ALFALFA AS A DIVERSIFICATION OPTION FOR GRAIN FARMS IN WESTERN CANADA

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Abstract
Western Canadian grain producers are considering diversifying from crop production and including forages in their rotations for hay production or livestock grazing. The addition of a livestock enterprise can stabilize farm income as returns from livestock are negative or weakly positively correlated with grain and oilseed returns. This study showed a high degree of risk and variability of revenue associated with the addition of forages to a crop rotation for livestock grazing, relative to hay production at the scale of this study. Revenue from grazed alfalfa exceeded that for hay production but costs were also higher. Sources of risk include cattle deaths and costs related to animal care. The choice between cattle or hay production should be based on an analysis of the uncertainty related to forage production, management of animal health, and contracted prices; and long-term fixed infrastructure costs such as fencing or watering systems.

Introduction
Western Canadian grain producers have diversified their crop production since 1990 with oilseed and pulse crops replacing cereal crops. However, the level of risk reduction and stability of income improved only marginally as most oilseed and pulse crop yields and prices are highly positively correlated with those of cereal grains. The addition of a livestock enterprise can diversify the farm operation as returns from livestock are negative or weakly positively correlated with grain and oilseed returns. This study addresses farming systems which include alfalfa-grass or straight alfalfa in the crop rotation for use in a commercial hay operation or in the backgrounding of steers.

Literature Review
Alfalfa increases yields of subsequent crops in a rotation where moisture is not a limiting factor in annual crop production (Entz et al. 2002). The ability of alfalfa to fix its own nitrogen and its deep root system help in increasing the fertility and tilth of the soil as nitrogen is available to subsequent crops and rooting depth increases. Also, forage crops play an increasingly important role in providing critical habitat for many species, including migrating waterfowl (Entz et al. 2001).

In a review of alfalfa production in pasture systems Popp et al. (1999) found that when pasture utilization is less than 70%, individual animal gains are maximized in a range from 107 kg ha^{-1} on dry land to 1946 kg ha^{-1} on irrigated pastures. Improved management techniques are required to attain the higher level of weight gains. Renewable resource management such as grazing systems can use a threshold policy to maximize production.

Costa and Meza (2006) have shown that threshold densities of vegetation combined with the proper stocking intensity can lead to a sustainable grazing system.

Zentner et al. (1986) reviewed data from long-term crop rotation studies at Agriculture and Agri-Food Canada Research Centres in Indian Head, Scott and Melfort Canada to determine the economics of forage-based cropping systems and estimated input costs, net returns and variability of income. Forage based systems had lower costs of production than continuous cropping systems but higher costs than wheat-fallow systems. Income variability was lower when forage was included in rotations for 2-3 years in 6-year crop rotations. Whole farm net income tended to be more stable over a range of crop prices when forage was included in the crop rotation. However soil erosion, nitrate leaching and the cost of terminating alfalfa have been a major concern. Zero tillage technology combined with chemical termination of alfalfa has been shown to be an effective way of limiting the cost and reducing the negative environmental impacts of termination using conventional tillage (Bullied et al. 1999).

Perillat et al. (2004) found that grazing had a similar net return to intensive feedlot systems. In the grazing system, productivity was enhanced by fertilizer and barley supplements to produce acceptable weight gains in livestock. These management practices tended to increase profitability and reduce risk. Variability of net return, or risk, is a function of management decisions in response to environmental effects on pasture production, and the livestock selling price (Perillat et al. 2004). This variability in net return is due to the fall selling price of steers, which is not known at the time of purchase unless a contract with a feedlot or meat packer is obtained.

Objectives

The objective of this study was to evaluate the economic return of a hay or steer backgrounding enterprise as part of a rotation with annual crops.

Materials and Methods

The Manitoba Zero Tillage Research Association Research Farm is located at Section 31-12-18 W, 17.6 kilometres north of Brandon. Relief at the farm is irregular undulating to hummocky with variable drainage. Drainage ranges from well to rapid on the upper slopes to very poor in depressed pothole areas. The research farm is situated within the Newdale Plain subsection of the Assiniboine River Plain. The area primarily consists of undulating to hummocky ground moraine characterised by numerous potholes and sloughs. Surface deposits consist of boulder till of mixed materials derived from shale, limestone and granite. The soils of the Newdale association at the study site are moderately to strongly calcareous and belong to the fine loamy particle size class. The dominant soil texture on the farm is clay loam (Podolsky et al. 1994).

The study started in 2001 when all fields were seeded to canola to assess the spatial variability of yield and provide information required to delineate boundaries. The crop rotations including alfalfa/grass were established in May 2002 with an experimental design based on landform and field analysis. The study was designed with four 16.2 ha fields. All rotations were managed using zero tillage in two replicate fields (Table I).

Weeds were controlled with herbicides, and crops were seeded without seedbed preparation. In-crop herbicides were applied to all treatments as required using recommended methods and rates of application (Crop Protection Guide, Manitoba Agriculture, Food and Rural Initiatives 2002-2007). Seeding rates averaged 134.5, 39.2, 114.3, and 5.6 kg ha^{-1} for spring wheat *(Triticum aestivum* L.), flax (*Linum usitatissimum* L.) oats (*Avena sativa L.*) and canola (*Brassica napus L.*), respectively. Alfalfa (*Medicago sativa L.*), orchard grass (*Dactylis glomerata* L.) and trefoil (*Lotus corniculatus L.)* seeding rates were 4.5, 2.25, and 2.25 kg ha^{-1}, respectively for hay and grazing establishment in 2002. In 2004, the hay and grazing plots were established with canola under seeded to alfalfa at 10 and 11.2 kg ha^{-1} for fields 103 and 203, respectively. An air drill was used to seed all annual crops under zero tillage and an air disc drill was used to direct seed the pasture and hay fields in 2002.

Table I: Crop Rotations 2001 to 2007

	Field Numbers			
Year	**103**	**104**	**203**	**204**
2001	Canola	Canola	Canola	Canola
2002	Wheat	Alfalfa/Grass	Wheat	Alfalfa/Grass
2003	Flax	Alfalfa	Flax	Alfalfa
2004	Canola / Alfalfa[a]	Alfalfa	Canola / Alfalfa[a]	Alfalfa
2005	Alfalfa	Oats	Alfalfa	Oats
2006	Alfalfa	Flax	Alfalfa	Flax
2007	Alfalfa	Canola / Alfalfa[a]	Alfalfa	Canola / Alfalfa[a]

a. Canola under seeded to alfalfa.

Fertilizer nitrogen (N) was applied to all annual crops based on soil analyses, provincial soil test recommendations and the expert guidance of the research committee. Phosphate-phosphorus (P_20_5-P), and sulphate-sulphur (SO_4-S) were applied according to guidelines established by the research committee. The majority of nitrogen fertilizer (urea ammonium nitrate solution) was dribble banded, with a small amount of N applied with the seed as mono ammonium phosphate. Spring wheat received an average of 68.5 kg N ha^{-1}, while flax received 70 kg N ha^{-1}, oats 32.5 kg N ha^{-1} and canola 75 kg N ha^{-1}. Phosphorus fertilizer (mono ammonium phosphate) rates averaged 33.6, 33.6 and 29.5, kg P ha^{-1} for spring wheat, oats and canola, respectively. Flax received no phosphorus. Sulphur fertilizer was applied to canola based on soil tests at an average rate of 22.4 kg S ha^{-1}. No fertilizer was applied to the alfalfa/grass or alfalfa in both the hayed and the grazed systems during the production years. The rate of P2O5 applied to the Canola in the year of establishment was increased by 12.4 lbs/hectare to be available for the alfalfa in the production years.

Hay and Grazing Systems

The crop rotation consisted of annual crops and 3-year forage stands in paddocks, half of which were hayed and the rest grazed. The economic analysis in this report was for 2003 to 2007. Precipitation was measured with a manual gauge at the research farm after rainfall events in 2001, 2003, 2004, 2006 and 2007 (Table II). Data were not collected at the site in 2002 and 2005 due to logistical problems. Precipitation data for 2002 and 2005 were recorded at an AAFC field site, 5 km south east of the research farm.

The forage-based system was replicated twice with hay and grazing fields in each replicate. In 2003 and 2004, the cattle were grazed for 100 and 99 days, respectively in two separate replicates, Fields 104 and 204. The days on pasture for 2005 through 2007 were 100, 97 and 82, respectively for fields 103 and 203. The stocking rates were higher for Field 204 because the total area was greater than Field 104, and the alfalfa was better established (Table III). The stocking rates for field 203 were higher than for field 103 in 2005 and 2006 due to deaths in field 103. Fields were grazed twice in 2003. In 2004, the cattle grazed on two replicated pastures, each consisting of six paddocks. The cattle were moved every 4-5 days on average, with four grazing periods per paddock. The rest period for paddocks was 20-25 days. In 2005 fields were divided into 6 paddocks and cattle were moved every four days with 4 grazing periods each followed by 20 days of re-growth . Initially in 2006 the fields were divided into 6 paddocks however, after the first 2 passes through these paddocks they were divided into 12 paddocks. The cattle were moved every 2 days providing 22 days of re-growth and 4 grazing periods. In 2007 the fields were divided into 12 paddocks. The cattle were moved every 2 days providing 22 days of re-growth and 3 grazing periods.

Table II: Annual Growing Season Precipitation (cm)

	2003	2004	2005[a]	2006	2007
	----------cm----------				
May	2.1	14.9	5.0	4.6	6.7
June	4.8	4.6	16.7	12.2	8.5
July	1.5	7.2	7.7	0.8	2.6
August	1.8	7.6	2.4	5.8	5.4
Sept	5.2	3.2	1.6	5.6	1.7
Total	15.4	37.5	33.4	29	24.9

a. Precipitation data for 2005 are from a AAFC field research site located 5 km south east of the MZTRA research farm. Precipitation is highly correlated between the two sites for other years though monthly totals are not the same.

Table III: Stocking Rate

	Treatment Fields			
	103	104	203	204
Year	Ha/head	ha/head	ha/head	ha/head
2003		0.55		0.49
2004		0.41		0.41
2005	0.44		0.38	
2006	0.40		0.36	
2007	0.33		0.40	

Source: Author's calculations

Economic Model

Annual net revenue was used to evaluate the economic performance of the hay enterprise and steer-backgrounding, by subtracting production and all input costs from gross revenue. Net revenue was calculated as the revenue remaining above cash costs (i.e., seed, fertilizer, chemical, fuel and oil, repairs, crop insurance premium, miscellaneous,

machinery rental, land taxes, labour and interest cost on variable inputs), ownership costs (depreciation, interest on investment, insurance and housing) for machinery. The labour costs and lifespan of machinery for field operations were calculated from the machinery work rate per hectare reported by Saskatchewan Agriculture, Food and Rural Revitalization (2002). Machinery costs for the haying operation (baler, mower, bale hauler) were based on published rental rates (Manitoba Agriculture Food and Rural Initiatives 2006). All annual inputs were incorporated in the analysis for each enterprise, including all pre-plant activities, fertilization, planting, insect and pest control, harvesting, storage, and transportation.

Returns were estimated from average farm-gate prices for alfalfa-brome and alfalfa in September – October of the production year and September steer prices (Saskatchewan Agriculture and Food; Canfax). The economic performance of the two diversification options was evaluated in regard to costs of production, gross revenue, and net return to labour and management. All purchased inputs and machine operations were valued at their annual cost levels. No allowance was made for interest costs associated with land equity. Fuel, fertilizer and crop protection product prices were obtained from various sources (Manitoba Agriculture Food and Rural Initiatives).

Results and Discussion

Hay Enterprise

Hay yields for the treatment fields are presented in Table IV. Hay was harvested twice in all years except 2005. The first cut in 2006 for both treatments was more productive than the average of the first cuts of all other years followed by a second cut that was 92% and 72% larger than the average of the second cuts of other years for fields 103 and 203, respectively. The price of hay over the course of the trials fell from a high of \$88.18 tonne^{-1} in 2003 to \$46.30 tonne^{-1} in 2006. Production of hay in 2002 and 2003 was reduced due to low precipitation, resulting in higher hay prices in 2003.

Table IV: Alfalfa Hay Yield (kg ha^{-1}) and Price (\$ tonne^{-1}) 2003-07[a]

		Treatment Fields			
	Price[b]	103	104	203	204
Year	\$ tonne^{-1}		-------Kg ha^{-1}------		
2003	88.18		4686		3883
2004	60.63		4490		5235
2005	63.93	4508		4585	
2006	46.30	8834		8911	
2007	50.71	4370		4399	

Source: Hay prices from Hay Market Report, Saskatchewan Agriculture and Food; and Manitoba Agricultural Yearbook, Manitoba Agriculture, Food and Rural Initiatives.

a. Two harvests of hay per year except in 2005.
b. Prices for mixed alfalfa hay for 2003 and 2004 and straight alfalfa hay for 2004-2007.

Net return to management and labour for hay production is presented in Table V. This analysis is based on the assumption that all labour is supplied by management. Hay production in 2006 had the highest net returns to management and labour followed in 2007 by the lowest returns. Overall treatments 104 and 204 had the highest returns to

management and labour as the price per tonne of hay was $20.76 tonne^{-1} higher on average combined with hay yields that were comparable to 2005 and 2007.

Net return to management, after accounting for all variable and fixed costs, ranged from a low of -$0.55 ha^{-1} for field 203 in 2007 to a high of $186.03 ha^{-1} for field 104 in 2003.

Table V: Net Return to Management and Labour for Hay Production

Year	Field	Gross[a]	Variable[b]	Revenue[c]	Fixed[d]	NRM[e]	Labour[f]	L&M[g]
		----------$ per hectare----------						
2003	**104**	413.24	144.80	268.44	82.41	186.03	23.34	209.37
	204	342.45	140.83	201.62	82.41	119.21	23.34	142.55
2004	**104**	272.23	116.25	155.98	82.41	73.57	23.34	96.91
	204	317.35	116.25	201.10	82.41	118.69	23.34	142.03
2005	**103**	288.18	165.77	122.41	81.01	41.4	23.34	64.74
	203	293.14	167.93	125.21	81.01	44.2	23.34	67.54
2006	**103**	409.02	162.71	246.31	81.01	165.3	23.34	188.64
	203	412.58	163.93	248.65	81.01	167.64	23.34	190.98
2007	**103**	221.6	139.76	81.84	81.01	0.83	26.45	27.28
	203	223.07	142.61	80.46	81.01	-0.55	26.45	25.9
		Gross[a]	**Variable[b]**	**Revenue[c]**	**Fixed[d]**	**NRM[e]**	**Labour[f]**	**L&M[g]**
Average		----------$ per hectare----------						
	104	342.73	130.52	212.21	82.41	129.80	23.34	153.14
	204	329.90	128.54	201.36	82.41	118.95	23.34	142.29
	103	306.27	156.08	150.19	81.01	69.18	24.38	93.55
	203	309.60	158.16	151.44	81.01	70.43	24.38	94.81

a. Gross revenue equals kilograms of hay times the price of hay.
b. Variable costs include all labour, seed, fuel, rental of haying equipment and repairs.
c. Revenue before fixed cost.
d. Fixed cost of seeding equipment and tractor for haying operations and a land rental charge of $77.04 per hectare.
e. Net return to management.
f. Labour cost included in the variable costs calculated @ $15 per hour in 2003 to 2006 and $17 per hour in 2007.
g. Return to Labour and Management if management supplies the labour.

Grazing Enterprise

The May and September weights for summer grazing of steers, average May (input) and September (output) steer prices and margins are presented in Table VI. Fields 104 and 204 had a wider range of steer weights on average over the trial period. Steers in 2003 had the lowest average weight gains while those in field 203 in 2006 had the highest weight gain. The productivity of the mixed alfalfa/orchard grass/trefoil pasture for fields 104 and 204 as measured in the weight gains of the steers on average ranged from 20-30 kg ha^{-1} lower than for the alfalfa fields (103 and 203). Improved efficiency due to rotational grazing with decreasing paddock size from 2004 to 2007 could explain part of the difference in weight gain from 2003 trials. The price margin fell in 2004 and 2005 after the steer market recovered from the discovery of BSE in the summer of 2003. However, price margins increased in 2006 and 2007 due to the rising price of corn related to the expanding ethanol industry.

Table VI: In and Out Steer Weights and Prices

		May Weight			Average			May	Sept	Price
		min	max	range	IN[a]	OUT[b]	AG[c]	Price[d]	Price[e]	Margin[f]
Year	Field	Kg	Kg	Kg	Kg	Kg	Kg	$ kg^{-1}	$ kg^{-1}	$ kg^{-1}
2003[g]	104	293	417	124	343	420	78	2.69	2.26	0.44
	204	305	387	82	345	426	81	2.69	2.27	0.41
2004	104	258	338	79	300	402	102	2.12	1.99	0.13
	204	230	361	132	297	418	121	2.13	1.94	0.18
2005	103	268	349	81	315	442	127	2.29	2.20	0.09
	203	266	371	106	316	441	125	2.34	2.14	0.20
2006	103	250	323	73	292	421	129	2.68	2.35	0.33
	203	250	338	88	293	433	140	2.66	2.29	0.37
2007	103	256	310	54	280	382	102	2.74	2.24	0.51
	203	243	305	62	273	375	102	2.77	2.26	0.51
Field Average										
	104	275	377	102	321	411	90	2.41	2.12	0.28
	204	267	374	107	321	422	101	2.41	2.11	0.30
	103	258	327	69	296	415	120	2.57	2.26	0.31
	203	253	338	85	294	416	122	2.59	2.23	0.36

Source: Author's calculations using weights from trials and prices from Canfax Alberta Direct Sales Price.
a. Average weight of steers at the beginning of trials.
b. Average weight of steers at the end of the trials.
c. Average gain of the steers in the trial.
d. Average price paid for the yearling steers for the week ending from the 13th to 19th for the various years.
e. Average price paid for the steers for the week ending from the 16th to 22nd for the various years.
f. The difference in the May price from the September price.
g. Bovine spongiform encephalopathy (BSE) was found in Alberta Canada in the summer of 2003.

Fields with greater average steer weight gains had higher gross returns when compared within each year (Table VII). Furthermore, the fields with higher stocking rates tend to have higher returns to management and labour. The difference between the May input cost of steers and the September output price (Price Margin) had less impact on gross returns when compared between fields in the same year. However, years with lower price margins were considerably more profitable than years with high price margins.

The net return to management from summer grazing steers is presented in Table VII. Labour varied considerably from year to year depending on time required to manage cattle, and was the largest single variable cost component (Table VIII). Treatment of pink-eye and foot-rot in steers represented the major expenditure in labour costs. The revenue generated from the fields in 2003 and 2007 was less than the variable costs. On average gross income from all fields exceeded variable costs over the trial period. Return to management was negative when all costs and losses from deaths were included for 2003 and 2007. On average, return to management was positive for field 203 and negative for the other fields. The net return to management ranged from -$400.10 ha^{-1} for field 104 in 2003 to $251.17 ha^{-1} for field 204 in 2004. It is important to note that the scale of production influences the results of this study. For example labour costs are likely high given the requirements of the experimental design, low land area and small herd size.

Table VII: Net Return to Management of Grazing Option

Year	Field	Gross[a]	Variable[b]	Revenue[c]	Fixed[d]	Net [e]	Death[f]	NRM[g]	Labour	L&M[h]
		----------$ per hectare----------								
2003	**104**	59.30	336.70	(277.40)	122.70	(400.10)		(400.10)	193.33	(206.77)
	204	118.98	336.70	(217.72)	122.70	(340.42)		(340.42)	193.33	(147.08)
2004	**104**	589.67	292.24	297.43	122.70	174.73		174.73	148.89	323.62
	204	666.11	292.24	373.87	122.70	251.17		251.17	148.89	400.06
2005	**103**	568.99	308.02	260.98	121.30	139.67	44.04	95.63	142.22	237.85
	203	531.82	308.02	223.81	121.30	102.50		102.50	142.22	244.73
2006	**103**	507.45	334.18	173.27	121.30	51.96	49.91	2.05	153.33	155.39
	203	597.73	334.18	263.55	121.30	142.24		142.24	153.33	295.58
2007	**103**	262.83	297.64	(34.81)	121.30	(156.11)		(156.11)	124.67	(31.45)
	203	226.52	297.64	(71.12)	121.30	(192.42)		(192.42)	124.67	(67.76)
		Gross[a]	**Variable[b]**	**Revenue[c]**	**Fixed[d]**	**Net [e]**	**Death[f]**	**NRM[g]**	**Labour**	**L&M[h]**
Average		**----------$ per hectare----------**								
	104	324.48	314.47	10.02	122.70	(112.68)		(112.68)	193.33	80.65
	204	392.54	314.47	78.08	122.70	(44.62)		(44.62)	148.89	104.27
	103	446.43	313.28	133.14	121.30	11.84	31.32	(19.48)	153.33	133.86
	203	452.02	313.28	138.74	121.30	17.44		17.44	124.67	142.11

Source: Author's calculations.

a. Returns after the cost of spring steer price have been subtracted.
b. Variable costs include all labour, veterinary, alfasure, seed, fuel, repairs and mineral costs.
c. Revenue before fixed cost and death loss.
d. Fixed cost of permanent fence, temporary fence, corral panels, watering system, seeding and chute and a land rental charge of $77.04 per hectare.
e. Net return to grazing before death loss.
f. Death loss.
g. Return to management.
h. Return to Labour and Management.

Table VIII: Cost of Hay and Grazing Systems

	Seed Cost	Fertilizer Cost	Chemical Cost	Labor Cost	Fixed Cost[a]	Repair Cost	Oil& Lubrication &Fuel Cost	Other Costs[b]	Total Cost
	----------$ per hectare----------								
Grazing	33	0	13	91	139	38	26	137	478
Just Hay	33	0	13	29	95	22	26	28	245

Source: Author's calculations.

a. Fencing and off-watering costs are included in the fixed cost.
b. Animal care and mineral supplements are included in the other cost.

The opportunity cost of labour either used in grain production activities or off-farm employment should be considered in evaluating diversification options. The hay enterprise uses considerably less labour and management while the return to labour and management of the grazing operation was low over this period.

Low precipitation in 2003 combined with the pasture management seems to have negatively affected grazing returns relative to the haying option. Drought conditions increased the price of hay while the price of cattle tended to be negatively affected as

more cattle were marketed. Consequently, the hay enterprise had a higher per hectare return to labour and management for fields 104 and 204 relative to grazing while the converse was true for fields 103 and 203.

Conclusions

This study showed a high degree of risk and livestock revenue variability associated with the addition of forages to a crop rotation for livestock grazing, relative to hay production on the scale of this study. However revenue from grazed alfalfa exceeded that for hay production but variable costs were higher. Sources of risk include deaths of cattle and costs related to animal care. In addition the discovery of BSE in the summer of 2003, and subsequent disruption to exports of cattle to major markets, has affected the price for all categories of cattle. This effect continued over the course of this study and also affected the hay market. The cattle industry was also affected by the increased use of corn and feed grains in the ethanol industry, which contributed to lower profitability in 2006 and 2007. Therefore, the scope to compare these data with previous studies is limited. Steers were not marketed in this study at the optimal marketable weight for two reasons. First, weights of steers going on to pasture varied considerably. Second, only small number of steers were marketed on the same day. Consequently the return to the grazing systems was less than optimal.

Contracted margins for backgrounding steers are important in ensuring profitability. However, attaining high rates of gain in the steers on pasture is the most important requirement of management. The quality of the pasture and rate of gain of the animals on pasture should be assessed on an ongoing basis to optimize profit by using the best management options. Forage production in fields 104 and 204 was not sufficient to achieve profitable rates of gain given market prices.

Diversification of annual cropping systems with cattle or hay production requires the producer to assess the relevant markets over the short and long term. In the short term forage production and risk related to the variability of the growing season are important factors to consider in selecting management options. The choice between cattle or hay production should be based on an analysis of uncertainty related to forage production, management of animal health, and contracted prices; and long-term fixed costs of infrastructure such as fencing or watering systems,.

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