The Value of Alberta's Forage Industry

A Multi-Level Analysis




Government of Alberta

AFIN
ALBERTA FORAGE INDUSTRY NETWORK

The Value of Alberta's Forage Industry

Prepared by Stephanie Kosinski, MSc., PAg.

Forage Specialist

Alberta Agriculture and Rural Development

Cover photos: from left, Duane McCartney (1, 2), Lee Townsend (3), Marc Lavoie (4)

Foreword provided on behalf of the AFIN Board by Don McLennan, President, Alberta Forage Industry Network

The publication of this report is the culmination of a cooperative effort by government and industry to address an identified need. In this case the partners were the Alberta Forage Industry Network (AFIN) and Alberta Agriculture and Rural Development (ARD), with input from various facets of the Alberta forage industry.

The Alberta Forage Industry Network is a new provincial organization. It was established in 2010 to represent the Alberta Forage Industry nationally and internationally; to foster communication between the forage industry, government and public; to champion research, education and extension for the management and use of forages; and to provide a forum for the exchange of ideas among those who have an interest in forages.

For years, people in both the agricultural industry and government have recognized the need to better quantify the size and value of Alberta's forage "crop". Recent interest in the value of forages from an environmental standpoint has helped further the drive to address this need. The formation of AFIN coincided with the release of a consultant's report, commissioned by its sister organization in Saskatchewan (The Saskatchewan Forage Council), which addressed the value of the Saskatchewan Forage Industry. Given AFIN's purpose, the publication of a similar report in Alberta became one of its top priorities.

This Alberta report was a joint undertaking between AARD and AFIN. While it was authored and published by AARD, AFIN helped coordinate input from various facets of Alberta's forage industry. In order to provide consistency, the partners felt there was value in using the Saskatchewan Forage Council publication as the template for this report. As such, numerous similarities exist in the format and descriptions of the value of each forage sector.

The purpose of this report is to highlight not only the valuable contribution Alberta's forage resources provide to the agriculture industry, but to also acknowledge the major contribution forages make to ecological goods and services provided within the agricultural landscape of the province.

This report should be considered a preliminary account of the value of Alberta's forage resources. Although every effort was taken to ensure accuracy using the most recent data and literature available, this report exposes the fact that there are gaps in, and a lack of timely, statistical information concerning the forage industry. Given the lack of timely statistical information, some readers may feel that this report contains inaccurate and/or controversial comments and assessments.

We hope this report will stimulate dialogue regarding: the need for timely acreage data of the various forage types/classes and the need to standardize methodologies for calculating the economic and ecological benefits of forages. AFIN would welcome suggestions for ways to address these needs and can be reached at info@albertaforages.ca.

AFIN would like to acknowledge the cooperation and effort provided by AARD management and staff in the publication of this report. In particular, we would like to acknowledge the professional work, effort and especially patience exhibited by the author, Stephanie Kosinski, in seeing this project come to fruition.

Executive Summary

The forage industry in Alberta is extremely diverse, and includes native range (natural land for pasture, including native pasture/hay, rangeland and grazeable bush), tame/seeded pasture, hayland, annual forage (fodder) crops, grass and legume seed, alfalfa leafcutter bees and sod. This diversity has led to some fragmentation amongst the different forage sectors, making it difficult to assess the overall industry value. In addition, the fact that many forage products are primarily used on their farm of origin and do not enter any formal marketing channel makes collecting statistics on production and pricing challenging.

This report examines the estimated direct and indirect economic value created by the forage industry in Alberta. The estimated direct value will be stated as it relates to the use of the different sectors' primary products. The value for each product will be based on its total production and sale (market) price, where available. The estimated indirect value is difficult to quantify as a great deal of uncertainty surrounds the valuation methodologies available. In this report, the indirect value forages generate is due to their contribution to ecosystem functions and other ecological goods and services (EG&S). Forages in Alberta provide numerous benefits to the citizens of this province due to their role in protecting the integrity of the environment.

According to the last published Census of Agriculture (Statistics Canada, 2006), Alberta contained more than 28.5 million acres (11.6 million hectares) of forage land. Producers reported 16.1 million acres (6.5 million hectares) of native range (natural land for pasture), 6.1 million acres (2.5 million hectares) of tame/seeded pasture and over 244,000 acres (98,900 hectares) of forage seed. Corn silage was grown on just over 70,000 acres (28,500 hectares) and all other hay and fodder crops covered more than 5.9 million acres (2.4 million hectares). Forage crops cover more acreage in the province than any other agricultural crop, reinforcing the need to accurately track their acreage, products, market price and define their value.

Through a comprehensive valuation and analysis of each forage sector present in Alberta, this report has concluded that forages make substantial contributions to the economic and environmental sustainability of the province. Major findings include:

- Estimated direct economic value generated by forages is approximately $1.6 billion annually, based on the production and sale of numerous forage products from a diverse group of sectors.
- Forages create indirect value through the EG&S they provide. Forages contribute to erosion control, water regulation, wildlife habitat, recreation, pollination and carbon sequestration. Based on the studies and references cited, forages generate an estimated $0.5 to $2.2 billion annually in relation to these goods and services.
- **Taken together, the annual total estimated direct and indirect economic value of the forage industry in Alberta ranges from $2.1 to $3.8 billion.**

The values reported here are estimates, based on the statistics, market information and literature available. Since the publication of this report, some values may have changed due to the influences of external factors on the forage industry (weather, commodity markets, livestock markets, etc.). Data and statistics from more recent years may have been released as well. There were some instances where up-to-date data and statistics were unavailable. As a result, industry experts were consulted and their value estimations used.

The purpose of this report is to provide a snapshot of the Alberta forage industry, with the hopes that it will be used to increase awareness of its value to the agriculture industry and its role helping to maintain the environment.

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1.0 Introduction

Agriculture is a vital part of Alberta's economy. In 2010, the provincial GDP for primary agriculture industries was $4.9 billion; $4.8 billion of this from crop and livestock production alone (Office of Statistics and Information, 2011). Farmland covers more than 52 million acres (32%) of the province's total land area (Statistics Canada, 2006). Our agriculture industry is multi-faceted and encompasses crop and livestock production, food processing and manufacturing. One key component of agriculture in this province that tends to be overlooked is the forage industry.

There are many definitions of what "forage" is, but it is generally accepted that forages are "that part of vegetation that is available and acceptable for animal consumption, whether considered for grazing or mechanical harvest; includes herbaceous plants in mostly whole plant form and browse" (Valentine, 1990). Both annual crops and perennial grasses and legumes can be classified as forages. However, in addition to providing feed for both domestic and wild animals, forages provide valuable ecological goods and services (EG&S). These services include wildlife habitat, maintenance of biodiversity, erosion protection, protection of water quality and water storage.

A number of diverse sectors and crops make up the forage industry. Annual crops such as oats, barley and triticale are harvested as greenfeed or silage, grazed during the growing season and swath grazed during the fall and winter months. Straw, a byproduct of annual crop production, is commonly included in livestock rations. Livestock utilize native range and tame/seeded pasture for grazing, in addition to annual cropland after harvesting the grain. Perennial grasses and legumes are harvested and stored as hay or silage. A few perennial species, such as timothy and alfalfa, are processed into compressed hay, cubes or pellets for export. There is also a vibrant forage seed industry present in the province.

Alberta's forage industry has a large land base. In 2006, Alberta reported 16.1 million acres (6.5 million hectares) of native range, 6.1 million acres (2.5 million hectares) of tame/seeded pasture and over 200,000 acres (98,000 hectares) of forage harvested as seed (Table 1.1). It should be noted that the Census of Agriculture does not include aftermath (chaff and other residue) grazing of annual cropland or straw utilized for feed. Chaff and straw can be substantial feed resources for livestock producers (McCartney et al., 2006). Therefore, it is likely there is a higher acreage devoted to the production of forage in the province than is reported in Table 1.1. Forages are grown on over 28.5 million acres (11.6 million hectares) of land in Alberta, more than 55% of the province's total farmland (Table 1.1).

Table 1.1 Forage Acreage in Alberta

Forage Type	Acres	Hectares
Native Range*	16,135,646	6,529,886
Tame/Seeded Pasture	6,137,362	2,483,711
Forage Seed	244,615	98,993
Alfalfa and Alfalfa-mixtures**	3,935,022	1,592,452
All Other Tame Hay and Fodder Crops***	2,060,967	843,047
Corn for Silage	70,411	28,494
Total	**28,584,023**	**11,576,583**

Source: Statistics Canada, 2006

* Refers to "Natural Land for Pasture" census category. Includes areas that have not been cultivated and seeded, or drained, irrigated or fertilized. Includes native pasture/hay, rangeland, and grazeable bush.

** Includes alfalfa and alfalfa-mixtures used for hay, silage, greenfeed, dehydrated alfalfa, etc.

*** Includes all other tame hay and fodder (perennial and annual crops in which the whole plant is used as feed) crops for hay or silage.

The value of the forage industry in Alberta is formidable, though often overlooked (Benoit, 1986). To illustrate this point, the production, farm value and production value of five annual crops and tame hay were averaged from 2004 to 2009 and compared (Table 1.2). Tame hay had the highest average production (8,043,700 tonnes), but the lowest farm value ($78.85 per tonne). Wheat had the second highest average production (7,616,500 tonnes) and the second highest farm value ($180.83 per tonne). Even though tame hay production was higher than those five annual crops, it was valued much lower. This reinforces the fact that, even though forages cover a large acreage and their production rivals that of the other agricultural commodities produced in Alberta, they are generally not as highly valued.

Table 1.2 Production, Farm Value and Production Value Averaged from 2004 to 2009 for Five Annual Crops and Tame Hay

Crop	Production ('000 tonnes)	Farm Value ($/tonne)	Production Value ($'000)
All Wheat	7,616.5	$180.83	$1,389,507
Oats for Grain	640.2	$137.67	$85,253
Barley for Grain	4,944.5	$144.67	$715,735
Canola	3,481.3	$364.17	$1,280,896
Dry Peas	623.0	$174.33	$110,317
Tame Hay	8,043.7	$78.85	$618,516

Source: Statistics and Data Development Branch, AARD 2010a
Refer to Appendix B, Table B.1 for above values in imperial

this report is to supply a current assessment of the estimated direct and indirect economic contributions the forage industry provides to Alberta.

1.1 Background

The primary products of Alberta's forage industry include pasture, hay, greenfeed, silage, seed and sod. In this report, only the value generated from primary forage products will be included in the analysis of the estimated direct economic value as per the methodology employed by the Saskatchewan Forage Council (SFC) in their forage valuation report (2010).

In Alberta, the livestock industry is the largest consumer of forage products. Within the livestock industry, cattle are the largest end users of forages. As of January 1, 2011, there were approximately 4.95 million head of beef and dairy cattle in the province (Table 1.3). Beef operations require vast amounts of forage for feed and exert incredible influence on the acreage, and types, of forage grown.

Due to the extensive and diverse nature of forage crops in the province, the industry has tended to be fragmented. As a result, regional forage organizations have emerged, such as the Alberta Peace Region Forage Seed Growers and Alfalfa Seed Commission, to advocate for their respective regional products. These organizations collect data on the production and sale of specific forage products in their regions. For several years, Alberta did not have a provincial forage organization. The Alberta Forage Industry Network was recently established to serve this purpose, and has also been actively involved in producing this report. Alberta Agriculture and Rural Development (AARD) collects statistics on seeded acres, harvested acres, average yield and production for certain forage products. Pricing of hay, silage, greenfeed and straw are collected by AARD and the Agriculture Financial Services Corporation (AFSC) through surveys. Many of these forage products are sold from farm to farm, and their final sale prices are not documented. Detailed information on the production and export of forage seed, processed alfalfa products and timothy hay are compiled by AARD and Statistics Canada.

Table 1.3 Beef and Dairy Cattle and Sheep on Farms as of January 1 in Alberta (2002-2011)

Year	Cattle on Farms (millions)	Sheep on Farms (thousands)
2002	5.825	218
2003	5.310	187
2004	5.675	175
2005	5.930	171
2006	5.900	151
2007	5.680	152
2008	5.560	125
2009	5.380	127
2010	5.190	127
2011	4.950	133

Source: Statistics and Data Development Branch, AARD, Livestock Inventory Estimates 2006a-2010b and Statistics Canada, 2011

The diverse nature of the forage industry, coupled with a lack of a unified voice, has contributed to its "second class" status. To bring forages to the forefront, the economic, environmental and societal benefits of forage crops need to be examined. The aim of

Forages are also a significant component of the diets of numerous other livestock species. (Table 1.4). The viability of these operations depends on forages to meet their animals' nutritional requirements.

Table 1.4 Livestock Numbers on Farm in Alberta

Class of Animal	2001	2006
Horses and ponies	159,962	155,533
Bison	79,731	97,366
Goats	42,270	29,113
Elk	31,304	33,783
Deer	8,331	8,965
Llama/Alpaca	12,894	14,734

Source: Statistics Canada, 2006

Both forages for grazing (tame/seeded pasture and native range) and conserved forages (hay, silage, greenfeed) are utilized throughout the livestock production cycle. Livestock are released onto native range and tame/seeded pastures to graze in the spring and summer months, while conserved forage is grown during this time for use during the late fall and winter. Without a stable and productive forage industry, livestock producers would have difficulty maintaining the number of animals currently on-farm.

Forages and forage products are also used in a number of non-agricultural industries. Sod/turf is sold for use in residential areas, parks and golf courses. Forages have the potential to be used as feedstock in the bio-energy and bio-fuel sectors. Native forage grasses are used for reclamation in the oil and gas industry, and perennial forages provide permanent ground cover to help reduce erosion and create habitat for numerous migratory birds and native ungulates (SFC, 2010).

The forage industry plays a vital role in the environmental health of the province and its citizens. Perennial forages play integral roles in preventing erosion, creating habitat for wildlife and pollinators, maintaining and improving water quality, sequestering carbon and creating beautiful vistas. Native range is often considered to be the largest contributor to the creation and maintenance of these EG&S due to its vast acreage. Other forage crops, such as tame/seeded pasture and hayland, play an important here role as well.

1.2 Defining Value

Due to the varied nature of the forage industry, it can often be difficult to assign a value to its products. For example, hay is produced from different combinations of perennial forages and harvested at different stages of maturity, affecting quality. Prices change with quality, region, the time of year the purchase is made and the influence of the cattle markets. The end price the buyer pays is not well documented, and one has to rely on word of mouth and provincial surveys for a picture of the market.

For the purpose of this report, the estimated direct value of forages will be stated as it relates to the use of the different sectors' primary products. This will include forage seed, leafcutter bees, hay, processed and compressed forage products, greenfeed, silage, straw, tame/seeded pasture and native range for grazing, sod and ag-tourism. The value for each product will be based on its total production and sale (market) price where available (SFC, 2010). The values reported here are estimates and should be viewed as such.

It should be noted that gathering current statistics and information on the production and value of many of the direct forage products was challenging. Forage products are often kept on farm, sold from producer to producer or sold through auction marts. As a result, there is very little formal documentation of forage marketing (Benoit, 1986). Production and production values are not collected with the same level of precision and accuracy, or as well understood, as with other agricultural commodities that have closely monitored formal marketing channels.

Forages not only provide value to the province's economy in terms of production and sales, they also provide other services that do not have an established market. These other services are often called "ecological goods and services" (EG&S). Ecological goods and services are the benefits society derives from ecosystem functions, either directly or indirectly (Costanza et al., 1997). They include services such as water regulation, erosion control, sediment and nutrient retention, pollination, recreation, climate regulation, wildlife habitat, maintenance of biodiversity and contributing to quality of life. Placing an economic value on these services is challenging (Costanza et al., 1997). While there are no set standardized calculations in place, different valuation methods have evolved to estimate the economic worth of EG&S. They include: economic damages, the willingness of individuals to pay for the service, the willingness to accept compensation for losses (Wilson, 2008), using

land prices (Ma and Scott, 2011) and Total Economic Value (Wilson, 2009). Some of these methods of valuation will be explored in the section on the estimated indirect value attributed to Alberta's forages.

The value of forages for EG&S, such as erosion control, recreation (fishing, hunting, wildlife viewing), pollination services and climate change services, will be examined with the caveat that this is an emerging field, fraught with uncertainty. The values for these EG&S will be based on previously reported values from stakeholder surveys and case studies conducted in Canada and the United States.

2.0 Estimated Direct Economic Value

2.1 Forage Seed

In 2006, forage seed was grown on 244,615 acres (98,992 hectares) in Alberta (Table 2.1). Reported acreage includes both tame and native perennial grasses and legumes. Alberta contains approximately 37% of the forage seed acreage in Canada.

Table 2.1 Forage Seed Harvested as Seed

	2001		2006	
	Farms Reporting	**Acres**	**Farms Reporting**	**Acres**
Alberta	1,506	409,251	1,046	244,615
Canada	3,808	799,415	3,069	661,923
Alberta's % of Canadian Total	40%	51%	34%	37%

Source: Statistics Canada, 2006

The forage seed industry in Alberta is concentrated in two main regions; the Peace in the northwest and the southern irrigated portion of the province. The Peace, including part of British Columbia, represents the second largest grass and legume seed growing region in the world. Forage seed crops grown here include creeping red fescue, bromegrass, timothy, red clover, alsike clover and specialty grasses. Numerous forage seed brokers and processing facilities have been established in this area due to the size of the seed industry. Brokers and processors purchase seed directly from growers, with a portion exported to overseas markets (Wong and Yoder, 2010). As of January, 2010, there were eight major processing facilities in the Peace; seven of which are located in Alberta.

In the Peace region, forage seed growers are represented by the Alberta Peace Region Forage Seed Growers association (PRFSG). The association was started in 1995 to advance the forage seed industry. The association is composed of producers, processors and government representatives. In 2004, it became a commission with the ability to set a refundable levy on the sale of forage seed grown in the region. The revenue generated by the levy is used for research and development, extension activities and the general promotion of the forage and turf seed industry in the Alberta and British Columbia Peace regions (PRFSG, 2011). The levy is 0.75% of the total sale price of product sold to a seed dealer, and covers tame and native grass and legume species. Since 2007, the levy has generated revenue ranging from $173,000 to $237,500 annually (PRFSG, 2011). Numerous projects, including grass cultivar trials, forage tours, herbicide minor use registrations and the distribution of publications to seed growers, have been funded through this refundable levy.

In southern Alberta, alfalfa seed is the primary forage seed crop grown. The Alfalfa Seed Commission was created through legislation tabled under the *Marketing of Agricultural Products Act*. The purpose of the Alfalfa Seed Commission is to provide a voice for the province's alfalfa seed and leafcutter bee producers. They use the revenue generated by their refundable levy (1.25% of the total sale price of product sold to a dealer) to fund research, extension events and promotional activities. This levy is restricted to alfalfa seed and does not include alfalfa seed produced in the Peace region. In 2010, the levies collected generated $118,064 for the Commission (Alfalfa Seed Commission, 2011). Alberta is one of the major alfalfa seed producing provinces in Canada, with an average of 2,964 tonnes (3,267 tons) of seed produced annually (Table 2.2).

Table 2.2 Alfalfa Seed Production in Alberta

	Inspected acres	Yield (lbs/ac)	Production (tonnes)	Production (tons)
2000	17,117	525	4,076	4,492
2001	15,381	385	2,686	2,960
2002	12,709	265	1,528	1,684
2003	11,292	550	2,817	3,104
2004	10,345	370	1,736	1,913
2005	10,050	270	1,231	1,458
2006	14,458	585	3,836	4,227
2007	17,030	600	4,635	5,108
2008	17,600	520	4,151	4,574
2009	18,235	345	2,854	3,145
Average	**14,422**	**442**	**2,964**	**3,267**

Source: Statistics and Data Development Branch, AARD, Specialty Crop Reports 2002-2010c
Numbers may not add due to rounding

The number of forage acres seeded yearly for seed production are tracked and reported in the Alberta Specialty Crop Reports, prepared by Alberta Agriculture and Rural Development (AARD). The average seeded acres of forages for seed is 56,268 acres, or 22,771 hectares (Statistics and Data Development Branch, 2002-2010). This acreage represents 5% of the total provincial specialty crop acreage seeded. Once established, these crops generate income over multiple years before being taken out of production.

In 2009, forage and grass seed farm cash receipts generated $8,237,000 for forage producers in the province (Table 2.3). This was the lowest value recorded since 2000. **On average, forage seed producers have received $23.8 million from their yearly forage seed sales since 2000**. Farm cash receipts are a measure of the gross revenue of farm businesses generated from the sales of crops, livestock and livestock products (Statistics and Data Development Branch, 2011). They do not include inter-farm sales. Therefore, the actual value of forage seed might be higher than what has been reported as seed sold between farms is not captured by this economic measure.

2.2 Alfalfa Leafcutter Bees

Alfalfa leafcutter bees are the primary pollinators of alfalfa. They are utilized by virtually every alfalfa seed producer in the province. Southern Alberta is the largest intensive leafcutter bee production area in North America (Weldon Hobbs, personal communication). As a result, the Alfalfa Seed Commission has made leafcutter bee research and industry promotion part of its mandate. In the Peace region, leafcutter bees are normally stocked at 20,000 to 25,000 per acre, or 2 to 2.5 gallons of bees per acre (Calvin Yoder, personal communication). One gallon of bees is composed of 10,000 live or viable bee larvae. In southern Alberta, where irrigation is commonly used for alfalfa seed production, leafcutter bees are stocked at 3.75 to 4.5 gallons per acre, or 37,500 to 45,000 bees per acre (Hobbs, personal communication).

Most alfalfa seed producers view their operations as producing two crops; alfalfa seed and leafcutter bees. Depending on management techniques during

Table 2.3 Alberta Forage and Grass Seed Farm Cash Receipts

	Value
2000	$42,091,000
2001	$19,804,000
2002	$22,999,000
2003	$21,381,000
2004	$17,532,000
2005	$28,298,000
2006	$31,076,000
2007	$26,508,000
2008	$19,893,000
2009	$8,237,000
Average	**$23,782,000**

Source: Statistics and Data Development Branch, AARD, 2010a

the growing season, producers are either pollinator neutral (bring back as many bees as they set out) or produce a surplus. On average, producers harvest a leafcutter bee population that is 0.5 to 0.6 times as large as the one they initially began the season with (Hobbs, personal communication). This excess stock can then be sold domestically or exported to the United States. There are approximately sixteen leafcutter bee brokers in Canada who export bees to an area that ranges from Montana south to California, and from Washington State in the west to Arizona in the east. In 2010, going in to the 2011 production year, the export price of a gallon of bees ranged from $85 to $90 U.S. Provincially, a gallon of bees is valued at $65 to $90 CAD, and $75 to $90 nationally (Hobbs, personal communication).

In addition to being reared for alfalfa seed production, alfalfa leafcutter bees are also utilized in southern Alberta for hybrid canola seed production. Custom pollinators are contracted by canola seed companies to deploy hives throughout their canola fields. Two to four gallons of leafcutter bees and one to two colonies of honeybees are placed per acre of hybrid canola when both bee species are used for pollination in the same field. Custom pollinators receive anywhere from $400 to $600 per acre of canola serviced (Hobbs, personal communication).

Unfortunately, statistics on the value of the alfalfa leafcutter bee industry in Alberta are not formally collected. It has been estimated that the value of alfalfa seed due to leafcutter bee pollination is around $13.5 million, with sales of bees from the pollination season adding another $2.5 million per year (Jim Calpas, personal communication). Since the value of alfalfa seed that depends on leafcutter bees for production is $13.5 million per year, this value can be thought to represent the value of the leafcutter bees produced and used in the forage industry. Taken with the average sales of $2.5 million, **the estimated annual value of leafcutter bees is approximately $16.0 million**.

2.3 Hay

Tame hay production in Alberta is closely tied to the cattle industry. Hay comprises a large portion of the cattle population's ration, in addition to that of other livestock species (horses, sheep, goats, etc.). Since 2006, beef and dairy cattle numbers in the province have declined steadily, reaching a low of 4.95 million head as of January 1, 2011 (Figure 2.1).

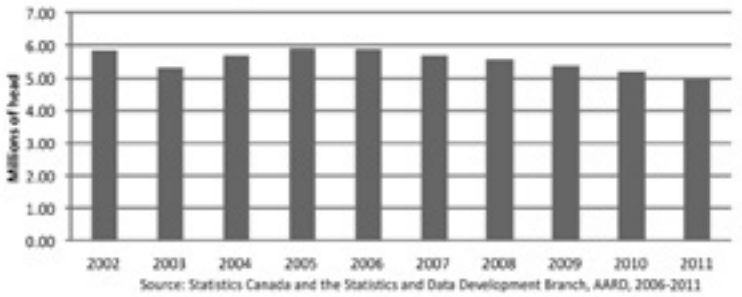


Figure 2.1 Cattle Numbers in Cattle

The decline in cattle numbers has not yet appeared to have impacted hay production. Seeded acres of hay in the province have remained fairly steady over the past ten years, with an average of just over 6.3 million acres (Figure 2.2).

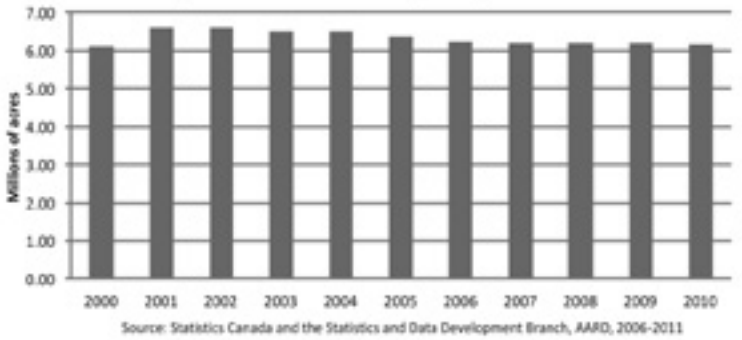


Figure 2.2 Seeded Acres of Forages for Hay in Alberta

In Alberta, tame hay production is tracked through seeding intention and harvest surveys conducted by Statistics Canada. AARD and the Agriculture Financial Services Corporation (ASFC) also gather information on pricing. Producers are able to advertise and market their hay on AARD's Hay and Pasture Directory. Unfortunately, actual hay sales are not monitored, creating a significant data gap.

Table 2.4 reports hay acres seeded and harvested, average yield, overall production, and average yearly farm price. The yield per acre is averaged over all types of hay (grass, legume, grass-legume mixed hay) and all production systems (dryland and irrigation) in the province. The farm price is averaged across all types of hay and all regions of Alberta. The estimated value is based on overall production and the average farm price in the province.

On average, 1.4 tons per acre (3.1 tonnes per hectare) of hay is harvested annually. The average production of hay in the province is 7.69 million tons (6.98 million tonnes). Based on these statistics, **the average direct value of hay in Alberta is estimated at just over $620 million**. This is a higher value than the reported farm cash receipts of $97.6 million for hay and clover in 2009 (Statistics and Data Development Branch, 2010a). However, the farm cash receipts do not capture the revenue generated from inter-farm sales, or the value of hay produced and kept on farm. In fact, the majority of hay produced does not enter a formal marketing chain (Agriculture and Agri-Food Canada, 2001). Hay tends to be sold directly from producer to producer, or remains for use on its farm of origin. To fully capture the direct value of hay for domestic use in Alberta, a market value was assigned to the entire crop produced.

Table 2.4 Tame Hay Acres, Production, and Pricing in Alberta

	Seeded Acres	Harvested Acres	Yield (tons/acre)	Production (tons)	Farm Price ($/ton)	Value ($)
2000	6,100,000	5,700,000	1.1	6,123,263	$75.74	$463,775,940
2001	6,600,000	5,275,000	0.9	4,748,628	$91.89	$436,351,445
2002	6,600,000	5,000,000	0.7	3,349,088	$123.17	$412,507,194
2003	6,500,000	6,200,000	1.1	7,048,061	$108.78	$766,688,119
2004	6,500,000	5,900,000	1.4	8,147,747	$75.90	$618,414,012
2005	6,375,000	5,525,000	1.7	9,647,239	$66.73	$643,760,232
2006	6,240,604	5,450,000	1.6	8,972,484	$59.71	$535,747,020
2007	6,240,000	5,585,000	1.8	10,222,152	$61.30	$626,617,918
2008	6,200,000	5,585,000	1.8	10,297,088	$70.29	$723,782,316
2009	6,200,000	5,015,000	1.2	5,898,345	$95.78	$564,943,465
2010	6,175,000	5,640,000	1.8	10,097,185	$102.28	$1,032,740,102
Average	**6,339,146**	**5,534,091**	**1.4**	**7,686,480**	**$ 84.69**	**$620,484,342**

Source: Statistics and Data Development Branch, 2010a, and Su, personal communication, 2011
Numbers may not add due to rounding
Refer to Appendix B, Table B.2 for values in metric

2.4 Forage Exports

Figure 2.3 2007 Canadian Forage Export Destinations

Canadian forages are primarily exported to Japan, which received 67% of all exported forage products in 2007 (Statistics Canada, 2008). The United States, South Korea, and Taiwan round out the top four countries receiving Canadian forage products.

Since 1998, Canada has exported over 63 million tonnes (69 million tons) of forage products worth over $1.6 billion. Forage products exported include grass and legume seed, non-timothy hay, processed alfalfa and compressed timothy hay (Statistics Canada, 2008).

Alberta is one of the top forage seed exporters in Canada. Approximately 38% of the total forage seed exported by Canada is supplied by the province. **These exports have generated an average yearly value of $36 million** (Table 2.5). During the past eleven years, over 226,000 tonnes (249,052 tons) of grass and legume seed produced by Alberta forage seed growers has been exported. The United States receives the vast majority of forage seed exported from the province. China, The Netherlands, South Korea and Germany round out the top five destinations of forage seed from Alberta (Statistics and Data Development Branch, AARD, personal communication).

Table 2.5 Export and Value of Forage Seed from Alberta

	Quantity (Tonnes)			Value (Millions $)		
	Alberta	Canada	AB % of Canadian Total	Alberta	Canada	AB % of Canadian Total
2000	16,050	45,701	35%	$39	$103	38%
2001	18,172	51,710	35%	$38	$101	38%
2002	18,523	52,029	36%	$31	$92	34%
2003	18,403	49,201	37%	$27	$86	31%
2004	20,734	52,454	40%	$34	$96	35%
2005	21,507	52,238	41%	$31	$89	35%
2006	29,428	70,172	42%	$41	$116	35%
2007	30,552	74,814	41%	$52	$140	37%
2008	24,308	67,963	36%	$48	$145	33%
2009	15,456	43,724	35%	$35	$106	33%
2010	13,532	37,892	36%	$25	$78	32%
Average	**20,606**	**54,354**	**38%**	**$36**	**$105**	**35%**

Source: Statistics Canada, World Trade Atlas 2011, and the Statistics and Data Development Branch, AARD

To convert tonnes to tons, multiply by 1.102

Table 2.6 Export and Value of Hay (other than Timothy) from Alberta

	Quantity (Tonnes)			Value (Millions $)		
	Alberta	Canada	AB % of Canadian Total	Alberta	Canada	AB % of Canadian Total
2003	10,679	40,213	27%	$3	$12	25%
2004	9,164	44,032	21%	$2	$12	17%
2005	12,513	46,977	27%	$3	$12	25%
2006	11,980	55,059	26%	$3	$13	23%
2007	23,308	77,590	42%	$5	$17	29%
2008	32,754	101,767	42%	$7	$24	29%
2009	16,278	62,597	16%	$5	$17	29%
2010	2,866	31,904	9%	$1	$ 7	14%
Average	**14,943**	**57,517**	**26%**	**$4**	**$14**	**24%**

Source: Statistics Canada, World Trade Atlas, 2011, and the Statistics and Data Development Branch, AARD

Non-timothy hay exported from Alberta makes up an average of 24% of the Canadian total (Table 2.6). An average of 14,953 tonnes (16,478 tons) is exported yearly from the province. **Approximately $4 million is generated by the export of this forage product**. The United States, Japan and Taiwan are the main countries non-timothy hay produced in Alberta is exported to. According to the Saskatchewan Forage Council (SFC, 2010), gaps exist in the monitoring of non-timothy hay exports. Therefore, the value reported here may under-represent the actual worth of these hay exports.

2.5 Processed Forages

The Canadian processed forage industry is based on two main products; compressed hay and processed alfalfa products. Compressed hay refers to forages, such as forage seed aftermath, timothy and alfalfa, which are compacted into tightly-bound, low-moisture, high-density bales (Wong, 2011). In Canada, timothy hay is almost exclusively used in the production of compressed hay. Virtually all compressed hay produced in the country is exported, primarily to the Japanese market. It is needed for use as fibre in dairy and beef rations (Wong, 2011). Compressed timothy hay must meet a series of strict export requirements, including being free from prohibited material and retaining a nice green colour.

An average of 88% of all compressed timothy hay produced in the country is grown and processed in Alberta (Table 2.7). There has been a contraction in the compressed hay market over the last few years, as evidenced by a reduction in exports and the closure of processing facilities (David K. Wong, personal communication). There are ten compressed hay processors currently operating, and are located

in Nampa, St. Isidore, Innisfail, Olds, Didsbury, Cremona, Crossfield and Lethbridge. Even though exports of compressed hay have decreased, **this forage product still generates an average of $78 million per year for the agriculture industry in Alberta** (Table 2.7).

Table 2.7 Export and Value of Timothy Hay from Alberta

	Quantity (Tonnes)			Value (Millions $)		
	Alberta	Canada	AB % of Canadian Total	Alberta	Canada	AB % of Canadian Total
2003	186,626	212,902	88%	$65	$74	88%
2004	287,453	323,814	89%	$88	$98	90%
2005	284,753	317,180	90%	$84	$93	90%
2006	343,756	386,366	89%	$94	$105	90%
2007	373,469	421,089	89%	$111	$123	90%
2008	206,212	248,162	83%	$67	$77	87%
2009	191,258	226,111	85%	$65	$75	87%
2010	206,566	233,147	89%	$46	$54	85%
Average	**260,012**	**296,096**	**88%**	**$78**	**$87**	**88%**

Source: Statistics Canada, World Trade Atlas, 2011 and the Statistics and Data Development Branch, AARD
To convert tonnes to tons, multiply by 1.102

The processed alfalfa industry produces two main products; “dehy” (dehydrated) alfalfa pellets and sun-cured alfalfa pellets or cubes (Tremblay, 2008). As with compressed timothy hay, the primary export market is Japan. However, over the last few years, the majority of processed alfalfa products produced in Alberta have been exported to the United States (Statistics and Data Development Unit, AARD, personal communication). Dehy plants contract out practically all forage acres needed, and have a set of standards they require their growers to follow (Tremblay, 2008).

There is one major alfalfa dehy plant currently operating in Legal, Alberta, and some small plants in Southern Alberta (Wong, personal communication). Alberta exports an average of 92,041 tonnes (101,429 tons) of processed alfalfa annually (Table 2.8). **This represents 35% of the total produced in Canada, with an average yearly value of $21 million**.

An estimated 85 to 90% of the total alfalfa pellet and cube production enters the export market (McCartney and Horton, 1997), with the remaining 10 to 15% sold domestically. Based on this estimation, and the value of processed alfalfa exported, **domestic sales of processed alfalfa have an estimated annual direct value of $3.7 million** (15% sold domestically).

Table 2.8 Export and Value of Processed Alfalfa from Alberta

	Quantity (Tonnes)			Value (Millions $)		
	Alberta	Canada	AB % of Canadian Total	Alberta	Canada	AB % of Canadian Total
2000	157,837	389,004	41%	$28	$67	42%
2001	236,293	477,952	49%	$49	$98	50%
2002	77,315	219,916	35%	$20	$56	54%
2003	69,800	185,614	38%	$16	$46	35%
2004	127,309	302,059	42%	$28	$58	48%
2005	91,152	241,629	38%	$21	$53	40%
2006	88,339	220,104	40%	$20	$49	41%
2007	75,862	235,792	32%	$18	$53	34%
2008	46,195	171,445	27%	$14	$46	30%
2009	28,216	108,017	26%	$10	$33	30%
2010	14,138	71,393	20%	$5	$21	24%
Average	**92,041**	**238,448**	**35%**	**$21**	**$53**	**39%**

Source: Statistics Canada, World Trade Atlas, 2011 and the Statistics and Data Development Branch, AARD
To convert tonnes to tons, multiply by 1.102

2.6 Greenfeed

Greenfeed refers to annual crops, such as oats, barley, wheat, triticale and canola, which are harvested while the grain is still "green" (prior to becoming fully mature). This material is then baled and used as forage. While numerous annual crops are intentionally seeded for use as greenfeed, often grain crops damaged by weather events are salvaged as greenfeed. AARD commenced a greenfeed and silage production survey in 2002. This survey is conducted in partnership with AFSC (Su, 2011). Greenfeed tends to be sold from one farm to another, or remains on the farm of origin. As such, data gaps exist in terms of price on the open market. The greenfeed prices reported in Table 2.9 are averages based on the AFSC Commodity Price lists (2006-2010). Provincially, greenfeed is harvested on an average of 635,000 acres (256,981 hectares) and produces approximately 1.5 million tonnes (1.65 million tons). Based on the production and average price, **greenfeed has an estimated direct value of $91 million annually**.

Table 2.9 Total Greenfeed Production and Value

	Harvested ('000 acres)	Average Yield (tonnes/ac)*	Production ('000 tonnes)	Average Price ($/tonne)**	Value (Millions $)
2006	600	2.61	1,565	$44.10	$69,016,500
2007	430	2.47	1,063	$48.51	$51,556,130
2008	335	2.61	875	$52.92	$46,305,000
2009	1,235	1.74	2,150	$72.77	$156,455,500
2010	575	3.02	1,737	$77.18	$134,061,660
Average	**635**	**2.49**	**1,478**	**$59.10**	**$91,480,958**

Source: Su, 2011

*Yields and production reported on a wet weight basis

**Average price from AFSC Commodity Price lists (monthly prices averaged within region and then across regions)

Refer to Appendix B, Table B.3 for values in imperial

In recent years, some of the acreage of annual forages that was previously harvested as greenfeed is now being swathed and grazed in the field by livestock during the fall and winter months. This method of harvesting greenfeed is known as "swath grazing". There is currently no data collected on the acreage being swath grazed in the province.

2.7 Silage

Silage is a type of feed produced through the preservation of green forage crops via acidification and fermentation (Aasen et al., 2004). Annual cereals, perennial grasses and perennial legumes are all commonly grown for silage. Silage allows producers to preserve and store high quality feed.

Corn is one annual crop harvested and stored as silage. Due to the heat requirements of corn, its production tends to be limited to the southern region of the province. Its cultivation in the central and northern parts of the province has been increasing with the release of new varieties with lower heat unit requirements. An average of 51,000 acres (20,639 hectares) of corn per year is harvested as silage in Alberta (Table 2.10). Yields range from 13.6 to 17.3 wet tonnes per acre (15.0 to 19.1 tons per acre), with total production averaging 796,480 wet tonnes (877,721 wet tons). The average value of corn silage reported below is based on the average silage price (at 60% moisture) from the AFSC Commodity Price survey. **The estimated direct value of corn silage produced in Alberta is over $25.8 million**.

Table 2.10 Silage Corn Production and Value in Alberta

	Harvested ('000 acres)	Average Yield (tonnes/ac)*	Production ('000 tonnes)	Average Price ($/tonne)**	Value (Millions $)
2006	55,000	17.3	952,500	$27.20	$25,908,000
2007	50,000	16.8	839,100	$32.60	$27,354,660
2008	40,000	14.3	571,500	$31.60	$18,059,400
2009	60,000	15.7	938,900	$35.85	$33,659,565
2010	50,000	13.6	680,400	$35.80	$24,358,320
Average	**51,000**	**15.5**	**796,480**	**$32.61**	**$25,867,989**

Source: Statistics Canada and the Statistics and Data Development Branch, AARD, personal communication, 2011

*Yields and production reported on a wet weight basis

**Average price from AFSC Commodity Price lists (monthly prices averaged within region and then across regions)

Refer to Appendix B, Table B.4 for values in imperial

Silage made from other annual crops in Alberta, such as barley, oats and triticale, is not tracked or reported on by Statistics Canada. However, information on acres harvested, average yield and overall production is collected by AARD. **An average of 3.5 million tonnes (3.9 million tons) of cereal silage is produced yearly, with an estimated direct value of over $114 million**.

Table 2.11 Total Silage Production and Value (for annual crops other than corn)

	Harvested ('000 acres)	Average Yield (tonnes/ac)*	Production ('000 tonnes)	Average Price ($/tonne)**	Value (Millions $)
2006	800	5.82	4,660	$27.20	$126,752,000
2007	550	5.64	3,099	$32.60	$101,027,000
2008	435	5.93	2,582	$31.60	$81,591,200
2009	945	3.66	3,460	$35.85	$124,041,000
2010	570	6.91	3,936	$35.80	$140,908,800
Average	**660**	**5.59**	**3,547**	**$32.61**	**$114,864,080**

Source: Su 2011

*Yields and production reported on a wet weight basis

**Average price from AFSC Commodity Price lists (monthly prices averaged within region and then across regions)

Refer to Appendix B, Table B.5 for values in imperial

2.8 Straw

Straw plays an important role in livestock production. In addition to being used as bedding, it is quite common for cattle producers to feed straw to their herds as part of a winter ration. Even though straw is a byproduct from another industry, it is highly valued as forage by livestock producers. As a result, the value of straw was included in this report.

Sokhansanj et al. (2006) estimated total production, availability and use of straw in different regions of Alberta and Saskatchewan. The province was divided up into three regions (southern, central and northern) based on winter feeding periods of 100, 135 and 170 days. According to the study, cattle consumed an average of 2.5 kg (5.5 lbs) of straw per day. Another 2.5 kg is used for bedding (Sokhansanj et al., 2006). Based on these values, and the average cattle population of Alberta from 1994 to 2003, the overall demand for straw by the cattle industry was 3.20 million tonnes. Of this, 1.94 million tonnes (2.14 million tons) of straw was required for feed.

In Alberta, there is an average of 37 lbs of harvestable straw produced per bushel of barley grain (Hartman, 2008). In 2009, the average barley yield in the province was 58.2 bushels per acre, with 2,153 lbs of straw produced per acre. Approximately 1.99 million acres (0.81 million hectares) of annual cropland would be needed to produce the estimated 1.94 million tonnes of straw used as feed. It could be argued that this annual cropland can be counted in the total amount of land in Alberta involved in forage production.

There is no formal marketing channel through which straw is sold. Some producers advertise it on AARD's Hay and Pasture Directory, while others sell it through word of mouth. Straw prices vary depending on the year, region and demand, making pricing difficult to track. The average price of straw in Alberta is $39.69 per tonne ($0.018 per pound), according to an average of the prices reported by AFSC since 2006. **Therefore, the estimated direct value of straw as forage is approximately $77.0 million annually**, based on the amount of straw required to feed cattle in the province (Sokhansanj et al., 2006) and the average price (AFSC 2006-2010). It should be noted that this value varies greatly from year to year, depending on the availability of more traditional forages, the price of straw and the need to include it in the rations fed to the province's livestock.

2.9 Pasture and Grazing

The prairies have a large native, or natural, land based used for grazing cattle. Traditionally, this land has been known as "native range". More recently, the term "rangelands" has been used. Alberta's native range, or rangeland, is classified into five sub-regions; grassland (51%), parkland (21%), foothills (6%), rocky mountain natural region and the boreal forest (22%) (Brierly and Adams, 2001).

Alberta is home to 44% of the Canadian tame or seeded pasture land, and 42% of the Canadian native range (natural land) used for pasture (Statistics Canada, 2006). There are 6,137,362 acres (2,483,702 hectares) of tame or seeded pasture land and 16,135,646 acres (6,529,863 hectares) of native range for pasture in the province. This land is necessary to support Alberta's thriving livestock industry.

Approximately 68% of the rangeland in Alberta is under public ownership and administration (Brierly and Adams, 2001). The majority of provincially owned grazing dispositions are administered under the *Public Lands Act*, with some administered under the *Special Areas Act*. Alberta Sustainable Resource Development administers the *Public Lands Act*, which provides grazing dispositions on more than six million acres of public land, providing over 1.6 million animal unit months (AUM's) of forage each summer to 14% of the cattle herd (Alberta Sustainable Resource Development, 2003).

Grazing rates on provincial grazing leases are set on an annual basis by the provincial government, whereas the cost to graze private land is market-based and varies across the province. Yearly surveys are carried out by AARD to collect information on pasture rental rates across the province. Based on these surveys, the average price charged to a renter for the use of fenced pasture land is $22.50 per AUM (Ted Nibourg, personal communication). This rate represents the cost to use the land and forage available, and does not include extra services the landowner might provide.

Table 2.12 provides an estimate of the total direct value for both native range and tame pasture. The stocking rates used in the calculations are based on averaged stocking rates from MacAlpine et al. (1997). The stocking rates were averaged across soil zones and pasture types across the province to calculate average rates for both native range and tame pasture. The rates were then adjusted by a factor of 1.5 to represent actual grazing practices, based on consultations with industry and government representatives (SFC, 2010). Based on the stocking rates and the AUM value reported, **the annual direct value of pasture for grazing in Alberta is estimated to be $349.8 million**.

It should be noted that an increasing number of Alberta livestock producers are grazing residue left in the field after harvesting annual crops for grain. Some producers also collect the chaff behind their combines and pile it in their fields for livestock use after harvest. This is called aftermath grazing. Aftermath grazing is proving to be invaluable to numerous mixed livestock and crop producers in the province.

Table 2.12 Value of Pasture for Grazing in Alberta

	Total Acres*	Average AUM/ acre**	Total AUM's	AUM Value ($)***	Total Pasture Value ($)
Native Range	16,135,646	0.45	7,261,041	$22.50	$163,373,416
Tame Pasture	6,137,362	1.35	8,285,439	$22.50	$186,422,371
Total	**22,273,008**		**15,546,480**		**$349,795,787**

*Source: Statistics Canada, 2006

**Based on stocking rate from MacAlpine et al., 1997. (averaged across all soil zones x 1.5 to reflect actual grazing practices)

***Nibourg, personal communication

Currently, no statistics exist on the prevalence of this practice in the province. With that said, the acreage and value of aftermath grazing were not included in the above valuation.

2.10 Sod

With the increased construction of housing developments, playgrounds and golf courses, sod is becoming an important forage product in Alberta. Sod is produced from perennial grass species, such as Kentucky bluegrass and different turf-type fescues (Charbonneau, 2003). Sod production requires intensive management and close proximity to the end user due to transportation costs and product quality. Approximately 60% of sod sold is for residential landscaping. The remaining 40% goes to golf courses, highways and other commercial developments (Charbonneau, 2003).

According to the 2006 Census of Agriculture, Alberta is home to 46 sod farms, with 9,402 acres (3,805 hectares) of sod in production. **In 2009, the Alberta farm cash receipts from the sale of sod were just over $30.3 million** (Statistics and Data Development Branch, 2010a). This can be used to represent the estimated direct annual value of the sod sector in the province.

2.11 Ag-Tourism

Tourism is a vital part of Alberta's economy. In 2008, direct visitor expenditures from tourists exceeded $5.69 billion. This resulted in an overall economic impact of $6.24 billion (Alberta Tourism, Parks, and Recreation, 2010). A total of 96,744 full time equivalent jobs in Alberta exist due to tourism, with 3% of these (approximately 2,900) in agriculture.

Ag-tourism is a rapidly expanding sector of Alberta's agriculture and tourism industries. It is the combination of recreation and hospitality with the products of agricultural enterprises. Unfortunately, there is not much data available for ag-tourism in the province. In 2003, AARD conducted a survey to gauge awareness of, and interest in, ag-tourism. The results showed that 47% of Albertans had participated in an ag-tourism activity over the course of a year. In addition, ag-tourism activities have a very broad appeal, with 88% of those surveyed indicating they were very likely to participate in one during the following year (AARD, 2003). Popular activities include horseback riding, experiencing the cowboy lifestyle, staying at an on-farm guest house, touring a specialized ranch and attending a camp on a ranch.

A market assessment of ag-tourism in Alberta was also conducted during 2003-2004. Its purpose was to assess the current market value and growth potential of ag-tourism, in addition to consumer awareness and consumer spending (AARD, 2004). Ag-tourism was defined as on-farm and off-farm activities requiring a visitor to travel a minimum one-way distance of more than 80 km from home. Total market penetration for ag-tourism trips according to the definition above was 17% of the population surveyed, with an average expenditure of $243 per trip (AARD, 2004).

Forages play an important role in numerous ag-tourism operations. Guest ranches, hiking and biking trails, haying demos, horseback riding and wildlife viewing all depend on forages. Out of a total 438 listings in the Alberta Agriculture Ag-Tourism Database, 246 can be connected to forages (Delores Serafin, personal communication). There were ten guest ranch listings, six working ranches, 47 with hiking/biking trails, 57 with horseback riding, 73 with wildlife viewing and 53 related to farm activities, such as haying. A single ag-tourism operation may have multiple activities listed as available on their operation.

Based on the market assessment, the overall value of ag-tourism ranges from $194.0 million for trips over 80 km from home to $325.6 million for all on-and off-farm activities (AARD, 2004). If we are to assume that one-third of these values can be directly attributed to forages (SFC, 2010), then **the direct value of forages to ag-tourism can be estimated at $64.7 to $108.5 million**.

2.12 Carbon Sequestration and Credits

Concerns over climate change and the increase in greenhouse gas emissions has led to the passage of legislation in Alberta aimed at reducing greenhouse gas emissions. The *Climate Change and Emissions Management Amendment Act* came into force July 1, 2007 (Koehler-Munro, 2010). The purpose of this legislation is to reduce the greenhouse gas emission intensity of regulated emitters, employing one or more of the four approved reduction methods. One method allows emitters to purchase carbon offsets created using Government of Alberta approved protocols.

Government of Alberta approved protocols outline the practices that create carbon offsets. These offsets must be real, quantifiable and verifiable (Nolan and Goddard, 2010). They are based on the best possible science available and provide certainty on the amount of greenhouse gases reduced. Currently, 29 offset protocols exist. Eleven of these are agricultural, and include tillage management, summerfallow reduction and reduced beef days on feed (Nolan and Goddard, 2010). To date, there are no approved protocols concerning forages, but a few, such as conversion to perennial cropping and pasture management, are in development.

The amount of carbon in a system is based on the balance between decomposition and plant growth (Bremer, 2008). If plant growth increases more rapidly than decomposition, there is an accumulation of carbon. As time progresses, decomposition will increase until a steady state between the two is reached. Any following increases in plant growth, or decreases in decomposition, that increase the level of carbon in the system, contribute to carbon sequestration (Bremer, 2008).

Perennial forages play a significant role in carbon sequestration. Root growth sequesters carbon dioxide in the soil. The carbon stored in the stems and leaves also returns to the soil through decomposition (Iwaasa, 2011). Gains in carbon sequestration rates on established pastures and hay fields can be achieved through changes in management. For example, improving rangeland condition (PFRA, 2000) or improving grazing practices (Bremer, 2008) can increase plant growth, thereby increasing carbon sequestration. It should be noted that Bremer (2009) concluded that the potential to use practices that reduce greenhouse gas emissions and increase carbon sequestration on Alberta rangelands was low due to the majority of rangelands in the province being rated as “healthy”.

It is widely thought that converting continuously cropped land to permanent plant cover (perennial forages) has the potential to sequester the greatest amount of carbon (Smith et al., 2001). More specifically, the conversion of land deemed marginal (Canadian Land Inventory classes 4-6) is thought to benefit the most from being seeded down to perennial forages (PFRA, 2000).

It has been estimated that these marginal lands have the potential to sequester 2.94 tonnes of carbon dioxide equivalents (CO_2e) per hectare per year or 1.31 tons per acre per year (0.8 tonnes of carbon per hectare per year or 0.36 tons per acre per year) if converted back to perennial cover (Bruce et al., 1998). In Alberta, there are approximately 940,000 hectares (2.3 million acres) of marginal land under cultivation (Table 2.13). This land represents an opportunity to produce carbon offsets in the future for trading in the Alberta carbon offset market.

Carbon sequestration rates vary with soil zone, temperature, plant health and other factors. Research into these rates on perennial forage land is ongoing. Mensah et al. (2003) examined the changes in soil carbon due to seeding perennial grasses into previously cultivated land in the brown/dark brown and black/grey soil zones of Saskatchewan. They observed a net carbon sequestration rate of 0.6 to 0.8 tonnes of carbon per hectare per year or 0.27 to 0.36 tons per acre per year (2.20 to 2.94 tonnes CO_2e per hectare per year or 0.98 to 1.31 tons per acre per year) at these sites. Seeding perennial grasses on marginal cultivated land increased the soil organic carbon in the surface layer after a period of five to 12 years (Mensah et al., 2003). The changes in soil organic carbon on cultivated land and restored grassland sites in south-central Saskatchewan have also been investigated (Nelson et al., 2008). Carbon sequestration rates varied from 0.3 to 2.9 tonnes of carbon per hectare per year or 0.13 to 1.29 tons per acre per year (1.10 to 10.64 tonnes CO_2e per hectare per year or 0.49 to 4.75 tons per acre per year) (Nelson et al., 2008).

Currently, the average value of a carbon offset in Alberta is $9.00 per tonne CO_2e or $8.16 per ton CO_2e (Graham Gilchrist, personal

Table 2.13 Environmentally Marginal Land Under Annual Cultivation by Soil Zone

	Black	Dark Brown	Brown	Dark Gray	Gray	Total*	Percent
				Hectares			
Alberta	185,000	293,000	234,000	93,000	135,000	**940,000**	**29%**
Canada	722,000	1,190,000	849,000	238,000	234,000	**3,233,000**	
				Acres			
Alberta	457,145	724,019	578,227	229,808	333,592	**2,322,791**	**29%**
Canada	1,784,101	2,940,554	2,097,925	588,111	578,227	**7,988,918**	

Source: PFRA, 2000.

communication). Using the acreage of marginal land under cultivation that can be converted to perennial cover, and average carbon sequestration rates of 0.28 tonnes of carbon per hectare per year or 0.12 tons per acre per year (1.03 tonnes CO_2e per hectare per year or 0.46 tons per acre per year) in the brown/dark brown soil zones and 0.73 tonnes of carbon per hectare per year or 0.33 tons per acre per year (2.68 tonnes CO_2e per hectare per year or 1.19 tons per acre per year) in the black/gray soil zones (Smith et al., 2001), the potential amount of carbon sequestered by seeding perennial forages on this land can be estimated (Table 2.14).

Table 2.14 Potential Carbon Trading Value from the Conversion of Marginal Annual Cropland to Permanent Cover

	Soil Zone		
	Brown/Dark Brown	**Black/Gray/Dark Grey**	**Total**
Area of marginal land (ha)	527,000	413,000	940,000
CO_2 sequestration rate* (tonne/ha/yr)	1.03	2.68	
CO_2 sequestered (tonne/yr)	542,810	1,106,840	1,649,650
Value of CO_2** ($/tonne)	$9.00	$9.00	$9.00
Potential yearly value ($)	$4,885,290	$9,961,560	$14,846,850
Potential yearly value ($/ha)	$9.27	$24.12	$16.70
Potential yearly value ($/ac)	$3.75	$9.76	$6.76

*Median values from Smith et al. (2001) converted to CO_2e

**Based on average value paid to producers ($/tonne CO_2e) in Alberta (Gilchrist, personal communication)

Table 2.14 suggests that an estimated average yearly value of $16.70 per hectare ($6.76 per acre) could be generated by the conversion of marginal cropland to perennial forages in the carbon offset market. **If all the marginal land currently cultivated in Alberta was converted to perennial forages, approximately $14.8 million could be generated for producers**. The carbon sequestration rates used here are based on the use of a model to estimate changes in soil organic carbon for the major soil groups in Canada as a result of different management practices over a period of ten years (Smith et al., 2001). Other research into the carbon sequestration rates has generated both higher and lower values than those used above. As a result, the estimated potential direct value reported here could be considered conservative.

2.13 Energy

With an increasing population, the global demand for energy has led to research on the suitability of different crops for heat and energy production. Biomass combustion systems are now available in Alberta on a range of scales (AgTech Centre, 2009). Many of these systems currently use pellets made from oat hulls, wheat bran or wood pellets, but the suitability of perennial grasses for this purpose is being investigated (Samson et al., 2007).

Switchgrass is a native, warm season grass that grows in areas of southern Manitoba and southeastern Saskatchewan. It has attracted attention as a source of raw material for biofuels and agro-pellets due to its lower ash content, efficient combustion and high yields (Manitoba Agriculture, Food, and Rural Initiatives). Switchgrass has potential as a feedstock in the production of cellulosic ethanol (Samson, 1991). Switchgrass grows best in high precipitation areas with 2,200 or more corn heat units. This would restrict its cultivation in Alberta since the higher corn heat unit areas of the province also have low annual precipitation rates (Appendix B).

In addition to switchgrass, other “second generation” bio-energy crops are also being investigated (Mangan et al., 2011). Work is being done in the United States examining the ability to convert the cellulose, hemicellulose and lignin components of perennial forages into fuels for energy production. Different native and tame grass and legume species are being studied in terms of ideal mixtures and their resulting yield (Griffith et al., 2011; Mangan, 2011).

There are no cellulosic ethanol plants currently operating in Alberta that would be able to use second generation bio-energy crops, and the agro-pellet industry is in its infancy. As a result, no direct value of

forages for these uses can be estimated. The potential exists for future contributions of forages to the energy industry as renewable energy research and development continues.

2.14 Estimated Total Direct Economic Value

Forages create economic value for Alberta in a variety of ways. They are grown and harvested as conserved livestock feed, grazed, processed into numerous products and exported, have the potential to create carbon offsets and play a role in tourism. The largest economic contributions are generated by hay and pasture, reinforcing the importance of forages to the livestock industry. Silage and greenfeed are also highly valued, while the forage export sector continues to play a vital role for forage producers in the province. Table 2.15 provides a summary of the current estimated total direct value of forages in Alberta. **The forage industry has an estimated direct value of $1,557.0 to $1,600.8 million annually**.

Table 2.15 Estimated Total Direct Economic Value from Forages in Alberta

	Current Value ('000 000 per year)	Potential Value ('000 000 per year)
Forage Seed - domestic	$23.8	
Forage Seed - export	$36.0	
Leafcutter Bees	$16.0	
Hay - domestic	$620.5	
Hay - export	$4.0	
Timothy Hay - export	$78.0	
Processed Alfalfa - domestic	$3.7	
Processed Alfalfa - export	$21.0	
Greenfeed	$91.5	
Silage - corn	$25.9	
Silage - other annual crops	$114.9	
Straw - feed	$77.0	
Pasture/Grazing Land	$349.8	
Sod	$30.3	
Ag-Tourism	$64.7 - $108.5	
Carbon Sequestration and Offsets		$14.8
Total	**$1,557.0 - $1,600.8**	**$14.8**

3.0 Estimated Indirect Economic Value

Forages cover over 28 million acres (11 million hectares) of land in the province (Table 1.1). They are present in all regions and affect numerous ecosystems. Native range and tame/seeded pasture represent 79% of the forage acreage in Alberta alone.

Native range is considered by many to be vitally important in the delivery of ecological goods and services (EG&S) (Lorne Fitch, personal communication). Native range has the ability to build soil, retain, store and filter water and successfully adapt to changing weather conditions (Fitch, personal communication). Maintaining native range in a healthy state has also proven to be invaluable in the face of drought (Don McLennan, personal communication).

Forages have the ability to create value not only through the production and use of marketable goods such as seed, hay and silage, but through EG&S as well. Ecological goods and services provide benefits both within and outside of their ecosystem of origin. They include water filtration, soil formation and erosion prevention (Pagiola et al., 2004). Indirect use values for EG&S are difficult to quantify as they have no established markets and pricing schemes (Pagiola et al., 2004).

Numerous EG&S have been attributed to perennial forage lands. Grasslands store and sequester carbon, regulate water flow, control erosion and contribute to pollination and soil formation (Olewiler, 2004). Due to public awareness of these services, an increasing number of researchers are investigating the economic values of these goods and services through a variety of methods. They include: avoided cost, replacement cost (Costanza et al., 2006), the willingness of individuals to pay for the service, the willingness to accept compensation for losses (Wilson, 2008) and their ability to be captured in land value (Ma and Scott, 2011). Avoided costs are costs that would have occurred in the absence of the service provided, while replacement costs are the costs to replace that ecosystem service with a man-made system (Costanza et al., 2006). Willingness to pay is based on surveys of what individual choices and preferences are in reference to different goods and services (Wilson, 2008). The Total Economic Value theory is another well known method of valuing EG&S. This theory breaks the valuation into three sections: direct use value, indirect use and option values (Wilson, 2009). Direct use values are for goods and services produced that are used directly by the landowner. Indirect use values refer to the life support services provided by the natural environment, and are used indirectly by society. Option values reflect the value placed on the future ability to benefit from these goods and services (Wilson, 2009). Consumer surplus values can also be used to place a value on land in relation to EG&S. A consumer surplus value represents the amount of welfare a consumer receives over and above the price they paid in the market to access it (Costanza et al., 1997).

The following section of this report attempts to place an economic value on some of the more widely researched EG&S provided by forages. These indirect and non-market values will be based on published research and case studies conducted in similar areas in North America. Wherever possible, values for Alberta were used. Due to the fact this is an emerging field, it was necessary to use values from other locations. This report is not attempting to predict what the value of the examined EG&S are, merely to apply published values to the situation that exists in this province at this time. In most cases, a range of values will be supplied due to the inherent uncertainty that exists with the wide range of valuation methods and values reported in the literature.

3.1 Erosion

Soil erosion is the movement of soil over the landscape due to wind, water or mechanical disturbance. The force of wind or water on uncovered soil results in its movement (Prairie Farm Rehabilitation Administration (PFRA), 2000). Erosion varies with soil type, moisture, topography, soil cover and management. It can negatively impact crop productivity, leading to substantial yield losses (Larney et al., 1995). It has been estimated that erosion can cause a reduction in net profit of $4.86 per cropped acre, or $12.00 per hectare (PFRA, 2003).

Erosion removes the finer soil particles that maintain soil structure and play a vital role in nutrient retention. If large amounts of soil are lost, the area available for plant root development is diminished (PFRA, 2000). In addition, the deposition of poor quality soil on good quality soil can lead to a reduction in plant growth (PFRA, 2000).

It is thought that the majority of soil affected by erosion does not leave its field or origin. When the energy of the wind or water moving the soil is removed, the particles end up in clumps behind trees or in depressions (PFRA, 2000). The sediments in these depositions have the potential to enter bodies of water in run-off. An increase in sediment

in water can render it unfit for human consumption, increase the cost to treat it and reduce water quality to the extent where it negatively affects aquatic life (Olewiler, 2004).

Management influences the amount of soil erosion that occurs in a field. Practices that retain plant material on the soil surface protect the soil from erosion, while those that leave the soil uncovered increase the risk. For example, Toogood (1963) monitored soil losses due to rainfall induced erosion in the black soil zone of Alberta. He found that the highest soil loss of 4.5 tonnes per hectare (2.0 tons per acre) per year was on traditional summerfallow. Tillage is another common practice that increases the risk of soil erosion. Tillage incorporates crop residues left on the soil surface and breaks up the soil surface, creating loose particles that can be moved by wind or water. Fortunately, tillage is not as popular today as when agriculture first came to the prairies. Zero-tillage, or no-tillage, is a practice rapidly gaining in popularity with producers in the province. It leaves crop residue on the soil surface undisturbed to provide protection from erosion and retain moisture. Over 3.6 million hectares (8.9 million acres) of crop land in Alberta are zero-tilled (Statistics Canada, 2006).

One of the best management practices for preventing soil erosion is permanent cover. Seeding perennial forages in areas prone to erosion can decrease soil loss and maintain land productivity (PFRA, 2000). They can stabilize the banks of rivers and other water bodies, preventing sediments from entering the water and decreasing its quality. Converting annual cropland to permanent cover can also reduce wetland filling by sediment movement and increase available habitat for wetland birds (Gleason et al., 2008).

Converting annual cropland to perennial forages reduced soil erosion on Conservation Reserve Program (CRP) land in the northern Great Plains of the United States. The estimated value of this service was $1.34 to $9.34 per hectare ($0.54 to $3.78 per acre) per year (Olewiler, 2004). Case studies of agricultural regions in Canada have been published, and some are still underway (Webs Project), examining the contribution that enhancing permanent vegetative cover makes to the reduction of sediment erosion and the resulting savings in water treatment.

The Grand River Watershed in Ontario and Upper Assiniboine River Basin in Manitoba are two such case studies. The Grand River Watershed has an estimated population of 875,000 (as of 2003). Approximately 75% of the watershed is agricultural land. This, coupled with large municipal areas, is placing increasing pressure on the environment. The Upper Assiniboine River Basin only has a population of 60,000, with 30% considered rural. The primary land use is agricultural, with annual crops, livestock and forages produced (Olewiler, 2004).

In the Grand River Watershed of Ontario, increasing vegetative cover reduced erosion from over six tonnes to less than one tonne per hectare (2.7 to 0.4 tons per acre) per year (Olewiler, 2004). The movement of sediment into water was estimated to decrease to between 0.15 and 0.6 tonnes per hectare (0.07 to 0.27 tons per acre) per year. The net value of the permanent vegetative cover to decreased sedimentation was $0.23 to $1.27 per hectare ($0.09 to $0.51 per acre) (Olewiler, 2004). In the Upper Assinboine River Basin in Manitoba, the value of permanent ground cover to reduce wind erosion was estimated at $1.34 to $4.01 per hectare ($0.54 to $1.62 per acre) per year. Converting tilled land to permanent vegetative cover could improve water quality by decreasing sedimentation and reducing wind erosion. In a paper on placing a value on the world's ecosystem services and natural capital, Costanza et al. (1997) calculated that the erosion control grass and rangelands provided worldwide was worth $29.00 per hectare ($11.74 per acre) annually.

There are approximately 11,548,089 hectares (28,513,612 acres) of forage land in Alberta, not including land seeded to corn for silage. This permanent vegetative cover helps reduce erosion and sedimentation. A value of $0.23 to $ 29.00 per hectare ($0.09 to $11.74 per acre) per year has been estimated for this service. Using this range, **a value from this province's forages to erosion reduction can be estimated as $2.7 to $334.9 million annually**. This value might be an over-estimate as some annual fodder crop land was included in the acreage used for this calculation (captured in the 'all other tame hay and fodder crop' census category).

3.2 Water Quality and Regulation

Grasslands and other perennial tame forages can regulate the flow of water over the landscape, stabilize its supply and quality and store it (Olewiler, 2004; Ducks Unlimited Canada, 2006; Wilson, 2009). These forages also slow the movement of surface water and help trap sediments. This decreases the amount of material moving into the water system. Finally, forages can increase water infiltration into

the soil, which maintains water tables and sources of drinking water for communities (Ducks Unlimited Canada, 2006). Without healthy grasslands, it is thought that the cost to treat water and make it fit for human consumption would rise dramatically, in addition to increasing the risk of future water shortages (Ducks Unlimited Canada, 2006). These services benefit both current, and future, water users.

Grasslands can act as biological filters, helping to maintain, and even increase, water quality. The Catskill/Delaware watershed in New York State has been providing clean water for New York City without the need for filtering for years (Wilson, 2009). Instead of building a new water filtration system, a watershed protection program was implemented that created conservation easements along the watershed, preserving natural ground cover. To date, this network is the largest unfiltered surface water supply in the world (Wilson, 2009).

In the Upper Assiniboine River Basin of Manitoba, the net benefit of protecting natural areas and converting tilled cropland to perennial cover to increase water quality was valued at $1.34 to $9.34 per hectare ($0.54 to $3.78 per acre) annually (Olewiler, 2004). Based on these values, and using the 11,548,089 hectares, (28,513,612 acres) of forage land in the province, **forages in Alberta are estimated to be worth $15.5 to $107.9 million to water quality**. This is likely a conservative estimate as it does not include savings from removing sediment during water treatment. However, it could also over-estimate the value as some land in annual forages was included in the forage acreage used.

In addition to maintaining and improving water quality, perennial forages have the ability to regulate and store water. Costanza et al. (1997) estimated that the water regulation provided by grass and rangelands was worth $3 per hectare ($1.21 per acre) per year. The value of carrying out these activities by land in permanent cover in Canada has been estimated to range from $1.87 to $10.27 per hectare, or $0.76 to 4.16 per acre (Olewiler, 2004). If we apply these values to the province's forage acreage, then **forages are estimated to be worth $21.6 to $118.6 million to water retention and regulation**.

3.3 Wildlife-Related Activities

Over 80% of the Canadian prairies have been transformed by agriculture. The majority of native grasslands have been cultivated, with only 10% of the fescue prairie, 24% of the mixed prairie and 25% of the aspen parkland remaining in their natural states (Baydack et al., 1995). As a result, wildlife in the province has become increasingly dependent on the remaining native range and tame/seeded perennial forage land for habitat and feed. Studies in the United States on Conservation Reserve Program (CRP) land have shown the importance of perennial cover to mule deer, white-tail deer and pronghorn antelope (Selting and Irby, 1997). Those animals consistently chose to use CRP forage land instead of annual cropland.

In the aspen parkland and prairie regions of Canada, many wetlands have been drained and fields cultivated. The absence of permanent cover makes these areas unsuitable for waterfowl. Hayland, or cropland that has been converted to hayland, is attractive to a variety of waterfowl species and other grassland birds as nesting sites (McMaster et al., 2005). Davis and Duncan (1999) examined songbird occurrence in native and tame/seeded pastures for the effects of plant species on habitat choice. They found that the tame/seeded pastures attracted just as many songbirds as the native grasses. In moderately grazed pastures, the full range of prairie passerines (perching songbirds) occurred, mirroring the diversity of bird species found on undisturbed native range (Owens and Myres, 1973). Cultivated cropland was found to be unsuitable for all species of passerine, save one.

Seeding perennial forages adjacent to wetlands, sloughs and other water courses can increase the reproductive success of certain species of nesting waterfowl (Wark et al., 1995). Converting annual cropland to perennial forages will help northern pintail populations recover from losses due to continuous cultivation and spring tillage practices (Podruzny et al., 2002). These studies highlight the integral role perennial forages play in providing habitat for the prairie passerine and waterfowl populations.

Wildlife use in Alberta can be broken down into two categories; consumptive and non-consumptive. Consumptive use relates to activities such as hunting, while non-consumptive use does not directly affect the wildlife population. It includes viewing and study (Adamowicz et al., 1991). A survey conducted by Environment Canada (2000) investigated the economic significance of nature-related activities. Consumptive and non-consumptive uses were examined in terms of participant daily and yearly expenditures (Environment Canada, 2000).

Hunting (consumptive wildlife use) is enjoyed by many residents and non-residents of the province. In 2008, there were over 99,000 adults

with hunting licenses for Alberta (Econometric Research Limited, 2009a). Albertans spent $71.0 million hunting wildlife (large and small mammals, waterfowl and other birds) in 1996. This represents the money spent on items such as accommodation, food and equipment (Environment Canada, 2000). In 2008, hunting related direct and capital expenditures in Alberta increased to $296.4 million (Econometric Research Limited, 2009b). These expenditures also resulted in significant economic impacts on employment in industries related to hunting, gross provincial product (income) and government related revenues (Econometric Research Limited, 2009b).

In a report on the value of natural capital in Canada, Olewiler (2004) conducted a case study of the conversion of cropland to permanent cover in the Upper Assinboine River Basin. The estimated value of forages (protecting natural areas or converting tilled cropland to permanent cover) to hunting ranged from $5.36 to $19.11 per hectare ($2.17 to $7.73 per acre). In the Mill River Watershed of Prince Edward Island, it was valued at $0.56 to $2.24 per hectare ($0.23 to $0.91 per acre) and $8.76 to $35.04 ($3.55 to $14.18 per acre) in the Grand River Watershed of Ontario (Olewiler, 2004). On CRP land in the Northern Plains of the United States, a consumer surplus for hunting of $7.41 per hectare ($3.00 per acre) of land in permanent cover was calculated (Feather et al., 1999). If we assume that a significant amount of hunting occurs on native range and tame pastures (SFC, 2010), then **forages contribute an estimated $5.0 to $315.8 million to hunting in Alberta** (calculated by multiplying the values of permanent cover to hunting per hectare by the total amount of land in tame/seeded pasture and native range, 9,013,597 hectares or 22,273,008 acres).

In addition to spending a significant amount on hunting, Albertans also spent $171.6 million on wildlife viewing activities (Environment Canada, 2000). The value of permanent ground cover to wildlife viewing was estimated at $2.08 to $6.45 per hectare ($0.84 to $2.61 per acre) in the Upper Assinboine River Basin (Olewiler, 2004). The value of permanent ground cover was $1.93 to $7.72 per hectare ($0.78 to $3.12 per acre) in the Mill River Watershed of Prince Edward Island and $17.24 to $68.97 ($6.98 to $27.91 per acre) in the Grand River Watershed of Ontario (Olewiler, 2004). The consumer surplus on CRP land in the Northern Plains was $7.43 per hectare, or $3.01 per acre (Feather et al., 1999). If we assume that, as with hunting, the majority of wildlife viewing occurs on native range and tame/seeded pasture (9,013,597 hectares), **the estimated value of these forages in relation to this activity is $17.4 to $621.7 million**.

3.4 Recreational Fishing

Native range, tame/seeded pasture and haylands help regulate and stabilize water flow in a watershed. Perennial grasses and legumes have extensive rooting systems that create pores in the soil, allowing water to enter, decreasing runoff. They also help prevent erosion and the movement of sediment and other nutrients into water bodies. Sediments that reach lakes and streams can damage feeding and spawning areas, and reduce the respiratory efficiency of fish (Olewiler, 2004). Seeding tame forages around water bodies, or preserving native range in these areas, can increase water quality. This improved water quality can have a positive impact on fish populations and, therefore, recreational fishing.

There are roughly 800 lakes in Alberta with natural sport-fish producing capacities and another 300 that are annually stocked with trout (Park, 2007). These lakes support just under 300,000 anglers (Park, 2007). In 1996, Albertans spent $147.8 million on recreational fishing (Environment Canada, 2000). In 2005, overall expenditures and investments that can be directly attributed to sport-fishing increased to $416.3 million, or $2,170 per licensed angler (Park, 2007). When this value is adjusted for inflation, it becomes $468.8 million in 2008 dollars (Econometric Research Limited, 2009b). This value can be compared with the value of forage land to this activity calculated by Feather et al. (1999) in the northern Great Plains of the United States. The consumer surplus value of forages in relation to maintaining fish-supporting water bodies, and therefore fishing, was $0.69 per hectare, or $0.28 per acre, per year (Feather et al., 1999). In the Grand River Watershed of southern Ontario, a value of $8.81 to $48.44 per hectare ($3.57 to $19.60 per acre) for recreational fishing was given to protecting natural areas or converting tilled cropland to natural areas (Olewiler, 2004).

It has been assumed that a minimum of 10 to 25% of the gross drainage area of sport fish bearing lakes and reservoirs is in perennial forages (SFC, 2010). Based on this, a minimum of 296,740 hectares (732,948 acres) of the drainage areas of the 29 largest sport fish bearing lakes and reservoirs in the prairie region, parkland region and agricultural areas of the boreal region of Alberta would be in perennial forages (Appendix C). **Taking this acreage into consideration, the value forages contribute to recreational fishing in the province ranges from $204,750 (consumer surplus value multiplied by 10% of the hectares in the drainage basins estimated to be perennial**

forage) to $35,935,217 (upper value from the Grand River Watershed multiplied by 25% of the hectares in the drainage basins estimated to be perennial forage).

There is also a small commercial fishing industry within the province. There are approximately 160 licensed commercial fishermen in Alberta. Their unfinished product has a value of $3 to $5 million annually (Terry Kosinski, personal communication). There are currently 84 lakes in the province listed as open for commercial fishing. However, the activity of commercial fishermen is not well tracked and it is difficult to pinpoint which lakes they frequent. As a result, the value of their product has been omitted.

3.5 Pollination Services

Pollinators are essential components in the life cycle of numerous plants. Globally, 35% of crop production depends on pollinators (Klein et al., 2007). Unfortunately, numerous pollinator species have declined over the years due to habitat destruction. Natural cover and diverse habitats provide pollinators with nesting sites, food sources and help maintain their health. Intensive agricultural operations have been found to harm pollinators through the removal of permanent cover and use of insecticides (Wilson, 2008).

Perennial forage land often contains numerous grasses, legumes and forbs. This diversity creates habitat for many insect and animal pollinators. A study in northern Alberta examined wild bee populations, surrounding habitat and canola seed production (Morandin and Winston, 2006). They found that bee populations increased with weeds and uncultivated land around the fields. This uncultivated land then has value to pollination.

Native range, tame/seeded pasture and other perennial forage land remain uncultivated for long periods of time. They could be assumed to have the same value as the natural, uncultivated lands do to pollinators. Costanza et al. (1997) estimated that the value grass and rangelands had to pollinator services was $25 per hectare ($10.12 per acre) per year. Based on this estimate, **forage land in Alberta (11,548,089 hectares or 28,513,612 acres) has an estimated annual value of $288.7 million to pollinators**. It should be noted that acreage used in this calculation includes native range, tame/seeded pasture, forage harvested as seed, alfalfa and alfalfa mixtures and all other tame hay and fodder crops.

3.6 Honey Production

There were 670 honey producers in Alberta in 2010. They produced 28 million pounds, or just under 13 million kilograms, of honey. This represents 38% of Canada's total honey production (Statistics Canada, 2010). Perennial legumes are important sources of nectar and food for honey bees. Sainfoin, alfalfa and clover are considered to be major nectar and pollen producing plants (Graham, 2001). Even though honey bees tend to prefer available plants, such as dandelions, flowering forbs and trees and hybrid canola, as sources of nectar, approximately 5% of the total amount of honey produced in Alberta can be attributed to these forage legumes (Medhat Nasr, personal communication).

The estimated value of honey produced in the province was $46.2 million in 2010. If 5% of this can be attributed to forage legumes, then **the value of forages to honey production can be estimated at $2.3 million**. This value does not include the cost savings producers experience from honey bees using forages as a feed source (provides energy and nutrients needed for increases in honey bee population per colony). Nor does it include the value of honey produced from other plants, such as dandelions and flowering forbs, commonly found in native range and tame pastures. If these two values were included, it is likely the value of honey production attributed to forages would increase.

3.7 Current Carbon Sequestration

Perennial forage land has the ability to store carbon in the soil. An average of 1.1 tonnes of carbon per hectare per year (0.49 tons per acre), or 4.04 tonnes CO_2e (1.80 tons), was stored in a survey of land in the Conservation Reserve Program (CRP) in the United States (Gebhert et al., 1994). How forage land is managed can also influence the amount of carbon stored. Improved grazing management practices often improve plant growth, which can increase the amount of carbon added to the soil (Boehm et al., 2004).

Boehm et al. (2004) modeled the rate of carbon sequestration for land in the prairies based on different management practices. Both permanent cover and improved grazing management resulted in net gains of carbon in the soil. An average of 1.77 tonnes of CO_2e per hectare (0.79 tons per acre) per year was sequestered by permanent cover across the brown, dark brown, black and gray soil zones (Boehm et al., 2004).

Table 3.1 Current Estimated Carbon Sequestration Value from Forage Land in Alberta

	Sequestration Rate	
	Boehm et al., 2004	**Gebhert et al., 1997**
Area of Forage Land* (ha)	11,548,089	11,548,089
CO_2e Sequestration Rate (tonne/ha/yr)	1.77	4.04
Amount of CO_2e Sequestered (tonne/ha/yr)	20,440,118	46,654,280
Value of CO_2e ($/tonne)**	$9.00	$9.00
Potential Yearly Value ($)	$183,961,058	$419,888,516
Potential Yearly Value ($/ha)	$15.93	$36.36
Potential Yearly Value ($/ac)	$6.45	$14.71

* Based on sum of native range, tame/seeded pasture, forage seed, alfalfa and alfalfa mixtures and all other tame hay and fodder crops from Statistics Canada, 2006

**Based on Gilchrist, personal communication

The estimated value of the current forage acreage in relation to carbon sequestration ranges from $184.0 to $419.9 million (Table 3.2).This estimated value should be viewed carefully as research into carbon sequestration rates on forage land is ongoing. In addition, no protocols for carbon sequestration have been approved for use in Alberta's carbon market. Therefore, this should be regarded more as the potential value existing forage land in the province represents.

3.8 Other Ecological Goods and Services

There are numerous other EG&S that are provided by perennial forage land. Increasing and maintaining biodiversity, biological control of pests, food production and other recreational opportunities are some examples of these goods and services (Costanza et al., 1997). Soil formation, nutrient cycling and waste treatment can also be attributed to perennial forages/land in permanent cover (Costanza et al., 1997; Olewiler, 2004; Costanza et al., 2006). As there is no standard method for calculating the value of EG&S, only a few have been explored in-depth in this report.

3.9 Estimated Total Indirect Economic Value

Forages make a significant contribution to numerous ecosystem functions. They provide habitat and feed for wildlife, help maintain water quality, prevent erosion and sequester carbon. They provide EG&S that are important to the economic and social welfare of Albertans. **The estimated indirect, or non-market value, of these resources is between $537.4 and $2,245.7 million** (Table 3.2).

Many complex relationships between these EG&S and the role certain types of land play in creating and supporting them are not well understood (Olewiler, 2004). For example, the role native range plays in creating and preserving diversity in the ecosystem. This service may prove vital to increasing the resilience of the agriculture industry to handle changing climatic conditions and market variability. The contribution of native range to soil formation is another ecological service that is starting to be explored and have a value placed on it (Costanza et al., 1997; Wilson, 2008). Only a few EG&S that have been attributed to perennial forages (land in permanent cover) have been

Table 3.2 Estimated Total Indirect Economic Value from Forages in Alberta

	Value ('000 000 per year)
Erosion Control	$2.7 - $334.9
Water Quality	$15.5 - $107.9
Water Retention and Regulation	$21.6 - $118.6
Wildlife – consumptive use	$5.0 - $315.8
Wildlife – non-consumptive use	$17.4 - $621.7
Recreation Fishing	$0.2 - $35.9
Pollination Services	$288.7
Honey Production	$2.3
Carbon Sequestration	$184.0 - $419.9
Total	**$537.4 - $2,245.7**

included in the indirect value of Alberta's forage resources as a result of the uncertainty surrounding valuation of EG&S.

Some studies have grouped numerous EG&S together, and placed a total value for them on the associated land base. A report on the ecosystem services found that the total non-market value was $1,354 per hectare of native grasslands annually in the Great Plains of the United States (Wilson, 2009). Another study of ecosystem services conducted by the U.S. National Wildlife Refuge System estimated the value of $126.96 per hectare per year for grasslands providing waste water dilution/purification, habitat and erosion control services (Ingraham and Foster, 2008). These studies, and the values they give to perennial forage lands, only illustrate the diverse methodologies being used.

The passing of the *Alberta Land Stewardship Act* has opened the door to potential compensation for landowners who have land that provides EG&S. Through the Land-use Framework and resulting development of each regional plan, ecosystem services attributed to native range, perennial forages, and other cropland are being examined. The first region has already submitted its recommendations to the government for the final plan. The South Saskatchewan Regional Advisory Council (SSRAC) recommended that EG&S are "a valued and profit-generating part of the agricultural economy" (SSRAC, 2011). It appears that in the future the indirect benefits of forages in Alberta may be examined and valued.

4.0 Total Estimated Economic Value Generated by Forages in Alberta

The purpose of this report is to provide an overview of each sector of the forage industry and illustrate the overall importance of forages in Alberta. Forages play a role not only in generating economic value through the creation of marketable products, but also in the health of the environment. It is vital that both the estimated direct economic value and indirect value the forage industry generates for the province are recognized.

4.1 Estimated Direct Economic Value Generated by Forages

The forage industry in Alberta is extremely diverse and is composed of numerous sectors. This diversity strengthens the ability of the industry to handle market variability. Each sector makes an important contribution to the overall economic value of the industry.

The forage seed industry is concentrated in two main regions in the province; the south and the Peace. Alfalfa, red clover, sweet clover, timothy, creeping red fescue and smooth bromegrass are just a few of the perennial forage species grown for seed. The formation of two organizations (the Alfalfa Seed Commission and the Alberta Peace Region Seed Growers) has led to advances in research and development, marketing and promotion of this sector. Forage seed produced in the province is sold both domestically and internationally. Alberta is one of the top forage seed-producing regions in North America, supporting numerous other businesses. The production of alfalfa seed in southern Alberta supports the alfalfa leafcutter bee sector. This has allowed alfalfa seed producers there to produce and market two crops each year; alfalfa seed and alfalfa leafcutter bees.

Perennial grasses and legumes are sown and harvested as hay and silage on more than five million acres in the province. Hay can be divided up into different product classes: hay, compressed timothy hay and processed alfalfa cubes and pellets. Hay makes up the bulk of the ruminant ration over the winter. Its sale is not formally tracked, making valuation difficult. Most of the hay produced in the province remains on the farm of origin. Compressed timothy hay is produced for the export markets. Alberta is the largest exporter of this product in Canada. Similar to compressed timothy hay, alfalfa pellets and cubes tend to be exported with only a small amount sold domestically.

Forages are not only perennial grasses and legumes. Annual crops such as barley, oats, corn and even canola are commonly fed to livestock. Greenfeed and silage are important players in a livestock ration. Both can have high feed values, and can maintain this quality if properly stored. Straw is also a valued livestock feed. It is often used in winter rations. Although not quantified in this report, the use of grain chaff and after-harvest crop residue for grazing is also vital to numerous livestock producers.

The vast majority of forage acreage in the province is native range and tame/seeded pasture for grazing. Livestock producers across Alberta depend upon this land to supply feed to their herds and flocks during the growing season. Some of this land is owned by the crown and leased to producers, while the rest is privately owned. Private grazing land is either used by the landowner or rented out. Rental rates vary between regions and the services provided by the landowner. Pasture/grazing land is the second most valuable forage sector.

Forages are utilized in products for non-agricultural industries as well. Sod is sold to commercial and residential developers for landscaping or to make fairways on golf courses. Trail rides, guest ranches and hiking trails are just a few ag-tourism activities that utilize forage land in their execution.

These different forage sectors have a combined current estimated economic value of $1,557.0 to $1,600.8 million. Once the policy surrounding carbon offsets and trading is established for forages, there is the potential to add to this total.

4.2 Estimated Indirect Economic Value Generated by Forages

Forages do not solely produce marketable products; they also possess a number of attributes that benefit the environment and society at large. The relationship between these ecological goods and services (EG&S) and forage land needs to be recognized.

Perennial forages can decrease erosion and the movement of sediments and nutrients. Permanent ground cover protects the soil and keeps it from being redistributed due to the force of wind and water. Perennial forages can be seeded on the banks of riparian areas to stabilize the soil and keep sediments from moving into the water in run-off. Reducing erosion has the added benefit of preserving soil quality and productivity.

Perennial forages, such as native range, tame/seeded pasture and hayland, are integral to water quality and retention on the prairies. They have been documented as being able to improve and maintain soil quality through filtration and preventing sediment from moving from the landscape into bodies of water. Perennial forages also have the ability to increase water storage and retention in the field and in shallow aquifers.

Wildlife utilizes perennial forage land for a number of purposes. Wild ungulates graze tame pastures and native range, waterfowl nest in forages along riparian areas and a myriad of other organisms pass through or make their homes on forage land. This use trickles down into recreational activities such as hunting and wildlife viewing. Often hunters ask producers permission to hunt on their fields. Wildlife viewing trails can wind through open fields, while those interested in waterfowl wait in the grassy areas along lakes, marshes and rivers. Perennial forages contribute to the improvement of water quality in lakes by preventing erosion and sediment runoff. This helps maintain fish populations and, consequently, the sport-fishing industry.

Forages are an integral component in the life cycle of pollinators. They provide habitat, food sources and health services to the insects and animals involved in pollination. Through the retention of permanent cover, forages allow pollinators to function without harmful disturbances.

Carbon sequestration is another EG&S forages provide. Carbon is added to the soil through the decomposition of plant material and root growth. The rate of sequestration on tame pasture and native range can be increased by the adoption of certain management practices, such as managed grazing and fertilization. Discussions on carbon offset standards and protocols for perennial forages in Alberta are ongoing as carbon sequestration rates are still being quantified.

Taken together, these indirect goods and services provided by forages annually contribute an estimated $537.4 to $2,245.7 million to the provincial economy. As mentioned earlier, this value is not meant to be an indicator of policy or the absolute value Alberta's forage resources possess in relation to the creation and maintenance of certain EG&S. There are no current standardized methods of accounting for the EG&S provided by forages, or any other ecosystem (Maler et al., 2011). Ecosystems are dynamic and proper standard accounting will have to be carried out on a case by case basis, examining all relationships within each situation in the future (Maler et al., 2011). Other limits to calculating the indirect value generated by forages in Alberta include the availability of ecological information on the relationship between the land and the EG&S provided, data on the current status of different ecosystems and land and studies documenting the impact of human land use on ecosystem services (Wilson, 2009).

Not all EG&S that have been attributed to forages were examined, making this estimation conservative in nature. The value reported here should be considered to be a snapshot in time of what the estimated value potentially is, based on published research and case studies of similar situations.

4.3 Conclusion

Forages play a significant role in the economy and should be recognized for their contribution to economic growth and environmental health. **Based on the findings of this study, the total value generated by forages in Alberta annually is estimated to be between $2,094.4 and $3,846.5 million** (Table 5.1). This represents a combination of direct and selected indirect (EG&S) values. Selected, because production and financial research data for most EG&S are not readily available.

Table 4.1 Total Estimated Direct and Indirect Economic Value of Alberta's Forages

	Value(Millions)
Direct	$1,557.0 - $1,600.8
Indirect	$537.4 - $2,245.7
Total	**$2,094.4 - $3,846.5**

The forage values reported are gross values and do not take into account input costs associated with production. This should be kept in mind when comparing the value of forages reported here to the value of other agricultural commodities. In addition, statistics on the acreage, yield, production and price of certain forages and their products are not collected to the same extent as for cereal grain and oilseed crops. Much of the hay, silage and greenfeed produced in Alberta do not enter any formal marketing channel. Prices depend on regional yields, quality and feed availability. Pasture rental rates vary with services provided, and are only tracked by annual surveys. Prices and economic values have not been adjusted for inflation and represent the value in dollars for the year they are reported.

The valuation of EG&S is an emerging field. No standard method of calculating the value of these goods and services has been adopted by the scientific community, although numerous ones exist. The values reported in this study are based on a review of the literature for similar landscapes as well as case studies from across North America. A value range is often presented due to the variations found in the literature. There is also the potential for Alberta's forages to be valued for more EG&S than mentioned here.

This report was published to provide a general overview of the estimated current, and potential, value of Alberta's forage resources. It is the first study on the total value of forages in Alberta to consider both direct economic and environmental goods and services provided. It is not meant to be an exhaustive in-depth economic analysis of the forage industry, but to illustrate the general overall production and value of this industry. These findings can be used to further promote and support the forage industry in the province.

References

Aasen, A., V. Baron, B. Doig, T. Yurchak, G. Hutton, M. Eliason, W. Winchell, L. Erickson, and A. Macaulay. 2004. Silage Manual. Alberta Agriculture and Rural Development.

Adamowicz, W., J. Asafu-Adjaye, P. Boxall, and W. Phillips. 1991. Components of the Economic Value of Wildlife: An Alberta Case Study. Canadian Field-Naturalist. 105(3): 423-429.

Agriculture and Agri-Food Canada. 2001. Bi-Weekly Bulletin: Forage. Vol. 14(7).

Agriculture Financial Services Corporation. 2006 – 2010 Commodity Prices. http://www.afsc.ca/Default.aspx?cid=82&lang=1. Accessed February, 2011.

Agtech Centre. 2009. Building a Future for Biomass Combustion. Agtech Centre Innovator. 9(1). http://www1.agric.gov.ab.ca/$department/newslett.nsf/all/agin15177. Accessed May, 2011.

Alberta Agriculture and Rural Development. 2003. Ag Tourism Market Potential Assessment. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/apa7606. Accessed April, 2011.

Alberta Agriculture and Rural Development. 2004. Alternative Agricultural Markets in Alberta: An Overview. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/apa547/$FILE/ReportAlternativeAgMarkets2008FinalRevised.pdf. Accessed June, 2011.

Alberta Sustainable Resource Development. 2003. About Public Lands: Grazing Statistics for Public Land. http://www.srd.alberta.ca/MapsFormsPublications/Publications/documents/GrazingStatisticsPublicLand-Dec-2003.pdf. Accessed March, 2011.

Alberta Tourism, Parks and Recreation. 2010. Tourism Works for Alberta: The Economic Impact of Tourism in Alberta, 2008. http://www.tpr.alberta.ca/tourism/research/docs/EconomicImpactAlberta2008communications.pdf. Accessed April, 2011.

Alfalfa Seed Commission. 2011. 2010 Annual Report. http://www.alfalfaseedab.com/page25.php. Accessed May, 2011.

Baydack, R., J. Patterson, C. Rubec, A. Tyrchniewicz, and T. Weins. 1995. Management Challenges for Canadian Prairie Grasslands in the 21st Century. Pgs 386-396. Transactions of the Sixtieth North American Wildlife and Natural Resources Conference. Minneapolis, Minnesota.

Benoit, D. 1986. Alberta's Forage Sector: Development Opportunities and Constraints.

Boehm, M., B. Junkins, R. Desjardins, S. Kulshreshtha, and W. Lindwall. 2004. Sink potential of Canadian agricultural soils. Climate Change. 65: 297-314.

Bremer, E. 2008. Potential of Rangelands to Sequester Carbon in Alberta. Technical Scoping Document Prepared by Eric Bremer of SymBio Ag Consulting.

Bremer, E. 2009. Potential for Reduction in Greenhouse Gas Emissions from Native Rangelands in Alberta. Technical Scoping Document prepared by Eric Bremer of Symbio Ag Consulting for Alberta Agriculture and Rural Development.

Brierly, D. and B. Adams. 2001. Range and Pasture Management: Alberta Rangelands. Alberta Sustainable Resource Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag2111. Accessed March, 2011.

Bruce, J., M. Frome, E. Haites, H. Janzen, R. Lal, and K. Paustian. 1998. Carbon sequestration in soils. Proceedings of the Soil and Water Conservation Society's Carbon Sequestration in Soils Workshop, Calgary, AB, Canada.

Charbonneau, P. 2003. Sod Production. Ontario Ministry of Agriculture, Food, and Rural Affairs. http://www.omafra.gov.on.ca/english/crops/facts/info_sodprod.htm. Accessed March, 2011.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. O'Neill, J. Paruelo, R. Raskin, and P. Sutton, 1997. The value of the world's ecosystem services and natural capital. Nature. 387: 253-260.

Costanza, R., M. Wilson, A. Troy, A. Voinov, S. Liu, and J. D'Agostino. 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Gund Institute for Ecological Economics. Burlington, VT.

Crosby, J., M. Bradford, P. Mitchell, E. Prepas, L. McIntyre, L. Hart Buckland-Nicks, and J. Hanson. 1990. Atlas of Alberta Lakes. Eds. P. Mitchell and E. Prepas. The University of Alberta Press, Edmonton, AB.

Davis, S. and D. Duncan. 1999. Grassland songbird occurrence in native and crested wheatgrass pastures of southern Saskatchewan. Studies in Avian Biology. 19: 211-218.

Ducks Unlimited Canada. 2006. Natural Values: Linking the Environment to the Economy – Grasslands. http://www.ducks.ca/conserve/wetland_values/pdf/nv7_gra.pdf. Accessed November, 2011.

Econometric Research Limited. 2009a. Hunting in Alberta in 2008: Performance, Value and Socioeconomic Impacts Volume II.

Econometric Research Limited. 2009b. The Economic Benefits of Hunting and Fishing Activities in Alberta in 2008.

Environment Canada. 2000. The Importance of Nature to Canadians: The Economic Significance of Nature-Related Activities.

Feather, P., D. Hellerstein, and L. Hansen. 1999. Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP. Resource Economics Division, Economic Research Service, U.S Department of Agriculture. Agricultural Economic Report No. 778.

Gebhert, D., H. Johnson, H. Mayeux, and H. Polley. 1994. The CRP increases soil organic carbon. Journal of Soil and Water Conservation. 49(5): 488-452.

Gleason, R.A., M.K. Laubhan, and N.H. Euliss Jr. (eds). 2008. Ecosystem Services Derived From Wetland Conservation Practices in the United States Prairie Pothole Region with an Emphasis on the U.S. Department of Agriculture Conservation Reserve and Wetlands Reserve Programs. U.S. Geological Professional Paper 1745. Reston, Virginia.

Graham, L.J. 2001. Commercial Honey Industry. Ag-Ventures Agdex 616/830-1. Alberta Agriculture and Rural Development. Edmonton, AB.

Griffith, A., F. Epplin, S. Fuhlendorf, and R. Gillen. 2011. A Comparison of Perennial Polycultures and Monocultures for Producing Biomass for Biorefinery Feedstock. Agronomy Journal. 103(3): 617-627.

Hartman, M. 2008. Direct Seeding: Estimating the Value of Crop Residues. Agdex 519-25. Alberta Agriculture and Rural Development.

Ingraham, M.W. and S.G. Foster. 2008. The Value of Ecosystem Services Provided by the U.S. National Wildlife Refuge System in the Contiguous U.S. Ecological Economics. 67: 608-618.

Iwaasa, A. 2011. Does Pasture Management Affect the Environment? BCRC Research Review Facts. http://www.cattle.ca/media/file/original/956_Does_pasture_management_affect_the_environment.pdf. Accessed May, 2011.

Klein, A., B. Vaissiere, J. Cane, I. Steffan-Dewenter, S. Cunningham, C. Kremen, and T. Tscharntke. 2007. Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society Biological Sciences. 274: 303-313.

Koehler-Munro, K. 2010. Agriculture in the Alberta Carbon Market. Alberta Agriculture and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl11618. Accessed March 2011.

Larney, F., R. Izaurralde, H. Janzen, B. Olson, E. Solberg, C. Lindwall, and M. Nyborg. 1995. Soil erosion – crop productivity relationships for six Alberta soils. Journal of Soil and Water Conservation. 50(1): 87-91.

Ma, S. and S. Scott. 2011. Valuation of ecosystem services from rural landscapes using agricultural land prices. Ecological Economics. 70: 1649-1659.

MacAlpine, N., D. Engstrom, J. Kirtz, and S. Cooke. 1997. Beef Resources for Beef Industry Expansion in Alberta. Alberta Agriculture and Rural Development.

Magnan, M., C. Sheaffer, D. Wyse, N. Ehlke, and P. Reich. 2011. Native Perennial Grassland Species for Bioenergy: Establishment and Biomass Productivity. Agronomy Journal. 103(2): 509-519.

Maler, K-G., S. Aniyar, and A. Jansson. 2011. Accounting for Ecosystem Services as a Way to Understand the Requirements for Sustainable Development. PNAS. 105: 9501-9506.

Manitoba Agriculture, Food and Rural Initiatives. _. Switchgrass as a Biofuel: Is it Economically Feasible? http://www.gov.mb.ca/agriculture/crops/forages/bje01s01.html. Accessed March, 2011.

McCartney, D. and P.R. Horton. 1997. Canada's Forage Resources. International Grasslands Congress Proceedings.

McCartney, D., H.C. Block, P.L. Dubeski, and A.J. Ohama. 2006. Review: The composition and availability of straw and chaff from small grain cereals for beef cattle in Western Canada. Ca. J. Anim. Sci. 86:443-455.

McMaster, D., J. Devries, and S. Davis. 2005. Grassland bird nesting in haylands of southern Saskatchewan: landscape influences and conservation priorities. Journal of Wildlife Management. 69(1): 211-221.

Mensah, F., J. Schoenau, and S. Malhi. 2003. Soil carbon changes in cultivated and excavated land converted to grasses in east-central Saskatchewan. Biogeochemistry. 63: 85-92.

Morandin, L. and M. Winston. 2006. Pollinators provide economic incentive to preserve natural land in agroecosystems. Agriculture, Ecosystems, and Environment. 116: 289-292.

Nelson, J., J. Schoenau, and S. Malhi. 2008. Soil organic carbon changes and distribution in cultivated and restored grassland soils in Saskatchewan. Nutr Cycl Agroecosyst. 82: 137-148.

Nolan, S. and T. Goddard. 2010. Overview of Alberta's Agricultural Carbon Offset Trading System 2007 to 2009. Alberta Agriculture and Rural Development. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl13212. Accessed June 2011.

Office of Statistics and Information. 2011. Alberta Official Statistics. Government of Alberta. https://osi.alberta.ca/osi-content/Pages/Factsheets/AlbertaandCanadaRealGDPforAgricultureIndustries.aspx. Accessed November, 2011.

Olewiler, N. 2004. The Value of Natural Capital in Settled Areas of Canada. Ducks Unlimited and the Nature Conservancy of Canada. 36 pp.

Owens, R., and M. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Canadian Journal of Zoology. 51: 697-713.

Pagiola, S., K. von Ritter, and J. Bishop. 2004. Assess the Economic Value of Ecosystem Conservation. Environment Department Paper No. 101. The World Bank Environment Department.

Park, D. 2007. Sport Fishing in Alberta 2005: Summary Report from the Seventh Survey of Recreational Fishing in Canada. Alberta Sustainable Resource Development, Fisheries Management Branch. Edmonton, Alberta, Canada. 37pp.

Peace Region Forage Seed Association. 2011. Past Use of Levy Funds. http://www.peaceforageseed.ca/levy.html. Accessed May, 2011.

Podruzny, K., J. Devries, L. Armstrong, and J. Rotella. 2002. Long-term response of northern pintails to changes in wetlands and agriculture in the Canadian prairie pothole region. Journal of Wildlife Management: 66(4): 993-1010.

Prairie Farm Rehabilitation Administration. 2000. Prairie Agricultural Landscapes: A Land Resource Review. Agriculture and Agri-Food Canada.

Prairie Farm Rehabilitation Administration. 2003. Prairie Soils: The Case for Conservation. http://www.agr.gc.ca/pfra/pub/prairiesoils_e.htm. Accessed May, 2011.

Samson, R. 1991. Switchgrass: a living solar battery for the prairies. http://eap.mcgill.ca/MagRack/SF/Fall%2091%20L.htm. Accessed March, 2011.

Samson, R., S. Bailey, and C. Ho Lem. 2007. The Emerging Agro-Pellet Industry in Canada. http://www.reap-canada.com/online_library/feedstock_biomass/The%20Emerging%20Agro-Pellet%20Industry%20in%20Canada%20(Samson%20et%20al.,%202007).pdf. Accessed March, 2011.

Saskatchewan Forage Council. 2010. The Value of Saskatchewan's Forage Industry – A Multi-Level Analysis.

Selting, J. and L. Irby. 1997. Agricultural land use patterns of native ungulates in south-eastern Montana. Journal of Range Management. 50: 338-345.

Smith, W., R. Desjardins, and B. Grant. 2001. Estimated changes in soil carbon associated with agricultural practices in Canada. Canadian Journal of Soil Science. 81: 221-227.

Sokhansanj, S., S. Mani, M. Stumborg, R. Samson, and J. Fenton. 2006. Production and distribution of cereal straw on the Canadian prairies. Canadian Biosystems Engineering. 48(3): 39-46.

South Saskatchewan Regional Advisory Council. 2011. Advice to the Government of Alberta for the South Saskatchewan Regional Plan. http://landuse.alberta.ca/AboutLanduseFramework/LUFProgress/documents/SSRP%20RAC%20Document%20Mar%2016%202011%20layout_FINAL.pdf. Accessed June, 2011.

Statistics and Data Development Branch. 2002. Alberta 2002 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2003. Alberta 2003 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2004. Alberta 2004 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2005. Alberta 2005 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2006a. Agri-Food Statistics Update: January 1, 2006 Livestock Inventory Estimates – Alberta/Canada. Issue No. 100. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2006b. Alberta 2006 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2007a. Agri-Food Statistics Update: January 1, 2007 Livestock Inventory Estimates – Alberta/Canada. Issue No. LS07-1. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2007b. Alberta 2007 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2008. Alberta 2008 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2009a. Agri-Food Statistics Update: January 1, 2009 Livestock Inventory Estimates – Alberta/Canada. Issue No. LS09-01. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2009b. Alberta 2009 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2010a. Agriculture Statistics Yearbook 2009. Agdex 853-10. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2010b. Agri-Food Statistics Update: January 1, 2010 Livestock Inventory Estimates – Alberta/Canada. Issue No. LS10-01. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2010c. Alberta 2010 Specialty Crop Report. Alberta Agriculture and Rural Development.

Statistics and Data Development Branch. 2011. Agri-Food Statistics Update: Alberta 2009 Farm Income and 2010 First Quarter (January to March) Farm Cash Receipts. Issue No: FI10-2. Alberta Agriculture and Rural Development.

Statistics Canada. 2006. 2006 Census of Agriculture. http://www.statcan.gc.ca/ca-ra2006/index-eng.htm. Accessed January, 2011.

Statistics Canada. 2008. Forage Statistics. http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1174494927045&lang=eng. Accessed March, 2011.

Statistics Canada. 2010. Service Bulletin: Production and Value of Honey and Maple Products. Catalogue no. 23-221-X. 6pp.

Statistics Canada. 2011. Cattle Statistics. Catalogue no. 23-012-X.

Su, C. 2011. Alberta 2010 Greenfeed and Silage Production Survey Results. Alberta Agriculture and Rural Development.

Toogood, J. 1963. Water Erosion in Alberta. Journal of Soil and Water Conservation. Nov-Dec: 238-240.

Tremblay, M. 2008. Alfalfa Production for the Dehy Industry. Saskatchewan Ministry of Agriculture.

Valentine, J.F. 1990. Grazing Management. Academic Press Inc.

Wark, D., W. Poole, R. ArnottL. Moats, and L. Wetter. 1995. Revegetating with native grasses. Ducks Unlimited Canada, Oak Hammock March, MB.

Wilson, S. 2008. Ontario's Wealth, Canada's Future: Appreciating the Value of the Greenbelt's Eco-Services. The David Suzuki Foundation.

Wilson, S. 2009. The Value of BC's Grasslands: Exploring Ecosystem Values and Incentives for Conservation. Grasslands Conservation Council of British Columbia. 43pp.

Wong, D. 2011. Marketing Timothy and Other Compressed Hay. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis11075. Accessed June, 2011.

Wong, D. and C. Yoder. 2010. Forage Seed Trade Companies Active in the Peace Region – January 2010. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis10048. Accessed May, 2011.

Appendix A. Consultations

Alberta Forage Industry Network.

Calvin Yoder, Forage Seed Crops Agrologist, Food and Bio-Industrial Crops Branch, Alberta Agriculture and Rural Development.

Dr. Carlyle Ross, Senior Economist, Policy Development Division, Agriculture and Agri-Food Canada.

Carmen Andrew, Organization Development Specialist, Local/Domestic Market Expansion Branch, Alberta Agriculture and Rural Development.

Chuanliang Su, Crop Statistician, Statistics and Data Development Branch, Alberta Agriculture and Rural Development.

Danielle Gabruck, Agrologist, Rangeland Management Branch, Alberta Sustainable Resource Development.

David K. Wong, Market Specialist, Ag-Info Centre, Alberta Agriculture and Rural Development.

Delores Serafin, Project Coordinator, Local/Domestic Market Expansion Branch, Alberta Agriculture and Rural Development.

Don McLennan, Board Member and Chair, Alberta Forage Industry Network.

Fred Hays, Policy Analyst, Alberta Beef Producers.

Graham Gilchrist, Assistant Farmers' Advocate Rural Affairs, Office of the Farmers' Advocate, Alberta Agriculture and Rural Development.

Grant Lastiwka, Forage/Grazing/Beef Specialist, Ag-Info Centre, Alberta Agriculture and Rural Development.

James Calpas, Branch Head, Crop Business Development Branch, Alberta Agriculture and Rural Development.

Lauren Makowecki, Resource Data Biologist, Licensing and Resource Data, Alberta Sustainable Resource Development.

Lorne Fitch, Provincial Riparian Specialist, Cows and Fish, Alberta Riparian Habitat Management Society.

Lyndon Mansell, Cow/Calf Council, Alberta Beef Producers and Board Member, Alberta Forage Industry Network.

Manitoba Forage Council.

Marion Harry, Research Assistant, Statistics and Data Development Branch, Alberta Agriculture and Rural Development.

Medhat Nasr, Provincial Apiculturist, Pest Surveillance Branch, Alberta Agriculture and Rural Development.

Michelle Gietz, General Manager. Alfalfa Seed Commission.

Ross Hutchison, Branch Manager, Ag-Info Centre, Alberta Agriculture and Rural Development

Saskatchewan Forage Council.

Statistics and Data Development Branch, Alberta Agriculture and Rural Development.

Ted Nibourg, Farm Management Specialist, Ag-Info Centre, Alberta Agriculture and Rural Development.

Terry Kosinski, Head, Resource Integration and Planning, Alberta Sustainable Resource Development.

Weldon Hobbs, Member, Alfalfa Seed Commission and alfalfa leafcutter bee broker.

Appendix B. Supplementary Data Tables

Table B.1 Production and Farm Value Averaged from 2004 to 2009 for Five Annual Crops and Tame Hay

Crop	Production ('000 tons)	Farm Value ($/ton)
All Wheat	8,393.38	$164.02
Oats for Grain	705.50	$124.87
Barley for Grain	5,448.84	$131.22
Canola	3,836.39	$330.31
Dry Peas	686.55	$158.12
Tame Hay	8,864.16	$71.52

Source: Statistics and Data Development Branch, AARD 2010a

Table B.2 Tame Hay Hectares, Production, and Pricing in Alberta

	Seeded Hectares	Harvested Hectares	Yield (tonnes/ hectare)	Production (tonnes)	Farm Price ($/tonne)
2000	2,468,636	2,306,758	2.5	5,556,500	$83.50
2001	2,670,983	2,134,763	5.0	4,309,100	$101.31
2002	2,670,983	2,023,472	1.6	3,039,100	$135.79
2003	2,630,514	2,509,106	2.5	6,395,700	$119.93
2004	2,630,514	2,387,697	3.1	7,393,600	$83.68
2005	2,579,927	2,235,937	3.8	8,754,300	$73.57
2006	2,525,538	2,205,585	3.6	8,142,000	$65.83
2007	2,525,293	2,260,219	4.0	9,276,000	$67.58
2008	2,509,106	2,260,219	4.0	9,344,000	$77.49
2009	2,509,106	2,029,543	2.7	5,352,400	$105.60
2010	2,498,988	2,282,477	4.0	9,162,600	$112.76
Average	**2,565,417**	**2,239,616**	**3.1**	**6,975,027**	**$ 93.37**

Source: Statistics and Data Development Branch, 2010a, and Su, personal communication, 2011

Table B.3 Total Greenfeed Production and Value

	Harvested ('000 acres)	Average Yield (ton/ac)*	Production ('000 tons)	Average Price ($/ton)**
2006	600	2.88	1,725	$40.00
2007	430	2.72	1,171	$44.00
2008	335	2.88	964	$48.00
2008	1,235	1.92	2,369	$66.00
2010	575	3.33	1,914	$70.00
Average	**635**	**2.75**	**1,629**	**$53.60**

Source: Su 2011

*Yields and production reported on a wet weight basis

**Average price from AFSC Commodity Price lists (monthly prices averaged within region and then across regions)

Table B.4 Silage Corn Production and Value in Alberta

	Harvested ('000 acres)	Average Yield (ton/ac)*	Production ('000 tons)	Average Price ($/ton)**
2006	55,000	21.0	1,049,655	$24.67
2007	50,000	20.4	924,688	$29.57
2008	40,000	17.4	629,793	$28.66
2008	60,000	19.1	1,034,668	$32.52
2010	50,000	16.5	749,801	$32.47
Average	**51,000**	**18.9**	**877,721**	**$29.58**

Source: Statistics Canada and the Statistics and Data Development Branch, AARD, personal communication, 2011

*Yields and production reported on a wet weight basis

**Average price from AFSC Commodity Price lists (monthly prices averaged within region and then across regions)

Table B.5 Total Silage Production and Value (for annual crops other than corn)

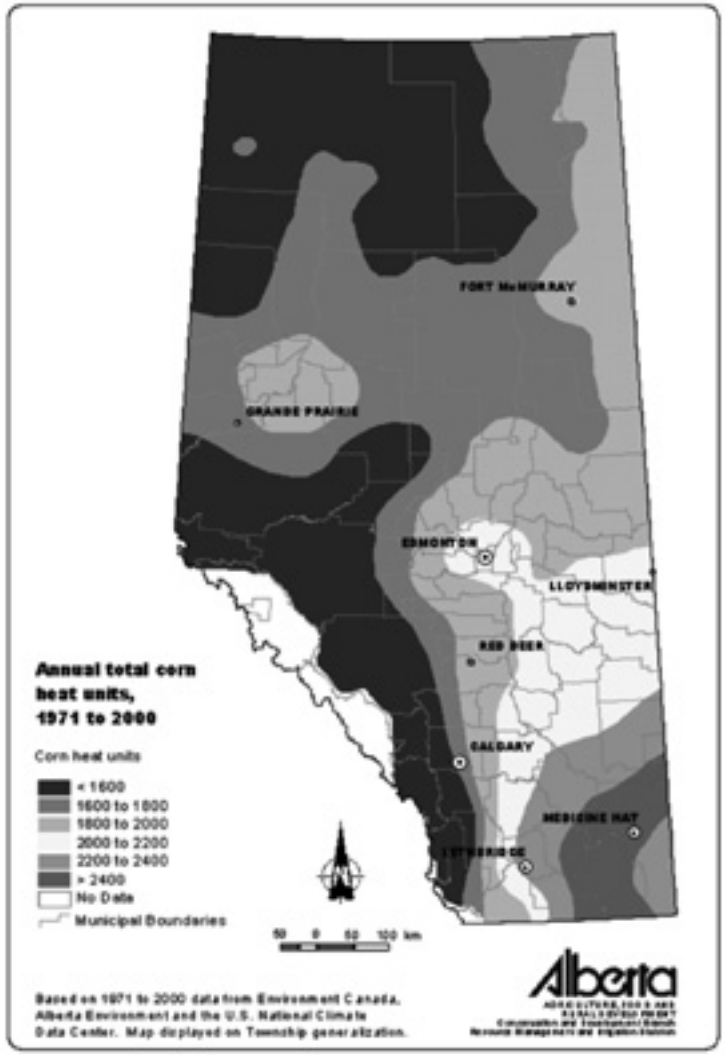
	Harvested ('000 acres)	Average Yield (ton/ac)*	Production ('000 tons)	Average Price ($/ton)**
2006	800	6.41	5,135	$24.67
2007	550	6.22	3,415	$29.57
2008	435	6.53	2,845	$28.66
2008	945	4.03	3,813	$32.52
2010	570	7.61	4,337	$32.47
Average	**660**	**6.16**	**3,909**	**$29.58**

Source: Su, 2011

*Yields and production reported on a wet weight basis

**Average price from AFSC Commodity Price lists (monthly prices averaged within region and then across regions)

Appendix C. Corn Heat Units in Alberta



Appendix D. Area and Gross Drainage Area for Sport-fishing Lakes in Alberta

Table D.1 Area and Gross Drainage Area for Sport-Fishing* Lakes/ Reservoirs in the Parkland and Prairie Areas of Alberta

	Area** (km^2)	Drainage Area*** (km^2)	Forage Area (km^2) 10%	Forage Area (km^2) 25%
Blood Indian Creek Reservoir	0.9	116	11.6	29.0
Buffalo Lake	89.9	1,440	144.0	360.0
Chain Lake Reservoir	3.21	209	20.9	52.3
Coal Lake	0.6	1,250	125.0	312.5
Crawling Valley Reservoir	1.8	802	80.2	200.5
Driedmeat Lake	0.1	7,220	722.0	1,805.0
Eagle Lake	11.6	120	12.0	30.0
Glennifer Lake	16.6	5,610	561.0	1,402.5
Glenmore Reservoir	–	1,210	121.0	302.5
Gull Lake	81.1	206	20.6	51.5
Little Fish Lake	–	157	15.7	39.3
McGregor Lake	0.21	993	99.3	248.3
Milk River Ridge Reservoir	13.6	168	16.8	42.0
Lake Newell	62.1	85	8.5	21.3
Pine Lake	4.05	150	15.0	37.5
St. Mary Reservoir	31.6	2,250	225.0	562.5
Sylvan Lake	42.2	102	10.2	25.5
Travers Reservoir	22.4	4,230	423.0	1,057.5
Tyrell Lake	3.8	122	12.2	30.5
Total	**385.77**	**26,440**	**2,644**	**6,610.0**

*Sport-fish bearing lakes include the following fish species: Brown Trout, Rainbow Trout, Cutthroat Trout, Brook Trout, Lake Trout, Bull Trout, Golden Trout, Mountain Whitefish, Cisco, Lake Whitefish, Arctic Grayling, Walleye, Sauger, Yellow Perch, Northern Pike, Goldeye, Burbot, Mooneye, Lake Sturgeon, Bull Trout x Brook Trout Hybrid, Cutthroat Trout x Rainbow Trout Hybrid

**Source: Makowecki, personal communication

***Source: Atlas of Alberta Lakes, Crosby et al. 1990

1 km^2 = 247 ac

Table D.2 Area and Gross Drainage Area for Sport-Fishing Lakes/ Reservoirs in Boreal Area of Alberta Cleared for Agriculture

	Area* (km^2)	Drainage Area** (km^2)	Forage Area (km^2) 10%	Forage Area (km^2) 25%
Buck Lake	25.3	233	23.3	58.3
Ethel Lake	4.9	542	54.2	135.5
Hastings Lake	7.9	269	26.9	67.3
Isle Lake	22.7	246	24.6	61.5
Lac La Nonne	12.9	277	27.7	69.3
Muriel Lake	69.0	384	38.4	96.0
Pigeon Lake	97.3	187	18.7	46.8
Lac St. Anne	56.6	619	61.9	154.8
Wabamum Lake	79.1	256	25.6	64.0
Winagami Lake	45.9	221	22.1	55.3
Total	**421.6**	**3234**	**323.4**	**808.5**

*Source: Makowecki, personal communication

**Source: Atlas of Alberta Lakes, Crosby et al. 1990

1 km^2 = 247 ac