note when looking at Ash and Mineral figures of our 2nd-cut hay that it was full of dirt from that rainy 2023 season, with minerals that my animals left in the offering-sled. (Our leaf-silages include no dirt.)

Fermentation & pH: In past I was confused by low 3.7 pH of spring-harvested Beech leaf-silage with almost no fermentation acids detected in any of 5 samples tested (Hanson 2020[b], linked above). I thought that perhaps different acids were produced (possibly that acidity was from Vitamin C, already present when leaves were fresh?). So we decided last summer to send 4 samples ensiled for more than a year; the usual fermentation acids did appear. PH went down from fresh to long-ensiled (over 1 year) 1.1 points in Big Toothed Aspen (going from 5.5 to 4.4), zero in July-harvested Beech (which stayed at 5.4 with very low .4% total acids), and 1.5 in Winterberry (going from 5.7 down to 4.2, the acceptable upper limit for grass silage. In the first winter as fermentation slowed, pH was 5.4). Across these three sample-pairs (Beech, Big-Toothed Aspen & Winterberry), fresh pH averaged 5.53, and 1+year ensiled pH averaged 4.67.

The animals consistently mobbed our pleasant-smelling 1+ year-old leaf-silages of palatable species and ate them, as they did in the first winter.

Dairy One FERMENTATION PROFILES & Nutrition, comparing 2018 short fermentation and 2023-'24 1 yr+ fermentation (pdf formatted to print on legal-sized, landscape-oriented paper)

Nutritional Changes from Fresh to Ensiled

We had Dairy One analyse nutrition in 24 matched fresh/ensiled sample-pairs of 23 species = 6 shrub plus 17 tree species (we included two pairs of White Ash, with much healthier-looking leaves from the site with later harvest-date, hence duplication), to look at nutritional changes when ensiled. My summary of most notable changes follows:

Dry Matter (DM) decreased slightly with ensilement, such that both types of

Acid Detergent and Neutral Detergent Fiber (ADF & NDF) both went slightly up as % of DM when ensiled, but since DM decreased, fiber % AS FED **stayed stable**.

Crude Protein (CP) went up slightly (whether considered as % DM or % AS FED). Within CP,

Rumen-Degradable Protein (RDP) %DM decreased to 95% of Fresh average, which indicates that the increase in CP consisted of rumen-escaping protected

proteins. Within decreasing RDP,

Soluble Protein (SP) %DM increased to 103% of the Fresh average. So Rumen-Degradable Insoluble Protein was what decreased, as CP went up as a whole with more rumen-protected protein plus more soluble protein. (*I realize I am be-laboring this, and also that my use of SP %DM versus %CP is unconventional, but I am trying to visualize complexity of the changing amounts).*

Water-Soluble Carbohydrates (WSC) %DM dropped by 34.5% of fresh level on average when ensiled, across all paired samples,and

Non-Fiber Carbohydrates (NFC) %DM as a whole dropped by 10% of fresh level; this is mosty accounted for by the drop in WSC, within NFC(so mostly sugars, and not much simple starches, probably got used up by acid-producing microbes).

Fat Ether Extract (Fat EE) went up. Fat content in ensiled samples averaged 111% of % DM levels (or 106% of % AS FED levels) in matched fresh leaf-samples (across 20 sample-pairs with full Fat EE data). Higher Fat level was fairly consistent across samples; only 2 pairs had higher Fat % DM fresh, or 3 pairs had higher Fat % AS FED fresh, versus ensiled, out of 20 pairs.

This rise of Fat when leaves are ensiled intrigues me; tree physiologist Kevin Smith, UNH Extension, Durham, said it can only happen in aerobic conditions (does it happen immediately upon sealing the barrel?) Perhaps the rise is in wax coatings, as the leaves suffocate? Do the wax coatings eventually break down through fermentation to become digestible fats?

My animals like most ensiled leaves as well as they do the same fresh, accepting even aged offerings even in summertime, when they wander plus graze pasture. Retired UMaine Cooperative Extension forage specialist Rick Kersbergen once told me “It’s all downhill, from fresh.” Maybe so, but it’s not a steep hill.

Dairy One 2023-2025 data comparing PAIRED FRESH & ENSILED leaf-samples (pdf formatted to print on legal-sized, landscape-oriented paper)

Harvest Date Effects

I divided our Fresh/Ensiled sample-pairs into 3 harvest-date categories, to look at the interaction of said-to-be lower protein at later harvest-dates, less warm weather left for fermentation in those harvested later, and any other observations related to date. Both comparison spreadsheets below have limited validity due to differing harvest-sites per date-period. The 1st and 2nd pages of the original "Dairy One data comparing PAIRED FRESH & ENSILED leaf-samples" spreadsheet ABOVE are actually as informative, with differing harvest-year groupings averaged across samples. (Different harvest-year groupings of Fresh samples especially have different average harvest dates, with 2025 having the earl;iest. Please refer to the "% DM & Harvest-Date Averages" sheet further above, included as a photo and also a link to pdf, to cross-refererence harvest-date averages for different harvest years.)

Dairy One PAIRED FRESH & ENSILED samples, HARVEST-DATE categories COMPARED

(pdfs above & below are formatted to print on legal-sized, landscape-oriented paper**.)**

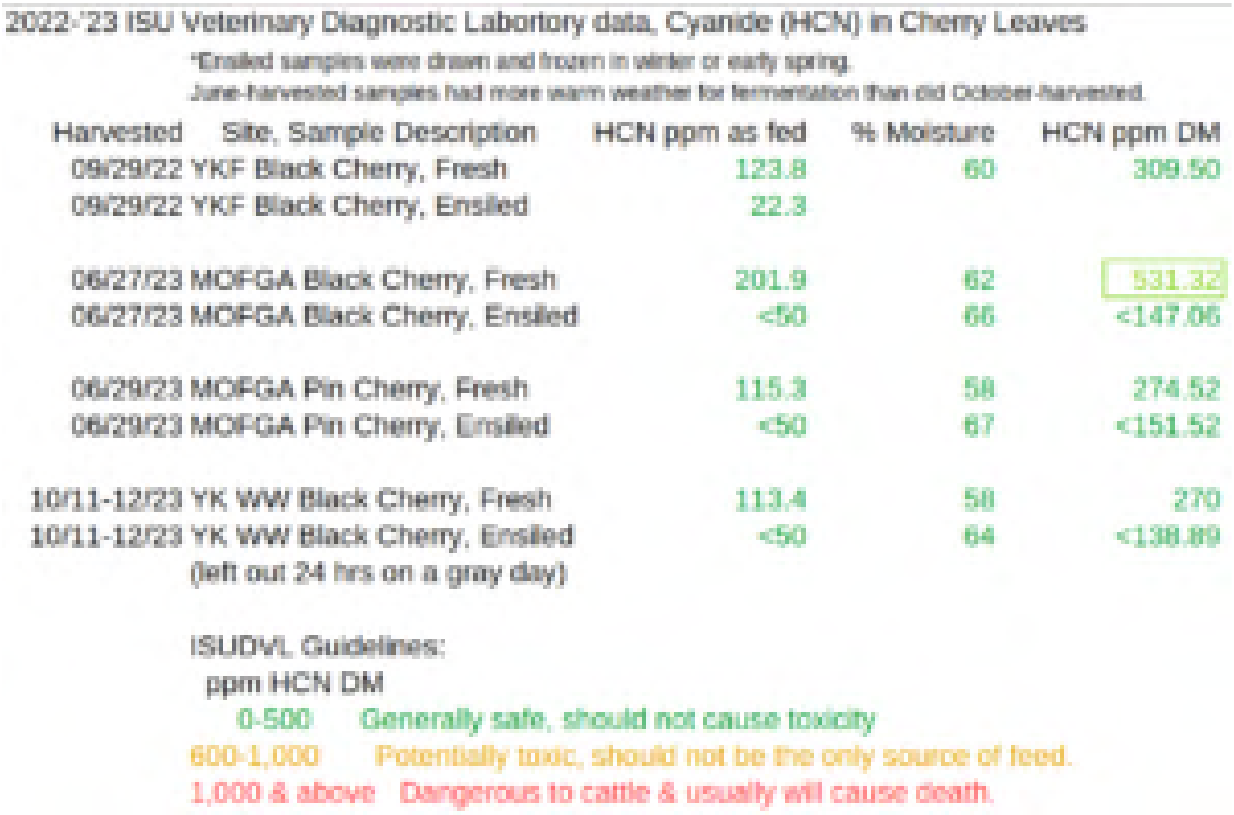
Selected leaf-samples comparing 3 HARVEST-DATE categories

TOXIN ANALYSES

Cyanide in Cherry Leaves

Initial results: Cyanide (HCN) tests on 4 fresh & ensiled sample-pairs, 3 of Black

Cherry and 1 of Pin Cherry, from our 2022-2023 harvests showed very safe reduction of Hydrogen Cyanide with ensiling. Even fresh levels were below the toxic threshold.



2022-'23 ISU Veterinary Diagnostic Laboratory data, Cyanide (HCN) in Cherry Leaves

*Ensiled samples were drawn and frozen in winter or early spring.
June-harvested samples had more warm weather for fermentation than did October-harvested.

Harvested	Site, Sample Description	HCN ppm as fed	% Moisture	HCN ppm DM
09/29/22	YKF Black Cherry, Fresh	123.8	60	309.50
09/29/22	YKF Black Cherry, Ensiled	22.3		
06/27/23	MOFGA Black Cherry, Fresh	201.9	62	531.32
06/27/23	MOFGA Black Cherry, Ensiled	<50	66	<147.06
06/29/23	MOFGA Pin Cherry, Fresh	115.3	58	274.52
06/29/23	MOFGA Pin Cherry, Ensiled	<50	67	<151.52
10/11-12/23	YK WW Black Cherry, Fresh	113.4	58	270
10/11-12/23	YK WW Black Cherry, Ensiled (left out 24 hrs on a gray day)	<50	64	<138.89

ISUDVL Guidelines:
ppm HCN DM
0-500 Generally safe, should not cause toxicity
600-1,000 Potentially toxic, should not be the only source of feed.
1,000 & above Dangerous to cattle & usually will cause death.

2022-'23 ISU VDL data, Cyanide in Cherry Leaves, 4 matched Fresh - Ensiled pairs

2022-'23 ISU VDL data, Cyanide in Cherry Leaves, 4 Fresh & Ensiled Pairs (<-- pdf link, in case above screenshot is not clear)

Struggles for a Cherry-leaf set with all treatments: In 2024 I made a full set of Y Knot Farm black Cherry samples with all combinations of fresh, wilted, and ensiled, but used double zip-lock quart freezer bags to ensile. This had worked for late-harvested 2023 samples in a basement, but these early-harvested ones in my warm house leaked and molded (the bags also seemed thinner with different texture – did they change design?).

In 2025 I collected samples on May 21st and June 3rd from mature Black Cherry trees at Y Knot Farm that were similar to those we harvested there in 2022 and '23. Such early-cut cherry leaves are reported to be more toxic, as are wilted leaves. June 3rd to 4th, I packed my 3nd try at a full matched array of 12 samples: fresh, ensiled 30 days, ensiled 60 days, and ensiled 90 days, then after branches wilted for 4 hrs in the trailer, 2 similar sets of 4 but first leaving one set to wilt for 4 hours and the other for 24 hours, before packing and sealing, this time in plastic wide-mouth laboratory containers with foam lid-liners (that worked). I also made a Dried sample from same harvest, but unfortunately packed that in bags (why that mattered becomes evident, if you read far enough into my typing).

All spring I was also collecting sample-pairs for Wayne Zeller's C Tannin work, and the ensiling ones for both purposes cluttered my cupboard, such that I did not notice my oversight of the 4 hrs wilted "fresh" Black Cherry sample, that had gotten in there instead of directly into the frreezer (my farm gremlins are interested to participate in anything I do here).

So on July 3rd I harvested my own stand of small Black Cherry pollards, selected new growth sprouts for higher Cyanide content (since the date was late), and made my 3rd try at a complete set of 12 samples that day and the next (again in plastic laboratory jars, and this time all made it into the freezer on designated days as planned!). I ran brush with remaining leaves of older growth through the Chain-Flail Leaf-Separator, to almost fill one barrel (a winter treat for my animals).

I did not have a protocol of weighing samples for equivalent air inclusion, and on retrospect should have done this. A few samples had a piece of bubble-wrap inserted at top to take up a bit of extra space (when leaves from each treatment were running out) - instead of a piece of paper that I use to make sure leaves don't get under the sealing edge - and I failed to note which ones had that extra space with bubble-wrap.

It is a daunting and pressured task for one farmer (whose animals rely on me wandering with them most of every day, and/or climbing trees) to get all those samples harvested then hand-stripped and packed, at right stages of wilt across two days. Choosing to up Cyanide potential by using new growth only precluded use of the SARE FNE22-013 Chain-Flail Leaf Separator, and even when I do use it, I remove sticks and twigs further by hand. Each quart jar packed tightly with leaves and labelled took me about a half hour, so the "wilted 4 hrs" and "wilted 24 hrs" are approximate.

A barrel of Black Cherry leaves from my sampling harvest, &

Observations: On December 24th and December 25th, I fed that barrel of older-growth leaves from the July 3rd harvest to 7 happy goats and the steer, Angelo.

Angelo ate a good quantity from a sled, for about ½ hour, then took a hay and water break, came back to eat more and I'd passed it to the goats. So he asked for me to open the barrel, which I did. The second day he had a sled-full and took the same break – can he sense Cyanide? I sent in no test of those older leaves (I wished to, but was already sending more tests than the grant funds were covering). The 7 goats did not have enough between them, so ate all straight up.

Angelo and the goats eagerly ate ensiled older leaves from my 7/3/25 Black Cherry sampling; Angelo took a break after half an hour, each day (does he know to let internal Cyanide dissipate?).

An animal can eat the toxic dose in a day and be fine, if they do not eat it all at once; Cyanide acts quickly, but then also exits the body quickly (at least when not fatal).

During our SARE FNE22-013 winter 2023-'24 trial, my animals ate free choice amounts of ensiled Black Cherry during 2 hr offering-periods, but with 2 other leaf-

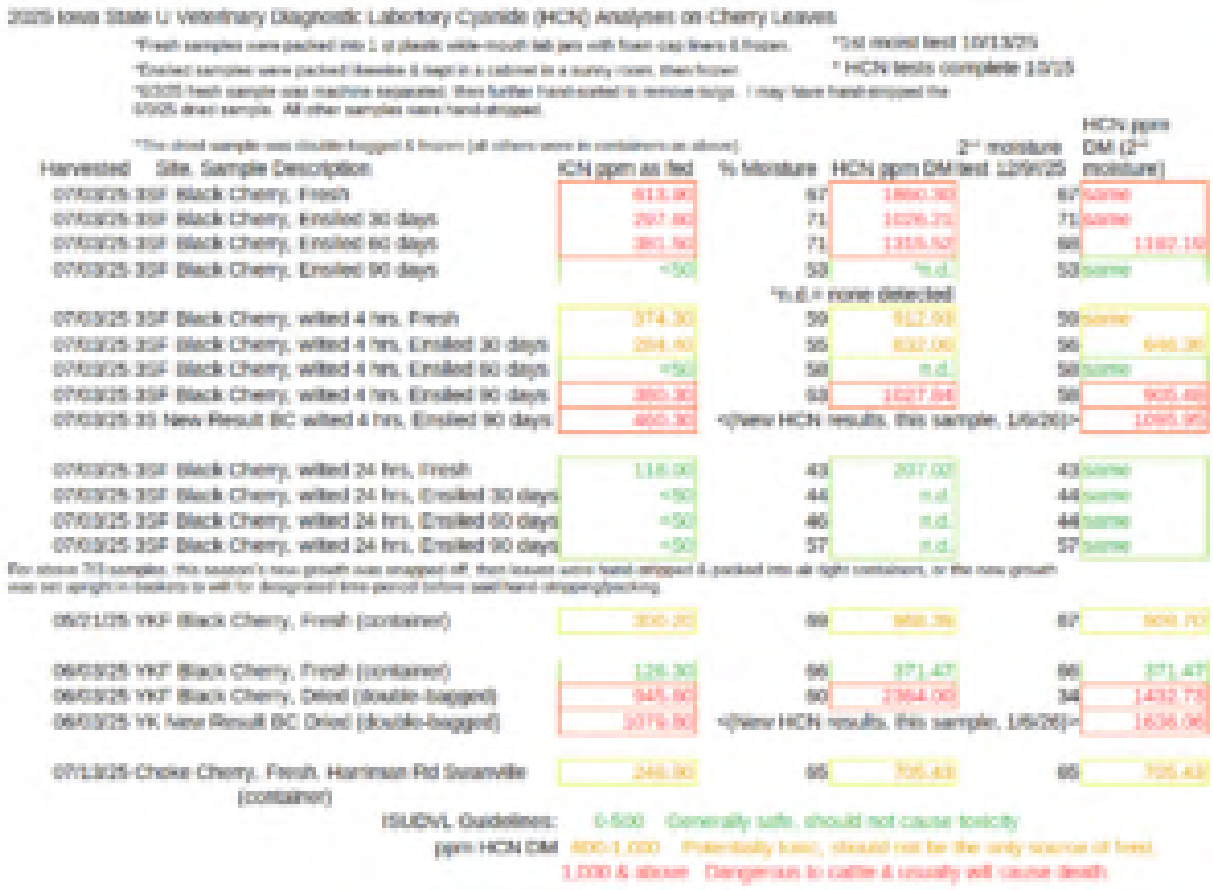
silage species simultaneously offered – except on one day (February 7th, the 5th measurement day of 7 in the last trial-rotation, when barrels were almost gone). That day, goats got just 2 species, Quaking Aspen and Black Cherry. Angelo was entirely refusing Quaking Aspen, so he ONLY got Cherry; he'd had one previous day like that (also in last rotation, when goats got Cherry along with Quaking Aspen and least palatable Gray Birch). Both those days Angelo was offered 14+ lbs as fed; on the earlier date, he ate 11.5 lbs and on the latter 9.25 lbs as fed; the 1st barrel (#9, harvested 6/30/23 and packed 2 days later in gray weather at MOFGA) had 40.3%DM, and the 2nd (#46, harvested and packed on 9/2/23 at Y Knot Farm) had 41.9%DM, so he ate 4.63 lbs DM and 3.88 lbs DM of ensiled Black Cherry leaves, respectively.

2 to 2.5 mg Cyanide per kg body weight is considered a fatal dose. Some Cyanide levels in my 2025 samples below, ensiled in small jars versus barrels, hand-stripped rather than machine-separated, frozen at lower temperatures than barrels outdoors, and with new growth selected separately from old, would have been sufficient to kill Angelo twice over, if levels were as high in Black Cherry leaf-silage that he ate so well on each of the above-discussed winter 2023-'24 trial days.

I saw my animals for the first time sparsely eat (versus gobble) fresh-cut Black Cherry from a lightly pollarded tree in their pasture this past early summer (2025). They did finished all leaves within a day. I really do conjecture that they know when to stop eating. Susan Littlefield, Y Knot Farm, has bountiful Black Cherry pollards and observes similar behavior in her milking sheep.

In June 2025, Susan Littlefield was admiring growth from our 2022-'23 harvest of her Y Knot Farm field edge. Her sheep enjoyed some 2025 excess Black Cherry from my sampling of a large tree not previously harvested.

2025 (strange) results: After a busy summer, I finally sent the July 3rd, 2025 frozen multiple-treatment 12-sample set, 2 Fresh samples with 5/21 and 6/3 harvest-dates, a matching Dried 6/3/25 sample, all Black Cherry, plus 1 Fresh 7/13-harvested sample of Choke Cherry, to Iowa State University Veterinary Diagnostic Laboratory (ISU VDL), and received results in October. Those results were not what either Scott Radke, ISU VDL Toxicologist and Director, nor I expected.



2025 ISU VDL data, Cyanide in Cherry Leaves,, Young, Fresh, Ensiled & Dried plus Choke Cherry

2025 ISU VDL data, Cyanide in Cherry Leaves, updated (<--pdf link, if screenshot above is not clear)

2025 ISU VDL Cyanide (HCN) results had one trend opposite of expected, and two sample results that were extreme exceptions to expected patterns. The fresh 7/3/25 sample, with leaves selected from new growth sprouts only, had higher Cyanide than did the same “wilted 4 hrs,” and then “wilted 24 hrs” had even less.

25 Black Cherry new growth wilted 24 hrs, baskets of same wilting 4 hrs outdoors, & new jars for ensiling; the paper on top helps keep leaves from intruding into seal as the lid is screwed down.

Perhaps the samples dried somewhat versus wilting; wilting is supposed to increase Cyanide, and drying is supposed to reduce Cyanide. But the 6/3/25 pair had 2x the fatal threshold level in the Dried sample versus the Fresh, which was well below toxic level. The dried sample somehow had gotten just as wet as the fresh; later a

2nd run of the moisture test registered half as much, but still 3x as wet as dried 2018 samples which I sent for nutritional testing in 2020. (They started out crisp; I regret double-bagging versus using a plastic lab jar with better seal.)

The commonly understood trend of Cyanide reduction when ensiled loosely held but with one frightening exception: 7/3/25 “Ensiled 90 days” sample had a bit more Cyanide than did the matched Fresh sample, jumping it to just above the fatal threshold. In the same matched set, 30- and 60-day ensiled samples had less than the Fresh sample, with a less-than-measurable amount in the “Ensiled 60 days” sample.

On 1/6/26, he lab kindly re-tested both the 6/3/25 Dried and the 7/3/25 4 hrs wilted ensiled 90 days samples above, that had such unexpectedly high levels. New levels were even slightly higher (new and old figures are included in the above spreadsheet).

I opened an unsent 6/3/25 ensiled then frozen sample, and it seemed properly fermented, despite the small quart container. Was there some way that Cyanide released by leaves got trapped in a non-gaseous form in my sealed containers, and so didn’t dissipate when opened?

What was happening? Scott Radke, Toxicologist and Director at ISU VDL, took generous amounts of time, intermittently for the next three months, consulting his past toxicology mentor, talking to me, and authorizing bits of re-testing at the lab.

Here are some details we pawed over, beyond my confession above about differing packing densities: All 2025 samples were frozen (some previous 2022-’23 ensiled samples were not frozen); 2025 samples were ensiled in containers that were not

opened prior to testing (2022-’23 samples were drawn from larger containers into double bags); the 2025 dried sample which got so wet was double-bagged & frozen, but in ULine bags with imperfect zippers. All 2025 samples were packed and the whole inner box went back in the freezer, before wrapping in a plastic bag and additional outer box at time of sending, a day or two later. Then all were sent in that one package by FEDEX overnight service (2022-’23 samples went piecemeal by UPS 2-day or slower ground service).

None of this got us much closer to understanding, except to recommend future studies using more separated packing with additional layers of plastic (that freezer does have a lot of frozen condensation, and perhaps condensation on cold samples once laid out to thaw at the lab might have gotten into the imperfect zipper-seals of that Dried sample?), possibly more real-life large-batch ensiling, and at least more careful weighing for equivalent packing density, and note-taking… if ever someone takes this up where I’ve left off. :)

Scott Radke sent me an article (linked below), about similarly irregular high Cyanide (a.k.a. Prussic Acid) results from drying regrowth of Sorghum. The authors indicate that if leaves are intact versus damaged, they can re-activate & make more HCN, even when dried.

https://enewsletters.k-state.edu/beeftips/2025/09/01/good-news-and-bad-news-on-prussic-acid/

I machine-stripped the 5/21 Fresh sample, & then hand-stripped to remove twigs; 2022-’23 samples were all machine-stripped then sorted similarly. But I used no machine & only hand-stripped the 7/3/25 samples, by running my hand down new growth only (hoping to get the highest Cyanide level in this young growth). I may have also hand-stripped the 6/3/25 dried sample. Perhaps doing that was less damaging? Yet our machine-separated leaves look mostly intact. And I would have thought that drying for many days in a sunny room & then freezing would cause sufficient damage to release all Cyanide potential, in that fatal dried sample.

As I type on January 11th, I await re-testing of Cyanide levels in those 2 worst samples, which Scott Radke has kindly gotten authorized for no additional charge.

Please if you know more about chemistry which may have happened to cause such results, CALL me! & leave Voicemail: (207) 338-3301

Gallic, Ellagic, & 4 non-proteinogenic Amino, Acid Toxins in Maples, Box Elder & Staghorn Sumac

A goat at Locust Grove Woodworks, Unity ME, died a few years ago of bloat from Box Elder, when fed in a stall with limited choices. Leaves of large, vigorous coppiced Box Elder from Diane and Kevin Weisner’s sunny roadside, Hubbard Brook Farm, Hunt Rd. Unity, ME, were eaten without issue by my steer and goats at June 28th, 2024 time of sampling for metabolomics work, but were refused when harvested from the same site in 2025, on May 1st, May 23rd, and June 21st (my palatability ratings were .5, .5 and 0 respectively, on a scale of 0 to 3, with 0=“refused without tasting,” 1=“tasted,” 2=“eventually consumed) and 3=“immediately consumed”).

This Box Elder harvested on 5/23/25 was REFUSED; they are just checking it out, here, without tasting. Later I saw a bite off – not sure who tried it; I suspect that was Angelo the steer.

Huge healthy growth of a pollarded tree in Unity at MOFGA South Orchard harvested on July 20, 2024 was also refused, when fresh and when ensiled. Yet at least 2 farmers, one in Windsor ME and one in NY State, have told me that their animals use significant amounts of Box Elder without issue.

Diane Weisner (Hubbard Brook Farm, Hunt Rd source of my samples) suggests feeding more repeatedly, to develop familiarity, or in case my animals' rumen microbes need some shift specific to Box Elder. My animals can count on long daily to twice-daily attended free wanders, or fresh Red Maple in winter, so I'm not sure this would work – though my animals have exhibited evidence of a rumen-adjustment process with more palatable White Birch, when felled in late June.

The Kitchen Box Elder (also previously pollarded) in Unity at MOFGA had a 2x+ greater spike of Hypoglycin B than our other 2 Box Elder samples in 2024. I re-pollarded it on June 21, 2025, and dumped it in shade by my driveway, where my animals passed by but (not surprisingly) took no interest.

(Before sampling, I spent most of a day driving and hiking, looking for Box Elders nearer than Unity. The only nearer Box Elder I found is along the downtown Belfast Rail Trail, in a narrow patch of well-disturbed soil between the rocky bay-front and the parking lot of the old potatoe factory. Karl Hallen, my Tech Advisor, sees lots of Box Elder in NY State and has observed them to thrive in toxic places.)

As noted in Westermann (2016), regarding levels of Hypoglycin A in Maple species), toxin levels can vary greatly from tree to tree. Our species with highest spikes of each toxin had broadly ranging levels among (3) same-species samples, mostly* taken within a day of each other. My animals will browse individual trees or shrubs selectively.

** Jack Kertez froze 2 samples of Box Elder from MOFGA, Unity, for me on the right day, while I was sampling in Belfast. When I fetched them, the trip home to my freezer had other stops; the samples thawed and I worried that their condition was too deteriorated, or at least dissimilar to other samples. So I collected 2 fresh Unity re-dos 4 days after the Belfast sampling.*

The animals' discernment is much more affordable than metabolomic analyses (plus the lab did not have the ability to quantify above toxins other than Gallic and Ellagic Acids), but sometimes the animals aren't present for my forage harvest. Scandinavian farmers of antiquity were said to taste tree leaves themselves, to know when to cut; this pertained to timing for best nutrition and tree carbohydrate stocking (probably not to toxin levels?). Short of that skill (though my NOSE DOES say Box Elder is not tasty when wilted or ensiled), and hoping that your animals are discerning enough to also guide you, I proceed to report comparison of our 3 samples-per-species average measurements (Gallic & Ellagic Acids) and comparative spikes (Hypoglicins and homologues):

Box Elder (often toxic), Norway Maple (non-toxic), Sugar Maple & Red Maple (both slightly toxic) leaves, fresh from the Leaf-Separator in 2023

Box Elder metabolomic analyses showed spikes of Hypoglycin B (HGB) and of related γ-glutamyl-MCPrG in each of 3 samples to be drastically higher than in our other species, with HGB barely present at all in other species. Box Elder was 2nd highest in HGA (to Sugar Maple, though one Sugar Maple sample was much lower), but lower in average spike-level of HGA homologue Methylenecyclpropylglycine (MCPrG) than all other species tested, with range similar to that of Staghorn Sumac and Norway Maple.

Our spikes of HGB in Box Elder leaves were consistently much higher than spikes of HGA; this was in contrast to findings of El-Khatib et al. (2022), who reported spike-average of HGB in leaves to be 26% of HGA spike-average. They quantified HGA in their leaves at 535 mg/kg DM.

Red Maple leaves are used by my livestock if eaten alternately with other forages over time. In our SARE FNE22-013 3 Streams Farm trial, goats averaged a low 1 lb As Fed (lbs DM) per goat in the 2 hr offering-periods, with 1.5 lbs As Fed (lbs DM) maximum average per goat (across 10 goats), and steer Angelo averaged 1/2 lb As Fed (lbs DM) with 1 lb maximum (lbs DM); 2 other leaf-silage species usually were offered just after interest in Red Maple slowed, during the 2 hr periods. Animals then finished last leaves plus all the twigs overnight. Winter twigs and bark are an immediately-consumed staple for us, with seemingly less digestive limitation than leaves. When I have brought home Sugar Maple, animal response has been similar (but with slightly less choice twigs and bark).

Red Maple leaf results show Free* Gallic Acid (GA) and Methylenecyclpropylglycine (MCPrG – homologue of Hypoglycin A) to have much higher spike averages than in the other species tested. All species tested showed HGA; Red Maple had the 2nd lowest level (Norway Maple had the lowest).

Both Gallic and Ellagic Acids have been batted around in research as potential additive to cattle feed to reduce methane emissions, or other benefits. Here's the latest quite detailed study I found, with conclusion that "more research is needed," before feeding these acids *in vivo* to cattle: Manoni et al. 2024: Gallic & Ellagic Acids Differentially Affect Microbial Community Structures...

More surely, Gallic Acid does have positive antioxidant health benefits for humans (Wianowska & Olszowy-Tomczyk 2023: A Concise Profile of Gallic Acid...). I live on Goats' milk, and the goats (and steer) do eat some Red Maple leaves regularly. I did not find anything about whether Gallic Acid makes it into milk (clearly not enough to curdle the milk, thank goodness).

**A discrepancy seemed to exist in the Free and Hydrolyzed (which was supposed to indicate Total GA, including free GA plus GA in more complex molecules such as toxic hydrolyzable Gallotannin) GA figures. In 7 of 12 samples (across species and including all 3 samples of Red Maple), Free GA level was higher than Hydrolyzed. Ellagic acid (EA) figures less strongly had the same issue.*

Zhentian Lei explained (1/16/25 email): " The hydrolyzable data (hydrolyzable gallic acid and hydrolyzable ellagic acid) contain the free data. Because the hydrolysis was performed at high temperatures in strong acid, some free gallic acid could be lost due to degradation. Thus, the free gallic acid is a better indicator of its content in the samples while hydrolyzable ellagic is a better indicator of ellagic content in the samples."

Sugar Maple had contrastingly low levels of the 2 toxins in Red Maple, while Hydrolyzed Ellagic Acid and Hypoglycin A were much higher on average in Sugar Maple than in ant other species.

It interests me that Hypoglycin A (HGA) showed a much higher spike in our Sugar Maple leaves than in our Box Elder leaves, and (homologue of HGA) Methylenecyclpropylglycine (MCPrG) showed a much higher spike in our Red Maple leaves than in those of Box Elder. I had found these toxins mentioned in literature as present in Box Elder and Sycamore leaves (plus maples in the Netherlands that we do not have: Westermann et al. 2016). On reviewing saved sources of info, I did find two studies confirming HGA in Sugar Maple (Novotná et al. 2023; Fowden & Pratt 1973).

El-Khatib et al. wrote that Hypoglycin B (HGB) and its homologue γ-glutamyl-MCPrG had been found in maple species 50 years before (Fowden & Pratt 1973, mentioned above) but were subsequently overlooked until their 2022 study, and all that time HGA was assumed to be the sole cause of poisoning from both Box Elder and Sycamore. (As mentioned above, we found higher HGA in Sugar Maple leaves than in those of Box Elder).

Norway Maple is a highly edible fodder tree from Europe, with leaves that my cattle and goats consistently devour. The leaves stay bright green when ensiled. Our results confirmed low presence of toxins indicated by other researchers (El-Khatib et al. 2022, Westermann et al. 2016).

Striped Maple bark is stripped from young trees by my goats, before it gets established here; I therefore thought they might like leaves from my blueberry property, but they didn't like them as well as I expected. Wayne Zeller screened relative level of Condensed Tannin in Striped Maple at "10" (on a 1 to 10 scale; Norway Maple was scored 3.5, and Red & Sugar Maple scored 5); I'm guessing that some of the toxins in other maples are there as well, and I'm sad that due to budgetary limitatiions, we did not include Striped maple in metabolomic analyses.

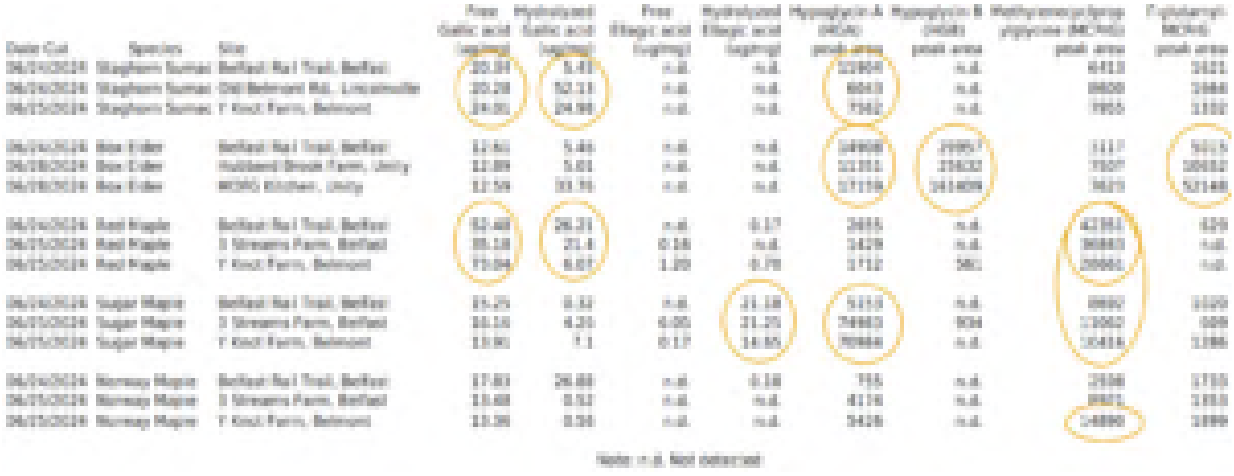
My palatability ratings for their spring of 2025 responses were 1.5= "tasted and ate a bit," when offered out on a walk, and 2= "eventually consumed" to a rare 3=

"immediately consumed" when small qiantities were given in their yard. On June 1st , 2025 Angelo ate some, then left the rest and went to point to Gray Birch in a sled outside the fence. June 24th was no better. September 6th through leaf-drop we lived on the blueberry parcel, and I never saw Striped Maple selected.

Staghorn Sumac is considered by Susan Littlefield to be a choice forage for her Y Knot Farm sheep; my goats refused senescing leaves but ate a few berries, in October of 2023 (the only time we were near some, that year). In 2025 they accepted some in their yard on May 28th, then we stayed on my blueberry field where it is a young weed, for most of June and then September 6th through December 6th. They hardly ate any leaves of that young sumac, but on the way there on September 6th, they briefly gobbled some leaves of a taller specimen along a shady road. Once leaves fell, they started stripping bark of the young field specimens quite eagerly.

Staghorn Sumac results showed second highest average Free GA level (well behind Red Maple), but higher Hydrolyzed GA average than Red Maple, with one sample twice as high as the highest Red Maple sample. The Staghorn sumac sample with lowest GA figures had HGA spike in range of that in our Box Elder samples.

As above described, my animals have given preliminary indication that as with Red and Sugar Maple, the bark has less or no toxins as compared to leaves, so fresh cutting and feeding in winter may be better use than ensiling summer leaves.



MU Metabolomics Center data on Toxins in Maple Species & Staghorn Sumac

MU Metabolomic Toxin Results on Maple Species & Sumac, Final

(pdfs above & below are formatted to print on legal-sized, landscape-oriented paper**.)**
MU Metabolomics Charts & Graphs made by Gentian Lei (edited slightly by Shana)

Antifeedants in Birches: I have in past looked for chemical info explaining my animals intermittent use of **Gray Birch** with a lot of refusals once stored, and somewhat less limited use of White Birch, to no avail. Yet just now I Brave-searched "Antifeedants in Gray Birch that inhibit browsing by animals" and got this: "**plant secondary metabolites**, including **alkaloids, tannins, and terpenes**, are known to contribute to antifeedant properties in birch species. These compounds are often bitter or toxic, reducing palatability and deterring feeding. For example, **bark**

phenolics and volatile terpenes in birch trees have been shown to reduce herbivore feeding behavior." Yet still I found no studies specific to birch, and cannot (at this late date of report submission) chase the references in general antifeedant studies. *Please call me if you do so, with palatable morsels of info for me to ruminate on, while I watch my herd devour Gray Birch fresh, next spring or fall: (207) 338-3301.*

Yet I included this section, to at least summarize my animals' limited intake amounts of Gray Birch leaf-silage from our SARE FNE22-013 3 Streams Farm trial, and tell you that our quite eager fresh eating of Gray Birch in spring or fall is more predictable and worthwhile than our storage efforts, either ensiled or dried.

White Birch leaves are preferred to Gray Birch when fresh or ensiled, with spring or fall harvest still preferred, and *hybrids* of the two seem to retain benefits of White Birch (wild hybrids seem to abound on our blueberry land, but as yet least palatable but best soil pioneer Gray Birch dominates).

Yellow Birch leaves are well-received all season whether fresh or ensiled.

If **leaf-species mixes** are to include Gray Birch, perhaps intake levels during the once-per-day 2-hr offering-periods in our SARE FNE22-013 3 Streams Farm trial can give some guidance; note that once interest waned for these species, I then stopped adding more and started offering other leaf-species (with aim for them to eat leaf-silage to full capacity, during those 2 hrs).

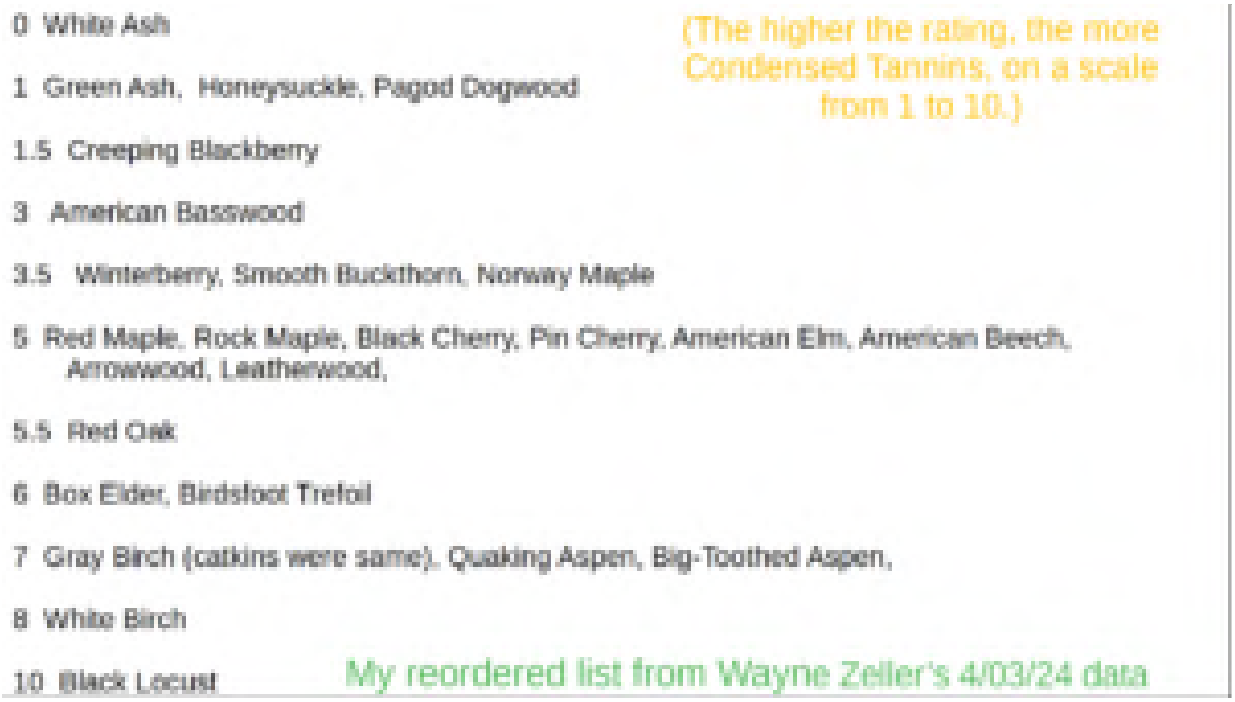
Gray Birch intake levels are offered here above levels of next most intake-limited Red Maple leaf-silage (discussed under Red maple in Maple Toxin section above).

	Lbs As Fed 1 Goat ave	Lbs DM	Lbs As Fed 1 Goat max	Lbs DM	Lbs As Fed Steer ave	Lbs DM	Lbs As Fed Steer max	Lbs DM
Gray Birch	0.25	0.11	1.00	0.46	1.58	0.73	4.50	2.07
Red. Maple	0.98	0.44	1.47	0.66	0.50	0.22	1.00	0.45

SARE FNE22-013, 3 Streams Farm Trial Goat & Steer Intake of Gray Birch & Red Maple Leaf-Silages

CONDENSED TANNINS (CT) *

Wayne Zeller, US Dairy Forage Research Center in Madison, WI, screened and continues to screen tiny fresh leaf-samples for comparative levels of Condensed Tannins (initially we used one ensiled: Quaking Aspen, as I had no fresh saved when we started collaborating). Some samples came from our 2023 harvests, plus I collected many more samples, including fresh/ensiled matched pairs of large samples, in 2025. Wayne is isolating, purifying, and identifying tannins from large-sample pairs of all species rating “5” or higher (and he is right now grinding leaves in order to screen the additional 2025 species). So far, CT in 4 species, including that in fresh and that in ensiled leaves, has been isolated, purified and identified. Wayne has been short of help at the lab, but a student will join him in this work very soon. They have fresh/ensiled sample-pairs of 22 to 31 species left to do! We’re not sure how many because 9 depend on unfinished screening results.



Relative concentrtion of Condensed Tannins, my list from Wayne Zeller's 2024 data. Note Birdsfoot Trefoil rated aat 6, for comparison.

Wayne Zeller's C Tannin Screening Method & Results with Photos, my slides and 3 of Wayne's used in NOFA MA 2024

To explore change in relative CT level across different harvest-dates, Wayne and his student will also be grinding and screening lots more tiny samples of a few species, just for my own curiosity. It's my fault that 9 species-screens are not done, as Wayne was waiting for all my date-screen samples to be there, to dry, grind and then screen all at once. If his results on my date-screens are complete soon after SARE's report deadline, I will update this report (per NESARE permission), to include those results here.

Wayne's CT identifications are breaking ground for other researchers to look at effects of woody forages on cattle protein utilization, methane emission and digestive efficiency, and internal parasites. Wayne is already collaborating with another USDA ARS researcher who will be running methane and digestive tests, in a continuous-feed rumen-simulator. (When I called him this week, he was in midst of dividing out and packing portions of my leaf-samples to send to her.)

Watch the scholarly journals for their articles, hopefully to be published by end of 2026 or start of 2027.

Wayne will soon retire, but he is committed to finishing this woody chunk of work with me, first. We need a younger scientist to take up his baton of CT work with woody forages in particular; most CT study is aimed at leguminous field crops (Alfalfa, White Clover) bio-engineered to produce CT, or naturally CT-producing field legume Birdsfoot Trefoil, versus historic and ubiquitous woody tree/shrub CT sources *with as yet unidentified CT structures (until Wayne completes these)*.

When Wayne retires, the scientific community will also experience a gap in CT expertise in general, as Wayne currently performs expert CT services for other researchers with a full spectrum of CT-related studies (he has those bioengineered crops in his freezer, along with my leaves).

Thank you, Wayne, and also a big thank you to Andrea Clemensen, Environmental Biologist, USDA ARS Northern Great Plains Agricultural Research Center, for connecting us. Andrea co-authored an excellent article on Tanniferous Forages. I

found her through that article, and she immediately agreed to a phone conversation, then organized a one-time multi-researcher zoom meeting where Karl Hallen and I described what we were doing, to foster collaborations. It worked!

* *All of this CT work was/is above and beyond our SARE committed research plans.*

RATION-PRODUCING STRATEGIES, & SETTING SPECIES PROPORTIONS (with regard to toxins, tannins, & other intake-limiting antifeedants)

Intake Summary per 9 Species of Leaf-Silage, offered as Rationing Guidance: I made a new spreadsheet using data from the 2023-'24 SARE FNE22-013 livestock trial at my farm, to make best use of animal guidance. Toxin and antifeedant information are spotty at best, with complexity of numerous compounds that the animals do seem to be better able to sort, than are researchers and laboratories at this point. At end of this spreadsheet, I've ordered leaf-silage species by intake of goats (most to least), and then of the steer. Intake levels were measured during once-per-day 2-hr offering-periods, with late-cut 1st-cut hay offered 24 hrs per day (no concentrates). Note that 3 leaf-species were generally offered side by side. These intake amounts are therefore NOT indicative of one leaf-species limits (excepting for Gray Birch and Red Maple, which I tended to offer first, in order to get animals to eat any at all).

3 Streams Trial Goat & Steer Ave & Max Intake Lbs, & Preferences Alongside Nutritional Data

(For full report on that trial, look for Hanson 2020[a] full reference for SARE FNE22-013, at end of "Introduction" section above.)

Efficient Production of Leaf-Silage, & Species-Mixing: Karl Hallen, my Tech Advisor and machine creator, is well-educated in cattle nutrition and keeps abreast of new info, used to dairy farm, and is a farm and forestry consultant on the side of his SUNY ESF Willow Biomass Project job. He thinks that for broad farm use of wild woody forage, woody harvests cannot efficiently descriminate by species, so mixing leaves in smaller pieces should be tried. Most* toxin-levels in Northeastern tree/shrub species can be sufficiently diluted through such mixing, to negate danger. (* *I say "most" because I am not sure about Lambs Kill, our wild laurel. Other well-known Northeastern toxins are in herbs such as Helebore and Hemlocks in the carrot family, not in wild woody forages.*)

I'm not sure that such mixing will work. My animals' input is that when species are palatable but poisonous, as in the case of Cherry species, mixing might be a perfect way to remove risk. But when toxic species are unpalatable (my animals indicate that's the case with most Box Elder batches), I fear that mixing will lead to poor utilization, thus wasting the tasty species along with the unpalatable. If you don't like Lima beans and asparagus, will you happily eat them if I mash them into a soup of other vegetables?

Very few species are unpalatable at all times, nor toxic at all times. Many species become unpalatable during certain parts of the growing season (Gray Birch being the most troublesome and hard-to-guess example of this on my farm). Also, animal groups differ in what they find palatable; this may reflect differing acculturation of their rumen biome, differing soils on their farms, different dietary array available, specific content that they are lacking, simple habituation, or other factors that the animals will have to tell us. :)

When/if wholesale industrial harvests of woody matter become available to farms, some indication of species content proportions or at least species array should be provided to receiving farms (and possibly Box Elder should be left in the woods – but I am biased on behalf of my own animals).

When farms develop their own wild woody forage edges, or develop fodder trees in fields (using existing or planted trees), or make whole areas of pollarded woodland on-farm, they can certainly respond to literal feedback from their animals, in decisions on area-specific and tree/shrub species-specific treatments. Excepting loads with known potentially fatal toxicity, bring a load of brush to animals whenever you are cutting, and if not well-utilized, try again for 4 days if you can. Sometimes animals' digestive microbes just need to populate in response to a new feed.

In such on-farm design, be alerted that stage of growth is yet another factor affecting palatability and utilization; my animals usually prefer tree leaves from well-developed growth out of reach versus from young coppice. I suspect that this is due to appropriate tree allocation of defensive chemicals (known as antifeedants).

On-farm woody forage designs can provide industrial-style harvests but with optimal species array with optimal years of rest between harvests, and optimal harvest-season timing (for best balance of palatability, nutritional value, and ongoing tree energy and health). When woody resources are developed on-farm or in leased areas that farmers control, all these factors can be fine-tuned to be optimally farm-specific, This includes herd specific, tree/shrub-growth specific, and yes, farmer-work-rhythm, farmer-method-preferences and any other farmer happiness-related specific. Susan's pollards are shorter than mine. :)

Some mechanical harvest equipment is readily available and in the price-range of other farm implements; for instance a sturdy sickle-bar on jointed arm or even one that simply tips to cut vertically can work when tree rows are trained as hedges for frequent (annual?) harvest. These small cuttings can be baled with normal hay equipment. Purchase of high-priced best industrial equipment to develop and harvest full-height side-canopies along fields will probably require farmer-cooperative arrangements for shared use and repair.

Karl and I suspect that aromatic compounds and countless other tree/shrub species-specific antifeedants (Hassan et al. 2020) that are not measured in nutritional testing, nor explored in my studies (except for unmeasured enjoyment of aromas when I open containers or barrels), are a huge factor affecting animal intake of tree and shrub matter. These compounds have positive medicinal qualities at correct levels, and also have intake limits, with anti-nutritiional effects when too much is eaten. These compounds differ per tree/shrub species, and animals balance them against each other with healthful effect. Again, offering multiple species separately is ideal to support animal selection, and mixing of species may work.

Once a significant quantity of woody forage can be stored, with broad mix of regionally prevalent species or better selection, in a form compatible with farm feed-out and waste-management methods, on-farm and researcher trials with greater numbers of animals can give better rationing recommendations than can I. I suspect that farmers and researchers will find that free-choice intake levels range, across different herds with differing diets, from minimal supplement to substantial staple, when offered along with usual feedstuffs (my steer ate leaf-silage as 1/3 his diet, while Nathan and Beth Zimmermans' cattle receiving optimal grass silage at Palmer Hill Farm only nibbled on pretty choice willow leaf-silage).

I suspect that farmers and researchers will have great animal performance results when mixed woody species or optimal species ration percentage is set based upon

such herd-specific supplementary free-choice intake rates. I suspect that at much higher % of rations (in case of grass-based forage sources becoming limited), such as 30-60% of forages for cattle, 60-100% for goats, and perhaps 40-80% for sheep, performance will drop mininmally, or be stable or even improved, once animals' rumen microbiomes adjust. Stable to improved is most likely when protein level is supplemented by that in remaining grass-forage proportion or concentrates, and of course larger farms and researchers would balance all nutrients within TMR (Total Mixed Ration). Based upon high energy levels in tree/shrub leaves (as discussed under NFC above), animals will require less total amounts of forage.

As on-farm need for shade and environmental cooling (through evapotransporation of leaf-surfaces) increases, and agroforestry and silvopastural systems take off, impetus is rising for others to follow my small farmer studies with more solid next steps, to fill out and firm up our still-spotty knowledge bank supporting use of temperate woody forages.

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Research conclusions:

3 Streams Farm goats eating ensiled Black Cherry, & Faithful Venture Farm cattle eating ensiled Red Oak in FNE22-013 winter trials

We wanted to:

- Understand the nutrition behind 2023 animal enthusiasm about (all except one species of) our SARE FNE22-013 machine leaf-separated field-edge tree/shrub leaf-silages from three sites (see SARE FNE22-013 Final Report, fully referenced in "Introduction" above, for details on the machine that Karl Hallen made, yields, etc.), plus explore additional tree/shrub species including those deemed “choice” by my animals but categorized “invasive,” with illegality of planting or sale in the State of Maine. We also wanted to detail and confirm or refute (now retired) Waldo County UMaine Cooperative Extension forage specialist Rick Kersbergen’s assertion that nutrition is “all down-hill” from fresh to ensiled, with comparisons of matched samples.

Honeysuckle was plentiful in our harvest for SARE FNE22-013 animal trials, but I had to specially seek out very tasty and nutritious Autumn Olive and Multiflora Rose, for use in this study. (Leaves shown above were all Chain-Flail Leaf-Separated.)

- Explore:

Why my steer and goats limit their consumption of regionally abundant Red (and Sugar) Maple leaves, but eagerly eat the twigs and bark in winter as a staple forage, and always devour fresh or ensiled Norway Maple leaves;

Why they only tasted fresh, and completely refused wilted Box Elder (another *Acer* maple species, sometimes called "Ash-leafed Maple") which I once brought from MOFGA (and why Kenneth Copp's doe goat in Unity died of bloat from Box Elder fed in her stall); and

Whether Staghorn Sumac which Susan Littlefield's Y Knot Farm sheep love (but my goats rarely browse except a few late berries, and even later bark, when we are near some in fall) has similar issues to maples - Karl Hallen had heard that Sumac also had Gallic Acid issues. (Ann Lichtenwalner, UME Animal Science Laboratories, now retired, had told me that Gallic Acid was one known toxicity in Red Maple, with other factors less understood.)

After sparse but fruitful literature-searching, we saw need to contribute new data to limited scientific understanding of multiple toxicities that may relate to our animals' responses to leaves of these Maple, Box Elder, and Sumac species, and chose Metabolomic Analysis examining 6 suspected chemical compounds.

Toxins in these species are especially pertinent to industrial leaf-silage sourcing where the farmer is not present to choose species, and to farms where animals are enclosed with limited experience and choice of browse. Forage experts need to understand what the toxins are, before measurement proceedures and level thresholds can be established.

- Delineate safe use of Black Cherry, and also test Pin Cherry and Choke Cherry, per Hydrogen Cyanide levels. (On retrospect, Elderberry, another highly palatable and nutritious but sometimes toxic forage, should also have been included in our Cyanide testing). Black Cherry grows substantially along field edges, and has been consistently a livestock top choice and sometimes staple forage for my own goats and cattle plus for Susan Littlefield's Y Knot Farm dairy sheep, when fed fresh, dried or ensiled.

Cherry leaves are said to be deadly when wilted; my animals and Susan's sheep eagerly eat a lot of cherry, and limit their own consumption when wilted. Farmers with less experienced animals need regionally pertinent information before initiating forage use of Cherry.

Black Cherry at Y Knot Farm in late September 2022 was below the toxic threshold fresh, & lost most cyanide when ensiled.

In 2 years time, with most everything else in my life except animals going by the wayside, and despite many lab-testing disappointments or surprises, we laid some good foundational pebbles to support the development of woody forage use on farms:

Usable Northeastern Nutritional Data: Our data will suffice to guide farmer rationing experimenttion with most common species of Northeastern leaf-silage, and fresh leaves as well. Trends are clear for well-known nutritional components. We still lack full understanding of intricate plant/animal antifeedant and medicinal chemical interactions, which we think strongly affect animal selectivity and intake of these deeply rooted, complex plants.

Farmer Awareness of Toxins: Countless farmers have thought to inform me not to use Cherry leaves (and my herd does use them), yet noone seems to know about dangers of feeding Box Elder. I hope that my discussion and metabolomic data regarding Box Elder draws farmer attention, to use Box Elder with caution, as poisoning symptoms are multiple and deadly, and differ from the bloat that my friends experienced: Bos et al. 2017, Boxelder tree intoxication in fallow deer & Dutch Landrace goats

Our Cherry-leaf Cyanide data indicates that Cherry species can indeed have fatal levels which storage methods may exacerbate or remediate (just one ensiled sample went up to a bit above fresh level, but our dried then acidentally wetted sample went WAY higher than fresh level). Yet our later-season 2023 harvests were safe for intermittent fresh eating, and safe in unlimited quantity when ensiled. Cyanide testing is affordable, and more data would be helpful.

I hope that my discussion of Maples alerts farmers that feed-out of barrels of Maple leaf-silage may take multiple days, with need to leave offerings overnight for full utilization (unlike some other species that are eaten without limits). These are some of our most numerous trees, and still worth using. Feed-out of fresh winter branches as I do is much more labor-intensive than use of leaves (one must turn the pile of cumbersome pieces repeatedly, to expose bark faces), but does seem to avoid toxin-related limits.

Angelo ate these raked Norway Maple leaves, which we were spreading in November 2025 for spring blueberry burning. A Norway Maple felled downtown in 2021 provided goats with a barrel of this tasty bright-green leaf-silage. Norway & Red Maple leaf-silages side by side show color difference. Angelo's bucket of Norway Maple leaf-silage came from our 2023 harvest for SARE FNE22-013.

Value of Norway Maple Leaves: I hope that our metabolomic data comparing Maples, Box Elder and Staghorn Sumac will change attitudes about “invasive” Norway Maple, for farmers to start utilizing this low-toxin, hand-snappable easily-harvested, choice European fodder-tree. I remain curious about the way Norway Maple leaf-silage retains the bright green color of fresh leaves; does this correlate with vitamin content? Aroma is minimal (but some of my favorite aromas in other species are actually antifeedant).

Landscape Benefits & Ecological Services of Regenerative Shrub Harvest: Our nutritional data on other blacklisted plants, including Multiflora Rose which surprised me by making it through the Leaf-Separator, and also especially including my ruminants’ 1st-choice long-season staple Smooth Buckthorn, strongly supports an approach of direct rotational browsing and regenerative forage harvest, versus uprooting and herbicidal extermination of these species. I’ve observed such shrub removal by do-gooders in my Belfast, Maine community to create an ongoing lack of green understory.

Impacts of herbicide on live soil, aquatic communities, pollinators, ourselves, and almost everyone I haven’t mentioned, are of course known to be detrimental. (*Some land preservation entities in Maine are indeed following our State’s directive to use herbicide. Preservation is apparently not required to be life-supporting*.)

A pro-life approach to “invasive” plants creates optimal biodiverse leaf-coverage, for climate cooling and soil-carbon increase, plus increased wildlife shelter and nesting sites. Browsing is known to increase biodiversity (Meuret & Provensa 2015), reducing long and tall growth, thereby stimulating concentrated dense growth of many species side-by-side. Such tending of growth maintains foliage height diversity (FHD), such a close correlate of biodiversity that it is used to estimate biodiversity - which is much harder to measure. Harvest cutting-cycles can do the same, supporting inclusive plant participation in multi-species communities (such participation is already happening even without cutting; Theodoropoulos 2003).

Some shrubs on the "invasive" plant blacklists are highly nutritious species from origins with domestic ruminant herd history. These species have through necessity developed hardy growth habits, to endure browse pressure, and are among our most viable Northeastern shrub-forages.

Surprises & Questions: As often happens, our multiple streams of new leaf-forage data have turned up these aforementioned curious surprises:

- Fat content rising when ensiled;
- Protein tests which gelled up and failed to yield results;

- Completely different toxin profiles in Red Maple and Sugar Maple leaves, edible but not choice;

- Zero screened rating of Condensed Tannins in White Ash, a highly tasty traditionally staple forage (we knew animals can eat more when tannins are low, but that is REALLY low!), while Black Locust scored 10 yet was as speedily consumed (and July-harvested Gray Birch at 7 was almost inedible – other antifeedants are probably at play).

So much work still to do... For a start, I'd love to know:

What type of fat increases through ensilement? and is it beneficial to the animals? Is the shiny cutin and wax leaf-coating on Gray Birch leaves objectionable to animals? (Gray Birch Fat EE is higher than average – is that due to this coating?)

What is the nature of those proteins that cannot be tested? and are Condensed Tannins binding them, to clog the filter? (Wayne Zeller says that if so, a change of pH to be higher or lower will prevent this binding.) Are those proteins that gell up contributing to low Gray Birch leaf-silage intake? Black Locust did not gell up, but oak, which the animals also love (despite toxin warnings that are beyond this study, and regionally insignificant), gelled every time.

Will Gray Birch screen at lower CT levels in spring and fall, when the animals love to eat it, fresh? (This info may soon arrive from Wayne Zeller, who has my many small samples.) Are Black Locust CTs tastier than Gray Birch CTs? (The animals seem to think so.)

Do the L**ipids** that Yulica Santos Ortega identified in our milk, with leaf-silage versus with only grass hay, **bestow health benefits on humans**? I've not yet found a Food Science person to tell me about these hundreds of lipids that Yulica identified.

What Lipids in leaf-silage are precursors of Lpids that Yulica found in our milk? I have leaf-samples saved, and would love for someone to complete such profiling.

Are proteins in tree and shrub leaves more complete? than the amino-acid-incomplete proteins of grass forages?Amino Acid profiling of leaves was beyong the scope and budget of our project.

Unexplored Vitamins & other Healthful Compounds present in leaves, per species, in the Northeast: We aren't yet testing for vitamins, or Volatile Organic Compounds - VOCs fill leaf-silage barrels with tree aromas, and probably increase the shelf-life of our milk, among other benefits.

I internet-searched vitamins in various species of tree leaves, and found a lot!

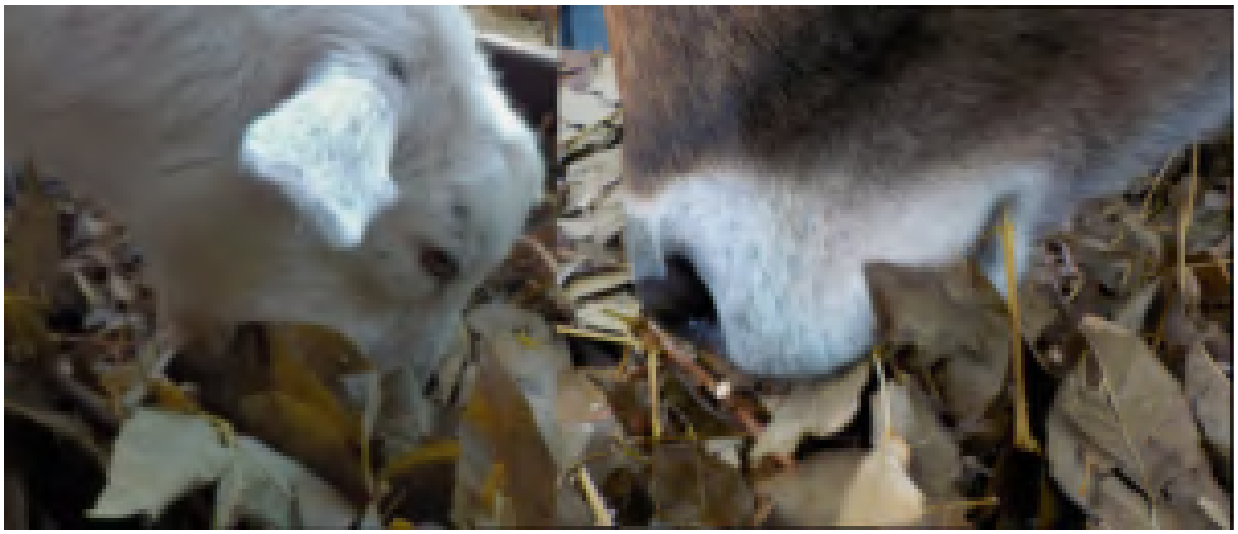
Tocopherol & Tocotrienol are forms of Vitamin E found in fruit tree leaves. https://scijournals.onlinelibrary.wiley.com/doi/10.1002/jsfa.11481?af=R

Rose leaves (at least the 13 varieties studied in Kumari et al. 2017 linked below) contain healthful Anthocyanins, Polyphenols and Phenolic compounds, high levels of total Carotenoids including Beta-Carotene, as well as substantial levels of Tocopherols (Vitamin E; after all, they are an Apple family member). Are Multiflora Rose leaves also a potential "nutraceutical?" https://www.researchgate.net/publication/337111623_Rose_leaves_a_Potential_Nutraceutical_An_Assessment_of_the_Total_Anthocyanin_Content_and_Total_Phenolic_Content

Ash leaves have too many beneficiall compounds for me to list! https://pmc.ncbi.nlm.nih.gov/articles/PMC5723943/#:~:text=Fraxinus%20plant%20has%20been%20accounted,antimicrobial%2C%20and%20antihypertensive%20(Figure%201).

My 94 year old mom asks me periodically how my eyesight is; she has watched a lot of people age, and is surprised that at 62 I read without glasses. In my above searches, vision benefits cropped up repeatedly when I searched benefits of compounds listed in leaves. A thank you is probably due to my goats, for their leafy milk.

Strangely, other farmers feeding leaves get just as excited as I do. Our results so far are substantial, and support continued work to enable increased leaf-silage use, and expand understanding of intricate animal/plant interactiions and hidden benefits beyond conventional forage laboratory measures.. Though not easy, nor efficient (yet), it’s somehow right. There are Quality of Life aspects of multi-sensory awareness, hard to explain, but simple, like wind in the trees.



Windy died at an old age during this study may she rest in peace. She could not eat hay any more, with teeth worn down below her gums, but COULD eat tree leaves until the very end. Here she was eating ensiled White Ash on the 1st measured day of FNE22-013 winter trials 2023-'24. Angelo's muzzle is shown doing the same.

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Participation summary

10 Farmers/Ranchers participating in research

1 Ag service providers participating in research

5 Others participating in research

Education & outreach activities and participation summary

22 Consultations

3 Curricula, factsheets or educational tools

1 On-farm demonstrations

2 Published press articles, newsletters

2 Tours

20 Webinars / talks / presentations

3 Workshop field days

3 Other educational activities: I tabled at three conferences, with tree/shrub silage samples plus visual and literary materials, to converse one-on-one with farmers about their farms' potential to use woody forages.

Participation summary:

121 Farmers/Ranchers

14 Agricultural service providers

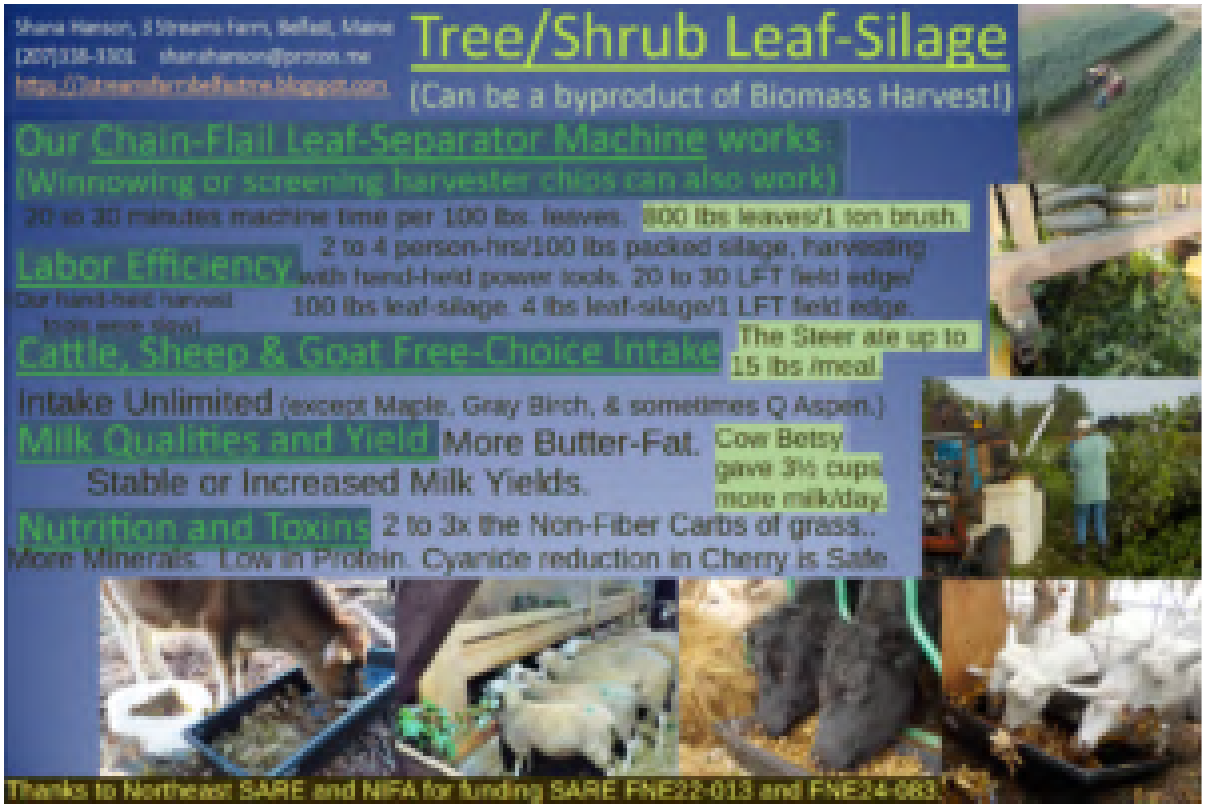
75 Others

Education/outreach description:

May 2nd, 2024 Webinar for NOFA MA "Go Nuts" Agroforestry Discussion Series had 35 attendees; Recording posted by NOFA MA has so far had 508 "visits;" Links are posted on my farm website to both Recording, and to Slides with Text Added (to be a stand-alone printable resource) which can also be found in the SARE FNE22-013 Final Report under "Information Products" (I am not posting that here to avoid redundancy; the Forage Conference Slides are more pertinent to this project). I described this current SARE FNE24-083 project within my 45 minute presentation, also reporting SARE FNE22-013 harvest and livestock trial results. Wayne Zeller's initial Condensed Tannin (CT) screens of our leaves are included. Discussion followed. One farmer said he is always cutting brush anyway, so can easily start using as forage.

zt the Short Rottio WoodyCrops Coferece i Missouri, I hd this tble, ad also preseted a Poster about our data o woody forages.

May 14-16, 2024 Short Rotation Woody Crops Conference, an international event hosted by University of Missouri Center for Agroforestry, had 65 attendees total including field-grown biomass researchers, service providers, students, and farmer attendees (I think Karl and I were two of 3 farmers there). I also set up a table full of historic and recent leaf-forage photos, and offered print-outs of leaf-silage nutritional data we had already received from Dairy One, of all charts from SARE FNE22-013, and of past reports and articles. I discussed Karl's idea that forage use can tip profitability for biomass producers with many individuals there, and offered leaf-silage samples. Chung-Ho Lin gave me a tour of the Center for Agroforestry laboratory, and planned to assess products of fermentation in my samples *(after I overnighted the samples to them, that plan fell apart; I recently emailed about it, with no response as yet).* I met and consulted with Lloyd Sumner of the MU Metabolomics Center, which led to my shift from plan to enlist UC Davis Metabolomics Center and instead use MU (with unknown benefit, on retrospect). A valuable side-benefit of my trip was return-trip collaboration with an attendee (whose name I can't find now; so sorry) , during which he showed me spreadsheet shortcuts; I worked to organize incoming Dairy One data on multiple trains and lay-overs, traveling to and from this conference.



My Short Rotation Woody Crops Conference poster presented at that international conference, hosted in 2024 by University of Missouri Center for Agroforestry

July 20th, 2024 Tree Canopy Harvests Rejuvenate Everyone! (trees, livestock, farmers, soil, Earth), Presentation & Workshop during the Permaculture & Agroforestry Convergence at MOFGA grounds (Unity, ME) drew 10 participants plus some part-time visits. I gave an over-view of forage use of trees including nutritional data and environmental benefits, and led discussion of applicability within participants' settings. We then moved to trees I'd pollarded years before that were due for re-harvest, and I guided participants who completed all cuts and packing of a barrel of American Elm and Green Ash. Young people from an intentional community in MA are planning silvopastural use with livestock.

Settig up the Chain-Flail Leaf-Separator for Common Ground Fair. (They actually invited i a 3rd year, but I'd had enough slow driving.)

September 20-22, 2024 Common Ground Country Fair: My presentations were Ruminants Eat Leaves! How Much? (& Why?) (x2) recorded by a participant on my

camera but as yet not posted, Tree Fodder and Browse for Livestock Q & A (x2), and Leaf-Silage! Chain-Flail Leaf-Separator Demo. Total participation for 5 timeslots was 35-40 (people come and go). The Fair drew 69,000 people mostly from the Northeastern US, and most of whom walked right by or looked at a visual display surrounding the Leaf-Separator.

(*I also had in-depth discussions with 2-3 more folks at non-presentation times by the Leaf-Separator as I was finishing the load of brush, and included 3 young people who work on farms in 3 days of climbing harvest and leaf-separation of MOFGA Hybrid Willow, after the Fair.*)

November 11th, 2024 Maine Forage Conference: Jaime Garzon asked if I had nutritional results (I sure do!), then invited me to be one of 5 farmer-panelists. I jam-packed 15 minutes with nutritional, toxin, Condensed Tannin, milk yield, harvest yield, and animal intake data, then fielded questions along with the other presenting farmers. The rest of that day I tabled with more leaf-forage info and aromatic samples, and talked with farmers and service providers about trees and leaves (*some of us almost missed lunch – so fun to connect*).

*** See **“Forage Conference Slides with text added” listed in the "Educational Products" section.** ***

March 22, 2025, Eastern Maine ROOTS Farms and Forests Conference, UMaine Center, Machias: I tabled, hoping to connect farmers with forest harvest professionals, to foster woody forage partnerships. There were few farmers or loggers attending, but meaninful networking happened with other presenters.

May 2, 2025, Vermont Farm to Plate online presentation: Alex Caske, Barred Owl Brook Farm in NY State, uses European Buckthorn as a staple forage for Katahdin sheep. He and I each presented briefly about using woody perennial forages, for this group of farmers and value-added business people based in Burlington,Vermont. I had only a week lead-time, and despite my tech helper Laura Nobel’s presence had sound gliches that made this event extra stressful. Yet I was very excited to learn about Alex Caske’s farming, and did cover my info.

June 21, 2025, MOFGA Farm & Homestead Day: I harvested forage from tall willows, and engaged a few people in making dried sheaves and wreaths, while sharing historic and nutritional information. The organizers misled people with signage as to where I was, which limited participation. (*I had painfully looked at a bright on-line map sent by email ahead of time, but misread it and thought they had me correctly placed in the willows.*)

September 20 & 21, 2025, Common Ground Country Fair: My presentations were all on Saturday and Sunday this year (on Friday I roved singing farm songs and playing instrumental music). Titles were Leaves of Trees & Shrubs for Livestock (2 times), “Invasives” for Winter Animal Forage (*in the Environmental Concerns tent, where only 2 people found me, one from a family farm where they’ve retired the dairy cattle, and now have too few to keep up with Multiflora Rose*), and Woody Plants to Ephemerals Forage Q & A (*well-attended in the Livestock Speakers Tent yet a few people came thinking I meant human forage; the titles are limited to 100 characters inc spaces. They did stay!*).

July 11, 2025, Dale Strickler, Regenerative Wisdom, Wichetaw Kansas, came and toured my browse lands and pasture, to learn more about my use of trees, the day before his Luminary Tour Event Day (pasture management workshop plus pasture walk) at Wolfe’s Neck Center, Freeport, ME. This was a mutually educational one-on-one consultation, yet I list it here as as educational, because Dale can then carry knowledge to farmers all over.

September 1, 2025, Browse Walk at Liberation Farms, Wales ME: Elizabeth Tarantino, Director of Forages and Livestock at Wolfe's Neck Center, joined Jacob Morton, Liberation Farms [Goatherd] Property and Livestock Manager and myself, to explore woody forage species and best use strategies for meeting woody forage needs of the Liberation Farms goats.

Elizabeth Tarantino's photo of our Browse Walk at Liberation Farms, with Jacob Morton (not shown) and their herd.

I put this out to Jacob as an event idea, with plenty of lead-time to publicize to their many Somali Bantu women who had just attended a "Setting up your Goat Herd" workshop there. But because Jacob was scrambling to fence differently plus walk the herd due to the drought, he got back to me too late for public inclusion, yet very much wanted to have us come. Elizabeth was finishing a multi-day Tree Fodder & Browse workshop at my farm, and we arranged this event to be on her way home to Freeport.*

** There were 2 "tree Fodder & browse" workshops here, the other with Wolfe's Neck Dairy Intern Tom Gallianno, but both were VERY informal and mostly one-on-one, so counting those as consultations versus events.*

Jacob had been reducing walks with increased herd numbers, then reinstated this practice plus started fenced edge browse rotation, necessitated by drought. We considered ways to avoid permanent damages to their incredibly rich species array of trees and shrubs, that the fenced approach was already beginning to manifest. We also visited their woodland, to consider year-round browse sourcing through pollarding. The herd experienced high death rates in the 2025 kidding; Jacob is hoping that previous health will be restored as they return to a greater proportion of woody forage use.

September 8 & October 20, 2025, 2 Webinars organized by Erica Frenay for their Agroforestry Group of NY agricultural educators: Titled . Karl Hallen joined me for

the second one.

October 27, 2025, Maine Forage Conference: I tabled with leaf-silages and visual plus literary materials. This was an opportunity to meet the Wolfe's Neck Research person Laura Sofen, and two Wolfe's Neck Dairy Interns Tom Gallianno and Amelia Crispell (*both with whom I now have ongoing involvement related to woody forages; Amelia will start residency at my farm later this month, January 2026*).

Learning Outcomes

178 Farmers/Ranchers gained knowledge, skills and/or awareness

55 Agricultural service providers gained knowledge, skills and/or awareness

500 Others gained knowledge, skills and/or awareness

Key areas in which farmers gained knowledge, skills and/or awareness:

Knowledge of tree/shrub-leaf nutrition, and safety/limitations/toxicities; attitude-shift that tree/shrub forage use may be worth pursuing; awareness that tree industries produce untapped forage resources, and that routine farm brush-clearing and ROW pruning can be forage harvests. (*Skills of pollarding trees, or of using our Leaf-Separator, were also part of activities during our 2 overlapping SARE projects, but pertain more to FNE22-013 than to this FNE24-083.)*

Awarenesses in particular that were raised: Concentrated energy in tree/shrub leaves as compared to grass forages may reduce grain cost (Jason Tessier, Tessier Farm); Leaf proteins that escape rumen fermentation may benefit cheese-making (Kaili Wardwell, Abraham's Creamery); Cherry leaves MAY have lower risk of Hydrogen-Cyanide toxins when ensiled (many farmers, including email conversations); Box Elder leaves can be dangerous to ruminants, especially once fully mature; Potential exists for mechanical improvements that can make leaf-silage available in quantity, and tree/shrub-leaf forage-value supports such development.

Project Outcomes

6 Farmers/Ranchers changed or adopted a practice

2 Grants applied for that built upon this project

Project outcomes:

I expect increased animal health and higher winter milk yields, as I incrementally pursue provision of a significant winter quantity of summer-harvested tree/shrub leaf-silage to my animals, in addition to daily fresh winter cutting of bare Red Maple branches, which have been a substantial feed complementary to hay here on my 3 Streams Farm for many years (plus intermittent fresh winter cutting of Hemlock, and a bit of White Cedar, which used to be a winter staple, but is looking thin ever since the 2015-'18 droughts).

At start of 2026, I am experiencing new pressure toward future leaf-silage, and also

toward an imminent search for logging of Hemlock and White Cedar, as soon as I finish this Report. A lot of 0 degree F nights have made it hard for animals to strip maple bark, such that our stored hay is getting fed way too fast to last. (*I do not have hay fields myself, so rely on increasingly expensive purchase.*)

The animals are so excited on days when they see I've brought out a barrel! (When my animals are happy, I'm happy!) The new skid road I've started at the blueberry field enables steer Angelo, or the tractor (*new to me but not to that field*), to get brush out to feed the Leaf-Separator.

Cutting, stacking and transporting brush remain labor-intensive, especially on the rough slopes of my own land. Due to a NRCS woodchip spreading erosion-control contract for the blueberry field (where past herbicide damage to soil life has caused persistent bare patches), I have a new connectiion with a Tree Service company (nearby arborists). Next summer, I hope to entice them to send leafy material my way (before chipping – or perhaps they will hold and use the Leaf-Separator?).

Due to protein data, in future I am going to try to purchase a higher proportion of

2nd-cut hay, as I used to do before droughts threatened supply. (I am committed to forage-only diets, grass silage holds threat of listeria for small ruminants; my steer eats with the goats, so also gets hay.) The blueberry mountain (Levenseller Mt., Lincolnville ME) has some Autumn Olive, but even with permissions I have received from landowners it is not enough to ongoingly meet our needs. It interestingly concentrates itself under a large powerline there, despite the blueberry soil coverage being identical to that on surrounding land. (*Will Autumn Olive's nitrogen-fixing ability help soil there deal with higher herbicide use on the powerline? No Autumn Olive is on my own land, and as said above, planting it is illegal.*)

I have ongoing communication/consultation with 15 Maine farms, with visits to some, to help them move toward increased tree/shrub forage use. Plus I am sprinkled with such phone calls from out of State (free consultations), and much enjoy such contact.

At this point, no one but me has a Chain-Flail Leaf-Separator, so these farms are limited to intact or chipped forages.

Our Chain-Flail Leaf-Separator is improving. I enlisted John Thomas Jr. and Jon Thomas Sr. at Thomas Bandsaw Mills, Brooks ME, to move our machine forward to tangle less, have an added safety shut-off, have matter fall into the bin more freely, and square up the trailer to possibly become TRANSPORTABLE AT REGULAR ROAD SPEED! It is now ready for the road-trip home; so transportability improvement may or may not be proven (I will pick it up as soon as this report allows!). These improvements may enable more machine-sharing, and also get us closer to pursuit of a funded second and more replicable model.

My own usefulness to a broader community of farmers has been personally enriching, plus feels much needed and useful, yet also has been a huge commitment which conflicts with my own farming (plus has obliterated all housework). I will soon be traveling to present at the Acorn Conference in Truro, Nova Scotia, next month (February 2026), and may be Tech Advisor and helper for Wolfe's Neck Center SARE Farmer Project proposal, with summer fresh woody forage harvest just after our blueberry harvest (if funded). I am planning a long break from leading any further grant projects in which data management and reporting fall on

computer-incompetent very slow me, as I need to address a 2018 1st SARE grant-to-now mess in my house!

8 New working collaborations

Assessment of Project Approach and Areas of Further Study:

Labor-intensity of harvest-cutting remains a primary limitation, to be addressed with further development of equipment plus collaborations with tree (inc field-grown biomass) industries, to separate leaves from what they are already harvesting.

My constant contact with machine-creator then Tech Advisor Karl Hallen, through these SARE projects, has fanned his own enthusiasm for woody forage use. He right now has collaborators at SUNY submitting grant proposals, which include funding for him to develop post-chipping screen-winnowing of willow biomass for leaf use, if awarded. We also are discussing use of a reaper-binder for dried willow sheaves, as a Canadian firm had Karl help them with such a willow harvest in NY State in past (but only for biomass, not livestock forage at that time).

I tried last fall 2024 to access funds for an improved manufacturable compact engineered replication of the Leaf-Separator, with added brush-processing features (baling, chipping). The engineer jumped ship; he wanted more market demand for this forage first, and such demand seems hard to create for an as-yet unavailable or labor-intensive product (a circular chicken or egg dilemma). Meanwhile, Lucas Tree owner Art Batson and his power-line pruning crews have remained ready to work with me, to produce leaf-silage in large volume; I hope to find someone who will move forward with them at some point (*as said above, I need a break*).

Local hay producer Dave Flood gave me a square baler, now waiting in my driveway, for Karl Hallen to use (disassembled or in entirety) with tree leaves from the Leaf-Separator, or with SUNY willow. With Karl so far away in NY State, the transfer of this piece of equipment will wait for him to have barrels or sheaves of willow to BRING to me, to make a worthwhile trip. (T*his likely depends upon their funding - fingers crossed!*)

Wayne Zeller who is analysing Condensed Tannins in our leaf-samples, and his colleague who is running digestive efficiency and methane emission tests on those samples, are breaking ground for more research attention to woody forages. Protein utilization and methane emission reduction, both in light of Condensed Tannin benefits, are hot topics currently. New information on these topics may help jump motivation and funding, to move forward the development of industrial woody forage supply-streams, as well as farm-accessible harvest equipment.

I continue to wish for and imagine metabolomic (expensive) research of leaf Lipids, which increase when ensiled. I have a hunch that special digestive impacts of fats in leaves may add to animals' enthusiasm, beyond abundant minerals and high level of Non-Fiber Carbohydrates. (Such info might also possibly support demand, to improve supply.)

My leaf-silage samples from the SARE FNE22-013 3 Streams Farm trial are available for someone to complete Lipid profiles per date eaten, to look at with Yulica Santos Ortega's Lipid data on the milk (with and without leaf-silage). Yulica's data on hundreds of milk Lipids is available for such comparison, and also has not yet been examined for human health benefits.

Amino Acid profiling of leaves could change how we view protein-contribution of woody forages (along with CT research contributions), as the array may be more complete than those of grass forages.

My leaf-silages were not chopped, and with aromatic compounds probably helping to preserve the leaves, fermentation did not reach acidity that silage specielists recommend until the 2nd year. Yet animals LOVE those almost-fresh, intact aromatic leaves. Researchers recommend additives; I could indeed add the 20% wheat middlings recommended by Steffen et al. (2024: Willow Silage...Steffen et al.

2024), but that would violate grain-free forage-fed status of my herd. It would be helpful for someone to explore whether the Botulism and Listeria they are preventng through low acidity can indeed grow at all in tree and shrub leaf-species. My harvests are very clean, but this issue becomes more pertinent as we move toward possible roadside or (soil-disrupted possibly dragged rather than carried) forestry harvests.

At this point, even before further resaearch, grass-fed ruminant farmers (such as myself), and all goat farmers , can especially benefit from tree/shrub use, especially when climate challenges reduce quantity or quality of grass harvests. Northeastern farms will find our regionally-limited data to be most pertinent to their farm resources, but some nutritional parameters may apply to broadleaf trees in general. Mid-sized and large farms probably need to develop tree-lines for machine-harvest along with compatible harvest equipment, to implement scale-appropriate leaf-silage harvests and make use of my data (except at Wolfe's Neck Center, where the cattle staff are especially enthusiastic and undaunted by manual labor). This all takes time (and expenditures), but that is true of any change in practice. Small Northeastern farms, including most Maine goat and sheep farms, are already able to use our information to beneficially ration leaf-forages.

Information Products

- Leaf-Silage as a Nutritious and Climate-Resilient Feed for Ruminants Less Labor and More Data for Farmers
- Shana Hanson Forage Conference Nov 8, 2024, more words for posting
- Trees & Shrubs Offer Useful Winter Forage for Ruminants
- Forage use of Northeastern woody species: Opportunities within existing silvopastural systems
- Scalable Development for Use of Temperate Woody Forages: Planning Efficiency

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This work is supported by the Sustainable Agriculture Research and Education (SARE) program under a cooperative agreement with the University of Maryland, project award no. 2024-38640-42986, from the U.S. Department of Agriculture's National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and should not be construed to represent any official USDA or U.S. Government determination or policy.