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Beef Enterprise Profitability and Greenhouse Gas Emissions on Manitoba Farms

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Abstract

Canadian agricultural emissions have decreased by 2 Mt CO2e (Carbon dioxide equivalent), or 3.2 percent of the total agriculture greenhouse gas (GHG) emissions during 1990 - 2016 period. Methane from beef cattle has been a noted as a major contributor to these emissions, as within the agricultural sector beef cattle emit more GHGs than other livestock types. Canada has agreed to reduce her future GHG emissions under the Copenhagen Accord, further confirmed under the Paris Accord. With the reduction of GHGs in view, alternatives are being sought. More frequently, such measures are developed using reduction in GHGs as the major objective, their adoption would not be wide scale unless producers are assured of maintaining their at least their current level (if not more) of profitability from beef production. To provide more information for these beef production stakeholders on these two aspects - profitability and GHG emission reduction, this study documented production patterns in four Manitoba farms. All farms were grouped into eight clusters, but farms in only four of them had complete information needed for the study. These were: (1) Small scale, part-time cow-calf operations, (2) Diversified cow-calf operations; (3) Large cow-calf backgrounding and (4) Crop-beef mixed operations. A single farm was selected for analysis that was close to the median of cow of the clusters. Each farm was subjected to economic profit estimation and greenhouse gas emissions using a model called Holos. The objective was to determine practices that will sustain profitability, while emitting the least amount of GHGs. Two of the study farms - Diversified cow-calf operations and Large cow-calf backgrounding, had shown a positive profit margin, with the first farm also emitted the least amount of greenhouse gases in kg per pound sold. This study shows that reduced GHG emissions is possible while maintaining profits on a cow-calf farm in Manitoba. At the same time, one of the most promising measure on such a farm is to convert cereal grain area to perennial forage. This reduces the GHG emissions from the farm while at the same time generating a high level of economic returns.

***Keywords:** Beef Enterprise; Greenhouse Gas Emissions; Manitoba Farms*

Introduction

Global GHG emissions have an effect on climate, resulting in an increase in average temperatures throughout the world [1], in addition to affecting precipitation distribution, frequency of extreme events and sea level rise. These changes would affect many economic activities, including beef cattle production, where changes in feeding efficiency and reproduction rate, among other things, are more likely to happen [2]. These impacts would make beef cattle profitability even more problematic for beef producers, especially in Canada, including Manitoba [3].

The beef industry is a major contributor of GHGs in Canada. In 2016, 60 Mt CO_2e (Carbon Oxide Equivalent[i]) of GHGs were emitted by the animal and crop production activities, which constituted 8.5 percent of total agricultural GHG emissions [4]. These emissions have increased by 11 Mt CO_2e since 1990, when such emissions were only 49 Mt CO_2e. Within the total agricultural GHG emissions, both methane (CH_4) and nitrous oxide (N_2O) emissions are significant part of the total GHG emissions, as 30 and 77 percent, respectively, of the total Canadian GHG emissions of these gases are contributed by agricultural production activities [4]. Most methane emissions are produced by farm animals, whereas nitrous oxide emissions come from the use of inorganic fertilizers as well as from use of manure on crop fields.

Eshel., *et al.* [5] have shown that on a per-calorie basis, beef is more impactful than milk, poultry, eggs, and pork in terms of land, irrigation water, and reactive nitrogen[ii]. In order to curb these emissions, various avenues have been proposed. Such examples may particularly include: changing consumption patterns, and reducing the amount of calories in current US food consumption patterns (powering beef consumption), as suggested by Tom., *et al* [6]. Such measures may reduce GHG emissions from agriculture, along with reduction in energy use and blue water footprint. As customs and culture play a large role in deciding consumption patterns [7], changing them might be appropriate but may prove to be difficult. Demanding lower beef consumption might not lead to an immediate or effective resolution to reduce GHG emissions from the industry, though there are other measures that could do so. Change in cultural practices and management of the beef enterprise, as well as changing feeding practices [8] have the potential to reduce GHG emissions.

Besides consumers, industry is also showing sign of changes towards more sustainable beef production. As an example, global food companies, such as McDonalds, have indicated that they would like to purchase food that has been deemed sustainable [9]. Since beef production sustainability differs greatly, depending on the region of the world and production methods, farms and companies that are able to prove that if they can produce beef in a sustainable manner, they could maintain or gain reliable business partners in the supply chain. Here sustainability would result in maintaining economic returns but at the same environmental damage would be lower through the use of sustainable production practices. Identifying and assessment of such beef production techniques should be considered to provide more immediate solutions.

In Manitoba, in 2016, there were 440 thousand head of beef cattle and 419 thousand calves under 1 year of age, in addition to beef heifers and steers [10]. They constitute roughly 11.5% of Canadian beef cow herd, and 10.9% of calves in Canada. Of this beef herd, 81% were on cow-calf farms, 11% on feeder and stocker operations, and the remaining 8% were on finishing operations in the province. Manitoba producers earned about 9% of the total farm cash receipts from sale of cattle and calves [11]. Similarly on the GHG emissions, animal production contributed some 57% of the total agricultural GHG emissions in Manitoba [12]. Being an important sector for Manitoba producers and a relatively high contributor to the GHG emissions, concerns for its sustainability are being raised. Measures that could lead to sustainable beef production are being sought. In other words, one needs information for a production system for cow-calf producers that can increase or maintain their economic returns but at the same time reduce GHG emissions. Since such information did not exist for Manitoba, this study was undertaken to fill this void.

Data

The data analyzed in this study were obtained from a 2012 mail-out survey of Canadian beef producers to record their total 2011 farm production and practices, including details on their beef and non-beef enterprises. Its intent was to understand "feeding strategies, forage and pasture management, animal management, and manure management practices for different types of beef practices across Canada [13]. Following the survey, data were scrutinized by independent individual experts associated with the broader study[iii], and any inconsistent information provided by respondents was removed [14]. While the survey instrument was reviewed by experts from animal, plant, and soil sciences prior to its distribution to producers, experts from agricultural economics were excluded. As such, some pertinent information in this survey regarding financial situation and economics of relevant cultural practices that affect financial conditions of the farm were not included. In order to analyze these farms, some assumptions were necessary, as gathering of new information from producers was not considered a feasible option.

[i]The carbon dioxide equivalency is estimated using a conversion factor of 23 for methane, and 296 for nitrous oxide.

[ii]Similar studies for other farm animals were not found.

[iii]The larger survey was undertaken under the auspices of "Beneficial Management Practices for Greenhouse Gas Mitigation from Agroecosystems, with Emphasis on Cow-Calf Non-confinement Production Systems in Western Canada", a project funded by the Agricultural Greenhouse Gas Program. Overall funding was received by the University of Manitoba.

In order to stratify sample farms (based on the beef production practice used) into homogenous groups, principle component analysis followed by cluster analysis was utilized [14]. This resulted in 16 principal components with eigenvalues, or weights, greater than 1, which explained 68 percent of total variability [14]. The end product of these analyses was creation of eight clusters [14] for Canada as a whole, with the following specifications:

- Cluster 1: Small scale, part-time cow-calf operation;
- Cluster 2: Diversified cow-calf through feedlot operation;
- Cluster 3: Large backgrounding and finishing operations;
- Cluster 4: Diversified cow-calf operation;
- Cluster 5: Extensive cow-calf backgrounding operation;
- Cluster 6: Large cow-calf backgrounding;
- Cluster 7: Crop-beef mixed operation; and
- Cluster 8: Large Commercial Finishing [14].

Of the eight Canadian clusters, only six of them had any farms for Manitoba. There was no cow-calf farm in either Cluster Five or Cluster Eight. In addition, two of these Manitoba clusters (Clusters two and three) only had a single farm. Due to privacy concerns, these two clusters were excluded from this study. Thus, this study is based on beef cattle farms belonging to four clusters -- Cluster One, Four, Six, and Seven.

Although each farm within a cluster could have been analyzed in detail, given the fact that all cluster farms were similar, only one representative farm was selected from each of the clusters. This farm was called a centroid cluster farm, and was assumed to be representative of that cluster.

Methods and Materials

Economic Analysis

All the cluster farms were analyzed at two levels - whole farm level and beef enterprise only level. Since the whole farm level analysis has been reported in Possberg., *et al.* [15], this paper focuses on economic measures and GHG emissions exclusively for the beef enterprise.

Beef enterprise profits are dictated only by those necessary to feed and care for cattle. The latter category of costs comprise of operating costs, interest, and depreciation. On all the Cluster farms, feed for the herd originated from several sources, including forage, oats, creep feed, and other supplemental minerals. Except creep feed and minerals, all feeds were produced on the farm. Data on these costs were obtained from Government of Manitoba [16] and adjusted for 2011 using Farm Input Price Index for Western Canada obtained from Statistics Canada [17]. All farm-grown feeds were first used to meet the herd's requirements, with any excess amounts sold at market value. As yields from crops change from year to year, producers cannot accurately predict the amount of feed available from farm production for their herd. In the periods of tight supplies, producers have to minimize cost of feed. For this reason, a linear programming model was used to find minimum cost of feed while meeting total digestible nutrients, protein, and energy requirements of the herd. These requirements were obtained from Subcommittee on Beef Cattle Nutrition [18]. Prices for forages and barley were obtained from Honey [19]. Costs for minerals were provided by MAFRI [20], and verified by data obtained from Alberta Agriculture and Rural Development [21].

Total operating costs for the herd included straw for bedding, veterinary medicine and supplies, breeding costs, utilities, marketing and transportation, manure removal, and miscellaneous costs. These costs were based on data obtained from MAFRI [20] with the exception of manure removal, which was based on the Manure Transportation Calculator [22]. Only one farm, Cluster Four farm, indicated that it used composting to manage its manure. In order to estimate the cost for composting, BC's Ministry of Agriculture and Food [23] data were used.

Interest on operating capital was calculated at 3.52 percent using average 2011 Canadian interest rate provided by Statistics Canada [24]. This figure was based on pre-tax saving rate or the cost of borrowing in 2011. Interest and depreciation costs were calculated on the machinery needed for field operations and on-farm and off-farm transportation (for feed and animals to the market). For this purpose, rate of depreciation and the salvage value remaining after use for the machinery were obtained from MAFRI [20] while the cost of each piece of machinery was obtained from MAFRI [25]. In this study, 2005 value of farm machinery was used since it was assumed that in light of large increase in machinery cost since that time (in response to increase in the price of grain), it was less likely that livestock producers would have purchased newer equipment in 2011.

Cost of maintaining pastureland included taxes ($4.35 acre^{-1}) [26] and seeding costs ($11.35 acre^{-1}) [27]. Annual cost were estimated using a ten-year rotation for tame pasture. Details on costs for other inputs for the pasture, which included the posts, wire, and fencing nails, as well as windbreak fences, handling facilities, and well and pressure systems, are described in Possberg [15].

GHG Emissions Analysis

In this study, GHG emissions[iv] for the study farms were estimated using the Holos model, which was developed by Agriculture and Agri-Food Canada [28]. Total GHG emissions from a farm were a sum total of sequestrations from forages and tame pasture land, emissions of major GHGs from crops and applied manure, as well as from the enteric fermentation of cattle.

Estimation using Holos was done using the results from the survey. Since the survey did ask producers to provide specific information pertaining to activities responsible for GHG emissions and carbon sequestration, the answers, in some cases, were incomplete[v]. In addition, since the Holos model uses a standard application rate for various inputs, and since in some cases producer did not report using certain farm inputs (such as fertilizer or herbicides), Holos coefficients were modified to reflect this situation.

Results

Total operations of a farm were segregated into two types of enterprises: (i) Beef cattle enterprise which included all activities directly and indirectly related to beef cattle production; and (ii) Non-beef enterprise, which included all other activities not account for under the beef cattle enterprise. As mentioned above, the latter enterprise is not reported here. The four cluster farms had different combination of enterprises and different size of operations. In order to compare GHG emissions and economic returns, a common basis was needed. This was accomplished by selecting total weight of cattle sold from each farm. Thus, both profitability and GHG emissions were expressed on a 'per pound sold' (PPS) basis. Each of these four farms are described below.

Cluster One: Small scale, part-time cow-calf operation

Cluster One farm was of 347 acres in size, and had the smallest amount of land dedicated to feed grains among the four Manitoba cluster farms. Of the total area, only 17 acres were devoted to oats for grain feed and the remaining 330 acres were under forage. About 30 percent of the forage area was alfalfa. This farm had the smallest amount of total pasture, at 150 acres, all of which was native. Its beef herd consisted of 56 beef cows and 8 replacement heifers.

Results of linear programming model estimated that only 16 percent of the forage was required to feed the herd over a one-year period. In addition, oats were not used for the herd by this producer. As such, all 17 acres of oats as well as 277 acres of forage were considered to be sold for cash (and therefore, excluded since they were considered a part of the non-beef enterprise[vi]). The herd used pasture grazing between May and October. For the remainder of the year, bales produced using the forage crop on 75 acres of land were grazed, which was assumed to have been a part of the pastureland[vii].

The total cost of beef enterprise on a PPS basis was $2.08. Major item of cost for this farm were the fixed costs (depreciation and interest) which constituted 70 percent of the total cost. Approximately 12 percent of the total costs were operating costs, while the remaining 18 percent were the feed costs.

[iv]As noted above, these estimated were provided by University of Manitoba.

[v]For example, not all producers tested their manure or their feed to inspect their contents, and therefore precise details could not be integrated into the Holos model. Instead, the default values for Holos were used.

[vi]The designated costs and revenues with this portion of the crops were also considered as a part of the non-beef enterprise, and excluded from this analysis.

[vii]This farm indicated that it had two paddocks. As the total pasture area was 150 acres, it was assumed that bale grazing occurred on one of the paddocks, which would be half of the pastureland, or 75 acres.

The gross revenue from the sale of cattle was $18,987 or $1.19 on a PPS basis, of which $16,345 (86 percent) was from the sale of weaned steers and heifers, while $ 2,642 (14 percent) was from the sale of cull cows. As a result of higher costs and slightly lower revenues for the beef enterprise, the farm suffered a net loss of $14,094 ($0.89 on a PPS basis) under average prices.

Cluster Four: Diversified cow-calf operation

This farm was largely a beef farm, though it also grew some crops. In fact, it was the only study farm which sold forages during 2011, reporting that 15 percent of its whole farm revenue was generated from this source. It had 120 cows, five bulls, and 30 replacement heifers. The birth weight at this farm was 90 pounds which was similar to that on Cluster Six and Cluster Seven farms, while its weaning weight (650 pounds) was the highest recorded among all four study farms. It reported that its calving occurred between March and April.

In addition to the forages fed to the cattle, Cluster Four farm purchased commercial protein as well as minerals to supplement feed for the herd. This farm used tame as well as native pastures, which added a cost of $11.39 per acre for seed, an increase by 44 percent to the cost of pastureland.

Unlike other study farms, Cluster Four farm opted to compost its manure. This manure was removed only once per year from its feeding area, and then composted, and stored. The storage method was not indicated in the survey responses, and therefore it was assumed to have been stored as an outdoor pile. This resulted in higher depreciation and interest costs for this farm.

The total costs for the beef enterprise for this farm were $0.95 on a PPS basis. The feed costs comprised 50 percent of total costs, operating costs comprised 18 percent of all costs, and depreciation costs comprised 16 percent, while interest comprised 17 percent of total costs.

The revenue generated from the sale of weaned steers and heifers was estimated at $75,786, while cull cows generated a total of $26,418. Therefore, the total revenue generated by the sale of cattle was $102,204, or $1.00 per PPS. After the above mentioned costs are paid, the average net profit was $4,925 or $0.05 on a PPS basis.

Cluster Six: Large cow-calf backgrounding

Cluster Six farm had the largest herd among the four Cluster farms studied. On this farm, there were 145 cows, eight bulls and 17 replacement heifers. The birth weight of the calves was 90 pounds, while the weaning weight was 600 pounds. The calving period was between March and April.

The linear programming model determined that about 27 percent of the forage was left unused, while none of the green-feed oats were needed. As there were no other grains grown on the farm, the non-beef enterprise consisted only of these unused feeds, and these transactions were excluded from the beef cattle enterprise.

Costs for the beef enterprise differed between Cluster Six farms and all other farms because this farm had land large enough to necessitate owning all of the equipment and machinery necessary to harvest forage crops. Although this eliminated the need to rent machinery, this cost increased from two sources: (i) machinery repairs were then included in the production of its forages, and (ii) depreciation and interest costs were also higher those from Clusters One and Four farms, due to the ownership of machinery.

This farm did not utilize any pastureland for the beef herd. Instead, it relied solely on bale grazing throughout the year. The cost for purchasing forages is typically higher than tending to native pasture, as forages required seeding at least every four to five years, which in turn required the use of fuel, machinery repairs, and seed, in addition to the land taxes and fencing related costs.

The linear programming model determined, based on the nutritional requirements for this farm, that to support the cattle and calves only the forage and grass was needed. The total costs for Cluster Six farm's beef enterprise were $1.14 on a PPS basis. Feed costs were the largest fraction of the total beef enterprise costs, at 61 percent. Depreciation and interest costs were 11 percent and 12 percent, respectively. The remaining costs were operating costs at 16 percent of total beef enterprise costs.

In order to increase the weaning weights of its calves, or to supplement their nutritional needs, this farm supplied its calves with creep feed. This, in addition to the cost of salt and mineral supplements, increased total feed costs for this farm.

Revenue from the sale of weaned steers and heifers generated $102,347, while the sale of cull cows generated another $14,970 per annum. Therefore, the total annual revenue generated from the sale of cattle on this farm was $117,317, or $1.15 on a PPS basis. However, on account of high costs for the beef enterprise, there was a profit of only $900 per annum or $0.01 on a PPS basis.

Cluster Seven: Crop-beef mixed operation

This Cluster Seven farm had only 55 cows, three bulls and seven replacement heifers. Like other farms, this farm grew a non-feed grain crop for sale, in addition to its beef enterprise. The average birth weight for calves on this farm was 90 lbs, and the average weaning weight was 600 lbs. Cows on this farm began calving in February and finished in March.

Feeds contributed 35 percent to the total cost of the farm, while operating costs contributed 17 percent, interest costs contributed 21 percent, and depreciation costs contributed 27 percent. The total costs of the beef enterprise amounted to $1.17 on a PPS basis. The feed costs included cost to buy the forage at market price that has been grown on the farm. The costs incurred for the beef enterprise on this farm were greater than the corresponding revenues.

The sale of weaned steers and heifers provided the farm with $38,268 in revenue, while the sale of cull cows provided the farm with another $6,164 in revenues. This contribution was 24 percent of all gross revenues on this farm. On a PPS basis, revenues were only $1.13. As a result, the beef enterprise showed a net loss of $1,399 in 2011, or $0.04 on a PPS basis.

Discussion

Comparative estimated profits for each of the four farms are shown in table 1. Only two of these farms has a positive net returns on PPS basis. Though these four farms captured tens of thousands in revenue, the costs for each of these farms were equally high. Within the beef enterprise, costs were a more deterministic factor that led to overall profitability on a farm. Among these costs, feed was the highest for three out of the four farms, as shown in figure 1. As noted in table 2, forage costs were more expensive than pastureland.

Particulars	Cluster One	Cluster Four	Cluster Six	Cluster Seven
Profit ($)	-0.89	0.05	0.01	-0.04
GHG (kg of CO_{2e})	4.77	1.00	4.34	6.55

Table 1: *Profit And GHG Emissions for beef enterprise on study farms in Manitoba on a per pound sold.*

	Cluster One	Cluster Four	Cluster Six	Cluster Seven
Forage	$ 0.32	$ 0.32	$ 0.54	$ 0.29
Salt and Minerals		$ 0.02	$ 0.03	$ 0.05
Pasture	$ 0.04	$ 0.14		$ 0.07
Additional Feed			$ 0.13	

Table 2: *Feed Costs for beef enterprise on study farms in Manitoba on a per pound sold.*

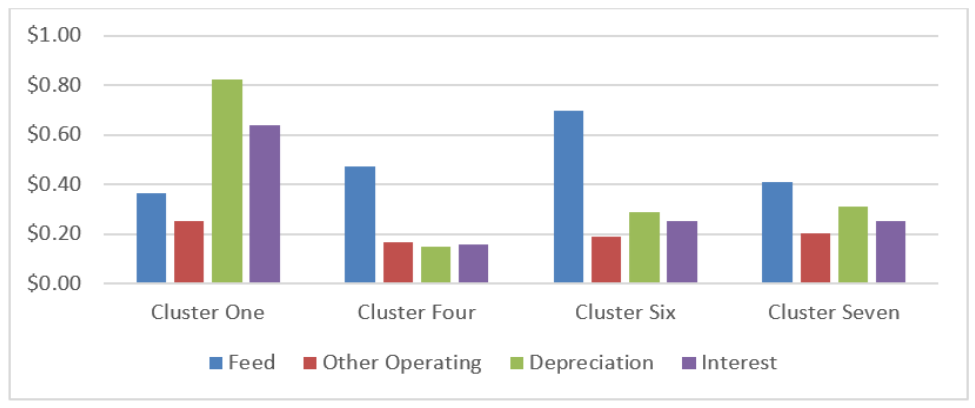

Figure 1: *Beef enterprise cost on a PPS basis, by major categories.*

While Cluster Six farm had a larger herd, which should have provided benefits through economies of scale, it was not the most profitable farm. The feed costs for Cluster Six farm, when compared to Cluster Four farm, were higher, and point to an its inefficient use of farm land as it used no pastures. However, relative GHG emissions showed a different picture. Here Cluster seven farm had the highest level of emissions on PPS basis while Cluster four farm generated the lowest amount of GHG on a PPS basis (Table 1).

Hypothetical strategy of land conversion

Although there are many different measures available to a livestock to reduce GHG emissions, in this study converting a portion of cropland to pastures was selected. The purpose of this was to see if such a measure could be environmentally and economically efficient. Cluster six farm was selected where one-half of the 650 acres of oat green-feed were converted to pastureland. The results were encouraging. This strategy decreased emissions by 1.74 kg of CO_2e, as noted in table 3. Tame pastureland decreased emissions by 1.58 kg of CO_2e, while the emissions from reducing oat green-feed production by half also reduced its emissions by half.

	Cluster 6 (Baseline)	Cluster 6 under scenario	Change under scenario
	GHG emissions in kg per pound sold		
Land Use	-3.14	-4.72	-1.58
Perennial Crops	-3.14	-3.14	0
Tame Pastureland		-1.58	
Crops/Soils	1.05	0.88	-1.58
Oats	0.33	0.16	-0.17
Hay	0.33	0.33	0
Applied Manure	0.39	0.39	0
Beef	3.65	3.65	0
Cows	3.02	3.02	0
Calves	0.23	0.23	0
Replacement Heifers	0.23	0.23	0
Bulls	0.17	0.17	0
Total	1.56	-0.19	-1.75

Table 3: *GHG Emissions on Cluster Six Beef Enterprise under Land Conversion Scenario.*

Converting cropland to pastures also decreased costs in Cluster Six farm, though it also decreased the amount of reserve oat green-feed leftover on the farm by half. Therefore, the amount of revenue from oat green-feed was also reduced by half. However, as forages were then not needed during the summer months, the amount of alfalfa, which was otherwise necessary during the months of April through September, was noted as remaining feed, that could be used or sold in subsequent years. As a result, the revenue gained from remaining forages increased revenues on the whole farm from $20,678 to $46,790. Since the producer was already assumed to have used at least 325 acres of its oat green-feed crop for bale grazing with fences, watering equipment, and other necessities for grazing, additional interest and depreciation costs were not necessary. As a result, the beef enterprise costs on this farm decreased by $26,456 or $0.26 PPS. Overall, Cluster Six farm, when it converted its land from oat green-feed production to tame pasture, had an overall profit of $27,356 or $0.27 PPS.

There are some caveats to converting crop land to pasture. There is a limited amount of pasture available to feed a cattle herd in a cold environment such as the Canadian Prairies. Cluster One farm had the greatest amount of pasture among the four study farms, and therefore it would be impractical to convert more of its land to pasture if it could not be utilized by its herd within the warm season. Therefore, it is also important to consider forages rather than cropland that can also sequester GHGs, and which can also be fed to cattle during cold seasons. This is particularly noted as seed costs are lower for alfalfa/brome grass mixes, rather than oat green-feed or oat grain. However, some animal health issues, such as bloat or rumen acidosis, might also become pertinent issues.

Conclusion

While a higher weaning weight does affect beef enterprise revenues, lower costs lead to a more meaningful way to attain profitability on a cow-calf operation. Feed costs were found to be the most significant cost factor for three of the four farms. Producing tame pastureland rather than grain is inexpensive, and necessitates less machinery or time. Cluster six farm, which did not originally have any pastureland, was adjusted to show the significance of converting oat green-feed to tame pastureland. Levels of GHGs on the whole farm shifted from emitting 1.55 CO_2e on a PPS basis to sequestering 0.19 CO_2e on a PPS basis. In addition, the profitability of the beef enterprise significantly increased from $0.01 on a PPS basis to $0.27 on a PPS basis. However, this study did not take into account long term ramifications of conversion of cropland into tame pasture, which should be investigated.

This study has shown that maintaining profitability and reducing GHG emissions are possible on Manitoba beef farms. To do so, producers should attend to several management practices on their farms: (1) Increase weaning weights, as there are several benefits: (i) it decreases the amount of GHGs emitted on a PPS basis; (ii) it also decreases the costs on a PPS basis; and (iii) it increases the revenue generated from a calf. (2) Increase the size of herd, as it decreases average fixed cost (depreciation and interest costs). (3) Invest in tame pastures when possible, in order to cost-effectively sequester GHGs; and (4) Use several cuttings of forage in the warm season, in order to decrease interest and depreciation costs to produce feed, while also increasing the amount of yield per acre of land.

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