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Economics of mitigating greenhouse gas emissions from beef production in western Canada

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ABSTRACT

Beef production plays a vital role in the economy of western Canada; however, in the wake of global warming as a result of increasing greenhouse gas (GHG) emissions, the industry has come under some scrutiny. Although there has been encouraging scientific findings on mitigation strategies applicable to beef operations, there is a lack of economic analysis of such strategies. This study extends on the work of Beauchemin et al. (2011) and evaluates the economic impacts of greenhouse gas mitigation scenarios (GHGMS) for beef operations, and in the process identifies economic and environmental sustainable scenarios. A whole farm economic simulation model was developed and used to measure the profitability of eleven GHGMS adopted from Beauchemin et al. (2011). Whole farm present value gross margin of the eleven scenarios was measured and compared to the conversional system (baseline) of a farm in Vulcan County, Southern Alberta. The farm had 120 cows and their progeny, which was raised and finished on the farm for sale. The study farm was simulated over a period of 8 years in order to fully account for the lifetime economic activity of the breeding stock, as well as the progeny raised for sale. Simulation results estimated a whole farm present value gross margin per ha of $3.51 for the baseline. Seven of the eleven scenarios evaluated were found to increase profitability of the farm by up to 4%. However, only six of the scenarios were found to be both economically and environmentally sustainable to the farm. Four of the six sustainable scenarios were strategies applied to the breeding stock and two to the feedlot. These results suggest that beef producers can profitably implement several GHG mitigation strategies to their operations without substantial changing their operational system.

1. Introduction

The interaction of agriculture and the environment has been under scrutiny in the wake of global warming and climate change discussions. In Canada, animal agriculture accounts for more than 60% of the 69 Mt carbon dioxide equivalent GHG emissions from agricultural emissions (CCA (Canadian Cattlemen Association), 2013a). In particular, beef production is a major contributor to Canadian agricultural emissions, estimated at 42% of total agricultural GHG emissions (CCA (Canadian Cattlemen Association), 2013b).

In December 2015 at the Paris Climate Conference, Parties under the United Nations Framework Convention for Climate Change (UNFCCC (including Canada) agreed to a historic new agreement to address climate change. Collectively, the countries of the world agreed to strengthen the global response to limit global average temperature rise to well below 2°C, as well as to pursue efforts to limit the increase to 1.5° (Environment and Climate Change Canada, 2016). This now creates a challenge to reduce GHG emissions to meet this target. Beef production being a major contributor of GHG emissions is perhaps one of the areas that need attention to achieve that objective. Several scientific researchers have identified GHG mitigation scenarios that can be adopted to Canadian beef operations to reduce GHG emissions (Boadi et al., 2002; DeRamus et al., 2003; Beauchemin and McGinn, 2005; Pelletier et al., 2010; Beauchemin et al., 2011). Some of the strategies identified as having a potential to reduce GHG emissions include: managing animal diets, manure storage and application, land management, shift towards high-grain diets (Legesse et al., 2016) and change in animal husbandry practices. Producers have made changes in land use practices and tillage systems, as well as in manure management, adoption of feed management by Canadian beef farmers has been reported to be very low (MacKay, 2010).

Review of literature on adoption of new methods of production (technology or cultural practises) has suggested that their profitability is an important consideration for producers (Smith et al., 2007). It has been found that Canadian farmers may not adopt a management strategy only because of its environmental benefits, but their decision is

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revered if their economic objective is met. It is therefore, important to perform an economic analysis of greenhouse gas mitigation scenarios (GHGMS) to see how they affect profitability of beef production at the farm level as the adoption decision lies with producers.

The objective of this study is to measure the economic impacts of implementing GHGMS to Canadian beef operations, and also identify economically and environmental sustainable strategies. This study was an extension of a study by Beauchemin et al. (2011) who studied the mitigation of GHG emissions from beef production in western Canada.

2. Material and methods

2.1. Beef production and greenhouse gas emissions from beef production

A review of Canadian studies and those in other jurisdictions resulted in no study that had compared beef production economics with GHG emissions trade-off analysis. Wall et al. (2010) has explored developing better breeds of dairy cattle for reducing GHG emissions. Subak (1999) has estimated the cost of environmental degradation from global beef production. Most studies have addressed one or the other issue in beef (and in general livestock) production and their relationship with GHG emissions but have not extended their analysis to bring economic cost of mitigation measures.

Several researchers have identified management practices that reduce GHG emissions from beef operations (Beauchemin et al., 2011; Beauchemin and McGinn, 2005; Pelletier et al., 2010; Boadi et al., 2002; DeRamus et al., 2003). Most of these researchers have concluded that beef producers can reduce GHG emissions by managing the diet of animals, manure storage and application, and through land management. DeRamus et al. (2003) have argued that traditional (without improved feed and grazing management practices) production systems are generally inefficient in converting plant biomass into animal protein. In support of this argument, these authors demonstrated that controlled rotational grazing systems have the potential to reduce GHG emissions by 22% compared to traditional continuous grazing systems. The type of production system used for beef production also determines the levels of emissions produced from beef farms. The cow-calf beef production system, common in Canadian beef operations, has been found to produce 80% of total GHG emissions from beef operations, compared to a mere 20% from feedlot systems (Beauchemin et al., 2011). A recent study by Alemu et al. (2017) has reported this to be between 65 and 70%. However, one should keep in mind that the feedlot system needs the cow-calf system and therefore, such a distinction is somewhat arbitrary. A similar study in the US also found cow-calf production to emit more methane and nitrous oxide than feedlot cattle (Phetteplace et al., 2001).

Most methane gas from beef production is emitted though enteric fermentation, which results from the inefficiency of ruminants to convert feeds into milk or weight gain (CCA, 2003). Beauchemin and McGinn (2005) and Beauchemin et al. (2011) have suggested that producers can reduce the amount of GHG emissions from their farms by selection of the type of feeds used. For example, Beauchemin et al. (2011) have shown that additives, such as crushed oil seeds, can be used as part of animal diets to reduce methane emission levels, thus increasing the efficiency of feed use in animals. Beauchemin and McGinn (2005) found that corn diets fed to beef cattle in Alberta, during the backgrounding and finishing phase, resulted in less emissions compared to barley grain diets.

A comprehensive study of a beef farm in southern Alberta by Beauchemin et al. (2011) has shown that different management strategies that include dietary supplements, land management, timing of moving calves from pasture to feedlot to market has the potential to reduce total farm GHG emissions by 8%, and if some strategies are combined reduction may be up to 17% of total beef production GHG emissions.

2.2. The study farm

Since this study is an extension of Beauchemin et al. (2011), to keep consistency with the findings of GHG emission levels of the study farm, information on resources and activities of the farm (i.e. farmland area, crop and pasture production, beef herd dynamics, feed requirements) were adopted from that study. In addition to this information, industry data and expert information were also used to build the study farm. However, the size of the farm was made to reflect the average cattle farm in the study region.

The study farm was located in Vulcan County in Southern Alberta. Agriculture is the largest economic industry in Vulcan County, employing 52% of the labour force (City-Data, 2013). In 2011, there were a total of 603 farms in Vulcan County, of which 355 reported having mixed farming with grain and oilseed, and 105 reported beef cattle ranching and farming, including feedlots (Statistics Canada, 2011). Of the total farmland area of 548,120 ha in the county, annual cropping (wheat, barley, oats and rye) occupied the largest land area, followed by native pasture, at 65 and 20%, respectively (Statistics Canada, 2011). Availability of annual crops and pasture supports livestock production (beef, dairy, pigs, sheep, goats, horses, llamas, and alpacas). The dominant livestock was cattle production reported by 277 farms with a total of 197,851 cattle and calves (Statistics Canada, 2011). This represents almost 4% of Alberta's total cattle and calves (Statistics Canada, 2011).

The study farm had a land area of 2334.8 ha for livestock feed production. Farmland was divided into annual cropping (293.2 ha) and native pasture (2041.6 ha). Annual cropping land was used for production of barley grain, barley silage, and alfalfa-grass hay. The land area under any annual crop was determined by first meeting livestock feed requirements. Any excess land not needed for meeting livestock feed requirements was put into cash crop for sale to boost the revenues of the farm. Hay production was chosen to be the cash crop as farmers tend to produce more hay than required as a buffer for droughts in the preceding years and some of it end up in the market. Any unused pasture was used for renting.

The farm kept 120 breeding cows, 4 bulls and their progeny. Table 1 shows the cattle numbers and the basic farm management variables used for the study farm which were adopted from Beauchemin et al. (2010). Beef cattle have different nutritional needs at different stages, and also have different feed intake capacity. For this reason, all cattle were divided into different classes: breeding stock, calves, backgrounders (feeders), and finishers. The breeding stock (cows and bulls)

Table 1
Cattle numbers and basic farm management of the study farm (from Beauchemin et al., 2010).

Particulars	Value
Breeding cattle	
Cows (head)	120
Bulls (head)	4
Calves (head)	120
Management	
Weaning rate per year	85%
Heifer replacement[a] per year	15%
Backgrounding death loss per year	3%
Finishing death loss per year	1%
Backgrounding feedlot days per year	110
Finishing feedlot days per year	170
Native pasture stocking rate (AUM[b]/ha)	0.113
Animal live weights (kg)	
Feeder finishing weight	606
Mature cow weight	601
Mature bull weight	821

[a] Heifer replacement The replacement heifer becomes the genetic building block for the cow herd to produce calves in the future (Troxel and Gadberry, 2018).
[b] Animal unit months.