Forage Blends for Newly Cleared Land

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Executive Summary

In Newfoundland, short seasons, lack of land base and poor soils leave many Newfoundland and Labrador (NL) farmers producing insufficient quantities of forage to meet the need of their livestock. Much of the available farm land in Newfoundland is "newly cleared" meaning that trees and brush were removed recently and the land has not been farmed in many years (or ever). Newly cleared land in Newfoundland tends to be low in pH and organic matter, and high in rocks and stones. Popular/recommended forage blends grown on the mainland of Canada are not necessarily suited to new clear conditions in our province, which is why it is imperative we increase our understanding of species performance under these conditions to efficiently utilize this growing land availability and maximize productivity for our farmers.

Forage oats (*Avena sativa*, L.) and ryegrass (*Lolium multiflorum*, Lam.) have traditionally been used in combination to condition soil. The authors were unable to find any studies assessing performance under new clear and soil and climatic conditions similar to Newfoundland. Additionally, no studies were found that address optimum seeding rates and blend ratios when both species are co-seeded under similar environmental conditions.

Low species diversity in the perennial forage stands of NL must also be addressed. Insular Newfoundland is isolated and because we are not yet self-sufficient, we do not export any forages to mainland Canada. This has contributed to a shortage of new forage species and knowledge of their performance in NL, and a lack of their better management practices. Many new species have the capacity to assist in soil conditioning and increase biomass production under new clear situations and should be examined for this potential. Festulolium – a cross between ryegrass and meadow fescue is of particular interest as it has high quality, persistence and stress tolerance (Anon. 2015).

The objectives of this study were: 1) to identify optimum forage oats and ryegrass blend ratios and seeding rates under new clear conditions and 2) to identify new and superior performing forage legume and grass varieties suited for insular Newfoundland conditions.

The field experiments were carried out at Pynn's Brook Research Station in NL during summer of 2014 (June-September) using two different plot trials. The first trial examined 12 different blends of oats and grasses – ryegrass and two varieties of festulolium. The second trial examined 16 combinations of grasses with legumes – ryegrass, two varieties of festulolium and timothy with birdsfoot trefoil, alfalfa, and red clover. Measurements were taken for time to establishment, soil properties, nutrient content and yield.

Based on results from this trial, ryegrass and festulolium performed very similarly. The addition of oats to any of the grasses resulted in higher fibre and biomass. Oats are a great addition to a grass stand as they germinate quickly and do not have to be killed in the following spring if the field is being rotated. They are also cost effective and can provide a quick feed source.

The second objective was to identify new and superior-performing forage and legume blends. A malfunction of the plot seeder made for less-than-ideal conditions and the legumes did not perform well. Festulolium and ryegrass performed very similarly. There was a trend for mixes containing timothy to be lower in available energy but higher in protein. Timothy is widely grown by dairy producers as it tends to have high forage quality however it is better suited as a pasture grass than as a silage crop.

Introduction

The objective of the Alternative Feeds Program (AFP) is to research and provide a cost-effective, high-energy feed for the livestock industry in Newfoundland and Labrador (NL). In NL, farmers are faced with the challenges of growing crops on a limited land base with short seasons. Imported feed is the largest farm operating expense in Newfoundland, and Island production is often insufficient to fulfil the needs of our dairy and livestock industry. The local production of food and livestock feed is essential, as it increases the province's self-sufficiency and reduces the cost of transportation and reliance on the mainland. To meet this goal, the AFP has evolved into two components: cereals and forages. Together, we work to assist the dairy and livestock industry by improving the sustainability and the productivity of their farms.

Background and Rationale for Investigation

In Newfoundland, short seasons, lack of land base and poor soils leave many Newfoundland and Labrador (NL) farmers producing insufficient quantities of forage to meet the need of their livestock. Dairy producers in central and eastern NL reported producing approximately 39,600 bales of forage in 2011 (dry matter basis); however, this decreased to approximately 26,500 bales in 2012. Although the difference of approximately 13,000 bales may not appear substantial, the demand for forage caused a spike in forage prices, resulting in producers spending over three times the amount they spent on forage in 2011. This equated to an extra $1.4 million dollars in forage costs in 2012 when the average price per bale was approximately $111.00.

Reduced forage yields in 2012 can partly be attributed to drought conditions in early summer which slowed forage growth. There was also an infestation of Armyworms (*Mamestra configurata*, Walker) which devastated forage stands by consuming plants which were already stressed by adverse environmental conditions. Conditions were more favorable in 2013 and forage production increased substantially from 2012 but armyworms were still detected (Leah Madore, Personal communication 2014). At the best of times, NL producers usually experience a shortage of forage which may be alleviated by expanding the available land base and initiating a few simple cultural practices such as increasing species diversity within forage mixtures, planting species that are better suited to the pH and soil characteristics of each individual field and increasing the interval/frequency of field renovation.

The *Growing Forward 2* land clearing initiative is one way the government of Newfoundland and Labrador is addressing the problem of limited available land base. The clearing of land will not only give producers the land base needed for forage growth, it reduces the reliance on existing forage stands. Growth performance standards and practices for many species under new clear and acidic soil conditions are unknown. It is imperative we increase our understanding of species performance under these conditions to efficiently utilize this growing land availability and maximize productivity for our farmers. Forage oats (*Avena sativa*, L.) and ryegrass (*Lolium multiflorum*, Lam.) have traditionally been used in combination to condition soil as they can assist in preventing erosion through their root structures, add organic matter, suppress weeds by fast germination, large biomass and ability to hold large amounts of water in climates with heavy rainfalls (Penn State Extension 2014). Forage oats can tolerate soils with a pH range of 4.5 to 8.6 and Ryegrass a range of 4.5 to 8.2 (Duke 1983). The author was unable to find any studies assessing performance under new clear and soil and climatic conditions similar to Newfoundland. Additionally, no studies were found that address optimum seeding rates and blend ratios when both species are co-seeded under similar environmental conditions.

Low species diversity in the perennial forage stands of NL must also be addressed. Insular Newfoundland is isolated and because we are not yet self-sufficient, we do not export any forages to mainland Canada. This has contributed to a shortage of new forage species and knowledge of their performance in NL, and a lack of their better management practices. Many new species have the capacity to assist in soil conditioning and increase biomass production under new clear situations and should be examined for this potential. Festulolium – a cross between ryegrass and meadow fescue is of particular interest as it has high quality, persistence and stress tolerance (Anon. 2015)

Funding

Budget for 2014-15 Forage Research Program

Item Description	Line Object	Requested Budget
100 Salaries		
Salaries - Temporary Employees	120	$56,693.00
Salaries - Other Employees	130	
Overtime	140	
Subtotal Salaries		**$56,693.00**
300 Transportation & Communication		
Freight Express and Cartage	312	$5,000.00
Travelling Third Party	326	
Telecommunication Services - Other	340	
Cellular Phones	342	$500.00
Vehicle Mileage	362	
Fuel (Travel Status)	363	$1,500.00
Meals (Travel Status)	364	$2,600.00
Accommodations	365	$1,200.00
Vehicle Rental (Travel Status)	366	$600.00
Airfare	367	$700.00
Other Modes of Travel	368	
Miscellaneous Travel	369	$1,000.00
Subtotal Transportation & Communication		**$13,100.00**
400 Supplies, Materials & Equipment Purchases		
Office Supplies	410	$200.00
Medical Supllies	412	$50.00
Agricultural Supplies	413	$10,000.00
Personal & Household Supplies	414	$500.00
Food Items	415	
Construction & Maintenance Supplies	416	$500.00
Machinery & Equipment Supplies (other small tools)	418	$2,500.00
Gasoline	419	$1,500.00
Small Tools and Appliances	420	$1,000.00
Miscellaneous Supplies	421	$3,500.00
Text Books	424	$350.00
Heating Fuel	425	
Subtotal Supplies, Materials & Equipment		**$19,750.00**
500 Professional Services		
Consulting Services	510	
Professional Services	511	$10,000.00

Consulting Services -Legal	513	
Management Consulting Services	515	
Consulting Services - Medical	518	
Subtotal Professional Services		**$10,000.00**
600 Purchased Services		
Advertising and Promotion	610	
General Purchased Services	611	$10,000.00
Training and Development	613	$1,000.00
Printing	615	
Purchased Vehicle Repairs and Maintenace	617	$1,000.00
Other Repairs and Maintenace	618	$2,500.00
Vehicles & Machinery Rentals	619	
Office Space Rentals	622	
Insurance	630	
Electricity	631	
General Maintenance	648	
Subtotal Purchased Services		**$14,500.00**
700 Property, Furnishings & Equipment		
Office Furniture and Equipment	710	
Machinery and Vehicles	711	
Subtotal Property, Furnishings & Equipment		**$0**
Total		**$114,043.00**

Project Objectives

We propose:

1. To identify optimum forage oats and ryegrass blend ratios and seeding rates under new clear conditions ; and,
2. To identify new and superior performing forage legume and grass varieties suited for insular Newfoundland conditions.

Methodology and Implementation

All experimental plots were planted in "new clear" conditions at the Pynn's Brook Research station. The field was cleared in fall 2013. Rocks were removed by hand and the field was limed. No agricultural crops had been grown on the land before commencement of this research trial.

Objective 1. Identify Optimum forage oats and ryegrass blend ratios and seeding rates under new clear conditions

This experiment was carried out at Pynn's Brook Research Station in a Randomized Complete Block design (Appendix 1). There were 14 treatments in total and 4 complete blocks. Grass species to be assessed with oats include ryegrass (*Lolium* var: "Lactal"), festulolium type #1 ("Perseus"), and festulolium type #2 ("Perun"). Each grass species was seeded with oats at a low, medium and high level and also seeded alone. For example, treatment B consisted of high seeding rate for ryegrass and low seeding rate for oats; treatment C was low seeding rate of ryegrass and high seeding rate of oats (see Table 1). Seeding rates were determined based on literature recommendations and personal communication with seed providers. Seed was purchased from Eastern Farmers Co-op in St John's, NL. Fertilizer application at seeding was 400 kg ha^{-1} of 5-20-20 and top-dressing application was 100 kg ha^{-1} of 34-0-0 (ammonium nitrate). Fertilizer was purchased from Cavendish Agri-Services in Truro, NS. Lime was applied in May 2014 at a rate of 3T ha^{-1}. All plots were seeded 1 July, 2014 and harvested on 25 August, 2014.

Table 1. List of treatment letters with corresponding grass + oat mixture

Treatment	Grass + Oat Mixtures and Seeding Rate Level
A	oats alone
B	high rate ryegrass + low rate oats
C	low rate ryegrass + high rate oats
D	med rate ryegrass + med rate oats
E	ryegrass alone
F	high rate "Perseus" festulolium + low rate oats
G	low rate "Perseus" + high rate oats
H	med rate "Perseus" + med rate oats
I	"Perseus" festulolium alone
J	high rate "Perun" festulolium + low rate oats
K	low rate "Perun" + high rate oats
L	med rate "Perun" + med rate oats
M	"Perun" festulolium alone

Seeding Rates for Treatments

All plots were seeded using Wintersteiger Plotseed XL plot seeder. The plot seeder was set incorrectly and resulted in ~30% increase in the original seeding rates. The adjusted seeding rates are listed in Table 2.

Table 2. Seeding rates for ryegrass and oats trial

Seed Type	Original Rate (kg ha^{-1})	Adjusted Rate (kg ha^{-1})
Ryegrass alone	67.2	100.8
Ryegrass High	22.4	33.6
Ryegrass Medium	16.8	25.2
Ryegrass Low	11.2	16.8
Festulolium* Alone	39.2	56
Festulolium* High	28	39.2
Festulolium* Medium	16.8	25.2
Festulolium* Low	13.4	20.2
Oats Alone	78.4	117.6
Oats High	67.2	100.8
Oats Medium	50.4	75.6
Oats Low	44.8	67.2

**"Perseus" and "Perun" festulolium seeded using this rate*

Objective 2. Identify new and superior performing forage grass and legume blends suited for insular Newfoundland conditions

This experiment was carried out at Pynn's Brook Research Station in a Randomized Complete Block design (Appendix 1). There were 16 treatments in total and 3 complete blocks. Grass species used were ryegrass (*Lolium* var "Lactal"), festulolium type #1 ("Perseus"), festulolium type #2 ("Perun") and Timothy (*Phleum pretense* var "Richmond"). Legume species used were Runner alfalfa (*Medicago sativa*), Standard alfalfa (var "Magnum VI"), birdsfoot trefoil (*Lotus cornicatus* var "AC Langille"), and red clover (*Trifolium pretense* var "Juliet"). Each grass species was seeded with each legume, which resulted in 16 treatments. For example, treatment 1 consisted of festulolium var "Perseus" with runner alfalfa (Table 3). Seed was purchased from Eastern Farmers Co-op in St John's, NL. Fertilizer application at seeding was 400 kg ha^{-1} of 5-20-20 and was purchased from Cavendish Agri-Services in Truro, NS. Lime was applied in May 2014 at a rate of 3T ha^{-1}. All plots were seeded 1 July, 2014.

Table 3. List of treatment numbers with corresponding grass+ legume mixture

Treatment	Grass + Legume Mixture
1	"Perseus" festulolium + runner alfalfa
2	"Perseus" festulolium + standard alfalfa
3	"Perseus" festulolium + birdsfoot trefoil
4	"Perseus" festulolium + red clover
5	ryegrass + runner alfalfa
6	ryegrass + standard alfalfa
7	ryegrass + birdsfoot trefoil
8	ryegrass + red clover
9	"Perun" festulolium + runner alfalfa
10	"Perun" festulolium + standard alfalfa
11	"Perun" festulolium + birdsfoot trefoil
12	"Perun" festulolium + red clover
13	timothy + runner alfalfa
14	timothy + standard alfalfa
15	timothy + birdsfoot trefoil
16	timothy + red clover

Seeding Rates for Treatments

Seeding rates were determined based on literature recommendations and personal communication with seed providers. All plots were seeded using Wintersteiger Plotseed XL plot seeder. The plot seeder was set incorrectly and resulted in ~30% increase in the original seeding rates. The adjusted seeding rates are listed in Table 4.

Table 4. Seeding rates for grass and legumes trial

Seed Type	**Original Rate (kg ha^{-1})**	**Adjusted Rate (kg ha^{-1})**
Clover	8.4	12.6
Alfalfa	13.4	20.2
Birdsfoot Trefoil	13.4	20.2
Ryegrass in mixture	11.2	16.8
Festulolium* in mixture	22.4	33.6
Timothy in mixture	5.6	8.4

**"Perseus" and "Perun" festulolium seeded using this rate*

Data Collection

Time to establishment was measured by visual assessment. Measurements for biomass (yield) and nutrient content were taken using two randomly placed 0.5 m^2 quadrats. Soil properties were measured by taking 10 samples from each plot, combining them in a bucket and taking a sub-sample from the bucket. Soil and tissue samples were sent to PEI Analytical Laboratories for analysis. Percent moisture was determined by weighing fresh samples, putting them in a drying oven until completely dry then weighing again. Plots were harvested on 25 and 26 August 2014. Soil samples were taken 27 August, 2014.

Data Analysis

All data were analyzed using JMP 11 ™ statistical software. Analysis of variance (ANOVA) was used to determine significant differences between treatments with $\alpha = 0.05$. "Pairwise comparisons" with Tukey's test was used for multiple means comparisons.

Results and Discussion

Objective 1. Identify Optimum forage oats and grass mixtures and seeding rates

Time to Establishment

The time to establishment for all plots was five days. The oats germinated and grew to ~3 inches within three days and all varieties of grass germinated and grew to ~3 inches within five days (Figure 1). This is not common for Newfoundland forage stands however the plots were seeded at a later date than is ideal. Ideal seeding for forage grass and oats in Newfoundland is June 1st or sooner (weather permitting). According to personal communications with seed suppliers and various online sources, typical germination time for oats can be anywhere from 8-20 days and 5-14 for ryegrass (www.ryegrasses.com; www.growinganything.com ; Atlantic Forage Guide). In July when the plots were seeded, daily high temperatures were between 23-30 degrees Celsius which may have caused the seeds to germinate and sprout more quickly than if they were planted earlier in June (Environment Canada).

Figure 1. Oats (med seeding rate) and ryegrass (med seeding rate) plot. July 8, 2014. Pynn's Brook, NL.

Forage Yield and Weed Content

Yield was determined using two 0.5 m^2 quadrats per plot (1 m^2 total). Yield in kg ha^{-1} was estimated based on the actual experimental harvest. Dry weight biomass was highest for low ryegrass seeding rate + high oat seeding rate (P = 0.0013) however the letter groupings show that treatment C was only significantly higher than ryegrass alone, "Perun" festulolium alone, "Perseus" festulolium alone, and medium rate "Perseus" + medium rate oats (Figure 2). There was no significant difference in the amount of weeds in each treatment, the average weed content ranged between 0.25-2.63 % of total harvest.

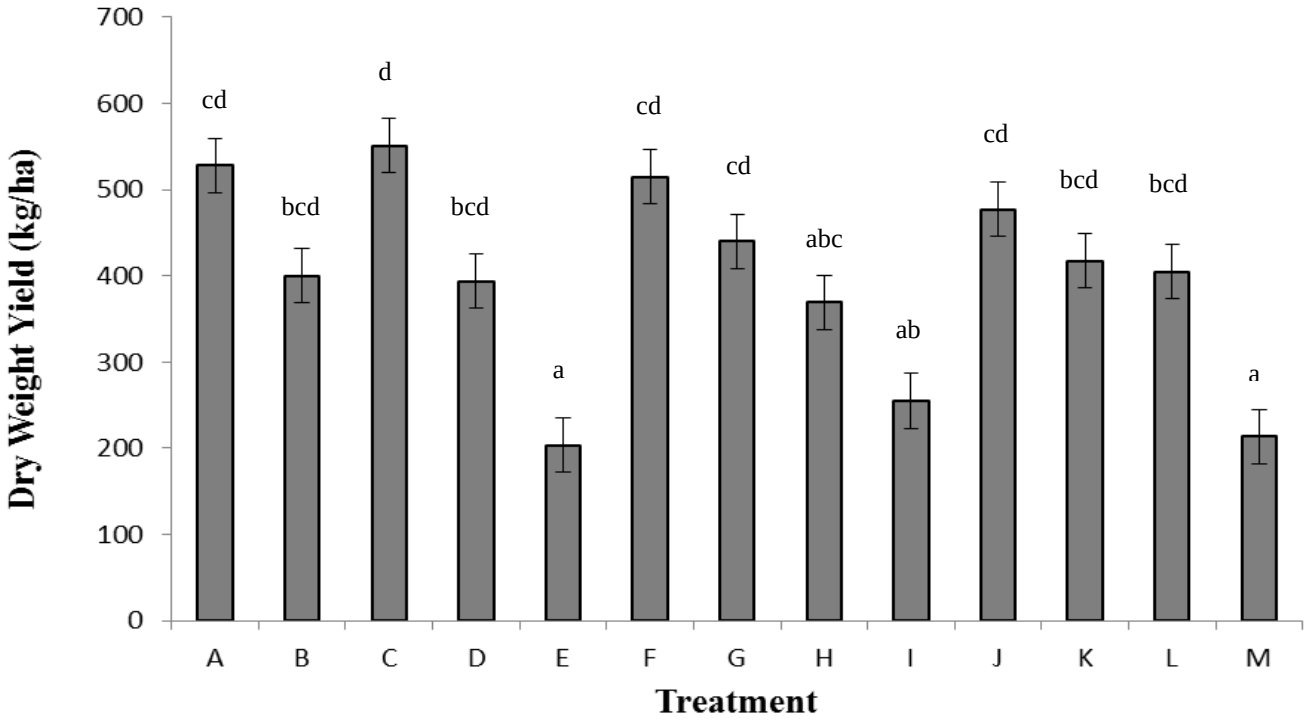

Figure 2. Bar graph representation of dry weight yield of grass and oat mixtures. August 2014. Pynn's Brook, NL.

List of treatment letters with corresponding grass + oat mixture

Treatment	Grass + Oat Mixtures and Seeding Rate Level
A	oats alone
B	high rate ryegrass + low rate oats
C	low rate ryegrass + high rate oats
D	med rate ryegrass + med rate oats
E	ryegrass alone
F	high rate "Perseus" festulolium + low rate oats
G	low rate "Perseus" + high rate oats
H	med rate "Perseus" + med rate oats
I	"Perseus" festulolium alone
J	high rate "Perun" festulolium + low rate oats
K	low rate "Perun" + high rate oats
L	med rate "Perun" + med rate oats
M	"Perun" festulolium alone

The addition of oats to any of the grasses used in this trial resulted in higher yield. This may be due to the quick growing habit of oats. Oats have a greater early growth than ryegrass (festulolium performs similarly to ryegrass as it was developed from ryegrass and fescue) and thus can produce higher yields than ryegrass alone (Kemp 1974). The yields presented are much higher than expected due to incorrect setting of the plot seeder which resulted in increased seeding rates (see Methods section above).

Nutrient Content

Tissue samples were analyzed for acid detergent fibre (ADF), neutral detergent fibre (NDF), bound protein, estimated digestible energy (Est DE), total digestible nutrients (TDN), crude protein (CP), net energy for lactation (NEL), calcium (Ca), phosphorous (P), potassium (K), copper (Cu) and zinc (Zn). Moisture content was also determined. Table 5 lists means for nutrient analyses of all treatments.

Acid detergent fibre (ADF) was lowest for "Perun" festulolium, "Perseus" alone, and ryegrass alone and higher in treatments containing oats ($p < 0.0001$). The acid detergent fibre component of a forage/feed is made up of undigestible material such as lignin and hemicellulose which are typical components of any plant fibre (University of Georgia; personal communications). Forages high in ADF are typically lower in digestible energy and thus a low ADF value is a desired result.

Treatments not containing oats (festulolium alone and ryegrass alone) were lowest in NDF while treatments containing oats were highest in NDF ($P < 0.0001$). Oats tend to have higher fibre content per gram than other grasses (Johnston et al. 1998). Neutral detergent fibre gives a close estimate of fibre constituents in feed. NDF measures cellulose, hemicellulose, lignin, tannins, and cutins. As NDF in forages increases, the feed intake by animals decreases. Producers use the NDF value to determine how much of a specific feed to add to their total mixed ration (TMR) and each farm may have a different goal for NDF. NDF is also used in formulas to predict dry matter intake of cows (Alberta Agriculture 2006).

Bound protein (%) was significantly lower for ryegrass alone than the "high rate "Perun" festulolium + low rate oats" and "low rate ryegrass + high rate oats" but bound protein in ryegrass was not significantly different from any other treatment ($P = 0.0255$). The addition of oats to ryegrass seems to have increased the bound protein in the forage sample. It is important to have lower amounts of bound protein as it is inaccessible to the animals consuming the feed. A value less than 12% is desired for bound protein (Alberta Agriculture 2006).

Estimated digestible energy (Est DE) was highest for plots without oats and lowest for treatments containing festulolium and oats ($P = 0.0014$). Oats alone had a moderate digestible energy value but was significantly higher than all treatments with "low rate grass + high rate oats". The digestible energy value gives an indication of the actual amount of energy available for the animal to use. Total digestible nutrients (TDN) of a forage sample are calculated in the feed analysis lab using a complex formula. This value gives an indication of the total nutrients of a feed and is used by producers when calculating TMR. Ryegrass alone and "Perun" festulolium alone had the highest TDN ($P = 0.0017$). "Perseus" festulolium alone had the next highest value for TDN but was not significantly different from any other treatment.

Crude protein was highest for ryegrass alone and "Perun" festulolium alone ($P = 0.0003$) but not significantly different from oats alone. Grasses alone have higher crude protein compared to blends of grass and oats. Net energy for lactation was not significantly different between treatments ($P=0.2314$). This value is important to dairy producers as it is an indication of the energy value of a feed used for maintenance plus milk production during lactation (Alberta Agriculture 2006).

Concentrations of calcium ($P < 0.0001$), potassium ($P = 0.0031$), magnesium ($P < 0.0001$) and copper ($P < 0.0001$) were highest for grasses alone compared to treatments containing oats. Concentrations of phosphorous, and zinc were not significantly different between treatments. Moisture content was not significantly different between treatments.

In summary, plots with grass alone were higher in energy and lower in insoluble fibre than plots containing oats. The value of adding oats to a grass for forage cropping is their early germination and high biomass.

Table 5. Nutrient analysis report means for all treatments for oats and grass mixtures. August 2014.

Treatment	% Moisture	ADF (%)	NDF (%)	Bound Protein (%)	Est DE (Mcal/kg)	TDN (%)	Crude Protein (%)
oats alone	25.37	28.54 ab	52.03 bc	5.3 ab	2.98 bc	66.53 ab	13.84 abc
high rate ryegrass + low rate oats	24.13	27.78 ab	49.27 bc	6.47 ab	3.03 bc	67.31 ab	13 a
low rate ryegrass + high rate oats	25.94	29.39 b	51.13 bc	7.94 b	2.93 ab	65.65 ab	12.09 a
med rate ryegrass + med rate oats	26.64	27.82 ab	48.56 bc	5.78 ab	3.02 bc	67.27 ab	14.37 abc
ryegrass alone	20	23.82 a	41.87 bc	3.88 a	3.26 c	71.41 bc	19.97 bc
high rate "Perseus" festulolium + low rate oats	28.44	28.22 ab	49.46 bc	5.62 ab	3 bc	66.86 ab	12.77 a
low rate "Perseus" + high rate oats	25.57	30.1 b	53.45 c	6.46 ab	2.89 a	64.92 a	13.08 ab
med rate "Perseus" + med rate oats	31.62	29.05 b	50.28 bc	6.82 ab	2.95 bc	66 ab	13.43 ab
"Perseus" festulolium alone	25.17	26.09 ab	44.21 ab	4.72 ab	3.12 bc	69.06 ab	20.26 cd
high rate "Perun" festulolium + low rate oats	22.78	29.42 b	50.1 bc	7.89 b	2.93 b	65.62 a	12.21 a
low rate "Perun" + high rate oats	23.85	29.51 b	51.57 bc	7.18 ab	2.92 a	65.53 a	13 a
med rate "Perun" + med rate oats	24.92	28.72 ab	49.42 bc	5.65 ab	2.97 bc	66.34 ab	14.958 abc
"Perun" festulolium alone	24.3	22.81 a	39.37 a	5.38 ab	3.31 c	72.45 c	16.69 abc

Treatment	NEL (Mcal/kg)	Ca(%)	P (%)	K (%)	Mg (%)	Cu (ppm)	Zn (ppm)
oats alone	1.49	0.35 a	0.33	1.76 a	0.2 ab	3.7 a	69.48
high rate ryegrass + low rate oats	1.52	0.38 ab	0.34	1.92 ab	0.19 a	3.94 ab	60.83
low rate ryegrass + high rate oats	1.48	0.28 a	0.27	1.56 a	0.18 a	3.17 a	45.97
med rate ryegrass + med rate oats	1.5	0.34 a	0.3	2.1 ab	0.22 ab	3.67 a	60.42
ryegrass alone	1.55	0.63 bc	0.45	2.85 ab	0.46 c	8.58 c	113.47
high rate "Perseus" festulolium + low rate oats	1.51	0.4 ab	0.34	1.91 ab	0.21 ab	3.89 ab	87.17
low rate "Perseus" + high rate oats	1.46	0.3 a	0.29	1.66 a	0.19 a	3.68 a	45.24
med rate "Perseus" + med rate oats	1.49	0.33 a	0.3	1.56 a	0.21 ab	3.13 a	48.35
"Perseus" festulolium alone	1.53	0.64 bc	0.42	3.41 b	0.38 bc	8.11 c	87.28
high rate "Perun" festulolium + low rate oats	1.48	0.35 a	0.34	1.78 a	0.22 ab	4.13 ab	75.64
low rate "Perun" + high rate oats	1.47	0.35 a	0.32	1.99 ab	0.21 ab	4.02 ab	60.79
med rate "Perun" + med rate oats	1.5	0.38 ab	0.32	1.76 a	0.24 ab	4.36 ab	52.23
"Perun" festulolium alone	1.55	0.69 c	0.3	2.56 ab	0.44 c	6.59 bc	98.66

**Means that share a letter are not significantly different. Columns without letter groups had no significant effects from treatments.*

Effects on Soil Fertility

Soil samples were analyzed for organic matter (OM), pH, phosphate (P_2O_5), potash (K_2O), calcium (Ca), magnesium (Mg), and aluminum (Al). There were no statistically significant differences in soil test results between treatments. All means are presented in Table 6. Effects of plants on soil properties and fertility typically takes multiple years to be evident.

Table 6. Soil test report means for all oats+ grass treatments. August 2014.

Treatment	Organic Matter (%)	pH	Phosphate - P_2O_5 (ppm)	Potash - K_2O (ppm)	Calcium (ppm)	Magnesium (ppm)	Aluminum (ppm)
oats alone	6.95	4.98	538.5	55.5	591.25	153.25	1761.25
high rate ryegrass + low rate oats	5.38	5.18	670.5	53.5	711.25	143.25	1771.5
low rate ryegrass + high rate oats	5.4	4.88	488.75	60.75	456.25	138	1777.5
med rate ryegrass + med rate oats	6.1	5.18	466	61.5	808.25	176	1725.25
ryegrass alone	5.68	5.05	452	54	474	131.75	1744.5
high rate "Perseus" festulolium + low rate oats	5.98	5.2	509	57.75	654.25	170	1812.5
low rate "Perseus" + high rate oats	5.95	4.85	486	59.75	478.25	139.75	1831
med rate "Perseus" + med rate oats	5.75	5.08	389.25	52.25	496.75	164	1821
"Perseus" festulolium alone	6.33	5.1	576.5	52.75	617.5	153.75	1776
high rate "Perun" festulolium + low rate oats	7.08	5.03	525.25	63.5	606	170.75	1734.75
low rate "Perun" + high rate oats	6.55	5	686.25	64.5	648.75	151.75	1735.5
med rate "Perun" + med rate oats	6.05	5	507.5	54.75	537.75	134.5	1802.25
"Perun" festulolium alone	5.55	5.3	275.75	47	430	113	1892.75

Objective 2. Identify new and superior performing forage grass and legume blends suited for insular Newfoundland conditions

Time to Establishment

The time to establishment for ryegrass, timothy, and festulolium in all plots was five days. The legumes were established after 18 days (Figure 3). The quick germination of grasses is not common for Newfoundland forage stands however the plots were seeded at a later date than is ideal (as stated above). In July when the plots were seeded, daily high temperatures were between 23-30 degrees Celsius which may have caused the seeds to germinate and sprout more quickly than if they were planted earlier in June (Environment Canada). The legumes did not perform well as they were out-competed by the grasses. This is due to the incorrect setting of the plot seeder and subsequent increased seeding rates (mentioned in Methods section).

Figure 3. Ryegrass + red clover plot. July 8, 2014. Pynn's Brook, NL.

Forage Yield and Weed Content

Yield was determined using two 0.5 m^2 quadrats per plot (1 m^2 total). Dry weight yield in kg ha^{-1} was estimated based on the actual experimental harvest. Dry weight biomass (yield) was highest for "ryegrass + red clover", "festulolium "Perun" + standard alfalfa" and "festulolium "Perseus" + standard alfalfa". These three treatments had significantly higher yield than "timothy + birdsfoot trefoil" and "timothy + standard alfalfa" (P = 0.0153) (Figure 4). There were no significant differences in the percentage of weeds for each treatment.

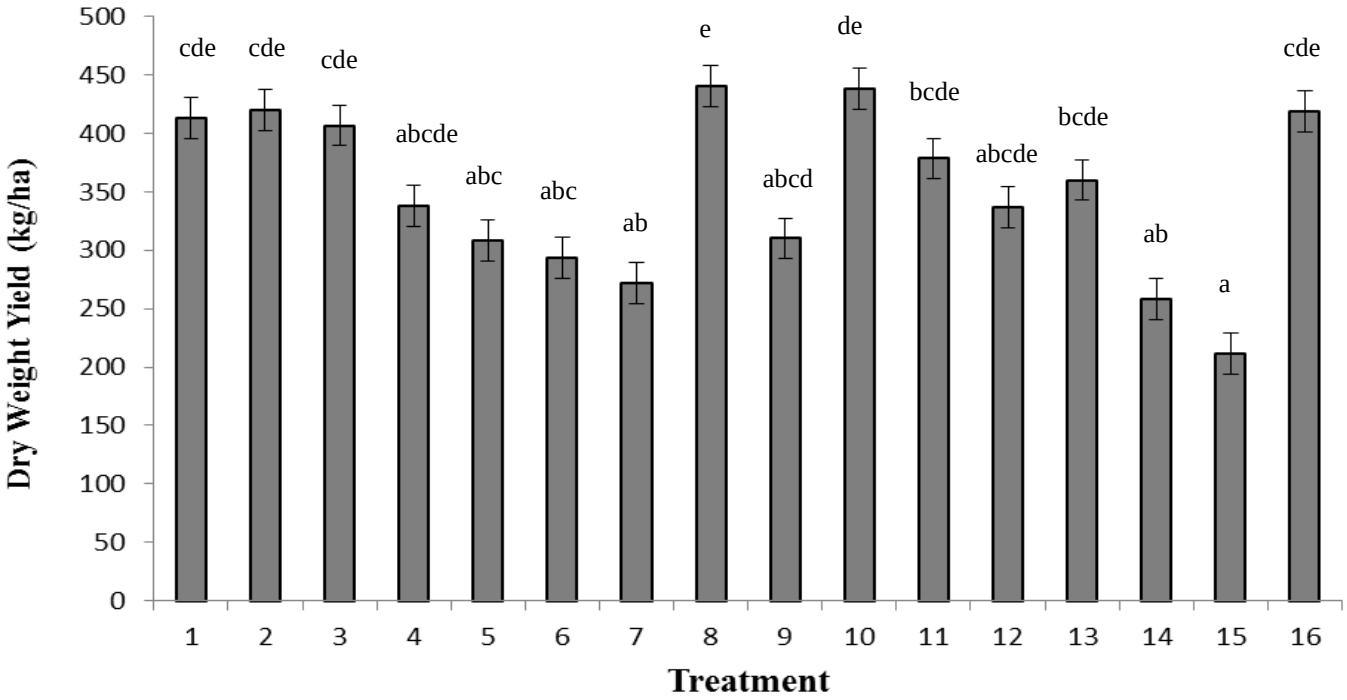

Figure 4. Bar graph representation of average dry weight yield per treatment for grass and legume mixtures. August 2014. Pynn's Brook, NL

List of treatment numbers with corresponding grass+ legume mixture

Treatment	Grass + Legume Mixture
1	"Perseus" festulolium + runner alfalfa
2	"Perseus" festulolium + standard alfalfa
3	"Perseus" festulolium + birdsfoot trefoil
4	"Perseus" festulolium + red clover
5	ryegrass + runner alfalfa
6	ryegrass + standard alfalfa
7	ryegrass + birdsfoot trefoil
8	ryegrass + red clover
9	"Perun" festulolium + runner alfalfa
10	"Perun" festulolium + standard alfalfa
11	"Perun" festulolium + birdsfoot trefoil
12	"Perun" festulolium + red clover
13	timothy + runner alfalfa
14	timothy + standard alfalfa
15	timothy + birdsfoot trefoil
16	timothy + red clover

The legumes in all treatments did not contribute greatly to overall biomass as the increased seeding rates (mentioned in Materials and Methods Section) along with low competitive ability of legumes led to "choking out" of many legume seedlings. Timothy is known to be a lower-yielding grass which is shown by its low yield compared to treatments with ryegrass and festulolium; however, it is typically of higher feed quality than ryegrass or festulolium (Charlton and Stewart 2000).

Nutrient Content

Tissue samples were analyzed for acid detergent fibre (ADF), neutral detergent fibre (NDF), bound protein, estimated digestible energy (Est DE), total digestible nutrients (TDN), crude protein (CP), net energy for lactation (NEL), calcium (Ca), phosphorous (P), potassium (K), copper (Cu) and zinc (Zn). Moisture content was also determined. Means for all treatments are presented in Table 7.

Acid detergent fibre (ADF) was highest for "timothy + runner alfalfa" ($P = 0.0117$) and all other treatments were not significantly different from one another, including other treatments containing timothy. Ryegrass and timothy tend to have similar ADF and NDF values in the spring but timothy will have higher NDF and ADF in the autumn (Thomson and Kay 2005). Neutral detergent fibre (NDF) and bound protein (BP) were not significantly different between treatments.

Timothy + runner alfalfa had the lowest estimated digestible energy (Est DE) compared to "ryegrass + birdsfoot trefoil", "Perun" festulolium + birdsfoot trefoil" and "Perseus festulolium + red clover" ($P = 0.0108$). Timothy tends to have higher ADF when harvested late summer/early fall which would cause it to have lower digestible energy. There is a direct relationship between Est DE and TDN. Total digestible nutrients (TDN) for "timothy + runner alfalfa" are significantly lower than "festulolium "Perseus" + birdsfoot trefoil" and "festulolium "Perun" + red clover" but not significantly different from any other treatment ($P = 0.0118$).

Crude protein of "timothy + red clover" was significantly higher than "festulolium "Perun" + birdsfoot trefoil", "festulolium "Perseus" + red clover", and "ryegrass + birdsfoot trefoil" but not significantly different than any other treatment ($P = 0.0043$). Protein content of a forage feed is used as an indicator of overall forage quality. Timothy is known to be high quality forage although it may not be the highest yielding or provide the most energy. Milk yield from cows feeding on timothy has been shown to be higher than ryegrass but this information is related to grazing animals (Thomson and Kay 2005). In Newfoundland most dairy producers use a total mixed ration (TMR) and cows are not pastured.

Net energy for lactation (NEL) is a very important value to dairy producers as it is an indication of the feed and is used in part for creating their TMR. Timothy + runner alfalfa had significantly lower NEL than any other treatment ($P = 0.0104$). Although there were no statistically significant differences between other treatments, there was a tendency for all treatments with timothy to be lower in NEL than treatments containing ryegrass or festulolium.

Calcium (Ca), potassium (K) and magnesium (Mg) values were highest for mixes containing timothy and lowest for mixes containing festulolium ($P < 0.0001$ for Ca and Mg; $P = 0.0253$ for K). Phosphorous (P) levels were not significantly different between treatments. Copper (Cu) and Zinc (Zn) levels were significantly higher for "timothy + red clover" compared to any other treatments ($P = 0.0008$ for Cu; $P = 0.0019$ for Zn). There is a distinct trend for mixtures containing festulolium to be lower in Cu and Zn than mixtures containing timothy. As mentioned previously, the legumes did not establish well and thus had minimal impact on the tissue analysis report. Moisture content did not differ between treatments.

In summary, mixtures containing timothy grass tended to be lower in Est DE and NEL and higher in ADF which are not necessarily desirable traits for forage feedstuffs; however, timothy mixtures were higher in crude protein (CP) which is an indication of higher forage quality.

Table 7. Nutrient analysis report means for all treatments for grass and legume mixtures. August 2014.

Treatment	% Moisture	ADF (%)	NDF (%)	Bound Protein (%)	Est DE (Mcal/kg)	TDN (%)	Crude Protein (%)
"Perseus" festulolium + runner alfalfa	22.74	26.12 ab	41.35	5.76	3.12 ab	69.03 ab	14.19 ab
"Perseus" festulolium + standard alfalfa	18.36	28.25 ab	47.79	8.07	3 ab	66.82 ab	15.15 ab
"Perseus" festulolium + birdsfoot trefoil	20.23	24.33 a	39.87	8.13	3.22 b	70.88 b	12.86 a
"Perseus" festulolium + red clover	19.86	26.66 ab	41.91	9.58	3.09 ab	68.47 ab	13.13 ab
ryegrass + runner alfalfa	22.22	28.07 ab	45.43	8.86	3.01 ab	67.01 ab	16.12 ab
ryegrass + standard alfalfa	23.11	25.83 ab	32.64	8.98	3.14 ab	69.33 ab	18.01 ab
ryegrass + birdsfoot trefoil	22.68	24.98 a	34.99	8.68	3.19 b	70.21 ab	12.79 a
ryegrass + red clover	17.78	28.14 ab	38.48	10.13	3 ab	66.91 ab	16.27 ab
"Perun" festulolium + runner alfalfa	24.16	25.54 ab	37.99	8.74	3.15 ab	69.62 ab	14.12 ab
"Perun" festulolium + standard alfalfa	21.83	25.81 ab	41.15	6.35	3.14 ab	69.35 ab	15.71 ab
"Perun" festulolium + birdsfoot trefoil	25.56	26.47 ab	42.81	6.97	3.1 ab	68.67 ab	14.81 ab
"Perun" festulolium + red clover	21.51	24.24 a	37.88	5.28	3.23 b	70.97 b	12.51 a
timothy + runner alfalfa	23.84	30.76 b	40.41	9.4	2.85 a	64.23 a	17.83 ab
timothy + standard alfalfa	27.18	26.81 ab	36.51	7.94	3.08 ab	68.32 ab	17.82 ab
timothy + birdsfoot trefoil	27.44	28.03 ab	38.19	11.73	3.01 ab	67.05 ab	13.21 ab
timothy + red clover	27.89	28.89 ab	34.88	9.62	2.96 ab	66.16 ab	19.47 b

Treatment	NEL (Mcal/kg)	Ca(%)	P (%)	K (%)	Mg (%)	Cu (ppm)	Zn (ppm)
"Perseus" festulolium + runner alfalfa	1.55 b	0.49 ab	0.28	3.24	0.34 ab	4.61 a	29.79 a
"Perseus" festulolium + standard alfalfa	1.49 ab	0.54 ab	0.26	3.15	0.35 ab	5.03 a	23.5 a
"Perseus" festulolium + birdsfoot trefoil	1.55 b	0.48 a	0.22	2.5	0.32 a	4.9 a	26.19 a
"Perseus" festulolium + red clover	1.52 ab	0.64 abc	0.27	3.18	0.39 ab	5.3 a	28.66 a
ryegrass + runner alfalfa	1.51 ab	0.58 abc	0.34	3.4	0.39 ab	5.84 a	55.43 ab
ryegrass + standard alfalfa	1.55 b	0.75 abc	0.33	3.09	0.49 bc	6.22 ab	51.21 ab
ryegrass + birdsfoot trefoil	1.55 b	0.66 abc	0.31	2.65	0.38 ab	5.67 a	56.54 ab
ryegrass + red clover	1.5 ab	0.95 cd	0.28	2.97	0.48 ab	6.97 ab	64.72 ab
"Perun" festulolium + runner alfalfa	1.55 b	0.55 abc	0.3	3.53	0.37 ab	5.6 a	36.86 a
"Perun" festulolium + standard alfalfa	1.53 ab	0.59 abc	0.28	3.21	0.4 ab	6.04 ab	40.23 a
"Perun" festulolium + birdsfoot trefoil	1.54 ab	0.49 ab	0.31	3.35	0.32 a	6.23 ab	39.74 a
"Perun" festulolium + red clover	1.55 b	0.58 abc	0.25	3.18	0.32 a	6.0 a	39.56 a
timothy + runner alfalfa	1.44 a	0.87 cd	0.37	2.81	0.51 bc	6.9 ab	64.07 ab
timothy + standard alfalfa	1.53 ab	0.99 d	0.3	2.76	0.49 bc	6.1 ab	61.68 ab
timothy + birdsfoot trefoil	1.51 ab	0.76 abc	0.3	2.99	0.54 c	4.99 a	57.18 ab
timothy + red clover	1.49 ab	1.18 d	0.37	2.66	0.53 c	8.83 b	97.29 b

**Means that share a letter are not significantly different. Columns without letter groups had no significant effects from treatments.*

Effect on Soil Fertility

Soil samples were analyzed for organic matter (OM), pH, phosphate (P_2O_5), potash (K_2O), calcium (Ca), magnesium (Mg), and aluminum (Al). There were no statistically significant differences in soil test results between treatments. All means are presented in Table 8. Effects of plants on soil properties and fertility typically takes multiple years to be evident.

Table 8. Soil test report means for all grass + legume treatments. August 2014.

Treatment	Organic Matter (%)	pH	Phosphate - P_2O_5 (ppm)	Potash - K_2O (ppm)	Calcium (ppm)	Magnesium (ppm)	Aluminum (ppm)
"Perseus" festulolium + runner alfalfa	5.1	5.67	104	63.33	512	157.33	1821.33
"Perseus" festulolium + standard alfalfa	4.7	5.6	108	56	503.67	135.67	1874.33
"Perseus" festulolium + birdsfoot trefoil	4.27	5.73	73.33	48.67	429	148	1859.33
"Perseus" festulolium + red clover	4.77	5.83	132	60	573.67	184	1777.33
ryegrass + runner alfalfa	4.8	5.4	186.67	50.33	449.67	114.33	1797.67
ryegrass + standard alfalfa	4.73	5.6	112.33	52.33	522	168	1833.67
ryegrass + birdsfoot trefoil	3.53	5.6	202.33	41	465.67	130.33	1807
ryegrass + red clover	4.63	5.77	101.67	56	577	171.67	1706
"Perun" festulolium + runner alfalfa	4.23	5.8	167.67	55	567	174.67	1747
"Perun" festulolium + standard alfalfa	4.53	5.4	219.67	58.67	487.33	127.33	1755.33
"Perun" festulolium + birdsfoot trefoil	4.13	5.57	230.67	44.33	444	129	1783.33
"Perun" festulolium + red clover	4.7	5.4	163	56.67	435.67	111.67	1769.33
timothy + runner alfalfa	3.87	5.47	138.33	45.67	450	128	1780
timothy + standard alfalfa	4.53	5.47	191.67	64	371	103	1851.67
timothy + birdsfoot trefoil	4.7	5.6	81.33	61	447.33	128	1821
timothy + red clover	4.77	5.3	296.33	47	536.33	131	1796.67

Conclusion and Future Recommendations

In summary, two different plot trials at the Pynn's Brook Research Station in NL were carried out in summer of 2014 in order to achieve two objectives: 1) to identify optimum forage oats and ryegrass blend ratios and seeding rates under new clear conditions and 2) to identify new and superior performing forage legume and grass varieties suited for insular Newfoundland conditions – particularly new clear. There were some set-backs – late seeding of the trials and incorrect setting of the plot seeder. These two set-backs may have affected the overall performance of forage crops being evaluated as the broad leafed legumes (birdsfoot trefoil, alfalfa, and red clover) are not as vigorous as grasses and were unable to compete for space. Grasses germinate quickly when planted early in the summer in cool temperatures so when they were planted later than ideal in hot temperatures, they were even more vigorous.

Soil test results did not vary between treatments for either trial. This is not surprising as soil properties are slow to change. In order to fully realize any benefits to soil from plants, the plots should be sampled again in 2015.

Part of this research project was identifying optimum seeding rates for oat + grass blends and due to the malfunction with the plot seeder, and optimum seeding rate was difficult to determine. All seeding rates were originally determined using recommendations from seed suppliers and literature values. Seeding rates for Newfoundland soils should be higher than for other provinces within Canada. Some sources advise to double the recommended rates for Newfoundland, this may improve germination and establishment of crops however there has to be an economic return for the producers. Seeding at a higher rate would cost the producer more for seed but if the yield is relative to the investment then it would be a wise decision.

Based on results from this trial, ryegrass and festulolium performed very similarly. The addition of oats to any of the grasses resulted in higher fibre and biomass. Oats are a great addition to a grass stand as they germinate quickly and do not have to be killed in the following spring if the field is being rotated. They are also cost effective and can provide a quick feed source.

The second objective was to identify new and superior-performing forage and legume blends. Again, the malfunction of the plot seeder made for less-than-ideal conditions and the legumes did not perform well. Festulolium and ryegrass performed very similarly. There was a trend for mixes containing timothy to be lower in available energy but higher in protein. Timothy is widely grown by dairy producers as it tends to have high forage quality however it is better suited as a pasture grass than as a silage crop.

All experimental plots from 2014 should be evaluated in summer 2015 for re-growth potential after overwintering. Plots were seeded late and legumes such as red clover, alfalfa, and birdsfoot trefoil usually have low yield in the first year, known as the establishment year. The perennial legumes may recover and perform better in year two.

Simplification of treatments and improved experimental design will help to better differentiate between treatment effects. Large-scale trials may be beneficial for examining the effect of crops on soil properties.

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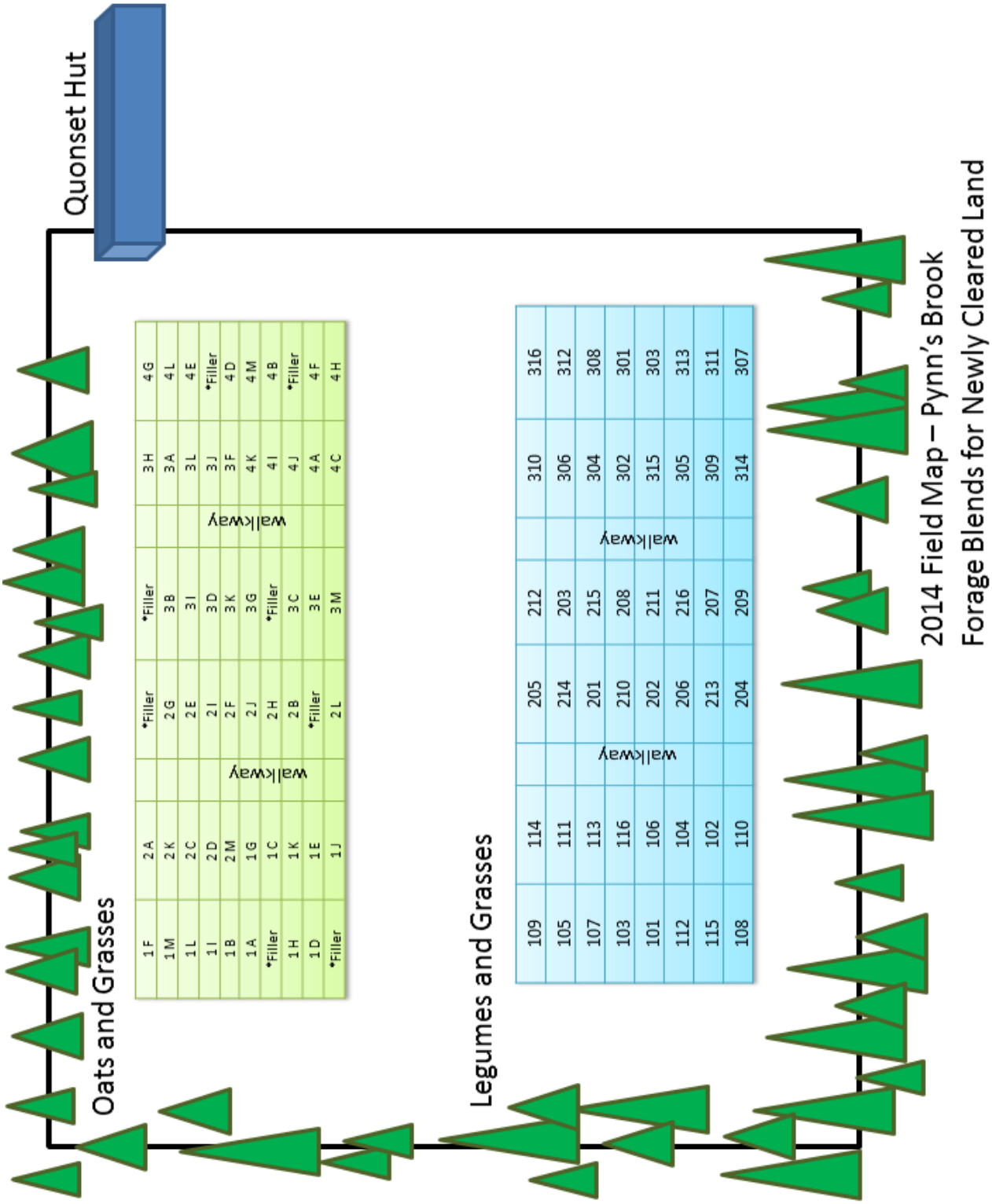
APPENDIX I – FIELD MAP OR PLOT TRIALS



List of treatment letters with corresponding grass + oat mixture

Treatment	Grass + Oat Mixtures and Seeding Rate Level
A	oats alone
B	high rate ryegrass + low rate oats
C	low rate ryegrass + high rate oats
D	med rate ryegrass + med rate oats
E	ryegrass alone
F	high rate "Perseus" festulolium + low rate oats
G	low rate "Perseus" + high rate oats
H	med rate "Perseus" + med rate oats
I	"Perseus" festulolium alone
J	high rate "Perun" festulolium + low rate oats
K	low rate "Perun" + high rate oats
L	med rate "Perun" + med rate oats
M	"Perun" festulolium alone

List of treatment numbers with corresponding grass+ legume mixture

Treatment	Grass + Legume Mixture
1	"Perseus" festulolium + runner alfalfa
2	"Perseus" festulolium + standard alfalfa
3	"Perseus" festulolium + birdsfoot trefoil
4	"Perseus" festulolium + red clover
5	ryegrass + runner alfalfa
6	ryegrass + standard alfalfa
7	ryegrass + birdsfoot trefoil
8	ryegrass + red clover
9	"Perun" festulolium + runner alfalfa
10	"Perun" festulolium + standard alfalfa
11	"Perun" festulolium + birdsfoot trefoil
12	"Perun" festulolium + red clover
13	timothy + runner alfalfa
14	timothy + standard alfalfa
15	timothy + birdsfoot trefoil
16	timothy + red clover