

Fodder Trees: 2015 Yield and Nutrient Analysis

This research note is part of a series detailing results from different facets of the trial. For more information, see:

2015 Sheep Production Report on Fodder Tree Diet

2015 Sheep Preferences of Fodder Trees

Economic Analysis and Practical Applications of Fodder Trees

RAIN has partnered with the Ontario Sheep Marketing Agency to investigate whether fast-growing, coppiced trees can be a nutritionally and economically viable fodder source for sheep. This project is taking place over the 2015 and 2016 growing seasons near Sault Ste Marie.

Thanks to our farmer co-operators Collen Alloi and Brent Atwell for their assistance with this project.



For more information on this project, please contact:

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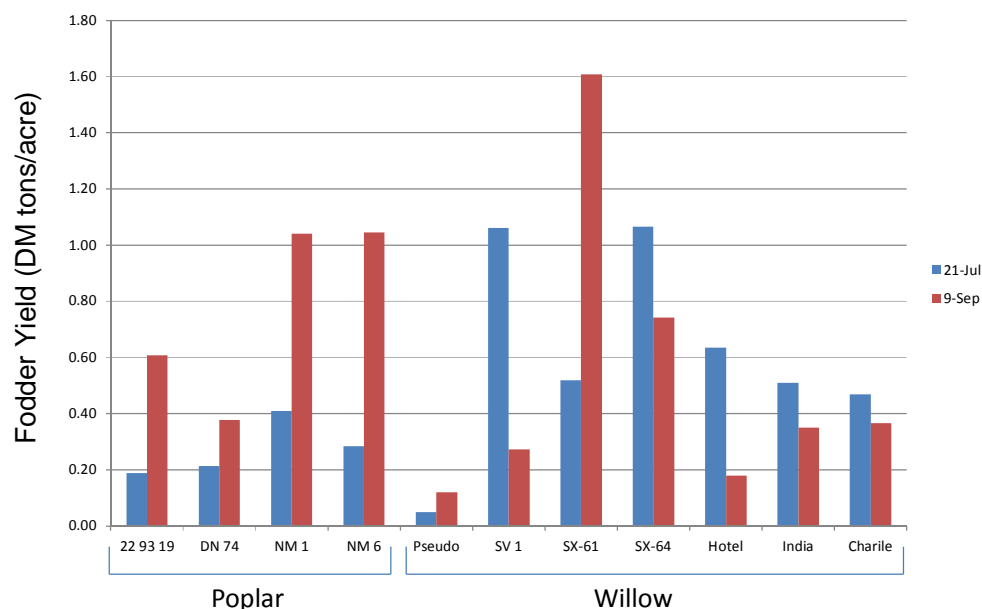
Method

In 2007, a short rotation woody coppice plantation was established by the Canadian Forest Service to assess the potential of fast growing willow and poplar for bioenergy. A section of this plantation was fenced off and split into four 0.75 acre paddocks. Trees were cut to 4" and allowed to regrow to heights of 12-24" before sixty mature, dry, Arcott Outaouais ewes rotationally grazed the new re-growth. Outside the grazed area, three species of native trees (Speckled Alder, Trembling Aspen, and White Birch) were also coppiced for comparison with the domestic varieties. Samples of the new growth were taken to determine dry matter yields and nutrient content of the tree re-growth.

Results

Tree Yield: Dry matter (DM) yield was assessed at two times during the growing season. Yields of tree crops in July ranged from 0.05 tons/acre to 1.07 tons/acre with an average of a 0.49 tons/acre. This sample included the entire succulent stem. In September, DM yields for leaves only ranged from 0.12 tons/acre to 1.61 tons/acre with an average of 0.61 tons/acre.

Figure 1. Dry matter yield (tons/acre) in the existing arrangement of fast growing willow and poplar fodder varieties for July and September 2015.



Nutritional Content of Trees: Leaf samples were sent to A&L Laboratories Canada for macro- and micro-nutrient analysis. Nutrient levels were reported for nitrogen (N), sulphur (S), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), copper (Cu), boron (B), zinc (Zn), manganese (Mn), iron (Fe), aluminum (Al), and molybdenum (Mo).

The data were analyzed to compare different groups of trees as follows:

- 1) Domestic (ie: artificially selected hybrids of fast-growing willow and poplar) vs native trees
- 2) All willow (genus *Salix*) vs all poplar (genus *Populus* – includes native Trembling Aspen)
- 3) Domestic willow (genus *Salix* – all willows were domestic) vs domestic poplar (genus *Populus*)

There were no statistically significant differences between any of the above tree groups for N (which is closely related to crude protein content), Na, B, Zn, Fe, or Mo.

Domestic tree varieties had significantly higher levels of S and Mg than native trees.

When comparing all willows to all poplars, willows had significantly higher levels of S, Mg, Ca, and Al. Poplars had significantly higher levels of K and Cu.

Some results changed when native Trembling Aspen was removed from the poplar group. When comparisons between willows and poplars were done using only domestic trees, willows had significantly higher levels of P, Mg, Ca, Mn, and Al. Poplars had significantly higher levels of Cu.



Figure 2. Sheep grazing coppiced regrowth

Table 1. Nutrient analysis of tree leaves

Genus	Variety	N (%)	S (%)	P (%)	K (%)	Mg (%)	Ca (%)	Na (%)	B (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Al (ppm)	Mo (ppm)
Populus	2239-19	2.04	0.56	0.13	0.72	0.34	0.96	0.01	17	167	153	133	12	55	0.01
Populus	DN	1.89	0.41	0.11	1.32	0.25	0.51	0.01	8	124	119	166	9	31	0.01
Populus	NM-1	1.72	0.55	0.13	1.06	0.34	1.03	0.01	26	196	155	195	11	48	0.01
Populus	NM-6	2.12	0.27	0.12	1.22	0.23	0.79	0.02	17	224	256	308	11	50	0.01
Salix	Charlie	1.68	0.75	0.17	0.7	0.69	1.97	0.01	26	100	189	170	6	99	0.01
Salix	Hotel	2.17	0.72	0.18	0.76	0.53	2.19	0.01	29	164	315	86	8	58	0.01
Salix	India	1.69	0.78	0.16	0.54	0.71	2.08	0.01	14	218	963	240	7	89	0.01
Salix	Pseudo	1.66	0.38	0.16	0.67	0.48	1.77	0.01	18	69	125	164	5	103	0.01
Salix	SV-1	2.2	0.71	0.33	0.6	0.44	2.18	0.01	19	196	480	207	7	68	0.116
Salix	SX-61	1.74	0.59	0.16	0.78	0.35	2.87	0.01	0.18	247	481	136	6	67	0.01
Salix	SX-64	1.69	0.58	0.16	0.99	0.31	2.21	0.01	14	233	527	238	7	87	0.348
Native Trees															
Alnus	Speckled Alder	2.22	0.15	0.12	0.45	0.24	0.56	0.02	4	37	206	145	8	67	0.01
Betula	White Birch	2.03	0.12	0.48	0.99	0.18	0.98	0.01	19	194	113	212	5	74	0.01
Populus	Trembling Aspen	2.74	0.25	0.22	0.93	0.23	1.94	0.02	9	325	295	130	12	53	0.01

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Method

In 2007, a short rotation woody coppice plantation was established by the Canadian Forest Service to assess the potential of fast growing willow and poplar for bioenergy. A section of this plantation was fenced off and split into four 0.75 acre paddocks. Trees were cut to 4" and allowed to regrow to heights of 12-24" before sixty mature, dry, Arcott Outaouais ewes rotationally grazed the new re-growth. Outside the grazed area, three species of native trees (Speckled Alder, Trembling Aspen, and White Birch) were also coppiced for comparison with the domestic varieties. Samples of the new growth were taken to determine dry matter yields and nutrient content of the tree re-growth.

Results

Sheep Weight and Body Condition Score:

Animal performance declined generally and could be attributed to numerous factors besides diet, such as stress due to change in environment (ewes were used to barn), absence of grain in their diet, and being older ewes. Sheep lost on average 3.9 lbs. over the four week period. Body condition scores were the same before and after grazing. This indicates that trees alone do not provide enough energy for ewes to maintain their weight, and a complimentary feed source would be required to meet sheep energy demands in a fodder tree system.



Figure 3. Arcott Outaouais ewes rotationally grazing coppiced trees

Nutritional Value of Trees:

Leaf samples were sent to A&L Laboratories Canada for macro- and micro-nutrient analysis. Nutrient levels were reported for nitrogen (N), sulphur (S), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), copper (Cu), boron (B), zinc (Zn), manganese (Mn), iron (Fe), aluminum (Al), and molybdenum (Mo).

The Nation Research Council (NRC) provides nutritional guidelines and recommendations for livestock. Based on the NRC guidelines for ewe maintenance requirements (ie: not growing, breeding, pregnant, or lactating), the trees in this study provided adequate levels of crude protein, calcium, magnesium, potassium, and sulphur. Some trees provided adequate phosphorus, but none of the trees contained enough sodium to meet ewe requirements.

For micronutrients (trace minerals), no tree exceeded the maximum tolerable level (MTL) for the sheep; iron, copper, manganese and zinc were all provided at adequate levels. Only molybdenum was deficient across all tree sources.

Table 2. Summary of NRC nutrient requirements for ewes (maintenance) and amounts of nutrient provided by different tree leaves

Ewe maintenance requirement in a diet that is 100% forages, based on DM content

		CP (%)	Ca (%)	P (%)	Na (%)	Mg (%)	K (%)	S (%)	Fe (ppm)	Cu (ppm)	Mo (ppm)	Mn (ppm)	Zn (ppm)	
		9.4	0.2 - 0.82	0.16 - 0.38	0.09 - 0.18	0.12 - 0.18	0.5 - 0.8	0.14 - 0.26	30 - 50	7 - 11	0.5	20 - 40	20 - 33	
		MTL:								500	25	10	1000	750
Species	Variety	CP (%)*	Ca (%)	P (%)	Na (%)	Mg (%)	K (%)	S (%)	Fe (ppm)	Cu (ppm)	Mo (ppm)	Mn (ppm)	Zn (ppm)	
Poplar	2239-19	12.75	0.96	0.13	0.01	0.34	0.72	0.56	133	12	0.01	153	167	
Poplar	DN	11.81	0.51	0.11	0.01	0.25	1.32	0.41	166	9	0.01	119	124	
Poplar	NM-1	10.75	1.03	0.13	0.01	0.34	1.06	0.55	195	11	0.01	155	196	
Poplar	NM-6	13.25	0.79	0.12	0.02	0.23	1.22	0.27	308	11	0.01	256	224	
Willow	Charlie	10.50	1.97	0.17	0.01	0.69	0.7	0.75	170	6	0.01	189	100	
Willow	Hotel	13.56	2.19	0.18	0.01	0.53	0.76	0.72	86	8	0.01	315	164	
Willow	India	10.56	2.08	0.16	0.01	0.71	0.54	0.78	240	7	0.01	963	218	
Willow	Pseudo	10.38	1.77	0.16	0.01	0.48	0.67	0.38	164	5	0.01	125	69	
Willow	SV-1	13.75	2.18	0.33	0.01	0.44	0.6	0.71	207	7	0.116	480	196	
Willow	SX-61	10.88	2.87	0.16	0.01	0.35	0.78	0.59	136	6	0.01	481	247	
Willow	SX-64	10.56	2.21	0.16	0.01	0.31	0.99	0.58	238	7	0.348	527	233	
Native Trees														
Speckled Alder		13.88	0.56	0.12	0.02	0.24	0.45	0.15	145	8	0.01	206	37	
White Birch		12.69	0.98	0.48	0.01	0.18	0.99	0.12	212	5	0.01	113	194	
Trembling Aspen		17.13	1.94	0.22	0.02	0.23	0.93	0.25	130	12	0.01	295	325	

*Crude protein content was calculated as 6.25 times the nitrogen content

MTL is maximum tolerable level

These results suggest that, while not a complete feed, the young regrowth of some coppiced trees can be a valuable source of nutrients for sheep. By working with a veterinarian and nutritionist, shepherds may be able to incorporate fodder trees into their management system to provide an alternative source of nutrition for their livestock during the growing season.

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Method

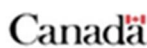
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Results

Sheep Preferences

Specific variety preferences were clear; the first species consumed were willow varieties SX-61 and SX-64, sharing similar genetics, qualities and yield. Secondly, sheep preferred to eat willow variety SV-1, then variety Charlie and Pseudo (these last two are tree-type willow varieties rather than shrub-type). Willow variety India was partially consumed and variety Hotel was completely avoided. Hybrid poplar varieties were also avoided, but sheep were witnessed consuming leaves on occasion. Utilization of preferred tree species was 100%.



Domestic tree varieties were ranked 1-5 based on the information above, with 1 being the most preferred. When this data was correlated with the data on nutrients that showed statistically significant differences between domestic tree types, it suggests that sheep were selecting for varieties with higher calcium, and were selecting against varieties with higher copper content.

Ewes requiring a maintenance diet (i.e.: not breeding, in later stages of pregnancy, or lactating) need calcium at 0.2% of their total diet in order to maintain their skeletal system. All leaf samples exceeded this requirement, so it is unlikely that their selection preferences were motivated by calcium content.

Sheep are more likely than any other domestic animal to develop chronic copper poisoning (CCP). Normal plant levels of copper are between 10 and 20 ppm (the tree leaves in this trial were between 5 - 12 ppm). Molybdenum plays a critical role in limiting copper uptake in sheep and preventing toxicity; sheep require at least 0.5 ppm molybdenum in their diet. None of the trees contained more than 0.35 ppm molybdenum. Soil sulphur levels influence molybdenum availability; high levels of sulphur tie up molybdenum and prevent it from regulating copper absorption. The soils on this site had very high sulphur levels, at 19 ppm. Because there may be a nutritional motive for sheep to select against copper content, the Rural Agri-Innovation Network (RAIN) is consulting a sheep nutritionist to determine if there is any evidence that sheep express copper avoidance.



Figure 4. Sheep consumption of their two favourite varieties of willow.

Table 1. Sheep preference ranking and nutrient contents – calcium (Ca) and copper (Cu) - with statistically significant correlations

Species	Variety	Preference Ranking	Ca (%)	Cu (ppm)
			0.2 - 0.82	7 - 11
			MTL:	
			Ca (%)	Cu (ppm)
Poplar	2239-19	5	0.96	12
Poplar	DN	5	0.51	9
Poplar	NM-1	5	1.03	11
Poplar	NM-6	5	0.79	11
Willow	Charlie	3	1.97	6
Willow	Hotel	5	2.19	8
Willow	India	4	2.08	7
Willow	Pseudo	3	1.77	5
Willow	SV-1	2	2.18	7
Willow	SX-61	1	2.87	6
Willow	SX-64	1	2.21	7

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Results

Applicable arrangements and projected yields

Using the information gathered from the first year of this project, we can assess practical arrangements that can be used by sheep producers in a pasture setting. Two arrangements were selected; 1) Full Planting (FP) for windbreaks and fence lines, and 2) Silvopastural planting (SP).

A FP would have a similar density to that on the study site, but would be planted linearly rather than in a full block. This arrangement is appropriate for establishing windbreaks along roadsides or fence lines or in other windy areas on the farm. The full planting stem density with 0.6m (~2ft) spacing between trees creates a population density of 11,242 trees/acre. To use this system as a wind break, trees must be allowed to grow to their full height for the entire growing season and animals introduced prior to leaf fall. Projected yield under this system, using the most productive and preferred willow varieties could be in the range of 1000 – 2500 lbs DM/acre per year (**Figure 1**).



The second arrangement, SP, fits with typical rotational grazing systems used by pastured livestock farms. This system aims to keep plants in a vegetative state, which provides increased plant growth and nutritional value. A typical arrangement may include evenly spaced rows 30 – 50 ft. apart within the pasture. At 34 ft. spacing, this works out to 1,210 trees/acre and if grazed three times in the growing season could yield in the range of 250 – 750 lbs DM/acre per year (**Figure 1**).

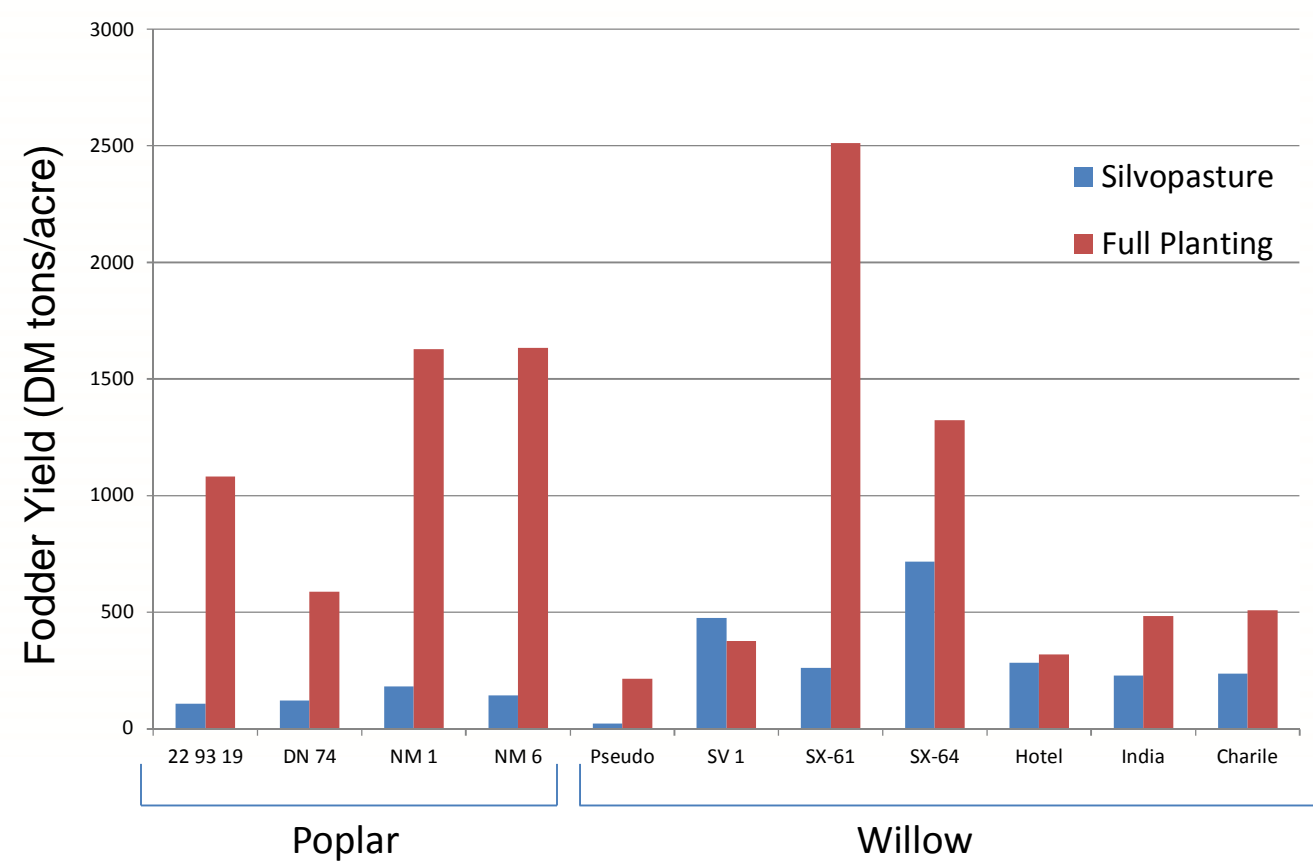


Figure 5. Projected Dry matter yield (tons/acre) for a Full Planting (FP) and Silvopasture (SP) scenarios.

Economic consideration between systems

Whether your farm application is FP or SP, costs can be considerably different. FP for windbreaks provides additional value outside of fodder, but costs are much higher per unit area to establish. Site preparation and weed control costs will be similar for both FP and SP, but tree material and planting costs vary greatly for an acre. For the FP system, at an installation cost of \$0.4/tree the total cost is for one acre is \$4,497 where one acre of SP will cost \$484. To take this and additional step further, we looked at cost per pound of dry matter. For the FP system with a yield of 1500 lbs DM/acre/yr over a five year period the cost is \$0.6/lb of DM. For the SP system with a yield of 500 lbs DM/acre/year over a five year period costs \$0.2/lb DM. Although the FP system offers a valuable dual purpose as windbreak and shelter, the cost per pound of DM over the first five years is triple. All forage production after five years is essentially free.

Economic analysis completed by Saul Fraleigh.