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TREE LEAF FODDER FOR LIVESTOCK; TRANSITIONING FARM WOODLOTS TO "AIR MEADOW" FOR CLIMATE RESILIENCE

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SUMMARY/ABSTRACT

I (Shana) observed trees already pollarded (pruned drastically above browse height, for re-harvest of new growth every 3 to 6 years) at 3 Streams Farm with guidance from international literature sources and contacts. Then Josh Kauppila and I, with Emily MacGibeny and occasional other helpers, harvested tree canopies of 1 acre of a mixed species 55 yrs. growth woodlot (which was lightly managed in multi-aged continuous cover for firewood 1963 to 2011). We used ladders, ropes and harnesses, hand saws and sometimes chain saw, with Pruning Rules based upon above observations (see D.1.a. below), to transition the acre into a Demo Plot of "air meadow" fodder production.

In the Demo Plot, red maples are more numerous among the 300 (+/-) retained trees than all other species combined, followed (most to least numerous) by white ash, quaking aspen, balsam fir, white birch, red oak, yellow birch, beech, white pine, big toothed aspen, hemlock, and white cedar. Trees (excepting two much larger white pines, retained intact) measured from 13 ½" to <2" Diameter at Breast Height (DBH, averaging 6") (we did not record the trees <2"), and were pollarded at heights varying from 6' to 63 ½,' with cut tops 3' to 48' in length, 2.82" average top cut diameter, and averaging 20.7 yrs. old (ring count) at top cut.

We timed our labor to be 604 person-hrs./acre, which included tight intricate felling of most firs before starting the pruning of canopies, very slow setting of climbing ropes by us amateurs, and piecing and stacking of brush throughout.

1,216 lbs. dry matter (DM) per acre were eaten within the Demo Plot by a small herd of dairy goats (averaging 7 individuals) during this transition harvest, with unexpected significant amounts refused by this highly selective animal group. Due to simple Farmer Grant research design the lbs. DM of these refusals (of which fresh leaf refusals were mostly dried, and dried leafy branch refusals were brought to hogs on-farm or to sheep at Y Knot Farm), plus about 95 gal. of silages and about 30 armloads of fresh and dried leafy branches removed for sampling at all farms were not measured. If fed to most appreciative Meadowsweet Farm beef cattle and sheep, these refusals and removals would likely have yielded 300 more lbs. DM edible portion/acre, giving a loosely estimated total of 1,500 lbs. DM edible portion/acre, or about one half the average Maine hay yield that year (and the wasted hay in feeding is unfairly not being considered here).

Subsequent harvests of 4 to 6 yr. old sprout-wood will be more palatable than these initial 20 yr. old tops, according to 3 Streams Farm goats and established pollards.

Winter storage methods of on-site stacking, chipping and drying, and container-ensiling both chipped leafy branches and hand-stripped leaves (usually leaf bunches with basal twigs), were trialed with about

20% mold or caterpillar damage observed (at leafy center tarp openings) in on-site horizontal stacks but 0% damage in Jackson Regenerational Farm's vertical stacks, 0% mold in chipped dried species other than aspens but about 90% mold observed in chipped dried aspens, and about 3% (seemingly edible) mold observed at air leaks in silages.

Cattle, sheep, goats, and hogs at 6 farms sampled fresh leafy branches both intact and chipped, and above forms of stored fodders of 15 tree species, plus cooked dried leaves of 8 species, with more than two thirds of offered samples accepted: 52% of 740 samplings rated by observation as "immediately consumed" and another 19% rated as "eventually consumed," versus 12% "tasted" and 17% "refused." Summary tables are offered here within, and the full data spreadsheet can be viewed at https://drive.google.com/file/d/1BgOksabfTq1hBPmraRYBzED8lCQOGTgV/view. Some photos are included below, and more photos and short videos of sampling by livestock can be viewed at https://drive.google.com/drive/folders/1Hd2de-xm5kvkXO7iNGNMNZ5zyL8AUzkI and https://drive.google.com/drive/folders/12E1tICQo-sMrZ3EE650-VYGXKMTlnZEU.

We expect 92% of demo plot trees to become productive healthy fodder trees on existing trunks. All white ashes produced large dark green heads of sprouts, mostly at or near cut locations. Red oaks sprouted strongly along their previously bare trunks as well as on and around branch stubs or collars, then were about 98% defoliated in mid-summer by insects. Most quaking and big toothed aspens started with particularly small canopies on tall trunks, and reverted to prolific root sprouts, which can be developed into more accessible understory pollards. Most white birches were similarly proportioned, and stayed alive but with little new growth. Red maples, the most numerous species, varied in sprouting strength with health possibly related to water access during the 2018 4th drought summer, or to sun exposure winter 2018-19 when fluctuating temperatures caused unseasonably repeated sap runs; season of canopy harvest, and tree age or height were not observed to correlate with strength of sprouting.

We collected harvest time moon phase data, but assessing effects is beyond the scope of this study.

Tree sprouting responses both of Demo Plot trees and of established pollards outside the Demo Plot were photographed and correlated with photos before and after canopy harvest. Some photos are included here within, and all can be viewed at https://drive.google.com/drive/folders/12dmc3K7kTklG-RHQ3m3S2erO8BC3ggtE.

Pollarding guidelines with species-specific comments are offered below, recommending ideally 3" diameter cuts in wood in young wood no more than an arm's reach from the trunk, and prioritizing trees that start with good health, low branches and full canopies, for economy of form that supports sap flow reaching sprout locations.

I have presented about our study at 9 outreach events in 4 states, reaching about 160 participants, and now have a contact list of people who want to know more about using tree leaf fodders.

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FORENOTE

As our complex endeavor closely fit the SARE Farmer Grant level of funding, please forgive rough computations, a few missed tree measurements, a day or two of lost livestock response data, and other mistakes that readers should tell me about which I haven't yet noticed.

Despite such farmer-researcher level of scientific rigor, I am hoping that our results will prove of practical use to farmers and researchers wishing to shift food production toward a "new" healthful and ancient way that can help to re-regulate weather extremes (Eisenstein, 2018; Jehne, 2019), while proving resilient to those same extremes.

INTRODUCTION

Our purpose was to trial historically common European methods of sustaining livestock with tree leaves from pollarded woodland "air meadow" (with modernized storage methods to save labor), as a reliable way (Austad and Hamre et al., 2003) to supplement Northeastern US pastures and hay storage when weather limits grass growth. Historically Europeans relied on pollards, trees heavily pruned above browse height with years of rest between harvests, to overwinter cows, sheep, goats and hogs (Brauner, 1756; Slotte, 2000; Carlsson, 1996). We suspect that this way of farming optimizes foliar health, leaf surface, and soil carbon sequestration, three factors which increase evapotranspiration to address the 95% of climate disruption caused by worldwide loss of plant cover (based in worldwide deterioration, destruction or loss of top soil) (Jehne, 2019; Hanes, 2019; Bane, 2019; Eisenstein 2018). This report of our trial offers information pertinent to Northeastern US farmers on labor feasibility and initial fodder yield, fodder processing and storage options, cattle, sheep, goat and hog tree leaf fodder preferences in the growing season and in winter, and pollarding guidelines with tree species specific pruning points.

I have been studying pollarding and use of tree leaf fodders since 2011, triggered by climate irregularities, failures of annual and biennial seed crops, and observations of my livestock. This funded project enabled me to have intern support of Josh and Emily to complete an intact area of woodland versus piecemeal patches and edges, plus committed me to pull knowledge together for others, to reach a broad audience of farmers who may benefit from this ecologically generous fodder alternative.

Droughts and floods emphasize need for climate-resilient and climate-stabilizing ways of farming. Trees participate critically in water cycling: their transpiration strongly moderates air temperatures and provides water vapor for up to 90% of rain in inland regions (Eisenstein, 2018), their pollen is necessary to seed rain (Ellison et al., 2017), their root turnover (especially when pollarded) is the best preventative against soil water-logging (Ninemets et al, 2006), and in dry soil they pull moisture upward into reach of ground layer plants (Zurcher, 2018). Their leaf litter aids cyclical root die-back in feeding biologically rich soil structure and crops beneath (Austad and Losvik, 1998), increasing soil water holding capacity and water clarity (Bane, 2019). Traditional farm fields all over Europe were interspersed with ubiquitous rows of pollarded trees, seen (correctly) as the sources of soil fertility.

‘Air meadow’ canopy harvest of existing woodland, and pollarding of trees in general, was historically known to increase health and longevity of the trees themselves (despite looking so hard-hit at initial pruning). And even unpollarded trees weather climate extremes more successfully than does open grassland.

Austad, Braanaas and Haltvik (2003) studied use of chipped tree leaf fodders both dried and barrel ensiled in Norway, EU, and found them economically worthwhile for commercial sheep farmers and nutritionally worthwhile for their sheep. These farmers and researchers harvested from very old pollards still present in the European landscape; we in North America must start with either young trees which bear little at first, or with mature trees of standard heights, which yield higher quantity sooner.

Transition from a woodlot of standard trees has been more labor intensive and less well-utilized by livestock than would be ongoing harvests of established “air meadow,” as branches from initial harvest are longer, heavier, woodier, more crooked, and less palatable than 3 to 6 year old sprouts. Yet in this first formal trial of fodders produced from Northeastern U.S. species, despite negative differences of initial harvest, responses of livestock clearly encourage us to take further steps.

“Multistrata agroforestry systems represent the highest level of carbon sequestration in food production…There is a need for development of multistrata production systems for non-tropical climates…Fodder tree silvopasture in particular is worthy of broad-scale expansion” (Toensmeier, 2016, pp.323-4), yet we have lacked regionally useful information, which we herein begin to provide.

COMPLETED OBJECTIVES

We:

- Examined our previously established pollards to guide development of durable and fodder-productive tree structures and to inform our instructions to others;
- Restructured 1 acre of woodland by felling most firs, felling or stripping ½ of pines, and heavily pruning 93% f remaining trees, to create pollarded 'air meadow' fodder canopies above browse height for cyclical (4 to 6 yr.) ongoing harvest;
- Recorded descriptive data for farmer woodlot comparison including end heights of pollarded trees;
- Tracked labor time/acre;
- Measured and calculated lbs. dry matter (DM) edible portion/acre from this initial harvest;
- Trialed storage methods of stacking branches to dry under tarps, chipping and drying in shallow wooden boxes in the barn, and hand-stripping or chipping to ensile in containers;*
- Rated goat, sheep, cow and hog responses to 15 species (7 of which were not offered in all forms) of intact and shredded 'twig-leaf' fodders fresh, dried, ensiled, and (hogs and cows mostly) dried then cooked,
- Wrote pollarding guidelines with Northeastern tree species-specific details based upon observations of trees previously pollarded at 3 Streams Farm plus 1 year progress of Demo Plot trees;
- Presented findings and pollarding instruction to regional farmers at 9 face-to-face events in 4 states.

* I additionally accessed a Vermont Grass Farmers' Association Mini-Grant for laboratory nutritional testing of winter fodders produced by this SARE project. That report will be available March 1. 2020. See Poster Presentation for Vermont Grazing and Livestock Conference on p. 41.

METHODS AND MEASUREMENTS

A. Study of pollards established 2011-'17 (big toothed aspen, quaking aspen, basswood, beech, black locust, American elm, red maple, red oak, white birch, yellow birch).

1. Observed productive forms:
    a. Tagged (surveyor tape, marker) 1 - 4 locations of past and/or planned cuts on beech, r. maple, w. ash, r. oak, b. locust, and w. birch due to be harvested.
    b. Photographed whole trees of all pollarded species to document one season's growth, plus close-ups of marked locations on tagged trees in a. before and after branch harvest (digital camera), then at one season's growth when possible (Browntail moth caterpillars were prohibitive on some trees).
    c. Reviewed prior pruning dates (pollard notebook plus observed annual growth segments) and located prior pictures to review and present tree progress.
2. Observed healing and structural concerns to inform development of durable structures. Photo-documented observations.
3. Applied observations to:

B. Demonstration plot

1. Created:
    a. Fenced (5 strands stainless steel wire and 1 strand poly-wire held onto poplar poles with strips of discarded bicycle inner tube) 1 acre square (208' 8.5" sides) plot of 55 yr.

multi-aged species diverse tree growth selectively cut for firewood since 1963; moved scale, strung tarp over.

b. Felled or pruned softwoods (retained all white cedar, hemlock).

c. Drafted our "pruning rules" using A (see D.1.a., p. 23).

d. Pruned broadleaf trees (hand and power saws, ladders, ropes, harnesses); processed fodder. Spacing generally >6' between retained branch structures of separate trees. Light >1/3 day = 60 degrees of sky (Slotte, 2000), eyed from pruning cut locations.

2. Described:

a. Tallied 104 felled live softwoods (mostly b. fir and some w. pine) by diameter class.

b. Recorded tree species, diameters at 4' (diameter tape), pruned heights, lengths of cut central leaders, diameters and # growth rings of cuts on central leaders (Excel). Photographed representative pruned trees before and after pruning plus at one year's growth (digital camera).

c. Summarized: Grouped tree data into 3 diameter classes/species, counted members/class/species, and computed mean measures/class/species (Excel).

3. Timed labor output: Recorded manual labor time on demo site in person-hrs. Time collecting data and packing silages not counted. Computed total person-hrs./acre.

4. Quantified fodder production from initial pruning/restructuring

a. Brought goats most site work days. Fed fresh or dried branches by sticking butt ends into brush piles, propping against trees, or laying on brush piles. Recorded goat weights and time at our entry and exit (platform scale, pen and paper then Excel).

c. During 2 hr. period of goats in enclosure, counted defecations and urinations/hr. Collected and weighed fresh defecation total (plastic bag inside paper bag, digital store scale). Captured and measured volume of 3 urinations; translated to weight. Computed rough goat "weight excretions/hour" to be .75 lbs./hr/herd of ave. 7 adult goats.

d. Computed total weight Demo Plot fodder consumed = (total goat exit weights + weight excretions/hr. x hrs. spent) – total goat entry weights = 1,704.75 lbs. Computed mean weight fresh tree matter consumed per 3.88 hr. ave. visit/(7 goat ave.) herd = 10.33 lbs.

e. Converted lbs. fresh fodder consumed to lbs. Dry Matter (DM), using simplifying assumption of approximate equivalence to grass/hay DM conversion, and dried and winter fodders using figures from VGFA Mini-Grant lab results and literature search, plus adding estimated amounts of fodder removed, to offer an approximate total of lbs. DM edible portion/acre = 1,500 lbs.

C. Processing and assessment of fodders

1. Stored

a. Dry intact: Set 10' D dry brush bases for branch piles, around rooted trimmed center poles cut at 8 ft. Pieced unbrowsed branches of each species to < 2 " butts, length < 8 ft. (wheeler saws, billhooks, loppers). Stacked nearly horizontally, leaf ends inward with 1 –3 ft. overlaps past center pole, such that subsequent layers sloped downward toward butts at circumference. Covered with 10'x12' tarp wrapped around pole, and long lumber tarp around sides. Leaned up junk wood to hold tarps.

b. Dry, chipped: Chipped (Craftsman chipper-shredder with 8 ½ horsepower Tecumsah engine) twig ends of fresh branches down to 1", of each species as sufficient quantities were harvested, into a calf hutch on cardboard and plywood. Spread approx. 3 gallons shredded leafy branches/species 3" deep in stacked wooden flats, in open barn.

c. Ensiled: Snapped off leaf bunches usually retaining short twigs; filled 1- to 14- gallon containers firmly (lined most with plastic bag - amount per species availability), for each broadleaf species present in Demo Plot (beech, white and yellow birch, white ash, red oak, big tooth, quaking aspen, r. maple, some obtained from outside Demo Plot when in short supply), plus willow and box elder from MOFGA; compressed with hands; tied tightly and sealed lid. Stored in cellar.
Packed chipped branches similarly in containers (chipped same time as b.).

d. Cooked: Added water to cover dried leaves, each species dried from on farm. Brought to a simmer. Took off heat and cooled slowly.

2. Rated livestock fodder responses: Made trips to farms for each or multiple feed item/s. Entered date, tree species and description (detailed in C.1. plus fresh intact and a lesser number of fresh shredded); ranked as 3="immediately consumed", 2="eventually consumed", 1="tasted," or 0="refused," by
   a. Freisan-Dorset cross dairy sheep, Y Knot Farm
   b. Saanen goats, 3 Streams Farm
   c. American Guinea hogs, 3 Streams Farm
   d. Holstein cows, Faithful Venture Farm
   e. Dexter cow, Dexter-Jersey heifer and unknown heritage bull calf all until fall slaughter, Jackson Regenerational Farm
   f. Icelandic sheep and mostly Black Angus beef cattle, Meadowsweet Farm (11/21/18 on)
   g. Jersey-Devon (some Holstein) mixed dairy cattle, North Branch Farm x 2 trips.

   Summarized data for each tree species and processed form.
   Ordered rankings of tree species per livestock species from summary chart.

RESULTS AND DISCUSSION

A. OBSERVATION OF EXISTING POLLARDS

In 2018 I (Shana) chose trees of various species previously pollarded, with growth due to be harvested, and took photos before and after harvest, then in early October 2019 at 1 yr's. growth. I examined and felt old cut surfaces to determine presence or absence of fungi, and found all cuts on r. maple and w. birch to be punky, but found even 9 yr. old 4" cuts on oak and beech to be quite solid. Healing edges were proceeding over the older cut surfaces with occasional bark die-back extending below the cut, usually no further in length than the diameter of the cut; when present, the die-back was always on a side of a cut where neither sprouts nor retained twigs were present to draw sap. I tagged 4 or more representative branches per species available, for close-up before, after and 1 yr. sprout photos, which can be seen at https://drive.google.com/drive/folders/1SJbB9PPc3ucqTne_ye526utC1Ah8eDKm .

2018 was the 4^{th} drought year in a row, plus the first year of Browntail moth and other caterpillar population explosions. Oaks sprouted well, but were most defoliated, attacked by shot hole flies, and then caterpillars mid-season. A black locust near the driveway delayed sprouting and then sprouted from bases of branches and trunk versus from out near cuts, probably due to lack of moisture. But 80% of these observed trees responded with healthy-looking growth and no apparent problems.

B. Demonstration Plot

B.1. Demo Plot Description and Changes

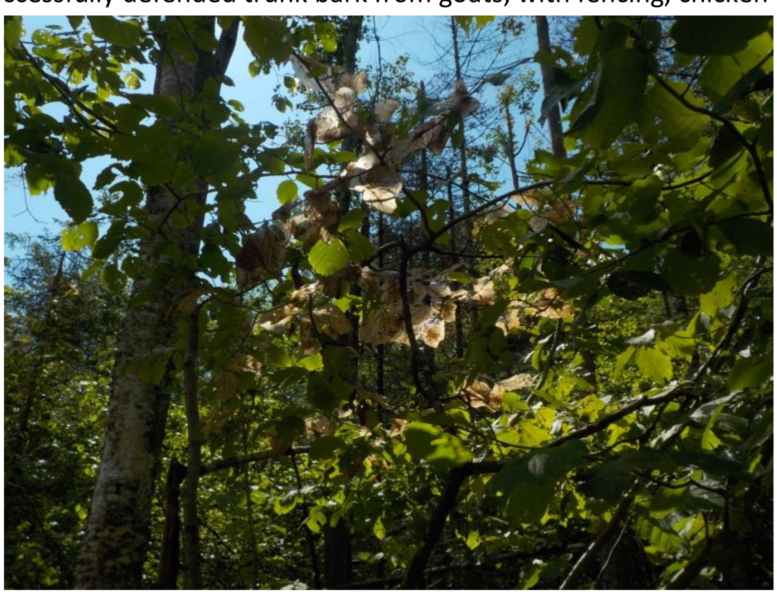
Our square 1 acre Demo Plot is on the north side of a stream, and includes an intermittent run-off stream and some flood zone. It is surrounded on 4 sides by similar 56 year old mixed tree growth, making the south corner particularly shady.

a. Ground and Bush Layers

The ground layer started out as mostly NY, cinnamon and interrupted ferns, poison ivy (small due to shade), and a bit of meadow rue, all in the wetter areas, and elsewhere bare shady needle and leaf drop. It is now much more diverse, with sedges, grasses, wild lettuces, asters, clover, turtle head flowers, various other herbs, aspen sprouts, and new seedlings of woody species not present before.



The bush layer is witch hazel, beaked hazel, winterberry, and alder, plus one small barberry. Bushes got defoliated by goats all summer in 2018, plus an intern made a mistake of cutting down ½ of alders.   The defoliated and cut bushes are weakly re-sprouting from their bases. The witch hazel is large and healthy; we fairly successfully defended trunk bark from goats, with fencing, chicken wire, and vigilance.



Caterpillar damage on otherwise healthy witch hazel

b. Broadleaf Trees in demo Plot

The woodland had been lightly cut for firewood since a heavier logging in the early 1960s. My fellings of a few trees approximately 4 years ago had created some openings near the middle, but canopies elsewhere were closing. Yet a layer of young tree regeneration, mostly seedling white ashes and coppiced red maples, was persisting in almost half of the Demo Plot.

We did not fell broadleaf trees. After felling most firs (see c. below), the reduced size of the canopies of pollarded trees allowed sun to reach top and sides of tall trees, small understory trees, bushes and ground layer without more thinning.

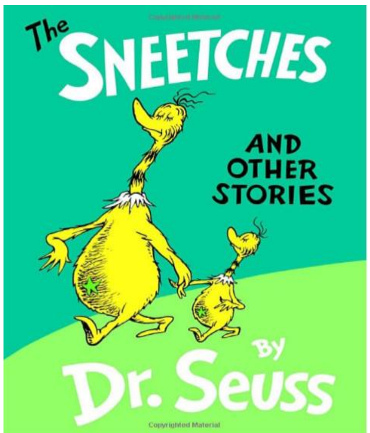
b.[1] Number of Broadleaf Trees Chart, sorted by Species & Diameter Class per Quadrant

Trees in Demo Plot sorted by species and diameter class per quadrant

		E	S	W	N	Totals
r. maple	>=8"	10	17	16	10	53
	>=6"	8	3	4	9	24
	<6"	34	14	15	10	73
	Totals	52	34	35	29	150
w. ash	>=8"	4	0	0	4	8
	>=6"	1	0	3	4	8
	<6"	7	10	9	11	37
	Totals	12	10	12	19	53
q. aspen	>=8"	4	3	1	0	8
	>=6"	3	2	0	0	5
	<6"	5	6	0	1	12
	Totals	12	11	1	1	25
r. oak	>=8"	1	0	1	4	6
	>=6"	0	1	0	0	1
	<6"	2	0	1	2	5
	Totals	3	1	2	6	12
w. birch	>=8"	2	0	3	4	9
	>=6"	0	0	1	0	1
	<6"	1	0	2	0	3
	Totals	3	0	6	4	13
y. birch	>=8"	1	2	0	3	6
	>=6"	0	0	0	1	1
	<6"	1	0	0	0	1
	Totals	2	2	0	4	8
beech	>=8"	0	0	0	0	0
	>=6"	0	0	1	0	1
	<6"	0	0	0	3	3
	Totals	0	0	1	3	4
b. t. aspen	>=8"	2	0	0	0	2
	>=6"	0	0	0	0	0
	<6"	0	0	0	0	0
	Totals	2	0	0	0	2

Top: Young trunk of a large r. maple, 9/19
B: Young maples under a tall maple, 10/18/19

We pollarded (cut off 66 to 100% of the foliage-bearing branch wood plus often shortened stems) about 249 broadleaf trees. The 18 broadleaf trees left intact were: one patch of 9 maples with 1 small ash in the south quadrant where shade and inefficiency of the tall tree forms would discourage sprouting (until we pollard trees beyond the Demo Plot fence another year); a group of 3 y. birch, 1 w. birch and 1 thin r. maple in the north quadrant, in shade of the largest retained intact w. pine and not shading other trees - I procrastinated due to presence of Browntail moth caterpillars in birches, which cause poison ivy-like rashes; 2 w. birches in the west quadrant also avoided due to this unusual season of Browntail moth caterpillars (I will pollard another year); and 1 large over-mature w. ash in north quadrant and same of r. maple in west quadrant, too grand and with small tops and lacking vigor.



This huge and unusual undertaking has transformed one acre offering little but firewood, into a dynamic sunny green livestock (and snowshoe hare, hornet, wasp, then next year nesting bird) destination point. We eagerly await the sneeches, and fish in our lollipop trees (Seuss, 1961 and 1963).

We kept most brush and felled softwood on site, piling tightly to the ground along contours, so as to encourage fungi and build the moisture-regulating capacity of the soil over time.

c. Softwoods in Demo Plot

We chose initially to fell many balsam firs and some w. pines, as they lacked sufficient greenery to stay alive if we shortened them, and at full height they shaded trees we were going to pollard. Pollards need 1/3 day sun minimum for healthy sprouting (Slotte, 2000).

c.[1] Felled Live Softwoods Chart

Felled live softwoods					
Quad	E	S	W	N	
Species	Mostly fir; 3 pines tallied but probably a more pine stumps mistaken for fir. Pines mostly in E quad; a few in N.				
x <6"	13	9	10	8	40
6"<= *x* <8"	6	6	8	9	29
8"<= *x* <10"	9	6	11	6	32
x >=10"	0	2	0	1	3
	28	23	29	24	

We chose to leave the two healthiest large pines intact early on, for environmental diversity, completely limbing the three other large pines to support piliated and other woodpeckers (our hope for future emerald ash borer defense). We left small softwoods intact when not shading other trees.

When shading other trees, we topped firs and pines whose green needles were within 10 ft. of the ground, leaving at least 1/3 greenery as in my observations (and Maschatchek, 2002) seems usually a minimum for survival of softwoods.

19 pollarded (mostly just topped with one trunk cut – some with branches also shortened) balsam firs were measured and recorded, most <6” diameter breast height (DBH) and two measuring 8” DBH.

(Some other small firs were topped before we decided to record them.) The recorded firs ranged from having 10 ft. to 19 ft. heights remain of their initial 13.5 to 52.5 ft. heights. Cuts were mostly <3", with two <4", and one >6". 2 w. pines were topped, measuring 2" and 8.5" DBH, with cuts 1.5" and 6.75" diameter respectively, cut at 9.5 ft. and 20 ft. heights respectively.

Our one barely alive w. cedar and the two healthy but porcupine-pruned hemlocks we pruned by shortening branches to leave reachable greenery, lightly topping, and as above leaving 1/3 foliage.

c.[2] SOFTWOODS RETAINED & PRUNED IN DEMO PLOT, FIELD INVENTORY WITH MEASUREMENTS

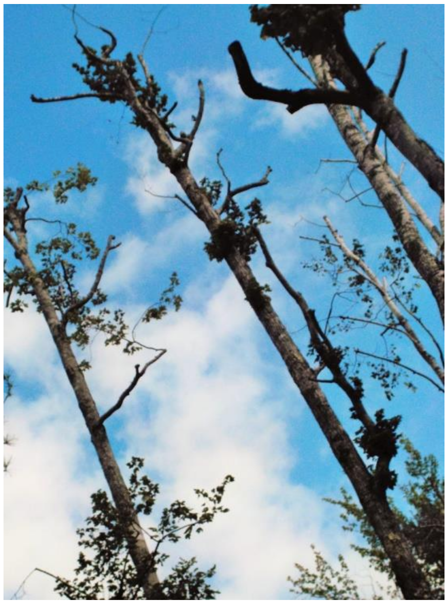
[redacted]	Who prun	Harness?		Quad.		DBH	Height cut	L cut piece	D cut piec	Rings @cu	Moon
11/19/2018	S	n	b. fir 1(st counte	S/s	near tent a	3.72	13.5	39	3	35	0.733333
11/22/2018	S	n	b. fir 2	E/n		5.69	15	18	4	37	0.933333
11/22/2018	S	n	b. fir 3	N/s		5.375	16	18	3.625	25	0.933333
11/22/2018	S	n	b. fir 4	N/s		2.75	16	15	2.25	23	0.933333
11/23/2018	S	n	b. fir 5	N/s		5.125	16.5	23	3.25	25	1
11/24/2018	S	n	b. fir 6	E/w	next to ba	8	16	13.5	3.5	18	-0.06667
11/25/2018	S	n (chainsa	b. fir 7	E/w	near old b	8	17	22	6.25	29	-0.13333
11/28/2018	S	n	b. fir 8	S/n		3.5	16	13	2.75	20	-0.33333
11/29/2018	S	n	b. fir 9	E/w	by central	3.25	10.5	9	2	13	-0.4
11/29/2018	S	n	b. fir 10	E/e	in 4 trunk	3.5	10.5	15	2.625	23	-0.4
11/29/2018	S	n	b. fir 11	E/e	NE next to	2.5	11.5	5	1.5	15	-0.4
11/29/2018	S	n	b. fir 12	E/e	under y. b	2.625	12.5	5.5	1.25	12	-0.4
12/6/2018	S	n	b. fir 13	N/s		4.75	17	9	3	21	-0.93333
12/12/2018	S	n	b. fir 14	E/e	not much	3.375	12	21	2.75	30	0.333333
12/12/2018	S	n	b. fir 15	E/e	healthy	2.375	10.5	15	1.5	12	0.333333
12/25/2018	S	n	b. fir 16	E/n	SE of 4" as	2.25	10	3.5	1.25	19	-0.2
2/2/2019	S	n	b. fir 17	W/e	Cut at stor	3.375	14	13	3.75	19	-0.86667
2/4/2019	S	n	b. fir 18	W/e	S of cedar	4.375	21	14	2.5	15	0
2/4/2019	S	n	b. fir 19	W/e	Center of l	4.25	19	11	2.25	15	0
11/23/2018	S	y loop of r	w. pine 1	N/e	close to m	8.5	20	27	6.75	24	1
12/22/2018	S	n	w. pine 2	E/n	only 2 bra	2	9.5	9	1.5	9	1
11/19/2018	S	n	hemlock 1 - start	S/s	supports tent						0.733333
1/1/2019	S	n	hemlock 2, start	N/w	well-branched healthy tree						-0.66667
1/31/2019	S	n	hemlock 2, finish	N/w	well-branc	12.75	43	10	2.25	10	-0.73333
2/4/2019	S	n	w. cedar 1	W/e	3 tops cut	10	35	9	2.25	22	0

Hemlock 2 with new growth 9/3/19

d. UNPREDICTED ENVIRONMENTAL CHALLENGES

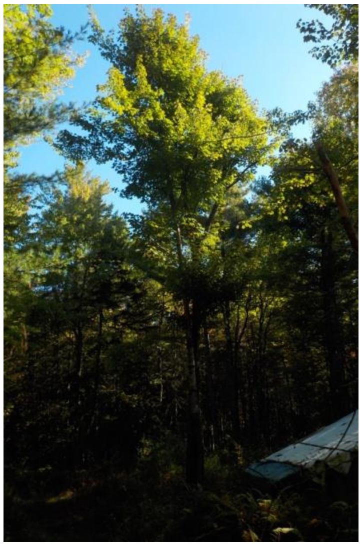
Unforeseen factors challenged our Demo Plot trees, such as a sudden spike in insect damage especially on r. oak, and 2019 leaf-out delayed by 10 days as compared to 2018 (16 days late as compared to 2012; each year has been 1 day later until this longer delay). Delayed leaf-out may have especially impacted the r. maples, who already had diminished energy from awakening with sap running at least once each winter month due to temperature fluctuations. The thick layers of ice versus snow that covered much of our woodland ground winter 2018-19 caused more run-off and frequent stream flooding, which froze and may have additionally challenged the Demo Plot trees.

Trees outside of the Demo Plot on sites enriched by livestock defecation, town leaf compost piles, old brush piles, and years of full sun have responded more reliably and vigorously to pollarding than did our thinner Demo Plot trees with their small high canopies (excepting Demo oak and ash which did fine).



R. oak 1 top, caterpillar damages, Sept. 3, 2019   R. maple 6, weak season's growth Sept.12, 2019

Red maples (below) pollarded in winter 2017-18 just before and at the start of our grant period sprouted more vigorously, and placed their sprouts more consistently at cut locations, than those pollarded in the Demo Plot winter 2018-19; we are uncertain how much difference is due to site and tree health versus the year's weather differences.

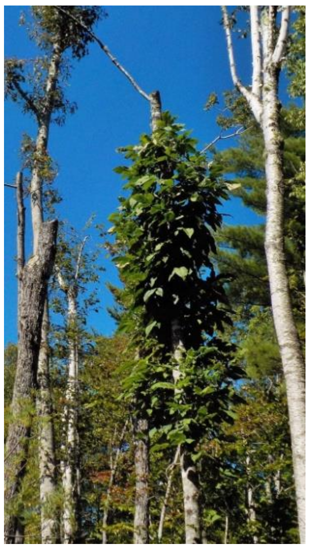


R. Maple by goat house, April 10, 2018   R. maple by goat house pollarded   R. maple by goat house Oct. 5, 2019.

This maple was on rich soil plus pollarded a season before most Demo Plot maples, and showed better growth than them.

Most of the original trunks of aspens are failing, to prioritizing new and widespread root sprouts. I counted about 25 trees responding weakly, so expect 92% of original trunks of Demo Plot trees to continue to live in good health. We suspect that more trees will thrive than the closing canopy would have allowed if left un-pruned.

Kanga eating side leaves of aspen root sprouts, Sept. 7, 2019



W. ash 10 pollarded Sept. 4, 2018, sprouted below top cut, but held leaves longest of the ashes. Sept. 13 & Oct. 18, 2019.

e. MOON PHASES RECORDED

Beyond the requirements of our SARE project, we recorded moon phases for most initial pollardings of Demo Plot trees. We have yet to relate this data to sprouting responses of trees. Read et al (2018) found that moon-related differences diffused in subsequent years, yet many traditions recommend cutting on a waning moon (Gallo, 1572), and Ernst Zurcher of University of Applied Sciences (in Bern) reports tree pulsations correlating with planetary as well as solar moon phases (Zurcher, 2018).

We look forward to observing tree progress over time, and welcome visitors curious about the trees.

B.2. LABOR TIME

We spent 604 person-hrs./acre, including felling softwoods at start, then pruning trees and piecing and stacking brush. We harvested 2 lbs. DM goat portion eaten on-site/ person-hr., skewed low due to our inclusion of the initial time felling softwoods, and due to silages and branch offerings for livestock response sampling (above) which were fed off-site.

a. IDEAS TO SAVE TIME NEXT TIME

Climbing spikes could save time. The lack of low branches in this closing 55 yr. old canopy necessitated the setting of ropes, which often took us novices as long or longer than pruning the tree. We await tree health results from spike climbing of 6 Demo Plot red maples by arborist Adam Lynn, as spike climbing would have decreased our person-hours by almost 1/2.

Starting with a younger stand could save time. Very young trees do not offer much fodder while being developed as pollards, plus benefit from free growth "to develop a rich crown" for their first 15 years or so (Maschatchek, 2002). Traditionally, initial pollarding cuts were made when the young trunk was "the diameter of a woman's lower arm" or "a wine bottle" (international pollarding discussion at Colloque Trognes, Sare, France, March 2018). A 30 year old woodland stand would offer a balance of optimum fodder and efficiency of form, as average height of top cuts could be much lower than ours.

Felling of trees with low odds of pollarding survival could save time. Most Demo Plot poplars and some of the less vigorous red maples are struggling to maintain life in their disproportionately high pollarded crowns. Felling such trees would have saved time, while still providing tops to goats and poplar root sprouts to pollard later (maple root sprouts do not survive the presence of goats).

A feller-buncher well-driven could pollard many trees within a certain height range, safely and effectively. In England, pollarding enthusiasts debate whether rough splintered cuts might be preferable to clean cuts (Green, 2017 & 2018), and mechanical canopy harvest was demonstrated plus two biomass projects presented at Colloque Trognes (Agroforesterie Francaise, 2018). Unless a very dry site, one should drive such heavy equipment as a feller-buncher over tree roots only when ground is solidly frozen. This forfeits the first harvest of leaves; only the goats ate significant amounts of bark.

2nd and subsequent harvests will be much quicker. We have structured sprouting places to be within easy reach of trunks. Oaks in particular are sprouting many lower branch-starts, increasing ease of future climbing.

B.3. DM/Acre from Initial Restructuring of Air Meadow Demo Plot

Computed at 40% DM for fresh leaves (to Nov. 1, 2018), 80% DM for mixed dried leaves, fresh winter maple bark and some needles (Nov. 1 – Dec. 24. 2018), and 70% DM for mostly winter maple bark (Dec. 25. 2018 – April 16, 2019), and adding .75 lbs./hr./herd defecation rate, goats ate 1,070.4 lbs. DM from .88 acre (9 w. ash and 2 r. maples were pruned summer 2019 after weighing stopped so those leaves were not included, and 20 trees of 258 have been left intact), so approximately 1,216 lbs. DM/acre were eaten by goats on-site during 165 days of visits averaging 3.88 hrs.. Unexpected significant amounts of fresh and dried fodder offered on the Demo Plot were refused by the highly selective goat group, of which fresh leaf refusals were dried or wasted, and dried leafy branch refusals were brought to hogs on-farm or to sheep at Y Knot Farm.

The Demo Plot also produced about 95 of our 123 gallons of silage (fed in the goats' home quarters or at other farms with no scale), and about 30 armloads of fresh or dried branches that were brought to other farms to solicit animal responses. Due to simple Farmer Grant research design the lbs. DM of silages, armload samples, and goat refusals were not measured. If fed to most appreciative Meadowsweet Farm beef cattle and sheep, these refusals and removals would likely have yielded 300 more lbs. DM edible portion/acre, giving a loosely estimated total of 1,500 lbs. DM edible portion/acre, or about one half the average Maine hay yield that year (wasted hay in feeding is unfairly not being considered here).

Summer 2018 became droughty after 2 rotations of 14 one-to-two day pasture paddocks, and we did not feed hay during the growing season. Goats have been found to be able to consume more woody browse if they can balance their diet with grass (Papanastasis et al., 2007); instead, in this challenging season (and perhaps less efficiently), ours balanced tree matter with walks to dried wetlands with sensitive ferns and buckthorn. I took the computer; all data entry happened there.

In summer, goats' favorite leaf species were the minority of Demo plot trees, and we needed to set aside enough fodder from all species for winter storage samples, as well as for fresh sampling at other farms. Goats eat limited amounts of red maple when in leaf. Also our learning curve meant slow placing of ropes for ascension in summer, speeding up by winter.

The goats were more contented eating in the Demo Plot in winter than summer, and ate more weight per hour, compounded by winter fodders having a higher DM%. There was always red maple bark, a favored winter staple, left from a previous day to strip, with a long "shelf life," along with the dried leaf piles while they lasted. They received grass hay with some dried leaves and fresh brush in their over-night quarters.

Nov. 1 thru Dec. 25 with both fresh bark and dried leaves offered, goats ate about .324 lbs. DM/hr./ adult, or about 1.3 lbs. DM/ 4 hr. stay each (figured at 90%DM). Dec. 27 – April 15 dried leaves were gone, yet my rate of pruning improved; they then consumed .47 fresh lbs. or .33 lbs. DM/hr./adult of maple bark and some hemlock (all figured at 70%).

At an average adult weight of 125 lbs., does such as these in very slight winter lactation are said to need about 3.25 lbs. DM/day (2.6% of body weight), based upon a hay diet. This would mean that, without other feed sources, each goat would need about 1,200 lbs. DM/year, or 80% of our initial 1 acre "air meadow" harvest for each, if feeding fresh plus storing for winter and all was palatable to them. (I wonder if their DM requirement is lower when fed choice tree matter; they seem to reach contentment with much narrower girth, and leave some hay bags untouched.)

Subsequent harvests of 4 to 6 yr. old sprout-wood are expected to be more palatable than these initial 20 yr. old tops, according to 3 Streams Farm goats and established pollards.

Cattle, sheep and hogs ate differently than goats and would have improved our fodder utilization if included on-site.

C. Processing and Assessment of Fodders

C.1. Storage Methods

Winter storage methods of on-site stacking, chipping and drying, and container-ensiling both by chipping and by hand-stripping leafy branches, were tried.

a. Dry Stacks

Fresh leafy branches up to 8' long were stacked at the Demo Plot horizontally in a circle over softwood brush bases, criss-crossing leafy ends, to make our three 10' diameter piles. The centers of piles were therefore most leafy and moist, exacerbated by tarp gaps around central poles used in some piles, and about 20% mold or caterpillar damage resulted.

Nick Jackson of Jackson Regenerational Farm stacked his leafy branch pile vertically around a central pole, with butt ends on the ground and a rope passed around the pile at start and after additions of a few layers. The pole need be no taller than the branches, so the tarp can cover completely. This pile had no damage and was easier to feed out than our horizontal piles.

Jackson Regenerational Farm dried leaves, and beginning of vertical pile

On-site feeding from the Demo Plot piles was labor-saving and of significant feed value. The small green caterpillars focused mainly on making lace and excrement of aspen and oak leaves; ash seemed immune, and r. maple and birches were barely touched. About 4/5 leaves in the 3 storage piles remained intact and mold-free; about 2/3 retained bright green color. Yet one doe one day was selecting molded aspen leaves over dried green aspen leaves (fresh aspen leaves from 2nd yr. and older root-sprouts and dried aspen leaves seem to have an anti-feedant issue for goats unless cut after frost, so possibly the deterioration was increasing digestibility?).

Barn dried leafy branches were insect free, but generally less colorful than those (shown below) from the densely packed tarped piles.

Only Josie wanted this dried oak from the demo plot. **Kanga eating a white birch layer of the pile.**

b. Dried Chips

We spread chipped fresh leafy branches in wooden boxes in an open barn to dry. Dried shredded spring beech, chipped white ash, white birch and red maple were most acceptable, and preferred in that order. No mold was observed in chipped dried species other than aspens, but about 90% of leaf surfaces were molded in chipped dried aspens, which proved palatable to only the mostly Angus beef cattle and Icelandic sheep at Meadowsweet Farm.

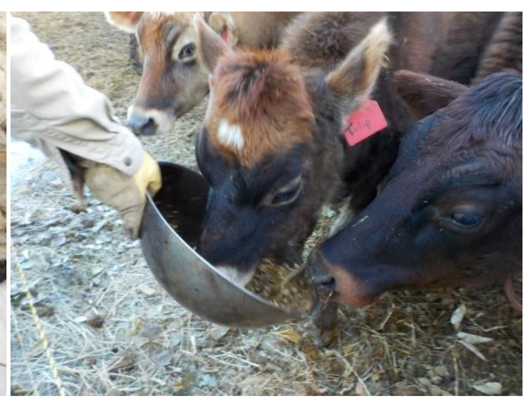
Kanga sampling dried chipped leafy branches of 6 species

c. Silage

We packed fresh leaves often including twigs that hand-snapped easily, or fresh chipped or shredded leafy branches, into plastic buckets and barrels with gaskets in lids. We lined most buckets with a contractor bag or smaller plastic bag and tied tightly, to have the option of removing from the buckets to store. It turned out that all were left in the containers, and just filling a smaller plastic bag to cover the top layer was sufficient to both ensure seal and help get all the loose ends tucked in as we put lids on. Seemingly edible white mold was observed (at air leaks around lid edges) on about 3% of silage.

All livestock preferred hand-stripped to chipped silages. Sheep and goats preferred courser shredding or chipping to fine, and picked through for largest leaf pieces, whether ensiled or dried. Cattle accepted more finely ground fodders, but palatability of bark and wood varies by tree species, with aromatic y. birch, high tannin oak, and latex-filled Norway maple wood less desirable. Humans consistently enjoyed the aromas of our leaf silages, and found ensiled hand-stripped ash, willow, and yellow birch to be good in salad.

Meadowsweet Icelandic sheep eating ensiled hand-stripped yellow birch.



Tulip ate EVERYTHING, and came home with me later.

C.2. Livestock Responses to various species and forms of Tree Leaf Fodders

Cattle, sheep, goats or hogs at 6 farms sampled leaf fodders as they became available from our pollarding of Demo Plot trees. Tree species on-farm but outside the Demo Plot, plus a few species from elsewhere in the community were additionally sampled. Our 3 Streams Farm, Faithful Venture Farm and Y Knot Farm sampled fodders spring thru winter; Jackson Regenerational Farm sampled from spring until slaughter in fall 2018, after which Meadowsweet Farm and later North Branch Farm were added.



Each category of fodder was sampled anywhere from 1 to 3 times by an animal group, varying with availability and schedule. Therefore these ratings are in no way definitive. "…food preferences depend on the needs of the animal relative to the mix of foods on offer," and "what matters is the mix of foods in time and space" (Meuret & Provenza, 2015, p. 13). The same animal on a different day might have a different response to the same sample.

Yet our observations and tentative interpretations can inform practical use and further study.

Intern Emily MacGibeny feeding fresh red oak to Faithful Venture Farm Holsteins

a. Summary Chart of Livestock Responses to Tree leaf Fodders

3= Immediately Consumed; 2= Eventually Consumed; 1= Tasted; 0= Refused

FVF = Faithful Venture Farm; JRF= Jackson Regenerational Farm; MSF = Meadowsweet Farm; YKF = Y Knot Farm; 3SF = 3 Streams Farm.

	Beech							W. birch						
	Fresh intact	Fresh chipped	Dried intact (	Dried chipped	Cooked (dried)	Ensiled intact	Ensiled shredded 5	Fresh intact	Fresh chipped	Dried intact	Dried chip	Cooked (dried	Ensiled intact	Ensiled chipped
Cattle FVF	0		3	0	3	2.5	0	0	0	3	0	3	0	0
Cattle JRF	3 early spring							2 fall						
Cattle MSF			3	3	3	3	3			3	3	3	3	2
Cattle NBF			3		3	3	2			3		3		3
Sheep YKF	1		3	2	2	3	2.5	3 fall		2.5	2	2	3	1.5
Sheep MSF			2	3	3	2.75	2			3	3	3	3	1.5
Goats 3SF	3 early spring	3	3 early cut	3		3	3	2.25 spring;	2.35	2.06	2.5		2.75	2.13
Hogs 3SF	3		2.5	1	1	3	2.5	3	2	1.92		0	3	0

	Y. birch							W. ash						
	Fresh intact	Fresh chipped	Dried intact	Dried chipped	Cooked (dried)	Ensiled intact	Ensiled chipped	Fresh intact	Fresh chipped	Dried intact	Dried chip	Cooked (dried	Ensiled intact	Ensiled chipped
Cattle FVF			3	0	3	3	0.5	3 (2, 0 when yellowing		3	0	0	2	3
Cattle JRF	3							3	0	3			1	
Cattle MSF			3	1	3	3	1			3	3	1.5	3	2
Cattle NBF			1		3		1					3		1
Sheep YKF	0		2	0	2	2.5	2	2.75	2	missing	2	2	2	1
Sheep MSF			3	0	3	3	3			missing	3	0	3	1.25
Goats 3SF	2.6		3	0		3	0.92	3	1	3	3		3	2.25
Hogs 3SF	1.33		3		0	3	1	3	0	3		0	3	1.5

	Q. aspen							B. t. aspen						
	Fresh intact	Fresh chipped	Dried intact	Dried chipped	Cooked (dried)	Ensiled intact	Ensiled chipped	Fresh intact	Fresh chipped	Dried intact	Dried chip	Cooked (dried	Ensiled intact	Ensiled chipped
Cattle FVF	1		1	0	3	3	0	2	2	3	0	3	3	2
Cattle JRF	2.75 (2 when yellowing)		3					3	2					
Cattle MSF			3	3	3	3	3			3	3	3	3	3
Cattle NBF			3		2.5							2		
Sheep YKF	3 (2.5 when yellowing)		2.5	2	2	3	1 (Susn says too ch	2.5	0	2	2	2	1	2
Sheep MSF			1.5	0.5	3	3	3			3	0.5	2	2	3
Goats 3SF	3		3 dried 10/1	0 (cut 9/25/18)		3	2.5	3	2	0	1	1	3	3
Hogs 3SF	1.9		1.68	missing	0	3	3	1.66	3	2	0	0	3	3
	Fresh cut on 9/4/18 all "3."													

	R. oak							R. maple						
	Fresh intact	Fresh chipped	Dried intact	Dried chipped	Cooked (dried)	Ensiled intact	Ensiled chipped	Fresh intact	Fresh chipped	Dried intact	Dried chip	Cooked (dried	Ensiled intact	Ensiled chipped
Cattle FVF	2	2	0.5	0	2.75	2	0	1	1	1	0	3	1	1
Cattle JRF	2	0	0.5		1	3		0.5	1					
Cattle MSF			3	3	1	3	3			3	1.5	2	2.75	2
Cattle NBF			3		1		3			3			2.75	2
Sheep YKF	2.5	3	2.33	2	2	3	2	2.5	2	2	0		2.25	2
Sheep MSF			1.5	0	0	3	1.25			3	2	0	2.75	1.5
Goats 3SF	3		1 (3 when fr	0		3	1	2.3		3	2.5		2.75	2.25
Hogs 3SF	3		2	0	1	3	2	0; 3 when tu	0	2		1	2.25	0

	H. willow				Box elder			Balsam poplar		A. elm	B. locust	Basswood	Prunus A.	B. cherry
	Fresh intact	Dried intact	Cooked (drie	Ensiled intact	Fresh intact	Dried brown in	Ensiled intact (wilt	Fresh intact	Ensiled intact (v	Fresh intact	Fresh intac	Fresh intact	Fresh intact	Fresh intact
Cattle FVF	3	3 (1 when just f	3	3	3		0	0	0	3 (1 fuzzy 1st	3	3	3	
Cattle JRF								0		3	3	3	3	3
Cattle MSF		3	3	3			3		2.5					
Cattle NBF		3					3							
Sheep YKF		2	3	2			1	1	3	2	2	2	3	3
Sheep MSF		3	3	3			2.5		3					
Goats 3SF	3	3	1 (old)	3	2.5 (0 wilted)	1	0	2.5	3	3	3	3	3	3
Hogs 3SF	3	3	3 (old)	3			0	0	0.5	3	3	0.5	3	3
		Fresh cut on 9/4/18 all "3."												

	N. maple			B. walnut	B. walnut
	Fresh intact	Dried chipped	Briefly Ensile	Fresh intact	Dried intact
Cattle FVF		0	0	2.5	2
Cattle JRF			0	2	
Cattle MSF		0	0		
Cattle NBF					
Sheep YKF	3	1	0		
Sheep MSF		0	3		
Goats 3SF	3	1	0		
Hogs 3SF	3	1.5			

The full data set with dates and comments is available at

https://drive.google.com/file/d/1BgOksabfTq1hBPmraRYBzED8lCQOGTgV/view b.[1] Animal Species' Response Rating Means of Summary Figures per Tree Species, inc. all fodder forms

See below for discussion of sampling inconsistencies. Not all tree species were offered in all forms.

3 = Immediately consumed; 2 = Eventually consumed (usually during our visit); 1 = Tasted; 0 = Refused

Hogs	Cattle	Sheep	Goats
3 Am. Elm	3 Am. Elm	3 B. Cherry	3 Am. Elm
3 Beech*	3 Basswood	3 Prunus Am.	3 Basswood
3 B. Cherry	3 B. Cherry	2.66 H. Willow	3 Beech*
3 B. Locust	3 B. Locust	2.5 W. Birch	3 B. Cherry
3 H. Willow	3 H. Willow	2.41 Beech*	3 B. Locust
3 Prunus Am.	3 Prunus Am.	2.33 Bals.Poplar	3 H. Willow
1.98 W. Birch	2.47 B. T. Aspen	2.22 Q. Aspen	3 Prunus Am.
1.92 Q. Aspen	2.37 Beech*	2.05 Y. Birch	2.75 Bals. Poplar
1.83 R. Oak	2.12 Q. Aspen	2 Am. Elm	2.56 R. Maple
1.75 W. Ash	2.1 W. Ash	2 Basswood	2.54 W. Ash
1.66 Y. Birch	2 R. Oak	2 B. Locust	2.4 W. Birch
1.52 B. T. Aspen	2 Y. Birch	1.9 W. Ash	2.3 Q. Aspen
1.41 R. Maple	1.8 W. Birch	1.84 R. Oak	1.9 Y. Birch
0.5 Basswood	1.49 R. Maple	1.83 B. T. Aspen	1.85 B. T. Aspen
0.25 Bals. Poplar	0.62 Bals. Poplar	1.75 R. Maple	1.8 R. Oak

*Beech ratings were for fodders cut in early spring. Only hogs liked beech once leaves matured.

Elm, basswood, locust, willow and prunus ratings may be skewed positively, as all except willow were only fed fresh, and no chipped fodders were fed of these species.

Cattle responses to fresh fodders were skewed negatively at Faithful Venture Farm by my tendency in summer to arrive just after afternoon feeding time.

Red oak and yellow birch may be skewed negatively, as these species of chipped fodders received particularly low ratings while fresh and ensiled intact r. oak and y. birch leaves were well-received. We suspect that oak twigs have tannins above animal tolerance levels, and that the volatile oils in y. birch twigs are unpalatable, despite human positive response to the wintergreen-like fragrance. Our balsam poplar leaves were harvested in spring, so were very intensely aromatic; goats and sheep found them more acceptable than did hogs and cattle.

Willow, beech, b. t. aspen and oak silages and some dried leaves came from trees in more sun, most previously pollarded, and all more vibrantly healthy than those in the Demo Plot. This difference in tree health tends to skew animal responses positively.

Dried aspen leaves received divergent responses. Goats refused q. aspen leaves dried before frost, despite immediately consuming leaves from the same tree harvest fresh or ensiled. The goats immediately and thoroughly consumed q. aspen leaves cut and dried from the Demo Plot as the leaves started to turn. Dried b. t. aspen cut before frost from the demo area was likewise refused (none was cut after frost).

b.2. Animal Species' Response Rating Means of Summary Figures per Tree Species, intact dried & intact ensiled only* (to exclude variability due to bark and wood palatability issues)
*9 tree species offering enough quantity to be both dried and ensiled

See discussion below (pertinent sections copied from above) for remaining sampling inconsistencies




3 = Immediately consumed; 2 = Eventually consumed (usually during our visit); 1 = Tasted; 0 = Refused

Hogs	Cattle	Sheep	Goats
3 H. Willow	3 B. T. Aspen	2.87 W. Birch	3 Beech
3 W. Ash	3 H. Willow	2.68 Beech	3 H. Willow
3 Y. Birch	2.91 Beech	2.62 Y. Birch	3 R. Maple
2.75 Beech	2.66 Q. Aspen	2.5 H. Willow	3 W. Ash
2.5 B. T. Aspen	2.6 Y. Birch	2.5 Q. Aspen	3 Y. Birch
2.5 R. Oak	2.5 W. Ash	2.5 R. Maple	2.4 W. Birch
2.46 W. Birch	2.4 W. Birch	2.5 W. Ash	2 Q. Aspen
2.34 Q. Aspen	2.25 R. Maple	2.46 R. Oak	2 R. Oak
2.12 R. Maple	2.1 R. Oak	2 B. T. Aspen	1.5 B. T. Aspen

Willow, beech, b. t. aspen and oak silages and some dried leaves came from trees in more sun, most previously pollarded, and all more vibrantly healthy than those in the Demo Plot. This difference in tree health tends to skew animal responses positively.

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D. Pollarding Guidelines for Broadleaf trees

D.1. Demo Plot Pruning Rules

a. Rules We Used for Initial Restructuring of Demo Plot Pollards

Cut where future sprouts will receive at least 1/3 day of sun (high if shaded). Sprouting locations of separate trees minimum 6 ft. apart. Cut beyond a collar or branching place when/if in arm's reach of trunk. Leave a "chunky collar" or even slight stubs. Okay to stub branches at 2-3" diameter at arm's reach with no collar nor branching if vigorous growth evident and tree well-stocked (mid-summer on).

Lowest (non-dominant) branch or branches in shade should be left intact especially if essential for future climbing, to be sure to stay alive. Other than leaving these low non-dominant branches, and cutting most severely at the tree top, amount removed should be consistent on a whole tree and on trunks from the same root.

In spring when trees' energy stores are depleted from leaf-out, retain more foliage; at minimum leave "sap risers" (small branches with small amount of foliage left) on every branch cut. Leave 1/3 foliage when possible on birches, aspens, and softwoods at all harvest dates, shortening branches always to a significant leafy twig or a few, to bring foliage in arm's reach of trunk where possible. Oaks and ash tolerate complete removal of foliage-bearing wood once fully stocked (late July probably for ash, depending upon weather; probably later for oak – Kays and Canham, 1991).

Cut in young vs. old wood when a choice is available. Shorten trees as much as can without opening up grain of trunk (cutting above collars), or if opening trunk grain cut ideally at <3" diameter, and without incurring undue personal risk (we made very few cuts needing ropes to direct the falling top, instead relying upon lean of tree or cutting pieces light enough to direct with a push).

Retain ergonomic "nest" perches to continue to work from in future, and strong top forks for rope setting. Cut dead wood off unless solid and useful for climbing or housing wildlife. Okay to clear live twigs in the interior of tree when in the way of ergonomic positioning.

b. Pruning Rules for Subsequent Harvests

Cut new growth leaving chunky collars of the new wood, or slight stubs to maximize retention of basal buds, where continued sprouting is desired.

Cut interior sprouts which compete with growth of desired sprouting locations, or which are in the way of climbing or perching, more closely, leaving a minimal collar; these can more beneficially be cut as soon as they appear, rather than at harvest time, on pollards where height access is not prohibitive.

Cut the few remaining long intact original branches back to new growth in reach of trunk, when available, to continue to develop accessible tree forms.

Cut off branches that have died closely, cutting into live bark, to allow live cut healing edges an easy surface over which to grow and close.

D.2. Pollarding Summary Chart by Tree Species

Tree tolerance and recommended harvest season based upon my limited tries on-farm.

Tree Species	Season of Harvest	Palatability Rating			Wilt issues
		Leaves	Bark	Chipped (inc. wood)	
Ash, White	July to Leaf-drop	Great	Good	Okay	No
Aspen, Quaking	Fall if Drying	Great	Horses	Okay	Poss. Dried
Aspen, Big Toothed	Fall if Drying	Great	Horses	Okay	Poss. Dried
Basswood, American	Aug. to Leaf-drop	Great	Good	Okay	No
Beech, American	May (Oct. okay)	Great	No	Okay	No
Birch, White	June & Fall (best)	Good	No	Okay	No
Birch, Yellow	Spring thru Fall	Good	No	No	No
Cedar, White	Winter	Great	No	not tried	No
Cherry, Black	July to Leaf-drop	Great	Great	not tried	Yes (Dried ok)
Elm, American	July to Leaf-drop	Great	Good	not tried	No
Fir, Balsam	Winter	Okay	Good	not tried	No
Hemlock	Winter	Good	Great	not tried	No
Locust, Black	I cut in Fall	Great	Excellent	not tried	No
Maple, Norway	All Year	Great	Excellent	No	not tried
Maple, Red	Winter best	Good	Great	Okay	Yes (Dried ok)
Oak, Red	Aug. to Leaf-drop	Great	No	Less ok	Poss. Dried
Pine, White	Winter	Okay	Good	not tried	No
Prunus Americanus	Aug. to Leaf-drop	Great	Great	not tried	not tried
Willow, White-Crack Hyb.	July to Leaf-drop	Great	Great	Okay	No

Tree Species	Growth Habit	Maximum Tollerance	Branch Strength	Rot Resistance (some guessing)
Ash, White	Single or Coppice	Complete harvest	Good	Good
Aspen, Quaking	Root-spread Grove	Leave 1/3 foliage	Somewhat Brittle	Okay
Aspen, Big Toothed	Some Root-spreading	Leave 1/3 foliage	Somewhat Brittle	Good
Basswood, American	Single or Coppice	Complete harvest*	Somewhat Bendy	Good
Beech, American	Root-spread Grove	Leave sap-risers	Very Strong	Great
Birch, White	Some Root-spreading	Leave 1/3 foliage	Okay	Low
Birch, Yellow	Single or Coppice	Leave 1/3 foliage	Bendy	Low
Cedar, White	Single	Leave 1/3 foliage	Brittle	Excellent
Cherry, Black	Single or Coppice	Leave sap-risers?**	Good	Great
Elm, American	Single or Coppice	Leave sap-risers?**	Good	Great
Fir, Balsam	Single	Leave 1/3 foliage	Good	Great
Hemlock	Single	Leave 1/3 foliage	Very Strong	Great
Locust, Black	Some Root-spreading	Complete harvest	Good	Excellent
Maple, Norway	Single or Coppice	Leave sap-risers	Brittle	Low
Maple, Red	Single or Coppice	Leave sap-risers	Strong	Low
Oak, Red	Single or Coppice	Complete harvest	Very Strong	Excellent
Pine, White	Single	Leave 1/3 foliage	Good	Great
Prunus Americanus	Medium Root-spread	Leave sap-risers?**	Good	Great
Willow, White-Crack Hyb.	Single or Coppice	Complete harvest	Brittle	Low

*Based upon literature (mine in shade, so I'm gentler)

D.3. Factors to Consider when Pollarding

Sunlight (Slotte, 2000), harvest date (related to energy stored, palatability, weather, and moon phase)(Kays & Canham, 1991; Zurcher, 2018), pollard form related to climbability, ergonomics, tree energy flow and efficiency of form (Zurcher, 2018; Fundación HAZI Fundazioa, approx. 2014), and collars (which affect fungal entry), are factors to be considered as one makes pollarding decisions.

a. Sunlight

Trees need energy, both stored carbohydrates and incoming energy from the sun (Slotte, 2000 says at least 1/3 day sun), to sprout and grow successfully. Decreased tree height diminishes tree access to sunlight. Therefore one can successfully pollard whole areas of a woodland, or individual trees in a pasture, but not usually individual trees in a woodland. In a woodland rotation, it is beneficial to prune adjacent areas consecutively, such that trees near a south boundary are not compromised.

R. maple pollarded high to catch sun, W. birch , and R. maple, R. oak and 3 W. ashes, all with sun on sprouts, July 7, 2019

b. Rotation Period

Pollarding rotations for fodder can be from 3 to 8 years (Slotte, 2000), or even 1 yr. if a very rich site (Machatschek, 2002) depending upon: growth rates affected by soil richness, tree species, tree health, and climate; and desired size of fodder product. Brauner (1756) recommends a 3 yr. rotation in Swedish woodland; Carlsson (1996) reports a 4 to 5 yr. rotation as average in Swedish farmer journals of the 1700s-1800s.

I plan to re-harvest our Demo Plot in 5 years, as a compromise between the ash that are growing fast and are prized for fresh or dried leaves, and the r. maple of which goats especially enjoy flower buds, and large branches to bear against to strip bark in winter.

L: Dried ash leaves from our storage pile were prized even if brown.

R: Maple buds and bark are a staple in winter.

c. HARVEST DATE (NUTRIENT STORAGE, PALATABILITY, WEATHER, MOON PHASE)

Swedish farmers used to taste tree leaves to know when to start harvesting for winter (Slotte, 2000); possibly the taste changes when the tree has recovered from leaf-out and stocked nutrients to capacity. The start of harvest varied by as much as a month, based on weather and moon phase (Carlsson, 1996).

We have been aware from past experience, and noticed anew, tree species-specific palatability issues for livestock related to dates of leaf harvest. Beech is a spring fodder, though hogs continue to eat it in summer; aspens were preferred to be dried after frost, and are eaten more eagerly fresh from tall trees rather than from school-aged root sprouts (infantile root sprouts do get hit as they emerge in spring); birches are enjoyed in spring, but seemed to have an even longer fall window of palatablilty, r. maple leaves are eagerly consumed both fresh and dried in limited quantity, but winter maple bark is a steady staple. Ash and oak are sought after during the whole growing season, yet some of the same oak was refused dried.

Trees stressed by drought or other challenges are sometimes refused, as tannins and other antifeedant plant compounds increase with stress.

2 ash trees next to each other, L not-pruned and suffering from drought - 1 yr. growth on vibrant R ash. Sept 2016

d. POLLARD FORM

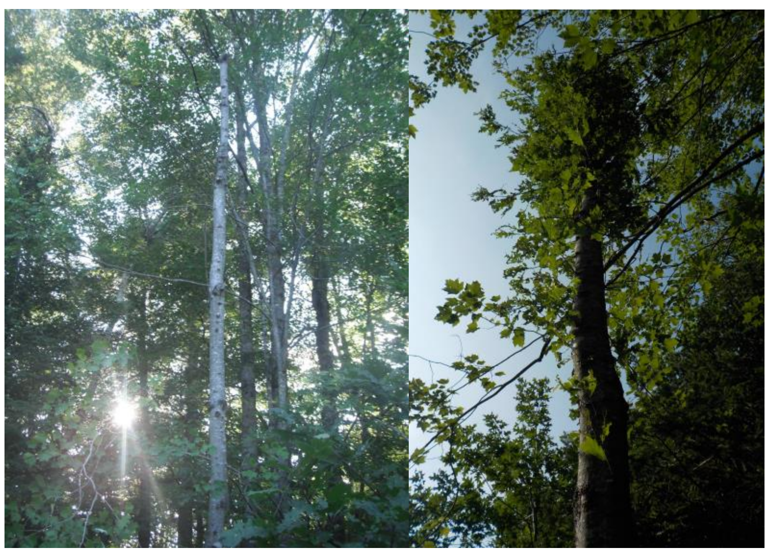
d.[1] HISTORIC FORMS

Pollarding historically doubled longevity of trees., which were most frequently reduced by an initial cut to 3 to 4 meters high, at about 15 years old or when the diameter of “a woman’s lower arm” or “a wine bottle.” Subsequently, branches could be cut again, in 3 to 8 yr. cycles, leaving new collars to form a boll around the initial cut, or a (less common perhaps agriculturally, but more ornamental) choice could be made to develop multiple bolls further from center.

R. maples,, to R pruned for multiple bolls, to L two single bolls that may merge some day. Pics June 14, 2018 & July 7, 2019

Starting with mature trees to make tall forms with shortened branches, ("fastigiate" or "columnar" form) was also a historic practice (Machatschek, 2002). I observe darker green foliage which holds longer into the fall, on even the tall trees I have pollarded, yet I also observe these tall trees letting go of some branches, and replacing with trunk sprouts, at each of my initial, 2nd, and some 3rd prunings.

Sprouting from tall branched forms is perhaps less predictable than from the physiologically efficient squat forms. "Shreds" are another historic tall form, where branches and top are cut back to collars on the trunk, usually in 3 year cycles to keep knots small. Shreds are harder to climb without a ladder, but make plenty of fodder, and become a saw log with ornate grain later in life (Law, 2001).



Oak shred 8/24/17 & 8/23/18.

d.[2] CLIMBABILITY AND ERGONOMICS

As our Demo Plot trees often required rope access, we made sure to leave tree formations for rope sets intact. We aimed to cut branches within arms' reach of our perches on branches near the trunk, so that sprouting might concentrate at the cut ends versus where we are comfortable to perch.

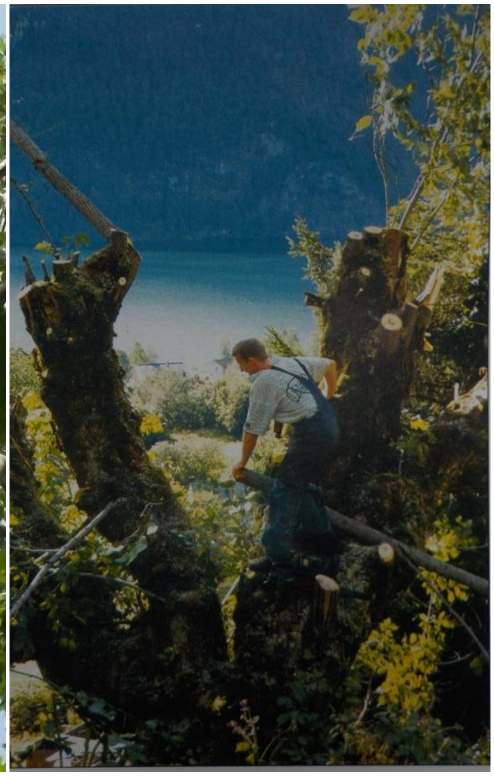


Foto: Malén Røysum.

Josh Kauppila in r. oak 5, 8/29/18.   Modern branch harvest of an old pollard for chipped sheep fodder, Austad et al, 2003

We topped smaller trees a bit above our favorite ladder heights, to comfortably reach up from the same ladder after sprouts thickly appear.

d.[3] ENERGY FLOW AND ECONOMY OF FORM

Trees must be able to replace enough foliage after pollarding to continue to keep sap flowing throughout their wooden form that remains. Bark will only remain alive where the fibers lead to live foliage or new sprouts.

Trees with plentiful energy stores and enough sun will create sprouts at each place where sap flow meets an end without foliage, or with insufficient foliage. If the vertical travel is too great, and sun is sufficient, they (especially oaks) may supplement with trunk sprouts. Alternatively if energy is insufficient or distance along wood is too great, trees will sprout a ways back from cut ends to stay closer to their roots, or will sacrifice an inefficient branch, or resort to root sprouts (especially aspens), or give up entirely (a few of our over-mature red maples and possibly white birches).

Lower branches have less energy than do tops of trees, due to tree hormones as well as sunlight (Zurcher, 2018). On our Demo Plot trees, when low branches were present, we sometimes left them intact or lightly pruned to assure their continued life. We often left no foliage-bearing twigs, or only small “sap risers” (small branches or branches cut back to retain a small amount of foliage, to start sap flowing before sprouting occurs) in or near dominant tops of trees where our cuts could be in vigorous young wood. Yet a small amount of foliage cannot evapotranspire enough to draw sap great distances up a bare trunk if the tree is TOO tall.

Our taller Demo Plot trees were/are challenged by height disproportional to foliage of canopies which were already small, and now are extremely reduced. Large trunk cuts apparently sometimes work to pollard beech (Fundación HAZI Fundazioa, approx. 2014), yet in my experience large trunk cuts cause tree death on r. maples or ash, our most numerous broadleaf trees. Also large trunk cuts at 3 to 4 meters are much more dangerous to accomplish than was our higher cutting in younger branch wood.

d.[4] Tree Measurement Charts

	DBH	Height to top cut	Length cut top	D top cut	# rings at top cut
Means r.oak	7.16	34.36	18	2.59	13.5
Means beech	4	26.6	17.37	1.84	15
Means w. birch	8.14	33	21	3.54	29.6
Means y. birch	8.5	22	20	2.37	15.5
Means r. maple	7.68	31.88	23.63	3.04	21.32
Means b. t. aspen	9.5	56.5	20.25	2.875	6.5
Means q. aspen	6.5	40.5	19	3	17
Means w. ash	4.8	20	35	3.75	18
Means of all	7.035	33.105	21.78125	2.875625	17.0525

Mean R. Maple Measurements per Diameter Class						
		DBH	Height Top Cut	Length Cut Piec	Diam. Top Cut	# Rings Top Cut
r. maples	DBH >=8"	10.82"	40.29'	23.17'	3.72"	24.62
r. maples	DBH >=6"	7.03"	28.63'	27.17'	3.37"	22.27
r. maples	DBH <6"	3.49"	14.91'	27.68'	2.52"	22.88

Cut top pieces were similar across diameter classes, but finished heights varied greatly by DBH (Diameter Breast Height).

Our average finished height of about 15 ft. for trees under 6” Diameter Breast Height (DBH) was slightly higher than the traditional 3 to 4 meters, as we occasionally have moose on snow to eat the sprouts, plus the intermingled taller trees limit sun. If some of the tall trees shift energy downward to sprout lower, or if some die, the younger shorter more efficient forms of pollarded trees below will capitalize on the additional sunlight.

Even when pollarded with much observation, understanding of tree physiology, and good guessing, a few trees will offer surprises.

We hope that the Demo Plot woodland as a whole will adjust in the next few years to optimize multi-level foliage on a diverse puzzle of efficient plant forms.

Goats pruning too-low sprouts of a Demo Plot r. maple

e. Tree Age and vigor

One can observe sprout lengths of the last few growing seasons, with winter twig divisions still visible even from below. The vigor of this recent growth gives one a sense of probable sprouting potential.

Not only the tree as a whole, but each branch should be assessed in this way, to decide how much foliage one must leave (if any) for the branch to continue to thrive.

Younger wood sprouts easier than older wood, yet small branches dry out easier than branches >2" diameter, which have better storage capacity.

W. ash joints on same tree; the small diameter branch on R was unable to maintain moisture to the cuts. 10/4/19

f. COLLARS AND FUNGAL ENTRY

Collars are in the swellings at bases of branches, and there are also winter divisions of seasons of growth. At these places, the grain forms a wall which prevents spread of fungi. One should always cut beyond a collar when this choice is available, to retain these protective barriers, and to keep a mound of younger wood, where sprouting will most likely occur. This is especially important when choosing where to shorten the main stem, as a cut into vertical trunk grain can lead quickly to a hollow trunk. Old squat pollards do tolerate hollow trunks for hundreds of years, when they have a sufficient proportion of healthy sapwood, but climbers must assess carefully.

As opposed to fruit tree pruning where one wants to minimize sprouting by leaving modest collars, when pollarding one can leave a more chunky collar, or even stubbed branches (which may become hollow, but are unlikely to transport fungi down the trunk).

Joint 2 boll-to-be mid-June, 2019 on r. maple by pond, many collars and slanted cut to shed moisture

View Sept. 3, 2019 from under Hemlock 2 near center of north fence line

D.4. Tree Species-Specific Pollarding Points (for broadleaf species present at Streams Farm)

3 shapes of beech at 3 Streams Farm, each with 1 yr. growth

a. Beech

Beech respond very well to all forms of pollarding, including the branchless shred form and trunkated 1 boll form. They grow slowly but surely at 3 Streams Farm (in England, they are not sprouting well; Helen Read, personal communication, and Veteran Tree Society, 2014). Traditionally they were pollarded in long cycles (Helen Read, 2003, was told in Romania of a 50 yr. cycle!) for fuel, perhaps cut in winter.

Also traditionally, leaves were hand-stripped (without pruning the tree) for early spring fodder; the trees will re-leaf from dormant buds. Slotte (2000) recommends to rest the tree at least a year between leaf strippings. I have done this successfully in past on small beeches at 3 Streams Farm.

For us beech offer prized spring fodder for all livestock groups, and all-summer fodder for hogs. Since we cut branches just after leaf-out, I have concern that tree nutrient storage may be insufficient, so I tend to leave "sap risers," small branches with a bit of foliage, wherever possible.

Be aware that for root-propagating tree species (beech, aspens, birches, locusts), and more obviously for multi-trunked trees from one base coppiced by past felling, trunks from the same root should be cut back similarly. Beech may tolerate unequal treatment of multiple trunks in a stand better than do other species, but risk remains that the tree will prioritize an un-pruned trunk.

W. birch in pasture just pruned June 6, 2018. Same tree Oct. 5, 2019

b. WHITE BIRCH

Slotte (2000) and Austad (1993) say that birches and aspens should be thinned rather than harvesting the canopies all at once. W. birch branches need a lot of sunlight to stay alive. Our few w. birches which had plenty of foliage-bearing branches low enough for continued harvest have responded well to removal of 1/2 to 2/3 of foliage-bearing branches, even when pruned soon after leaf-out in spring.

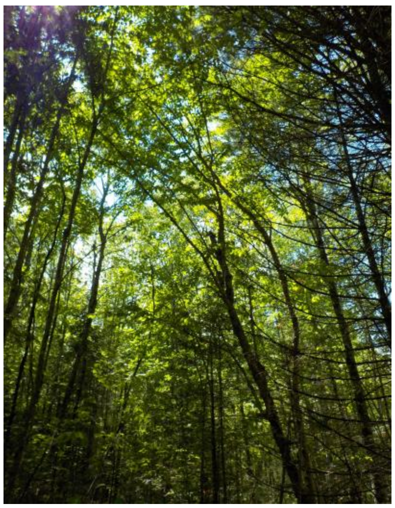
Through this study, we noticed a longer and more popular fall window of palatability for w. birch. Fall pollarding should be less taxing of tree energy than spring pollarding.

Fungi soften cut surfaces quickly on birches, so expect some hollow places with time, and place oneself with safety in mind. Lightly knock off anything dead, as it will bear no weight.

Most of the Demo Plot w. birches, and w. birches throughout our woodland, have small high tops and no other foliage; therefore our pollarding of these left tall inefficient forms with probably insufficient foliage. Most remain alive to date, yet with little new growth.

We were surprised to see no root sprouting response from the w. birches, and minimal basal sprouts despite our severe top cutting, probably due to low energy of these over-mature trees.

We tried making cuts in bark down bare w. birch trunks at 2-3 ft. intervals, either with bill hook or saw, to enable lower trunk sprouting, but with no response from the trees.



1st y. birch in Demo Plot before.

1st y. birch pollarded on June 8, 2018.

1st y. birch Sept. 3, 2019

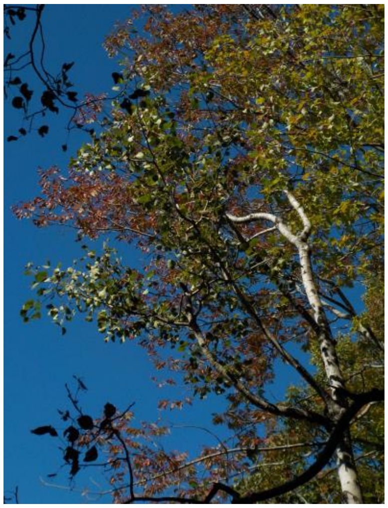
c. YELLOW BIRCH

Unlike w. birch, y. birch branches are shade-tolerant. Even under a closed canopy, y. birches are likely to retain a climbable form, easily accessed by ladder versus ropes. Yet they need an increase in sunlight to sprout new growth when diminished in spread and height by fodder harvest.

Y. birch is palatable to livestock spring to fall, yet is not 1st pick. Ensiled y. birch was very popular when only leaves; chipped twigs are highly aromatic and apparently less desirable (Meadowsweet cattle fought to smell but not eat – the sheep there did eat).

As with other birches and aspens, 1/3 to 1/2 of foliage should be retained on y. birches.

As with w. birch, hollows occur easily and dead things should be lightly knocked off as they can bear no weight.




Q. aspen with 1 yr. growth. B. T. aspen on leaf pile, 2 yr. growth. Balsam poplar re-pollarded 5/18/18. Same 6/7/19.

d. Quaking and Big Toothed Aspen

As on birches, on aspens Slotte (2000) recommends thinning rather than cutting branches all at once. Of species at 3 Streams Farm, aspens are most likely to sprout from roots versus from the intended pollard, which happened on all but the healthiest most branched aspens in our Demo Plot.

Successful pollards of quaking and big toothed aspen at 3 Streams Farm have branching along at least 1/3 and preferably 1/2 or more of the retained trunk, with a significant plume of foliage left on each retained, shortened branch.

For fresh eating, foliage of mature trees is preferred over that of root sprouts, which seem to chemically defend against herbivory (though still will be browsed in a paddock). Possibly similar chemical defenses seem to occur in drying leaves if cut before frost; quaking aspen leaves cut after frost and dried were well-received; all ensiled aspen leaves were well-received.

Megan Gerritsen of Wood Prairie Farm reported that her Dexter cattle noticeably benefited from eating winter root sprouts. Horses eagerly strip aspen bark in winter.

When climbing aspens, be sure to step on bases of branches touching the trunk, and keep multiple holds or tie into a solid crotch. Aspen wood snaps off easily, even when live and healthy.

Aspen 25, healthiest in Demo, Sept. 3, 2019

R. maple by goat house, 2 season's growth Oct. 5 2019

e. MAPLES

Maples were said to have been pollarded for fodder in Europe, but were not the long-lived enduring pollards that remain in the landscape. Pollarding of r. maples at 3 Streams Farm has been highly successful, despite initial concern about sap dripping from winter cuts, and despite that fungi surely enter all open cuts.

Leaves of r. maple if healthy are well received both fresh and dried so long as other feeds are available for a mixed diet, to balance gallic acid content. For goats, the winter bark, twigs, and buds are a more valuable staple, seemingly with little or no gallic acid issue. Striped and Norway maple leaves and even summer bark are chosen by goats ahead of those of r. maple. Sugar maple is the least preferred by 3 Streams goats, yet is a winter staple for goats at Mahna Farms in Ontario (Walder, 2017).

When chipped and ensiled, Norway maple was refused by all livestock groups, possibly due to latex in the chipped wood. R. maple chipped dried or chipped ensiled was accepted.

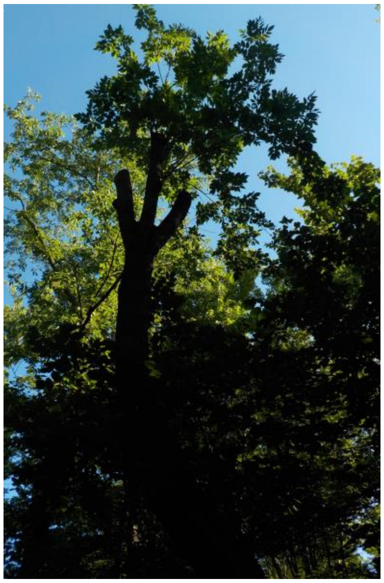
f. WHITE ASH

Ashes were consistently prioritized as pollards for livestock fodder across Europe, in branched and single boll forms. Our livestock groups confirmed desirability of ash in all forms (though Y Knot Farm sheep had other more highly rated favorites).

Despite some evidence of initial poor health (ashes are drought-sensitive, and ours may have "ash decline" or "ash die-back," plus the threats of "ash yellows" and emerald ash borers approach), once pollarded our ashes consistently have large dark green foliage and vigorous growth. Most of these are fastigiate (columnar) forms with shortened branches and bits of foliage left; a few are one boll forms.

A few years ago, a tree with 7" trunk cut and no branches left sprouted from rough bark, but did not survive. Alternatively, an initially huge branched ash with 3 large-diameter cuts in rough bark near the tree's center (large stubs but no branches left) has 5 yrs. healthy growth from rough bark in two high locations; cuts were above collars from previous breakage long ago, and this tree has good access to water and rich bottomland soil (see pic.below).

Ash have strong joints and branches for climbing.



Large ash July 19, 2019, 1st cut fall 2014. 9th & 23rd w. ash, & r. oak 5 (to R), season's growth Sept. 3, 2019

g. RED OAK

Red oaks sprouted very well (see r. oak 5 to R above), similarly to the ashes. In mid-summer, caterpillars arrived (probably Browntail moths and others). Our oak sprouts also tend to be damaged for the first couple years by shot hole fly larvae. Most oaks pollarded at 3 Streams Farm have maintained progress despite these severe defoliations by insects.

R. oak leaves are a first choice of Streams heifer and goats on walks, threatening development of small trees. Our animals don't eat bark and twigs (but Eli Berry's nearby cattle DO eat 1st yr. shoots in winter).

Oak joints and branches are strong enough that I climbed 3 year old sprouts to re-prune our one oak shred last year. They also are rot resistant, so have a chance of cut closure before fungal entry.

I met an oak pollard in England that was alive at over 1,000 years old.

CONCLUSION

Our Northeastern tree leaves were readily eaten fresh, dried, and ensiled by cattle, sheep, goats, and hogs, and have potential to increase farm feed security. Chipped feeds fresh, dried, and ensiled of most species were accepted, and would take less storage space if a leaf-separating rake preceded, or in-line fan followed (idea thanks to Aidan Clowes, Westminster, Vt.), the chipper intake to keep wood chip (bedding) and feed portions separate. On-site tight stacking of <8' fresh leafy branches to dry under tarps worked, with some loss of quality where leafiest branch tips overlapped in pile centers (we had butts outward to avoid theft by goats); such quality loss was avoided in Jackson Regenerational Farm's vertical butt-down stacking.

Pollarding a woodland above browse height allowed livestock access without tree sprout damage, and the increased light, droppings and trampling stimulated unexpected grazable ground layer greenery. 30 year old or younger woodland growth should be tried with power tools or even feller-buncher, as our 55 yr. old growth with mostly hand saws was too time-intensive at initial restructuring to be viable for most farmers. Labor of subsequent harvest cycles is likely to be more economical, though still more time consuming than harvest of a hay field (but also cooler and very fun I think).

Fodder yield/acre of this 55 year mixed-age woodland from initial re-structuring was about one half the average 2018 Maine hay yield, and a transition to hay there would not be advisable due to the flood zone and uneven ground. The next harvest, in 4 to 6 years, we expect will have higher palatability and % edible portion (as yet unmeasured for the Northeast; Brauner, 1756 in Sweden wrote “as good as a good hay meadow”).

Labor and yield differences in using these mineral- and plant compound-rich feeds may be possible to offset through study of health benefits to humans who eat the food products raised, and pricing that reflects this quality difference.

Environmental benefits of food production from woodland may at some point trump all economic concerns, or receive policy-related payment rewards, if climate patterns and ecological systems continue to deteriorate worldwide.

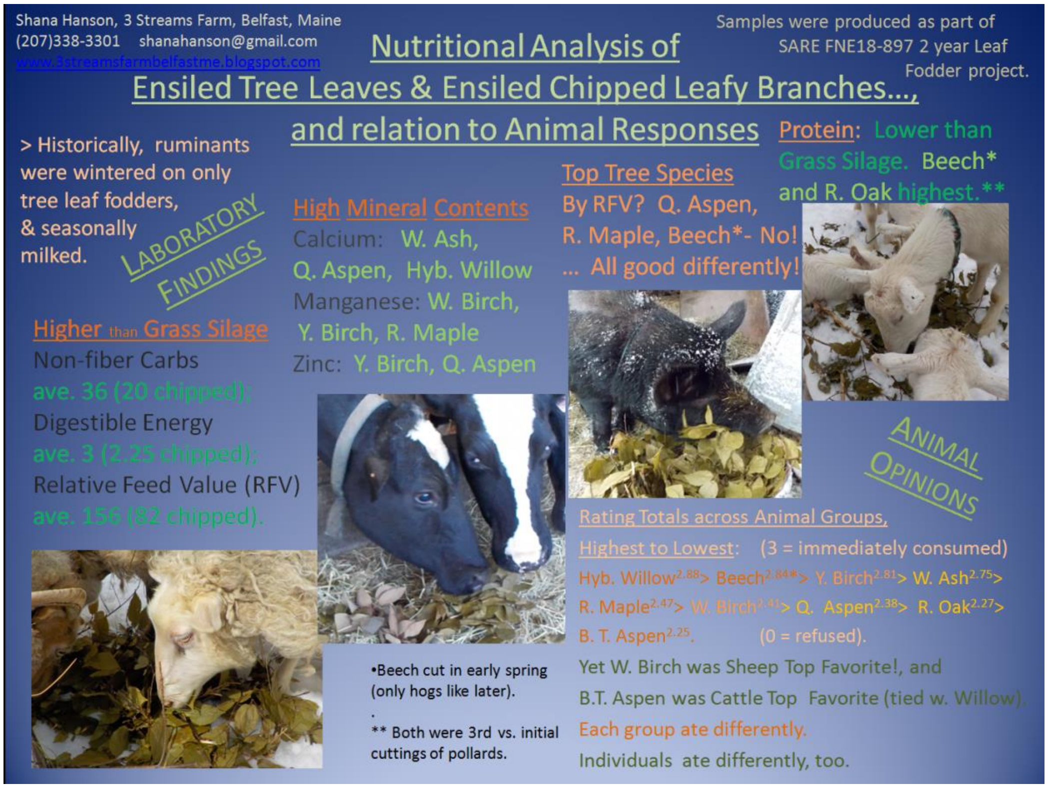
Environmental benefits to livestock on-farm may also raise the value of an “air meadow” woodland strategy, which can buffer temperature extremes while allowing enough light for new pasture growth under the pollards. The cyclical canopy harvest of “air meadow” maintains steadier ground light over time than do silvopastural models that rely on cycles of felling, and makes the difficulty of successional tree plantings among livestock unnecessary.

Northeastern farmers can beneficially work on areas of “air meadow” tree canopy harvest in woodland, or use easy-access trees in or along edges of pastures (that start with broad canopies and low branches) at times when feed shortages raise feed value and decrease feed source choices, or at points in the year when time allows, in preparation for such need.

EDUCATIONAL EVENTS

About 130 people attended our tree fodder presentations and events 2018-2019. Updates on progress were offered at both 2018 and 2019 MOFGA Tree Fodder Days, and attendees of the 2018 and 2019 Tree Fodder Seminars spent time learning various skills in the Demo Plot. Shana led people in pollarding willows at the 2018 MOFGA Farm and Homestead Day, and helped them make and use climbing harnesses in 2019. She presented “Tree Leaf Preferences of Cattle, Sheep, Goats and Hogs” at both the 2018 and 2019 Common Ground Fairs (the second was a scheduling mistake by MOFGA – the 2019 paper speaker application with updated presentation titles apparently was lost). Shana made it to NOFA MA Winter Conference (powerpoint at https://drive.google.com/drive/folders/1P4NHKslaS5FHt_FT94ZlnltmcMoBrOw) to present with a week’s notice, due to a mistyped email address, and to NOFA NH 2019 Winter Conference (powerpoint at https://drive.google.com/file/d/1rsFQ48y_iG4Mz-FQ6ccUNkP2xUDKY3ON/view) in a more graceful fashion, and with the most full audience. MOFGA Farmer to Farmer Conference requested a broader (and somewhat confusing) presentation topic (see videos at https://www.youtube.com/watch?v=Ku0aIUS_rts and https://www.youtube.com/watch?v=Ex05wSQSDp8&t=28s, plus powerpoint at https://drive.google.com/file/d/1JEnMgruxOgo7Ca4qiSBn02QviClqGLb7/view).

Shana tabled with her extensive collection of literature about tree leaf fodder at Vermont Grazing and Livestock Conference January 17-18, 2020, answering questions, learning from others, offering a "poster presentation" of results of the VGFA Mini-grant which has paid for lab testing of samples created by this SARE project, and offering materials from this SARE Final Report.



VGFA Mini Grant Poster Presentation for Vermont Grazing and Livestock Conference, Jan. 17-18, 2020

Learning Outcomes (Changes in Knowledge)

A. Learning from Observation of Existing Pollards

I used to advise that healing edges should close over initial pollarding cuts before the next harvest; this would be ideal, except that I saw one sprout often becoming dominant to replace the branch over time, versus developing sprouting heads or bolls, and very few cuts closed completely even when cut 9 years ago. So I have tended to prune sooner to train the trees toward more prolific and accessible sprouting.

Maples and birches had soft fungal wood in almost all exposed cuts by year 3, yet growth was strong and healing edges healthy. So I have been letting go of my concerns about healing and fungus, and gaining trust in the trees' ability to thrive. Ancient pollards still alive in Europe are riddled with fungus and hollows, supporting incredible biodiversity. It does remain important to observe and assess where one places one's weight when climbing, and large diameter trunk cuts are still not recommended.

Growth on previously pollarded large maples on-farm has been more vigorous than what we are seeing in the Demo Plot. This difference does not seem solely due to starting with broader healthier canopies, nor does it seem that even the 4th consecutive summer of drought would cause such difficulty in a flood zone. I guess the learning is about mystery, and gratitude for the miracle when trees sprout well.

B. Learning from Demonstration Plot

We had no idea how much work we'd committed to! We did learn to climb. I would advise writing such a proposal as working a set number of days, THEN measuring the area completed. Yet the area now is a joy to visit, and I look forward to observing it as the goats and cow browse, as we pollard adjacent areas (which I have begun).

As stated under "Labor" above, Demo Plot poplars and some of the less vigorous red maples are struggling to maintain life in their disproportionately high pollarded crowns. Felling such trees would have saved time, while still providing tops to goats and poplar root sprouts to pollard later (maple root sprouts do not survive the presence of goats).

There were also a few unexpected failures to sprout among small understory firewood-coppiced maples, on the drier east side of the Demo Plot.

Our 2.88 " average diameter top cuts averaged about 20 years old, older than I expected. Clearly growth had slowed in this closing canopy, and we would have done well to start this area 20 years ago.

C. Learning from Storage Methods

I already knew that drying leafy branches is much easier and less weather-dependent than making grass hay, but was impressed at the bright color retention and good condition of most of the leaves in our piles, especially considering the non-traditional long length we chose (my sense has always been that goodness from the leaves recedes back into the wood, to try to stay alive as they dry). My impression is that traditional sheaves were quite standardized at about 1 meter long.

The chipper blew our first shredded beech fodder right through a previously intact tarp; the spare calf hutch provided a better catchment system. We chipped most too finely to be ideal for sheep and goats, and should have continued to shred more and chip less, perhaps varying speed to find the best texture. Ensiling was surprisingly easy and fool-proof, and shelf life was longer than expected; goats and heiffer enjoyed some left-overs in mid-summer. Drying chips took way too much space and care (I think Austad et al used a fodder drying machine).

D. Learning from Livestock Responses

Sampling by livestock caused me to organize a lot of information to share with others. I already knew a lot about browse, from 15 years with goats, and from endlessly collecting browse literature. I'd even brought elm silage to Glendon's Holsteins the year before. Yet there were points of learning for me too.

Meadowsweet Farm and I were amazed at the appetites of their beef cattle and sheep for almost all our offerings, including chipped fodders. At North Branch Farm, one heifer wanted way more than the others (she ate everything we brought), so she moved to my farm – my first cow, for ongoing learning and draft power. Once there, she sought out woodland duff and rotten stumps to eat, as do all my baby goats – but she was 2 yrs. old. She also wanted to taste all conk fungi and strip moss off rocks, all fringe benefits from the "air meadow" for the rumen.

I was surprised that our drab traditional dried leaves cooked in water were as popular with the Holsteins as were bright aromatic ensiled leaves. But the ensiled leaves were more convenient.

The hogs strangely did not want basswood, despite having similar digestive systems to ours, and wanted mature beech leaves in summer. They pointed me to the beech tree – I would not have otherwise cut beech then, based on many years with goats.

E. Learning from writing Pollarding Guidelines

This task was humbling; I had to face how organic and fluid my process is with trees, and how little I can assure someone of results, especially without seeing their trees. I pray that my attempt is more helpful than confusing. I continue to seek instruction from all others who pollard.

Project Outcomes (Changes in Behavior) inc. Next Steps

I have been speaking with fabricators about what a leaf rake attachment would look like, to precede the intake hopper of Meadowsweet Farm's PTO driven chipper, such that leaves and chipped wood would land in separate containers. This would improve palatability and save silo (container) space, while still producing bedding material as a byproduct.

A three-sided silage bunker with tarp well-weighted and tucked in edges would avoid cost of containers and use less plastic. Alternatively, sections of 4 ft. diameter silage tube might be tried on pallets with bottom ends folded under, and top folded and taped, for movable tractor-scale leaf silage. I wrote a grant pre-proposal to support trying this and other ideas to scale up, but must continue to apply.

I have begun a conversation about mechanical pollarding with Graham at the Great Farm in Jackson, ME, who is using his feller-buncher to thin trees for silvopasture. I have located a log arch for my cow-ox to use to move pine logs here, if she becomes handy enough, to let sun into more pollardable trees.

Meanwhile, I continue to climb, but now with determination to complete enough "air meadow" for a 5 year rotation. I am more assertively felling trees who are unlikely pollard candidates, and am currently focused on the bit of my land blessed with white and brown ash near the front stream, for happy goats this summer (pruning the red maples there 1st, this winter). This will give the south edge of our Demo Plot much-needed sun.

At Meadowsweet Farm, Eliot is contemplating sapling protectors, to plant more shade and leaf fodder into the pastures. In summer and fall of 2018 he and Reyna extended paddocks into woodland in response to drought, and felled trees for the cattle and sheep. In winter they bale-grazed cattle under trees, to start more pasture there. In both 2018 and -19 they stored dried leafy branches in their capacious barn.

I called and talked to 5 people who attended my various presentations and did not provide emails. 4 of them are feeding more tree matter than before, 2 are beginning to pollard ash, one is planning a sod bunker to hold hand-snapped silage, and wonders if the probiotics of leaf silage can increase digestive efficiency of sheep, to decrease winter hay rations (I recommended that he apply for a SARE grant).

I likewise called Judy Holland at Ravenwood, Searsmont, ME, who replied by email: "After learning from Shana Hanson a bit about leaf fodder I have experimented with feeding leaves to my sheep. I have watched the sheep self select during the summer season and supplement their limited pasture with branches. I now have a leaf shredder and can make silage or shredded leaves for winter consumption. Still a work in progress as time and energy permit."

A contact from our 2019 Tree Fodder Seminar has created an email list, from my paper notes of 150 tree fodder presentation contacts (plus now 18 more to add), and has sent a link to our website with this report, with a request to hear what folks are doing. It seems that face-to-face and phone contact get more response, but these folks may contact me as they start making changes toward using their tree resources.

References

Austad, I., Braanaas, A., and Haltvik, M. (2003). Lauv som ressurs; Ny bruk av gammel kunnskap. HSF rapport nr. 4/30, English summary pp 121-122.

Austad, I. (1993) Wooded Pastures in Western Norway, History, Ecology, Dynamics, and Management In M. Peoletti, W. Foissner & D. Coleman eds. Soil Biota, Nutrient Cycling and Farming Systems. Lewis Publishers, USA pp 193-205.

Austad, I, Hamre, L.N., Rydgren K, & Norderhaug A.(2003) Production in wooded hay meadows. In Ecosystems and Sustainable Development - IV Vol. 2 E. TIEZZI, University of Siena, Italy, C.A. BREBBIA, Wessex Institute of Technology, UK and J-L. USO, Universitat Jaume I, Spain: WIT Press.

Austad, I. & Losvik, M.H. (1998) Changes in species composition following field and tree layer restoration and management in a wooded hay meadow in Nordic Journal of Botany 18(6) pp. 641-662.

Bane, Peter (2019). From Grassroots to Tree Crowns; Organizing to Cool the Climate. Soil and Nutrtion Conference, live presentation 11/16/19, Southbridge Hotel and Conference Center, Southbridge, MA: Bionutrient Assoc.

Brauner, J. (1756) Tankar wid skotseln och nyttan af boskap och fjaderfa, med botemedel I vanlige och mast tillfallige siukdomar samt skogars bruk och missbruk I alla dera grundade hushallsmal. Stockholm.

Carlsson, Å. (1996) '**Lövtäkt i Västergötland. Bondedagböckerna berättar**', **i**n Slotte, H. and Göransson, H. (eds.) *Lövtäkt och stubb- skottsbruk. Människans förändring av landskapet – boskapsskötsel och åkerbruk* ***med*** *hjälp av skog*. Stockholm: Kungl. Skogs- och Lantbruksakademien (Skogs- och Lantbrukshistoriska meddelanden Nr. **17),** pp. **69-85**. Available at http://www.ksla.se/anh/publikationer/solmed/171-lovtakt-och-stubbskottsbruk-manniskans-forandring-av-landskapet-boskapsskotsel-och-akerbruk-med-hjalp-av-skog-del-1/ (Downloaded 26 January 2018). Informal translation to English available from shanahanson@gmail.com.

Eisenstein, C. (2018). Climate; A New Story. Berkley, CA: North Atlantic Books.

Ellison, D., Morris, C. E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, DA., Gutierrez, V., van Noordwijk, M., Creed, I. F., Pokorny, J., Gaveau, D., Spracklen, D. V., Tobella, A. B., Ilstedt, U., Teuling, A. J., Gebrehiwot, S. G., Sands, D. C., Muys, B., Verbist, B., Springgay, E., Sugandi, Y., & Sullivan, C. A. (2017). Trees, forests and water: Cool insights for a hot world. *Global Environmental Change* 43, pp. 51–61.

Fundación HAZI Fundazioa (about 2014). Notes on pollards; Best practices guide for pollarding. CH 1. Cantero, A. (HAZI), Passola, G. (Doctor Árbol) CH 2. Aragón, A. (UPV/EHU), CH 3. de Francisco, M. (HAZI), CH 4. Cantero, A. (HAZI), CH 5. Mugarza, V. (GFA/DFG), Riaño, P. (HAZI), CH 6. Cantero, A. (HAZI). EDITION: Gipuzkoako Foru Aldundia-Diputación Foral de Gipuzkoa, http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=TRASMOCHOS_Best_practice.pdf

Gallo, A. (1572). Le vinti giornate dell'agricoltura, Venezia.

Green, T. (2017). Conversation during personal tour of Windsor grounds, 2/2/17.

Green, T. (2018). Trees on the menu – a forgotten irreplaceable fodder, live presentation and discussion, Colloque Trognes, 3/2/18, Sare, France: Agroforesterie Francaise.

Hanes, Christopher (2019). The Heat Planet; A New Approach to Climate, Live presentation 6/16/19, Cambridge, MA: Biodiversity for a Livable Climate.

Jehne, Walter (2019). The Soil Carbon Sponge. Soil Carbon Sponge Gathering, live presentations 8/15-17/19, Lake Morey Resort, Fairlee, VT.

Kays, Jonathan S., and Canham, Charles D. (1991). Effects of Time and Frequency of Cutting on Hardwood Root Reserves and Sprout Growth. In *Forest Science* vol. 37, No. 2, pp. 524-539.

Law, Ben (2001) The Woodland Way – A Permaculture Approach to Sustainable Woodland Management East Meon, Hampshire, UK: Permanent Publications.

Machatschek, Michael (2002). Laubgeschichten (foliage stories); Gebrauchswissen einer alten Baumwirtschaft, Speise – und Futterlaubkulture. Wien: Bohlau. 542pp., ill.

Meuret, Michel & Provenza, Fred D. (2015). When Art and Science Meet: Integrating Knowledge of French Herders with Science of Foraging Behavior. *Rangeland Ecology & Management*, 68/1, Jan., pp. 1-17.

Ninemets, Ulo, and Valledares, Fernando (2006). Tollerance to shade, drought, and waterlogging of temperate northern hemisphere trees and shrubs. *Ecological Monographs*, 76(4), pp. 521-547.

Papanastasis, V.P., Yiakoulaki M.D., Decandia, M., Dini-Papanastasi O. (2008) Integrating woody species into livestock feeding in the Mediterranean areas of Europe. *Animal Feed Science and Technology*, 140(1) pp 1-17.

Read, H. J.(2003). A study of practical pollarding techniques in northern Europe; Report of a three month study tour, August to November 2003. Sent on CD by the author. 226pp.

Read, H. J., Rubio, S. A., Wheater, C.P. & Garcia, A. S. (2018) Assessing the impact of moon phase on the cutting of lapsed beech pollards, *Arboricultural Journal, 40:3*, 137-152, DOI: 10.1080/03071375.2018.1485388 https://doi.org/10.1080/03071375.2018.1485388

Seuss, Dr. (1963). Hop on Pop. NY & Toronto: Random House.

Seuss, Dr. (1961). The Sneetches and other Stories. NY & Toronto: Random House.

Slotte, Håkan (2000). Lövtäkt i Sverige och på Åland; Metoder och påverkan på landskapet. Doctoral Thesis, Swedish University of Agricultural Sciences, Uppsala.

Toensmeier, E. (2016). The Carbon Farming Solution: A Global Toolkit of Perennial Crops and Regenerative Agriculture Practices for Climate Change Mitigation and Food Security. White River Jct., VT: Chelsea Green.

Veteran Tree Network (2014). Management of Veteran Trees Still in a Regular Cycle of Cutting (video). https://www.vetcert.eu/node/9 Accessed 1/7/20.

Walder, Michael (2017). Tree hay for meat goats. *Acres USA,* May, pp 24 -26.

Zurcher, E. (2018). Tree physiology – why pollards can make a difference, live presentation, Colloque Trognes, 3/2/18, Sare, France.