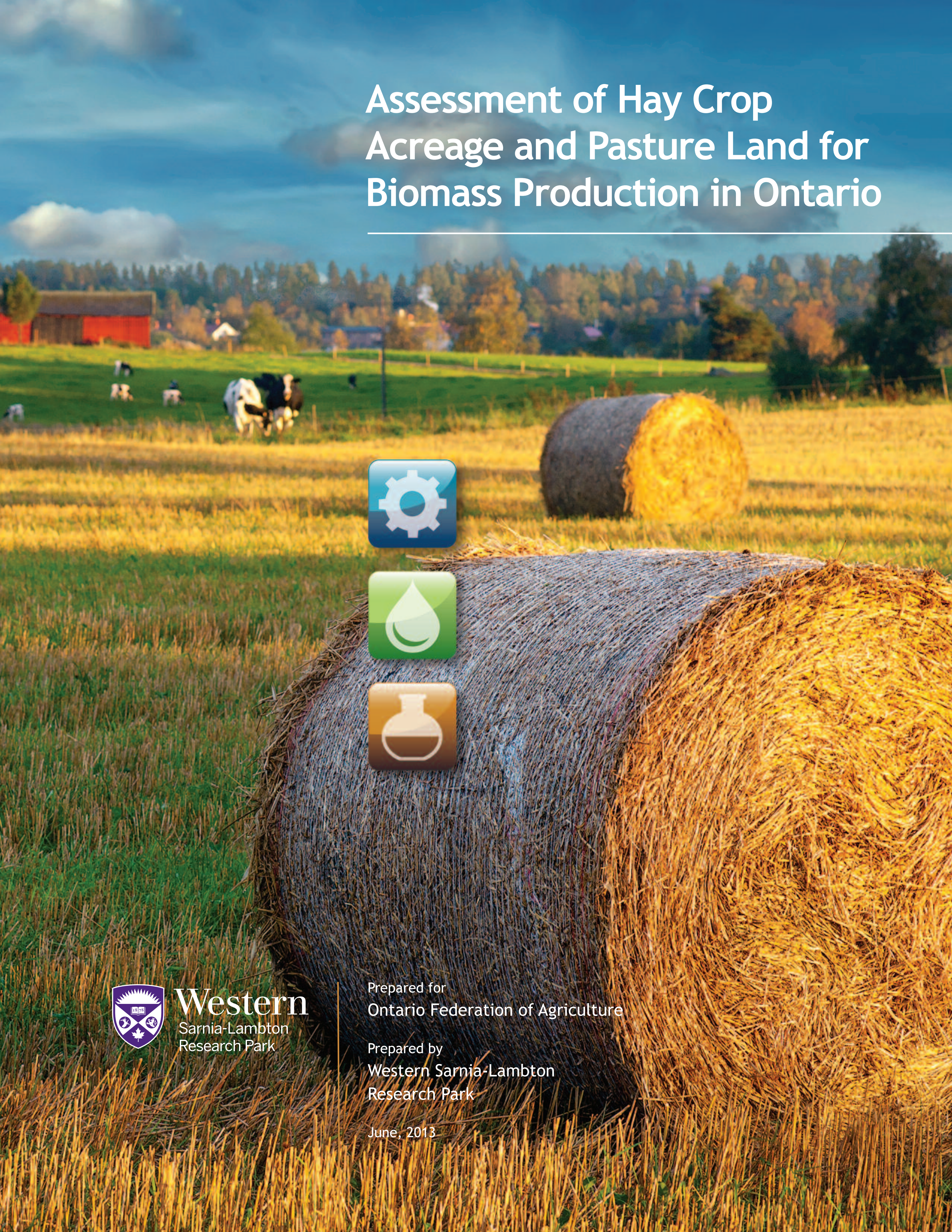
Assessment of Hay Crop Acreage and Pasture Land for Biomass Production in Ontario



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Prepared for
Ontario Federation of Agriculture

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Table of Contents

Preface 5

Executive Summary 6

1. Overview of Agricultural Sector and Land Use Changes in Ontario 8
   - 1.1 Ontario Agricultural Sector and Cattle Industry....................................8
   - 1.2 Improvement in Grain Prices and Land Use Changes 10
   - 1.3 Options for Hay Crops and Pasture Land 11

2. Estimation of Surplus Hay Crop Acreage and Pasture Land............................14
   - 2.1 Agricultural Land Productivity 14
   - 2.2 Productivity of Agricultural Land in Ontario Regions..................................15
   - 2.3 Hay Crops and Pasture Land in Ontario Regions..................................16
   - 2.4 Estimates of Surplus Hay Crop Acreage and Pasture Land 17
   - 2.5 Potential Biomass Production 19

3. Economics of Biomass Production from Hay Acreage and Pasture Land 20
   - 3.1 Major Crops and Net Margins................20
   - 3.2 Economics of Biomass Crops 23
   - 3.3 Comparison of Cash Crops and Perennial Biomass 26

4. Assessment of Emerging Bio-Processing Industries..............................28
   - 4.1 Biomass Applications.............................28
   - 4.2 Bio-Energy...29
   - 4.3 Bio-Fuels and Bio-Chemicals..................31
   - 4.4 Bio-Materials 33
   - 4.5 Evaluation of Emerging Bio-Processing Industries 36

5. Summary, Conclusion and Recommendations...38
   - 5.1 Summary of Findings and Conclusion 38
   - 5.2 General Recommendations 41

References..43

Appendices...44


COMPOSITES
FUELS
CHEMICALS

Preface

In 2010, the Ontario Federation of Agriculture (OFA) received funding from Agriculture and AgriFood Canada through the Canadian Agricultural Adaptation Council to conduct producer level research and value chain determination in support of commercializing agricultural biomass into energy and co-products.

The study "Assessment of Hay Acreage and Pasture Land for Biomass Production in Ontario" was developed as a foresight tool for the benefit of agricultural producers. With competing land uses in agriculture and with the need to provide biomass in the future, knowing where additional biomass crops can be produced in Ontario is crucial. On one hand, biomass availability close to existing end users is important. On the other hand, as the bio-economy develops, this study will help situate appropriate regions where new investments may be more feasible.

The information provided in the report will provide a greater understanding of the opportunities for agricultural biomass use in Ontario. The report also identifies the geographical areas and potential for biomass production. The report concludes that in addition to crop residues, Ontario can produce biomass at scale sufficient to support several industrial applications. Since the areas suitable for biomass production are located in central, eastern and northern Ontario, a unique opportunity to positively affect rural development in these regions exists. The southwestern region of Ontario has crop residue opportunities to sustain industrial development.

The study was guided by an advisory group that provided valuable comments to the authors. The authors would like to thank the following OFA Directors and Executive members as well as OFA staff:

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Aung Oo

Charles Lalonde

Executive Summary

The utilization of surplus hay crop acreage and pasture land in Ontario for biomass production is assessed in this study. The declining cattle industry and improvement in grain prices have led to land use changes in the province. Some hay and pasture land have been converted to annual cash crops such as grain corn, soybeans and winter wheat. However, hay acreage and pasture land are under utilized in some Ontario regions since the conversion to cash crops are economically unfavourable in those areas. The surplus hay and pasture land are estimated based on the land use comparison for the cattle industry in Ontario regions. The economics of biomass crops, miscanthus and switchgrass are also investigated in this study. The net margins of traditional cash crops in Ontario are then compared with that of biomass crops for different grain price scenarios and land classes. Major land use conversion scenarios for biomass from hay and pasture land are explored. The emerging bio-processing industries are reviewed and evaluated as potential end-users of biomass from hay and pasture land.

The decline in the number of cattle by 23.8% in 15 years, from 2.29 million in 1996 to 1.74 million in 2011, has considerable effects on crop rotation, management of hay and pasture land, and crop mix in Ontario. Hay, which used to be the largest crop in Ontario, is usually grown as a perennial crop for 3-4 years before requiring tillage and re-seeding. Agricultural producers prefer to grow hay in crop rotation with other grain crops since the perennial nature of hay crops improves soil significantly. However, inclusion of hay in the crop rotation is no longer feasible in some areas due to the decreasing number of cattle. Improvement in grain prices in recent years has accelerated the conversion of hay and pasture land to annual cash crops rather than leaving such land in an unproductive state. In 2006-2011, approximately 485,000 acres of hay crops were converted to cash crops and this trend continues. The most productive hay and pasture land in Southern and Western Ontario agricultural regions has been converted to cash crops due to favourable economics. Perennial crops offer better environmental attributes for soil by reducing erosion, increasing soil tilt, improving water retention, etc.

The estimated surplus hay acreage and pasture land in Ontario is 864, 000 acres, and the largest acreage is located in the central and eastern region with approximately 323,000 acres and 298,000 acres, respectively. Total annual biomass production potential from the surplus hay crop acreages and pasture land in Ontario is estimated at 3.3 million tonnes. The northern region also offers 218,000 acres of surplus hay and pasture land. However, more research and field data are required for the agronomics and yields of biomass crops in the northern region before considering conversion to purpose grown biomass crops. Compared with the central and eastern regions, there are relatively fewer surplus hay crops and less pasture land in the southern and western regions due to increased grain production. However, the continued high grain prices could experience result in additional displacement of cattle from the southern and western regions to other regions where cash cropping is not as profitable. The authors estimate that an additional 10% drop in the number of cattle would result in an additional 40,000 acres of land available for conversion to cash crops or biomass crops in the southern region and 113,000 acres in the western region.

The acceptable price of biomass ranges from \$100/acre to \$140/acre at the farm gate, depending on crop types, land classes, and competing grain prices. The net margins of perennial biomass crops, miscanthus and switchgrass, are estimated for different land classes and biomass prices using the spreadsheet models developed and reported in the OFA Business Case Study. On class 3 land, the net margins of miscanthus at the farm gate are $174.6/acre and $34.6/acre for biomass valued at $120/tonne and $100/tonne, respectively. On the same land class, the biomass price for switchgrass is estimated at $120/tonne to achieve a positive net margin. On class 4 & 5 land, the net margins of switchgrass are $115.5/acre and $43.3/acre for the farm gate biomass price of $140/tonne and $120/tonne, respectively. Ontario agricultural producers will not be persuaded to grow perennial biomass crops on a large scale unless the net margins of biomass crops are comparable to that of major field crops. At grain corn prices of $6/bushel, the approximate acceptable price of biomass is $120/tonne on class 1-3 lands. If the price of grain corn improves to $7/bushel, the equivalent price for biomass should be approximately $140/tonne.

Bio-composites, bio-chemicals, and liquid bio-fuels are the most promising emerging bio-processing industries with the potential to create markets for perennial biomass crops produced on surplus hay and pasture land. Emerging bio-processing industries are evaluated based on their need in accessing perennial biomass feedstock produced in Ontario. The evaluation parameters used to assess are: technology maturity, profitability, economic development potential, competition with substitutes, niche market existence, regulatory and institutional support, and existing value chain infrastructure. The major strengths of bio-composites industry include technological maturity and competition with substitutes. The demand from building construction material in the most populated province can become very significant in the future. With its large automotive industry, there is also plenty of opportunity in Ontario to develop bio-products for this sector. The superior properties of light weight and better insulation offered by agricultural biomass create competitive cost advantages over other substitutes.

The existing value chain and infrastructure in place of the petroleum and chemical industries in Ontario offer important advantages for the development of emerging bio-chemical and bio-fuel industries. The well-established petro-chemical industry in Ontario can provide synergies with its fossil fuel based assets to reduce the required capital investments to develop bio-processing facilities. There is also a potential for integrating biomass residual feedstocks from bio-materials or bio-fuels/chemical industries in combined heat and power generation facilities. This integration could not only improve the economics of energy generation from biomass but also allow the cascade use of biomass.

Due to their infancy, all emerging bio-processing industries require a certain level of regulatory and institutional support to accelerate commercialization. Regulatory support can include government procurement initiatives for bio-base products, risk-sharing mechanisms, and research and development grants for the emerging industries. Partnership between industries and universities/research institutions is essential in the development of bio-processing industries. Governmental support through appropriate policies for risk sharing is recommended to maximize the economic value of surplus hay and pasture land in Ontario by producing perennial biomass to support bio-processing industries. Comprehensive biomass field research trials on agronomic considerations and yield should be performed for low productivity farm land in Ontario. The potential productivity improvement in hay crops should be investigated. This improvement would increase surplus hay acreage and pasture land for biomass production.

Chapter 1 - Overview of Agriculture Sector and Land Use Changes in Ontario

The agricultural sector in Ontario has been an important economic pillar. It provides over 200 commodities such as grains, beans, dairy products and meat produced in Ontario for human consumption. It also supplies feedstocks for various industries to manufacture bio-fuels, bio-chemicals, bio-materials and other bio-based consumer products. The declining cattle industry in Ontario in recent years has led to some land use changes. Hay used to be the largest crop in Ontario, providing feed for the cattle industry. More and more farm lands are now used to grow row crops due to improved grain prices. In this chapter, an overview of major crops and land use changes in Ontario are presented. Options for hay crop land and pasture land for perennial crop production as part of potential crop rotation systems are explored.

1.1 Ontario Agricultural Sector and Cattle Industry

Ontario is one of the major agricultural provinces in Canada and home to approximately 50% of Canada's agricultural Class 1 land. Ontario is the largest producer of grain corn and soybeans, about 65% and 75% of Canadian totals, respectively (Statistics Canada, 2011). The four largest field crops in Ontario are soybeans, hay, grain corn and winter wheat, collectively representing approximately 80-90% of total crop land. Other crops include barley, fodder corn, sugar beet, spring wheat, beans, oats, rye, tobacco, canola and others. Table 1.1 gives the acreages of major and other crops and total farm land in Ontario compiled from the agricultural census data.

There is a gradual decline in total farm land, 8.7% in 1996-2011, likely due to urbanization in Ontario. However, total crop land remains relatively the same, a slight increase of 1.7% from 1996 to 2011. Total farm land includes crop land, pasture land, Christmas tree area, woodlands, wet lands and other areas such as storage, livestock buildings, etc. The census data suggest that the farming activities related to growing crops in Ontario have been steady over the past 15 years.

Livestock farming is equally as important as growing crops in Ontario agricultural sector. The agricultural census in 2011 indicates that total market receipts of top commodities from Ontario's farms are $10.2 billion. Approximately 50% of total market receipts is from livestock

Table 1.1 Acreages of Major Crops and Total Farm Land in Ontario

Crop/Land	1996	2001	2006	2011	% Change (1996-2011)
Hay	2,515,846	2,504,026	2,562,637	2,077,911	-17.41
Soybeans	1,918,055	2,248,466	2,155,884	2,464,870	28.51
Grain corn	1,895,650	2,003,025	1,577,862	2,032,356	7.21
Winter wheat	719,498	545,380	1,028,476	1,100,003	52.88
Other crops	1,691,063	1,713,856	1,680,101	1,213,051	-28.27
Total crop land	8,740,112	9,014,753	9,004,960	8,888,191	1.69
Total farm land	13,879,565	13,507,357	13,310,216	12,668,236	-8.73

Source: Agricultural Census

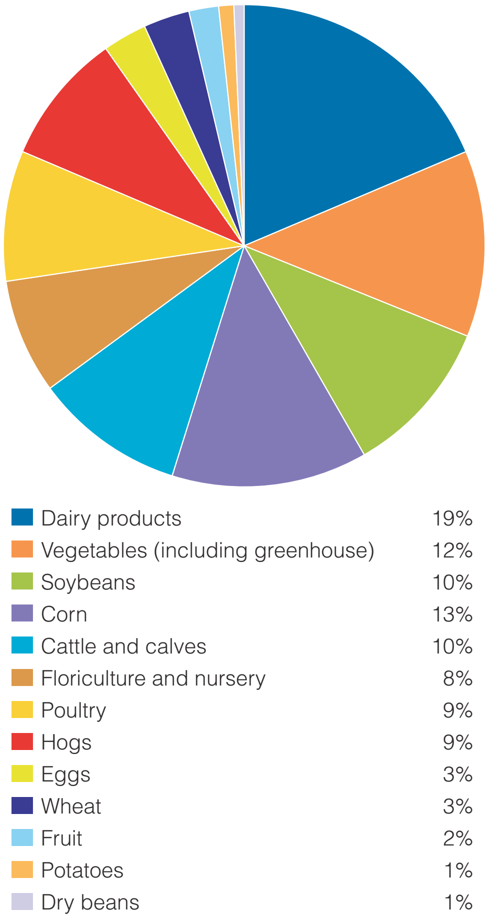

Figure 1.1 Shares of Top Commodities in Total Market Receipts in Ontario

(Source: Agricultural Census)

farming (see Figure 1.1). Dairy and beef farms, the largest proportion of farm operations in the province, represent about 60% of total livestock market receipts.

The cattle industry in Ontario has been declining due to the changing diet of the general population, trade impacts following the BSE crisis limiting export market access and from protectionist labelling requirements in the US. The total number of cattle in Ontario decreased from 2.29 million in 1996 to 1.74 million in 2011 as shown in Figure 1.2. This decline of 23.8% in 15 years has a considerable effect on crop rotation, management of hay and pasture land, and the crop mix in the province.

It is a typical practice that crops are grown in rotation largely for three reasons: to maintain yields, to control pests and to maintain soil quality. If one crop is grown continuously, pests and diseases related to that crop can become established in the soil over time. Crop rotation usually reduces the population level of a particular type of pest. Another benefit of crop rotation is the control of tough weeds by breaking its growth cycle. Crop rotation improves the health of soil by adding nutrients. Hay, one of the largest crops in Ontario, is usually grown as a perennial crop for 3-4 years. Farmers prefer to include hay in the crop rotation since the perennial nature of hay crops improves soil significantly. However, inclusion of hay in the crop rotation is no longer feasible in some areas due to the decreasing number of cattle.

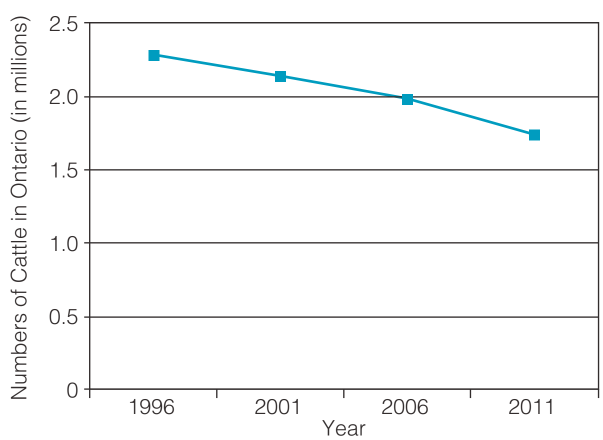

Figure 1.2 Number of Cattle in Ontario

(Source: Agricultural Census)

1.2 Improvement in Grain Prices and Land Use Changes

Ontario farmers have been experiencing a gradual improvement in grain prices in recent years, starting from 2005-2006. Industry experts believe that the growth of the middle class in emerging economies has contributed to this global price increase of agricultural commodities. The OECD-FAO Agricultural Outlook 2011-2020 forecasted that grain prices would continue to improve. Figure 1.3 shows the trend for grain prices of Ontario major cash crops, namely soybeans, grain corn and wheat. Ontario agricultural producers grow hay crops for their own cattle and export surplus quantities. Although hay is not a commodity like cash crops, a small percentage of hay is traded internally in the province or exported to the US. Figure 1.4 compares the price increase of hay with that of cash crops.

As indicated in Figure 1.4, the percentage increase in the price of hay is comparable to that of other cash crops. However, the declining number of cattle and the increasingly better margins of growing cash crops in some regions have accelerated significant negative changes in hay and pasture land use in Ontario. The price of hay was abnormally high in 2012 due to droughts in some US and Ontario regions. Hay was trading as high as $400/tonne in 2012 as opposed to the normal price of $120-180/tonne. However, this unusual high price of hay in 2012 could be considered as a remote event.

The changes in cash crop acreages, hay and pasture land, and the numbers of cattle in Ontario from 1996 to 2011 are graphically exhibited in Figure 1.5. Pasture land has declined in parallel with the number of cattle in Ontario. However, hay acreages were relatively stable from 1996 to 2006. This was likely because conversion of hay land to cash crops was financially unattractive at relatively lower grain prices in the 1996-2006 period. A significant decline in hay acreages was observed from 2006

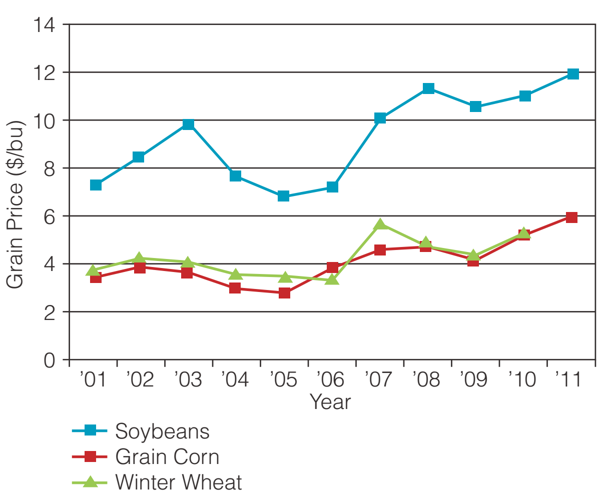

Figure 1.3 Trends of Grain Prices for Ontario Major Cash Crops

(Source: OMAF Statistics)

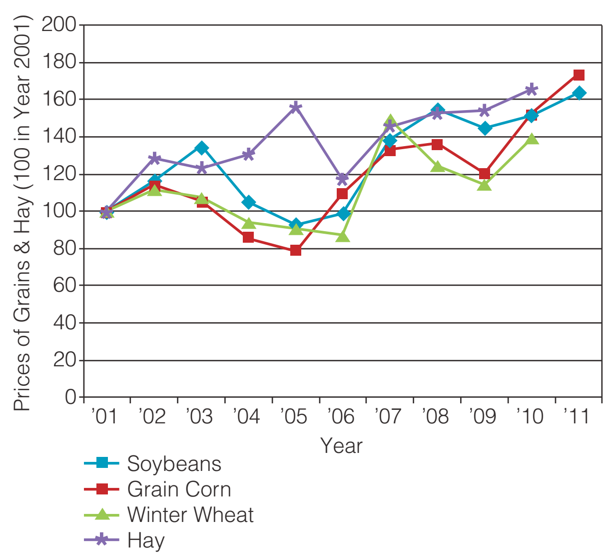

Figure 1.4 Comparison of Price Increases for Hay and Cash Crops

(Source: OMAF Statistics)

to 2011, coinciding with noticeable jumps in cash crops, especially soybeans and grain corn. The improvement in grain prices starting from 2005-2006 has likely contributed to these changes in agricultural land use in Ontario.

In 2006-2011, approximately 485,000 acres of hay crops were converted to cash crops. The grain corn experienced an increase of 455,000 acres, the largest in 2006-2011 period. Soybeans and winter wheat acreages also increased by 380,000 acres while a decrease in other crops was estimated at 467,000 acres. Communication with Ontario farmers during this study suggested that most productive hay and pasture land have been converted to cash crops due to favourable economics, especially in Southern and Western Ontario agricultural regions. When compared to row crops, the perennial nature of hay and pasture land offer better environmental attributes such as improving soil, preventing erosion, using fewer chemicals, etc.

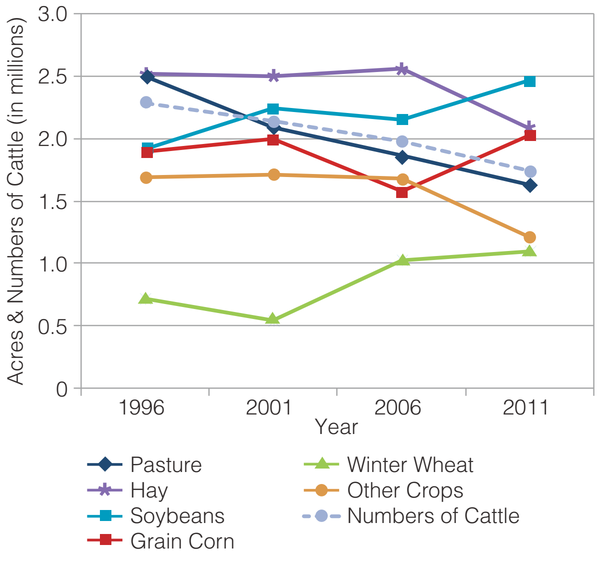

Figure 1.5 Changes in Acreages of Crops, Hay and Pasture Land and Number of Cattle in Ontario

(Source: Agricultural Census)

1.3 Options for Hay Crops and Pasture Land

The decline in the number of cattle by 23.8% from the 1996 to 2011 period has greatly reduced the hay and pasture land available in Ontario. Hay acreages and pasture land decreased by 17.4% and 34.7%, respectively, in the same period. The most significant decline in hay acreages occurred in the 2006-2011 period, while pasture land has been gradually decreasing along with the number of cattle in the 1996-2011 period. There are three main options for using surplus hay and pasture land in Ontario:

- Converting to annual cash crops such as grain corn, soybeans and wheat
- Developing hay export markets, and
- Growing perennial biomass crops, such as miscanthus and switchgrass, for the development of bio-processing industries.

As shown in Figure 1.5, hay crops are being replaced by grain corn, soybeans and winter wheat due to the recent improvement in grain prices and the continued decline in the cattle industry. The favourable economics of growing annual cash crops have also shifted cattle farms to areas with less productive farm lands. Some pasture land coming out of service, especially in Southern and Western agricultural regions, are being converted to grow annual crops (personal communication with producers in the regions). This conversion of hay and pasture land to annual cash crops could have a negatively impact on the environment unless producers adopt crop rotation and soil erosion best management practices. Annual crops usually require more chemicals and fertilizers in comparison with perennial hay crops.

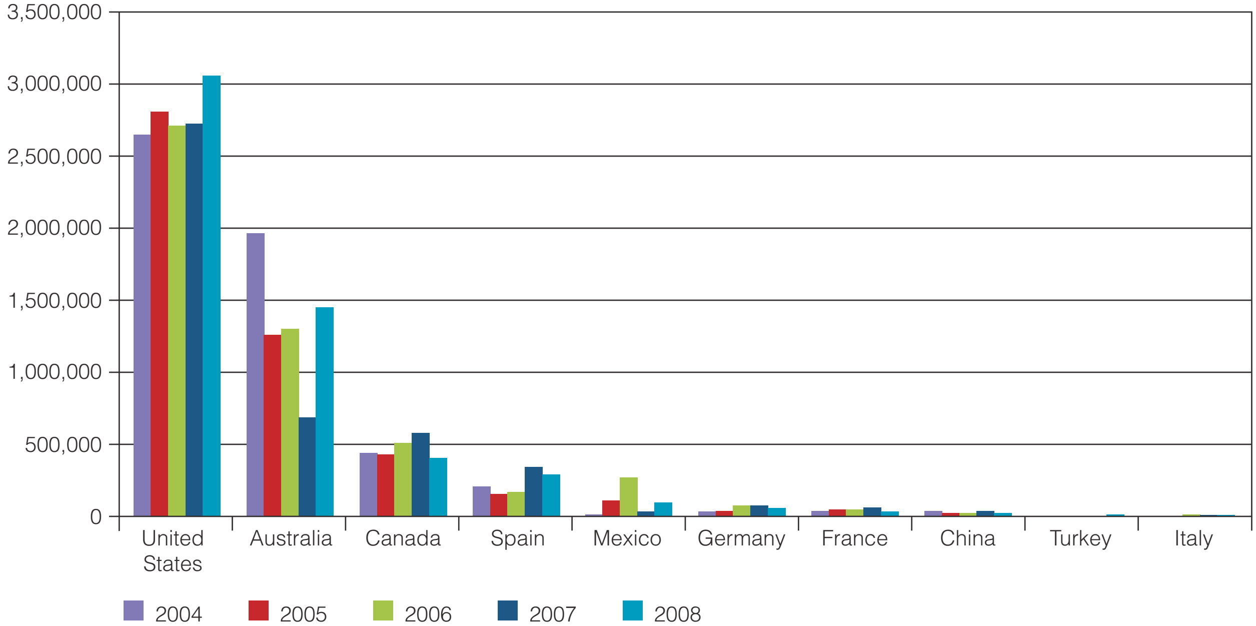

Figure 1.6 Top Ten World Exporters of Forage in Tonnes

(Source: Global Trade Information Services)

An option to keep perennial hay crops in the crop mix in Ontario is to develop hay export markets. A small percentage of hay produced in Ontario is currently exported, mainly to the US. The majority of hay crops is for the livestock industry in the province. Ontario farms produced approximately 5.4 million tonnes of hay in 2011 (Statistics Canada). Hay export from Ontario estimated by Statistics Canada in 2011 was 27,000 tonnes. The estimate of hay export by Ontario hay exporters was 46,000 tonnes, which is less than 1% of total production, in 2011 (Tyrchniewicz, 2012). The Canadian Forage and Grassland Association (CFGA) which represents provincial councils and the Ontario Forage Council have been providing export development assistance to forage producers, processors and exporters.

Canada is one of the largest forage exporters as shown in Figure 1.6. Although Ontario farms produce approximately 25% of Canadian forage (Statistics Canada), the majority of forage products are consumed in the province.

Canadian forage exports are mainly from Alberta and Saskatchewan to the US and Asian markets. Global top forage importers are listed in Figure 1.7. Since Japan and Korea are the largest importers of forage products, Canadian western provinces are geographically better positioned for hay export markets. Additionally, the economies of scales are favourable for farm lands in western provinces.

There are emerging markets for Ontario forage products. Government water conservation policies in the Middle East have increased forage imports in countries in that area, including United Arab Emirates, Bahrain, Qatar and Kuwait, and Saudi Arabia. China and Mexico are also potential markets for Ontario hay (Tyrchniewicz, 2011). One of the challenges in exporting Ontario forage products is the higher moisture content of hay harvested in humid Ontario climate. Moisture levels higher than 14% are considered as hazardous materials by most shipping companies (Tyrchniewicz, 2012). Drying hay

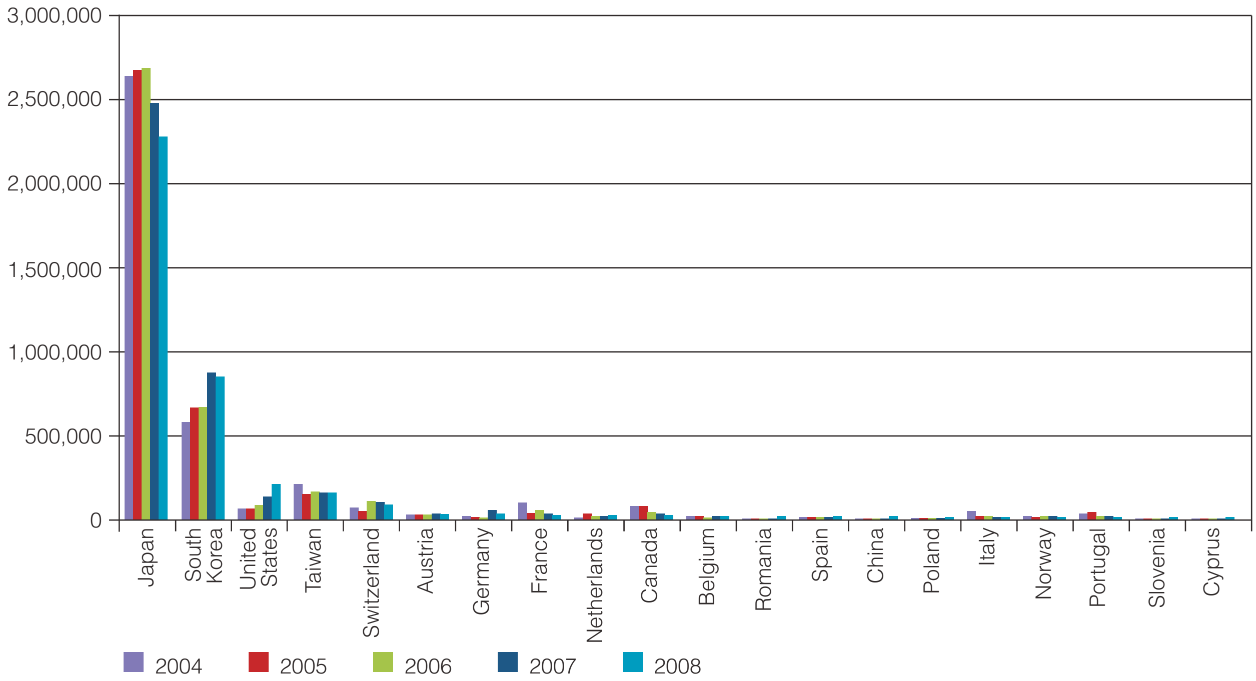

Figure 1.7 Top 20 World Importers of Forage in Tonnes

(Source: Global Trade Information Services)

to a moisture content of 10-12% would increase the production cost and reduce the competitiveness of Ontario forage producers in the global markets.

The surplus hay and pasture land in Ontario can be used to grow perennial biomass crops, such as miscanthus and switchgrass for energy and bio-processing uses. Biomass could also be supplied to the traditional markets of animal bedding and feed during drought periods. Biomass could also be used as feedstocks for emerging bio-processing industries. Emerging biomass applications include bio-materials, cellulosic bio-fuels, bio-chemicals, and bio-energy generation. In addition to these perennial crops playing an important role in the crop mix, the use of these biomass crops positions Ontario agriculture favourably for attracting bio-processing industries to Ontario. Bio-processing industries provide business diversification to both the agricultural sector and the manufacturing sectors.

There are challenges in developing bio-processing industries in Ontario. Biomass crops are relatively new to Ontario agricultural producers. Comprehensive yield data and the agronomy of biomass crops for different land classes are required for Ontario producers for large scale biomass production required to support industrial applications. The economics of emerging bio-processing industries have yet to be proven at commercial scales; therefore, there are market uncertainties for biomass. Policy and regulatory drivers are needed to develop bio-processing industries in Ontario. Despite the presence of these challenges, growing biomass crops on the surplus hay and pasture land seems to be the most promising option due to the considerable benefits in the development of agricultural-based bio-processing industries.

Chapter 2 - Estimation of Surplus Hay Crop Acreage and Pasture Land

There are surplus hay crop acreage and pasture land in Ontario due to the declining number of cattle. Some surplus hay and pasture land have been converted to grow cash crops such as grain corn, soybeans and winter wheat. Hay crops and pasture land are under utilized in some Ontario regions since the conversion to cash crops are economically unfavourable in those areas. In this chapter, the utilization of hay crop acreages and pasture land in Ontario regions are analyzed. The cattle industry in each Ontario region is also examined. Productivity levels of agricultural land in Ontario regions are assessed and compared. Surplus hay crop acreages and pasture land are estimated as well as their locations. Potential biomass production from the surplus hay crop acreages and pasture land is also calculated.

2.1 Agricultural Land Productivity

Agricultural producers attempt to maximize the net margin of their farm land while maintaining soil quality. Crop rotation and the inclusion of perennial crops in the rotation are usually considered best practices for increasing the long-term productivity of the soil. Producers also diversify agricultural products from their farms. In Ontario, vegetables are grown on the most productive farm land, which is the best of class 1 land. In general, cash crops are grown on class 1-3 land and hay crops are grown on class 2-4 land. Pasture land is usually class 3-5. There are exceptions in some regions where livestock are kept as a business diversification. The conceptual model of the net margin versus land productivity is shown in Figure 2.1.

The yields of annual row crops are usually more sensitive to the quality of land in comparison with perennial crops. Additionally, the operating costs of annual row crops are higher than that of perennial crops. Therefore, hay crops, which are perennial grasses, are more frequent in the rotation for land with lower productivity. In general, the net margins of hay crops are better than that of annual cash crops for lower land classes, as shown in Figure 2.1. The intersection point of two conceptual curves in Figure 2.1 depends on the relative price of grains, hay and land value.

If the hay demand in Ontario continues to drop due to the declining cattle industry, the relative benefit of grain farming increases. This would move the intersection point of two curves to the left on X-axis in Figure 2.1. If an attractive price is offered for perennial biomass by bio-processing industries, the intersection point would move to the right on X-axis. Figure 2.1 suggests that Ontario regions with greater percentage of lower productivity land are potential locations for the large scale production of perennial biomass.

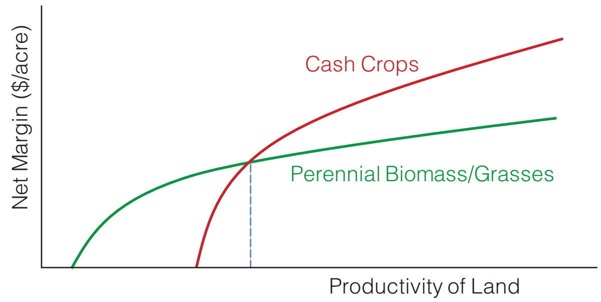

Figure 2.1 Conceptual Model of Net Margin versus Productivity of Land
(Adapted from Classsen et al., 2011)

2.2 Productivity of Agricultural Land in Ontario Regions

Ontario is divided into five agricultural regions. The map of the regions and the constituent counties are given in Appendix A. Acreages of crop land, total farm land, the number of cattle, and farm cash receipts of the regions are presented in Table 2.1. Total farm cash receipts of Ontario farms were $10 billion in 2011. The southern region has the highest farm cash receipts, representing 47.5% of the provincial total. The western region has the highest number of cattle, representing 48.7% of the provincial cattle industry. The southern and western regions are the most agricultural active areas in Ontario.

In order to compare the productivity of farm land in Ontario regions, farm cash receipts per acre were estimated and shown in Figure 2.2. Farm cash receipts per farm land acreage in the southern region in 2011 were $1,241/acre, which is the highest in the province. This was followed by the western region with the average farm cash receipts per farm land acreage of $910/acre. Figure 2.2 suggests that the most productive farm land in Ontario is located in the southern and western regions. In addition, farm cash receipts per farm land acreage in the central and eastern regions are comparable. The northern region, the least agriculturally active area in the province, has the lowest farm cash receipts per acre. The average farm cash receipts of all Ontario farms are estimated at $812/acre.

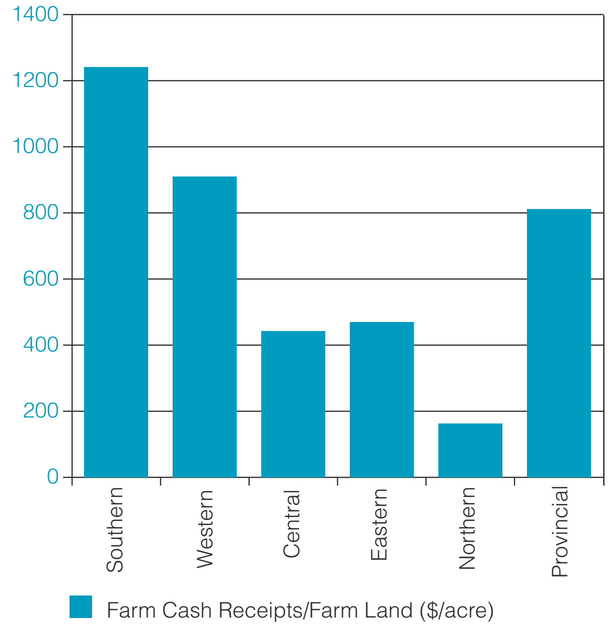

Figure 2.2 Comparisons of Farm Cash Receipts per Acre of Farm Land in Ontario Regions

Table 2.1 Farm Activities and Cash Receipts in Ontario Agricultural Regions

	Land in Crop (acre)	Farm Land (acre)	Numbers of Cattle	Farm Cash Receipts ($B)
Southern	3,303,054	3,826,309	290,600	4.75
Western	2,912,723	3,880,728	848,639	3.53
Central	1,015,978	1,772,867	209,536	0.79
Eastern	1,333,723	2,257,165	300,358	1.06
Northern	360,660	925,763	92,248	0.15
Provincial	8,926,138	12,662,833	1,741,381	10.00

(Source: Agricultural Census, 2011)

2.3 Hay Crops and Pasture Land in Ontario Regions

All Ontario agricultural regions grow hay crops and maintain pasture land to support the cattle industry. Figure 2.3 shows the farm cash receipts per acre and hay acreages as a percentage of total crops in Ontario regions. As illustrated in Figure 2.3, there is an inverse relationship between farm cash receipts ($/Acre) and the hay acreage percentage. The southern region has the highest cash receipts per acre and the lowest hay acreage percentage: only 8.6% of total crop land is used to grow hay crops. Agricultural producers in the western region use 24% of their crop land to grow hay crops, which is comparable to the provincial average. In the northern region, hay acreages represent 57% of total crop land.

The relationship between the farm cash receipts per acre and the hay acreage percentage indicated in Figure 2.2 agrees with the conceptual model of net margins versus land productivity shown in Figure 2.1. The most productive farm land in Ontario is in the southern and the western regions, and hay crops represent relatively lower percentages of total crop land. The economics of growing annual cash crops are more favourable in these regions. For farm land with lower productivity, growing hay crops in integration with cattle production seems to be a more attractive option in Ontario.

If the grain prices remain high, it is possible that the cattle farms in the southern and the western regions would move to other regions. Figure 2.4 presents hay acreages and pasture land in percentages of the crop land and total farm land, respectively, for Ontario regions. The pattern for pasture land percentage is similar to the hay acreage percentage.

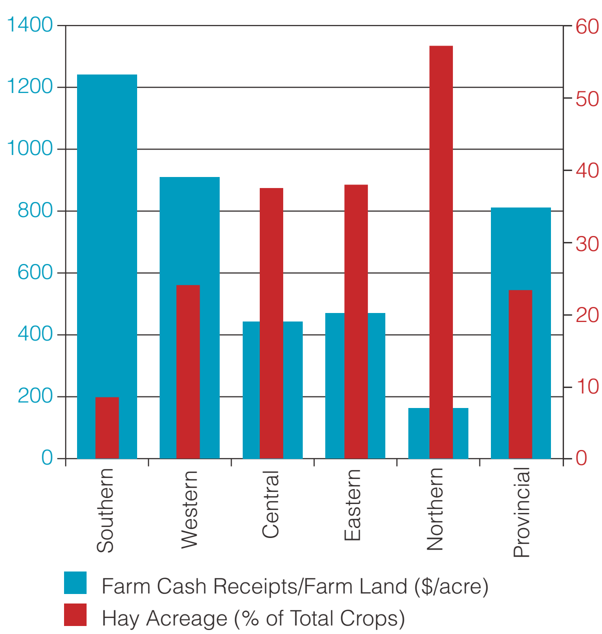

Figure 2.3 Farm Cash Receipts per Acre and Hay Acreage Percentages in Ontario

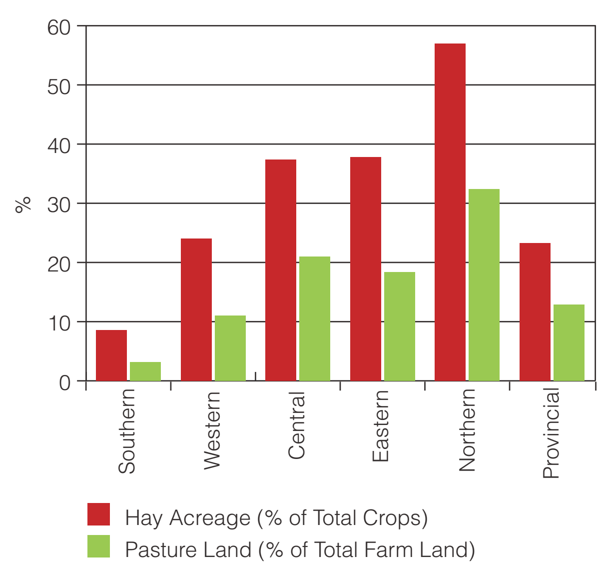

Figure 2.4 Hay Acreage and Pasture Land in Percentages in Ontario

2.4 Estimates of Surplus Hay Crop Acreage and Pasture Land

The utilization of hay acreages and pasture land in Ontario regions are compared by estimating the land use per cattle as given in Table 2.2. The largest cattle industry is located in the western region with approximately 50% of the provincial cattle population. The western region, therefore, has the largest hay crops and pasture land in Ontario. The number of cattle in the southern and eastern regions is comparable. The beef to dairy cow ratios of the southern and the eastern regions are also similar. The western and central regions have approximately the same beef to dairy cow ratio. These ratios are significantly different from those 15 years ago due to the changes in the cattle industry. The number of cattle in the northern region is the lowest in the province.

The last two columns of Table 2.2 compare hay and pasture land use per cattle for Ontario regions. For a similar beef to dairy cow ratio, the producers in the western region use 0.83 acres to grow hay crops for each cow, while hay acreage per cattle in the central region is 1.82. The average yields of hay crops in the western region and the central region are not that different in order of magnitude, according to the OMAF statistics. The pasture land acreage per cattle in the central region is 1.77, which is 3.54 times higher than that of the western region. Similar comparisons could be made for the southern and eastern regions, which have approximately the same beef to dairy cow ratio. The comparisons in Table 2.2 suggest that hay crops and pasture land in the central and eastern regions are underutilized. The higher land use per cattle in the northern region could be accounted by the shorter growing season and the lower productivity of agricultural land in the area.

Hay crops and pasture land conversion for biomass crops considered in this study are categorized as follow:

1. Pasture land no longer in service – some have been converted to cash crops, especially in the southern and the western regions;

2. Underutilized hay land – hay acreage per cattle could be reduced to the provincial average in the central and the eastern regions and to 1.5 times the provincial average in the northern region;

3. Underutilized pasture land – pasture land per cattle could be reduced to the provincial average in the central and the eastern regions and to 1.5 times the provincial average in the northern region; and

Table 2.2 Comparisons of Land Use per Cattle in Ontario Regions

Region	Hay Crops (acre)	Pasture Land (acre)	Numbers of Cattle	Beef/Dairy Cow Ratio	Hay Acreage/Cattle	Pasture Land/ Cattle (acre)
Southern	282,524	120,183	290,600	1.59*	0.97	0.41
Western	700,139	426,868	848,639	3.34#	0.83	0.50
Central	380,440	371,663	209,536	3.39#	1.82	1.77
Eastern	504,472	415,031	300,358	1.41*	1.68	1.38
Northern	205,615	299,821	92,248	4.82	2.23	3.25
Provincial	2,077,911	1,633,566	1,741,381	2.50	1.19	0.94

(Source: Agricultural Census, 2011)

* Similar beef to dairy cow ratio for Southern and Eastern regions

\# Similar beef to dairy cow ratio for Western and Central regions

4. Hay crops and pasture land available due to further decline in number of cattle.

Table 2.3 gives the estimates of hay crops and pasture land potentially available for biomass crops for the first three categories mentioned above. From 2006 to 2011 pasture land acreage had decreased due to the declining cattle industry in all Ontario regions. Although some of this acreage especially in the southern and western regions have been converted to cash crops, some of this acreage is still potentially available for biomass crops. The percentage conversion of the pasture land in each region is assumed and given in Table 2.3. Approximately 78,000 acres of pasture land came out of service in the western region in 2006-2011. Based on the assumption of this study, about 20,000 acres of this pasture land could be converted to biomass crops in the western region. The similar conversion of pasture land in the central region and the eastern region are about 17,000 acres and 18,000 acres, respectively.

The hay acreage per cattle and pasture land per cattle of the southern and western regions are expected to remain at current level. Therefore, no underutilized hay crops and pasture land are available for biomass crops. Based on communication with agricultural producers during this study, there is room for improvement in managing hay crops and pasture land in the central, eastern and northern regions. Considering the difference in land productivity in these regions, hay acreage and pasture land per cattle in the central and eastern regions are assumed to be reduced to the current provincial averages. Due to a shorter growing season and a lower productivity of agricultural land, the hay acreage and pasture land per cattle in the northern region is assumed at 1.5 times of current provincial averages. The surplus hay and pasture land estimated from these assumptions are given in Table 2.3.

The largest acreages of surplus hay crops and pasture land are located in the central region and the eastern region with about 323,000 acres and 298,000 acres, respectively. The northern region also offers considerable acreages of surplus hay and pasture land as seen in Table 2.3. However, more research and field data are required for the agronomic practices and yields of biomass crops in the northern region. The cost of transporting bulky biomass could also be an issue for the northern region, which is relatively far from industrial users unless new investments are attracted to the region. If the grain prices remain high, more cattle could move to the northern

Table 2.3 Estimates of Surplus Hay Crops and Pasture Land for Biomass Crops

	Southern	Western	Central	Eastern	Northern
Pasture land coming out of service (2006-2011)	33,781	77,781	47,970	50,844	18,445
% Conversion	20	25	35	35	40
1. Conversion from unused pasture	6,756	19,445	16,790	17,795	7,378
Number of Cattle	290,600	848,639	209,536	300,358	92,248
Hay Acreage	282,524	700,139	380,440	504,472	205,615
Assumed hay acreage/cattle	0.97	0.83	1.19	1.19	1.79
2. Conversion from underutilized hay land	0	0	131,092	147,046	40,952
Pasture land (acre)	120,183	426,868	371,663	415,031	299,821
Assumed pasture land/cattle	0.41	0.50	0.94	0.94	1.41
3. Conversion from underutilized pasture	0	0	174,699	132,694	169,751
Total acreage for biomass (1+2+3)	6,756	19,445	322,581	297,536	218,081

region. The surplus hay crops and pasture land in the southern and western regions are relatively less but would continue to be converted to row crops as the beef sector migrates northward. Therefore, for a large scale production of biomass, the central and eastern regions could be the most attractive areas in Ontario.

Continued high grain prices could move more cattle from the southern and western regions, where the most productive farm land is located, to other regions. Some of the resulting surplus hay crop acreages and pasture land could be converted to cash crops, and some could be available for biomass crops. An additional 10% drop in the number of cattle would result in 40,000 acres of available land in the southern region and 113,000 acres of available land in the western region for conversion to cash crops or biomass crops.

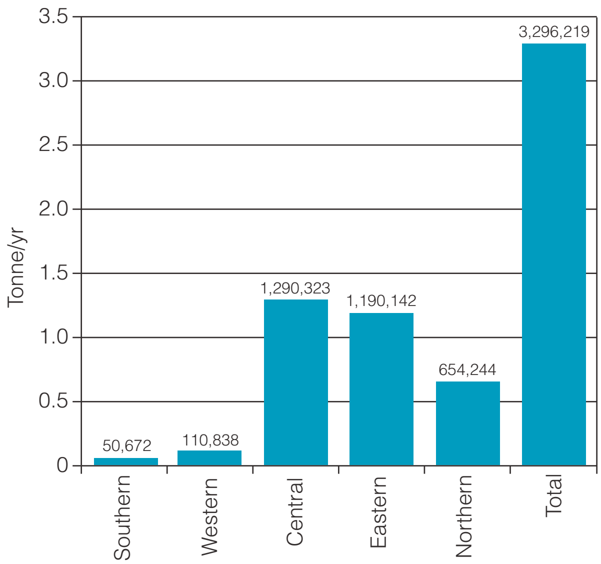

Figure 2.5 Potential Biomass Productions from Surplus Hay Acreage and Pasture Land in Ontario

2.5 Potential Biomass Production

Based on the surplus hay crop acreages and pasture land shown in Table 2.3, potential biomass production in Ontario regions is estimated. For a conservative estimate, biomass yields for the southern region and the western region are assumed at 7.5 tonne/acre and 5.5 tonne/acre, respectively. Biomass yields in the central and eastern regions are expected to be lower and assumed at 4 tonne/acre. Due to a shorter growing season and lack of data for biomass crops in the northern region, a conservative biomass yield of 3 tonne/acre is used for the estimation. The potential biomass productions are shown in Figure 2.5.

The largest biomass production potential from the surplus hay crop acreages and pasture land is in the central Ontario region with an annual biomass quantity of 1.29 million tonne. Approximately 1.19 million tonne/yr of biomass can be produced from the surplus hay crop acreages and pasture land in the eastern region. The northern region also has a potential of producing 0.65 million tonne/yr of biomass; however, an assessment would be required on the feasibility of growing biomass crops such as switchgrass in the area; other grass crops such as reed canary may b more suitable. Total annual biomass production potential from the surplus hay crop acreages and pasture land in Ontario is estimated at 3.3 million tonne.

Chapter 3 - Economics of Biomass Production from Hay Acreage and Pasture Land

Soybeans, hay, grain corn and winter wheat are the four major crops which collectively represents 80-90% of total crop land in Ontario. Except for hay, others are traded as commodities. Ontario agricultural producers greatly understand the agronomics and the economics of growing these major crops. In order for producers to consider growing biomass crops, the net margins of biomass crops should be comparable to that of major crops. In this chapter, the net margins of growing major crops are presented for different land classes. The economics of biomass crops, miscanthus and switchgrass, are also investigated. The net margins of traditional cash crops in Ontario are then compared with that of biomass crops for different grain price scenarios and land classes.

3.1 Major Crops and Net Margins

The economics of crop production depend on grain prices, yields, variable costs, and fixed costs. The net margin is also influenced by the crop type and the quality of soil. For the best agricultural land, class 1 & 2, soybeans, grain corn and winter wheat are the most frequent crops in rotation. These annual cash crops may also be grown in rotation with perennial hay crops on class 1-3 land. Hay crops are usually the most predominant crop in rotation with corn on class 3-4 land. The seeded and natural pasture lands are mostly class 3-5. On class 5 land, the opportunity to grow row crops is very limited. In general, the net margin of annual cash crops is higher on the more productive farm land, while perennial crops financially perform better on less productive land.

Table 3.1 Economics of Ontario Major Crops for Class 1 & 2 Land

	Hay	Soybeans	Grain Corn	Winter Wheat
Yield and Revenue				
Yield (bushel/acre or tonne/acre)	6	58	200	96
Price ($/bushel or $/tonne)	145	14	6.5	7.2
Straw (tonne/acre)				0.75
Straw Price ($/tonne)				60
Total Revenue ($/acre)	870	812	1300	736.2
Variable Cost Items				
Seed ($/acre)	60	56	91	49
Fertilizers and Chemicals ($/acre)	60	65	138	76
Other Operating Costs ($/acre)	141	113	236	111
Total Variable Costs ($/acre)	323	234	465	236
Fixed Cost Items				
Depreciation ($/acre)	19	25	28	30
Land Cost ($/acre)	350	350	350	350
Other Fixed Costs ($/acre)	16	21	24	28
Total Fixed Costs ($/acre)	385	396	402	408
Gross Margin (Rev. - Total Variable Costs) ($/acre)	546.8	578.0	835.0	500.2
Net Margin (Gross Margin - Total Fixed Costs) ($/acre)	161.8	182.0	433.0	92.2

Table 3.1 summarizes the economics of growing major field crops in Ontario for class 1-2 land. Yields and revenues, variable and fixed costs, and gross and net margins of the major crops are estimated. Data are based on OMAFRA crop budget worksheets and personal communication with a number of farm operators. Variable cost items include seed, fertilizers, chemicals, crop insurance, seeding, harvesting, storage and handling, fuel and lubricants, labour, equipment repair and maintenance, and interest on operating capital. Fixed cost items include depreciation of equipment, land cost, and interest on term loans. Gross margin is calculated by subtracting variable costs from the revenue. Net margin is the gross margin less the fixed costs.

At current grain prices, grain corn followed by soybeans offers the highest net margin among the major field crops in Ontario. The variable costs are also highest for the grain corn. As shown in Table 3.1, the annual land cost of class 1 & 2 land is assumed at $350/acre. The average yield of grain corn on highly productive farm land is estimated at 200 bushel/acre. The estimated yields of soybeans and winter wheat on class 1 & 2 land are 58 bushel/acre and 96 bushel/acre, respectively. Communication with agricultural producers suggests that the yield of hay crops could be 6 tonne/acre if the crops are properly managed. The average net margin of annual cash crops for class 1 & 2 land is $235.7/acre at current grain prices. Hay crops on class 1 & 2 land would net $161.8/acre. Soybeans and grain corn are the most frequent crops in rotation for class 1 & 2 land. Ontario is the largest producer of soybeans and grain corn, about 75% and 65% of Canadian total, respectively (Statistics Canada, 2011).

The net margins of Ontario major crops are estimated for class 3 land and are shown in Table 3.2. The annual land cost for class 3 farm land is assumed at $200/acre. The yields of major crops are lower than those for class 1 & 2 land. The yields of well-managed hay crops are estimated at 4.5 tonne/acre, and the average yield of grain corn on class 3 land is 150 bushel/acre. The estimated yields of soybeans and winter wheat on class 3 land are 43.5 bushel/acre and 72 bushel/acre, respectively. At current grain prices and the estimated costs of growing crops, grain corn offers the best net margin of $258/acre for class 3 land. The average net margin of annual cash crops on class 3 land is $152.1/acre, and that of hay crops on the same land class is $136.6/acre as shown in Table 3.2.

In general, annual cash crops are not grown on class 4 & 5 land due to lower yields. However, if grain prices continue to improve, the economics of annual cash crops could be attractive on land with lower productivity. The net margins of Ontario major crops are estimated and shown in Table 3.3 with assumed yields and costs. The average yield of well-managed hay crops on class 4 & 5 land are estimated at 3.2 tonne/acre. At current grain and hay prices, hay crops offer the highest net margin for class 4 & 5 land. This could be due to lower yield sensitivity of perennial hay crops to the soil quality in comparison with annual cash crops.

Table 3.2 Economics of Ontario Major Crops for Class 3 Land

	Hay	Soybeans	Grain Corn	Winter Wheat
Yield and Revenue				
Yield (bushel/acre or tonne/acre)	4.5	43.5	150	72
Price ($/bushel or $/tonne)	145	14	6.5	7.2
Straw (tonne/acre)				0.75
Straw Price ($/tonne)				60
Total Revenue ($/acre)	652.5	609.0	975	563.4
Variable Cost Items				
Seed ($/acre)	60	56	91	49
Fertilizers and Chemicals ($/acre)	60	65	138	76
Other Operating Costs ($/acre)	141	113	236	111
Total Variable Costs ($/acre)	281	234	465	236
Fixed Cost Items				
Depreciation ($/acre)	19	25	28	30
Land Cost ($/acre)	200	200	200	200
Other Fixed Costs ($/acre)	16	21	24	28
Total Fixed Costs ($/acre)	235	246	252	258
Gross Margin (Rev. - Total Variable Costs) ($/acre)	371.6	375.0	510.0	327.4
Net Margin (Gross Margin - Total Fixed Costs) ($/acre)	136.6	129.0	258.0	69.4

Table 3.3 Economics of Ontario Major Crops for Class 4 & 5 Land

	Hay	Soybeans	Grain Corn	Winter Wheat
Yield and Revenue				
Yield (bushel/acre or tonne/acre)	3.2	29	100	48
Price ($/bushel or $/tonne)	145	14	6.5	7.2
Straw (tonne/acre)				0.75
Straw Price ($/tonne)				60
Total Revenue ($/acre)	464	406	650	390.6
Variable Cost Items				
Seed ($/acre)	60	56	91	49
Fertilizers and Chemicals ($/acre)	60	65	138	76
Other Operating Costs ($/acre)	141	113	236	111
Total Variable Costs ($/acre)	253	234	465	236
Fixed Cost Items				
Depreciation ($/acre)	19	25	28	30
Land Cost ($/acre)	100	100	100	100
Other Fixed Costs ($/acre)	16	21	24	28
Total Fixed Costs ($/acre)	135	146	152	158
Gross Margin (Rev. - Total Variable Costs) ($/acre)	211.3	172.0	185.0	154.6
Net Margin (Gross Margin - Total Fixed Costs) ($/acre)	76.3	26.0	33.0	-3.4

3.2 Economics of Biomass Crops

Perennial biomass crops are plants cultivated to produce biomass which have non-traditional applications such as heat and power generation, bio-fuels, bio-chemicals and bio-composite materials. Ideal attributes of biomass crops for those applications include low cost, low crop maintenance, high yield, and minimal environmental risks. Biomass crops could be categorized as either woody or herbaceous. Short rotation coppices such as willow and poplar are examples of woody crops. Herbaceous perennial crops include miscanthus, switchgrass, Indian grass, reed canary grass, big blue stem, and native tall grasses.

Ontario's farmers have a great deal of experience with hay production, which is the largest field crop in the province, and most equipment used for haying can be employed to grow and harvest herbaceous crops with the exception of specialized planting equipment required for miscanthus and prairie grasses. Miscanthus and switchgrass are the most widely grown herbaceous crops in Ontario with several hundred acres at commercial and semi-commercial scales. Oo et al. (2012a) investigated the economics of miscanthus, switchgrass, tall grass prairies and sorghum as energy crops in Ontario. In this study, the economics of miscanthus and switchgrass are examined using the spreadsheet models for different land classes.

Miscanthus is currently the highest yielding biomass crop for Ontario's climate and soil. This herbaceous perennial grass possesses the efficient C4 photosynthetic pathway and requires relatively low amount of nutrients and water. Once established miscanthus becomes perennial and can be productive with a stable yield for 10-15 years. The economics of miscanthus for class 3 land are given in Table 3.4 as an example. The analysis considers yields, revenues, variable cost items and fixed cost items to estimate the net margin of miscanthus. Although miscanthus grows fairly quickly, first-year growth is usually insufficient to be economically worth harvesting. The crop can be harvested from the second year onward. Miscanthus usually reaches a mature yield in the 4th year from establishment. Based on communication with biomass growers, the yield of miscanthus is more sensitive to soil quality in comparison with switchgrass. As miscanthus is left to stand through the winter and harvested in the spring, the crop is unsuitable in heavy snow areas due to lodging.

Switchgrass is a perennial warm season grass native to North America. Like miscanthus, switchgrass grows through the C4 photosynthetic pathway, offering low nutrient requirement and efficient water use. Since it is a native plant, switchgrass adapts to a wide range of soil and has a good resistance to drought, pests and diseases. Once it is established, switchgrass will remain productive for 15-20 years with a stable yield. There are over 1000 acres of switchgrass in Ontario at commercial and semi-commercial scales, providing biomass to space heating, animal bedding, and bio-composite material markets. The economics of switchgrass for class 3 land are given in Table 3.5 as an example. No switchgrass harvest can be expected during the first year of establishment. A low yield of about 1 tonne/acre may be produced in the second year. Switchgrass reaches its mature yield by the third year, and economical annual harvests can take place starting from the third year. All farming operations for switchgrass can be done using existing equipment.

Table 3.4 Economics of Miscanthus for Class 3 Land

	Yr-1	Yr-2	Yr-3	Yr-4	Yr-5	Yr-6	Yr-7	Yr-8	Yr-9	Yr-10	Yr-11
Yield (tonne/acre)	0.0	3.0	6.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Price of biomass ($/tonne)	120	120	120	120	120	120	120	120	120	120	120
Revenue ($/acre)	0	360	720	1020	1020	1020	1020	1020	1020	1020	1020
Net income from cover crop in Year-1 ($/acre)	95										
Variable cost items ($/acre)											
Propagation plugs	720.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fertilizer	40.0	80.0	45.0	45.9	46.8	47.8	48.7	49.7	50.7	51.7	52.7
Herbicides	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crop insurance	15.0	15.3	15.6	15.9	16.2	16.6	16.9	17.2	17.6	17.9	18.3
Custom work (planting, applications, harvesting, bailing)	100.0	75.0	95.0	96.9	98.8	100.8	102.8	104.9	107.0	109.1	111.3
Fuel and lubricants	16.0	14.0	18.0	18.4	18.7	19.1	19.5	19.9	20.3	20.7	21.1
Equipment repair and maintenance	15.0	15.3	15.6	15.9	16.2	16.6	16.9	17.2	17.6	17.9	18.3
Labour	25.0	15.0	25.0	25.5	26.0	26.5	27.1	27.6	28.2	28.7	29.3
Interest on operating capital	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3
Storage and handling	0.0	35.0	50.0	51.0	52.0	53.1	54.1	55.2	56.3	57.4	58.6
Other variable costs	4.0	5.0	7.0	7.1	7.3	7.4	7.6	7.7	7.9	8.0	8.2
Sub-total variable costs	1028.3	302.9	319.5	324.9	330.5	336.1	341.9	347.7	353.7	359.8	366.1
Fixed cost items ($/acre)											
Depreciation	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Land cost	200.0	204.0	208.1	212.2	216.5	220.8	225.2	229.7	234.3	239.0	243.8
Interest on term loan	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
Other fixed costs	7.0	7.1	7.3	7.4	7.6	7.7	7.9	8.0	8.2	8.4	8.5
Sub-total fixed costs	251.0	255.1	259.4	263.7	268.1	272.5	277.1	281.8	286.5	291.4	296.3
Gross margin (Revenue - Variable costs) $/acre	-933.3	57.1	400.5	695.1	689.5	683.9	678.1	672.3	666.3	660.2	653.9
Net margin (Gross margin - Fixed costs) $/acre	-1,184.3	-198.0	141.1	431.4	421.5	411.3	401.0	390.5	379.7	368.8	357.6
Average gross margin ($/acre/yr)											447.6
Average net margin ($/tonne)											24.9
Average net margin ($/acre/yr)											174.6

Table 3.5 Economics of Switchgrass for Class 3 Land

	Yr-1	Yr-2	Yr-3	Yr-4	Yr-5	Yr-6	Yr-7	Yr-8	Yr-9	Yr-10	Yr-11	
Yield (tonne/acre)	0.0	1.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
Price of biomass ($/tonne)	120	120	120	120	120	120	120	120	120	120	120	
Revenue ($/acre)	0	120	660	660	660	660	660	660	660	660	660	
Net income from cover crop in Year-1 ($/acre)	95											
Variable cost items ($/acre)												
Seed	135.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Fertilizer	25.0	45.0	45.9	46.8	47.8	48.7	49.7	50.7	51.7	52.7	53.8	
Herbicides	48.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Crop insurance	9.0	9.2	9.4	9.6	9.7	9.9	10.1	10.3	10.5	10.8	11.0	
Custom work (seeding, applications, harvesting, bailing)	18.0	50.0	84.0	85.7	87.4	89.1	90.9	92.7	94.6	96.5	98.4	
Fuel and lubricants	11.0	11.2	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1	16.4	
Equipment repair and maintenance	12.0	12.2	12.5	12.7	13.0	13.2	13.5	13.8	14.1	14.3	14.6	
Labour	13.0	13.3	15.0	15.3	15.6	15.9	16.2	16.6	16.9	17.2	17.6	
Interest on operating capital	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	
Storage and handling	0.0	20.0	35.0	35.7	36.4	37.1	37.9	38.6	39.4	40.2	41.0	
Other variable costs	3.0	4.0	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.9	
Sub-total variable costs	286.5	189.4	233.2	237.6	242.1	246.7	251.4	256.2	261.1	266.1	271.1	
Fixed cost items ($/acre)												
Depreciation	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	
Land cost	200.0	204.0	208.1	212.2	216.5	220.8	225.2	229.7	234.3	239.0	243.8	
Interest on term loan	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	
Other fixed costs	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.9	6.0	6.1	
Sub-total fixed costs	238.0	242.1	246.3	250.5	254.9	259.3	263.9	268.5	273.2	278.0	282.9	
Gross margin (Revenue - Variable costs) $/acre	-933.3	57.1	400.5	695.1	689.5	683.9	678.1	672.3	666.3	660.2	653.9	
Net margin (Gross margin - Fixed costs) $/acre	-1,184.3	-198.0	141.1	431.4	421.5	411.3	401.0	390.5	379.7	368.8	357.6	
Average gross margin ($/acre/yr)												310.3
Average net margin ($/tonne)												11.0
Average net margin ($/acre/yr)												50.5

The net margins of miscanthus and switchgrass are estimated for different land classes and biomass prices using the spreadsheet models. The results are provided in Table 3.6 and Table 3.7 for miscanthus and switchgrass, respectively. As mentioned earlier, the yield of miscanthus is sensitive to soil quality in comparison with switchgrass. The net margins of miscanthus are positive for all biomass prices considered on all land classes. The economics of miscanthus is better for land with greater productivity as shown in Table 3.6. However, the net margin of miscanthus must be comparable to that of annual cash crops for better land classes in order for Ontario producers to consider the adoption of the crop on productive farm land. The economics of switchgrass is better on land with lower productivity as shown in Table 3.7. The biomass price of over $120/tonne is required to achieve a positive net margin for switchgrass.

3.3 Comparison of Cash Crops and Perennial Biomass

For Ontario agricultural producers to grow perennial biomass crops on a large scale, the net margins of biomass crops should be comparable to that of major field crops. The net margin of grain corn, one of Ontario's major field crops, is compared in Figure 3.1 with the net margin of biomass crops. The assumptions for the comparisons in Figure 3.1 are that miscanthus is the biomass crop for class 1-3 land and switchgrass is the crop for class 4-5 land. The yields and input costs of grain corn are estimated

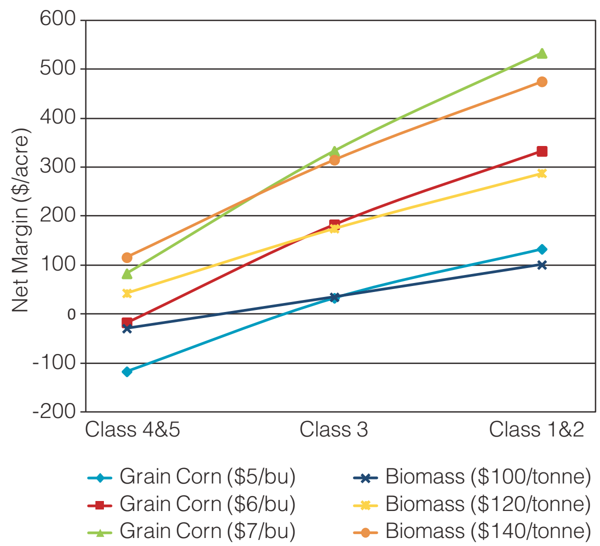

Figure 3.1 Comparisons of Net Margins for Grain Corn and Biomass Crops

Table 3.6 Net Margin of Miscanthus

Land Class	Annual Land Cost ($/acre)	Yield (tonne/acre)	Net Margin ($/acre) @ Biomass Price		
			$100/tonne	$120/tonne	$140/tonne
1 & 2	350	11.7	101.4	287.9	474.5
3	200	8.5	34.6	174.6	314.6
4 & 5	100	7.0	36.1	154.3	272.5

Table 3.7 Net Margin of Switchgrass

Land Class	Annual Land Cost ($/acre)	Yield (tonne/acre)	Net Margin ($/acre) @ Biomass Price		
			$100/tonne	$120/tonne	$140/tonne
1 & 2	350	6.5	-125.4	-17.2	91.0
3	200	5.5	-41.3	50.5	142.4
4 & 5	100	4.3	-28.8	43.3	115.5

and discussed in Section 3.1 (Table 3.1 -3.3). This is one of several possible scenarios as switchgrass can be grown on class 1-3 land.

The price of grain corn during the preparation of this report is approximately $6.5/bushel. At the grain corn price of $6/bushel, the approximate acceptable price of biomass is $120/tonne for class 1-3 land. At those grain and biomass prices, the net margin of biomass crops could be higher than that of grain corn on class 4-5 land, as shown in Figure 3.1. If the price of grain corn improves to $7/bushel, the price of biomass should be about $140/tonne for Ontario agricultural producers to be interested in growing biomass crops. At the grain corn price of $5/bushel and the biomass price of $100/tonne, the net margin could be negative for class 4-5 land. The average price of hay in 2006-2011 was $113/tonne in Ontario (OMAF statistics).

Grain corn offers the highest net margin among the major annual cash crops in Ontario as discussed in Section 3.1 (Table 3.1-3.3). However, Ontario agricultural producers grow grain corn in rotation with other crops, mainly soybeans and winter wheat as a crop management practice. Therefore, it is more appropriate to compare the net margin of biomass crops with the average net margin of annual cash crops. The average net margin of grain corn, soybeans and winter wheat is calculated for the comparison as shown in Figure 3.2. At the grain corn price of $6/bushel and the biomass price of $120/tonne, the average net margin of annual cash crops would be lower than that of biomass crops on all land classes. Figure 3.1 and Figure 3.2 only compare the economics of growing cash crops and biomass crops. There could be other reasons Ontario agricultural producers would grow biomass crops if there is a stable biomass market. These reasons include lower maintenance, fewer chemicals, business diversification, soil improvement, etc.

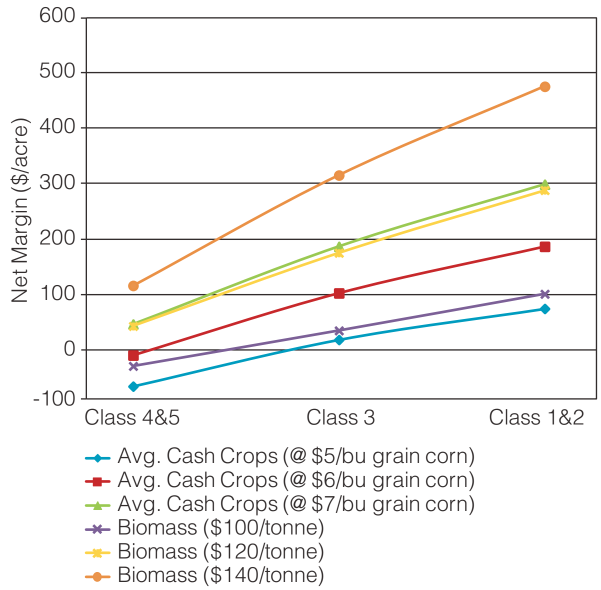

Figure 3.2 Comparison of Net Margins for Cash Crops and Biomass

Chapter 4 - Assessment of Emerging Bio-Processing Industries

Biomass crops are relatively new to Ontario agricultural producers with respect to agronomics and applications. Biomass produced from surplus hay acreage and pasture land would have diverse applications. Animal bedding and feed offer local markets opportunities for new biomass crops. There are also a number of emerging bio-processing industries which could use biomass as feedstocks. Biomass crops have to compete with other biomass sources such as agricultural residues and forestry biomass for most applications although it is a reasonable assumption to believe that both crop residue and purpose-grown crops will be needed in a new bio-economy. In this chapter, major applications for biomass from hay acreage and pasture land are explored. Emerging bio-processing industries are reviewed and evaluated as the potential users of biomass from hay acreage and pasture land.

4.1 Biomass Applications

Biomass can be defined as any organic material which could be grown as a renewable resource. Biomass, therefore, includes annual and perennial crops, trees, aquatic plants, wood wastes, grasses, etc. The majority of global demand for food, feed, energy and materials were met by biomass resources before the discovery of oil and gas. Today's society heavily depends on fossil resources for its energy and material needs. The advancement in plant genetics and better production practices account for improvements in crop yields over the past decades. The agricultural sector is now positioned again to provide more than food and feed on a sustainable basis.

The bio-economy can be defined as the commercial and industrial manufacturing of an array of competitive products from renewable biomass resources. The final products could range from heat and power generation to bio-chemicals and bio-materials. The intermediate chemicals produced from biomass could be further used to manufacture high-value cosmetics, pharmaceutical and other consumer products. Canada and other countries with considerable agricultural and forestry resources have been developing bio-based industries for economic and environmental reasons.

In the Ontario agricultural sector, the declining cattle industry has resulted in the surplus hay acreage and pasture land in some regions. The share of perennial hay crops, which are beneficial to soil and environment in crop rotation, has also been decreasing. The best option for those surplus hay acreage and pasture lands in Ontario could be the plantation of perennial biomass crops and the development of bio-processing industries in the province. Biomass crops could also meet the demand from traditional applications such as animal bedding and feed. Some Ontario areas experienced hay shortages due to the drought in 2012. Nott Farms, which grows switchgrass for bio-composites and energy usage, harvested green switchgrass for feed during 2012 in response to an immediate need for livestock feed. The economics of a biomass production system where an early harvest of grasses for feed followed by a late fall biomass harvest has yet to be documented.

In order to maximize the value of biomass grown on surplus hay acreage and pasture land year after year, the preferred uses for biomass are in the production of bio-energy, bio-fuels/chemicals, and bio-materials as shown in Figure 4.1. Some applications are relatively mature, and some are still being developed and commercialized. Strategies to extract cellulosic sugars are being developed to optimize the value of biomass prior to using the remaining lignin as a fuel source.

4.2 Bio-Energy

Biomass is the only renewable source of carbon which can be converted to heat and power through a number of technologies. Based on an annual cycle, it is carbon neutral. Biomass pellets produced from woody biomass and perennial energy crops are currently used in combined heat and power generation and space heating application in many jurisdictions around the world, especially in Europe. Direct combustion is the most common technology to convert solid biomass fuel into energy. Anaerobic digestion is another relatively mature technology to covert biomass into energy. There are emerging technologies such as pyrolysis and gasification being developed as advanced bio-energy conversion (Oo et al., 2012b).

In Ontario, New Energy Farms (http://newenergyfarms.com) has been growing miscanthus and other energy crops for space heating at vegetable greenhouses. Biomass fuels are cost competitive in some Ontario areas where end users do not have access to natural gas (Oo et al., 2012a). The estimated cost of different types of energy sources are compared with biomass pellets in Figure 4.2. The costs at the consumers' gate are compared as a unit cost per energy content ($/GJ). Coal and natural gas are the most cost-competitive fuels in Ontario. However, coal for combustion into electricity purposes is being phased out by 2014 and smaller coal applications are being discouraged. Biomass pellets, both forestry and agricultural, are relatively less inexpensive than heating oil and propane in rural areas. Therefore, some Ontario areas, where heating oil and propane are heavily used for space heating due to lack of natural gas infrastructure, could offer potential markets for biomass pellets. The fuel cost of such

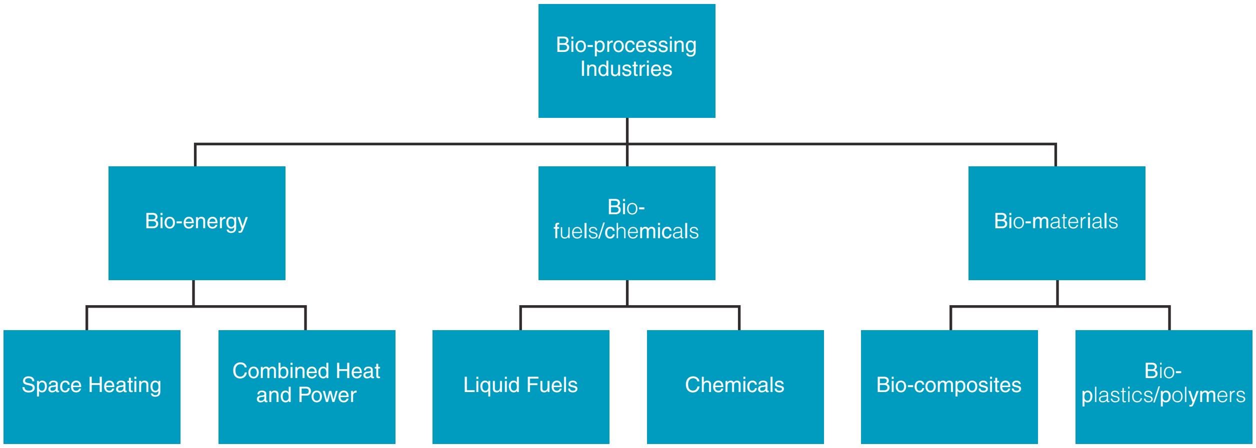

Figure 4.1 Potential Applications for Perennial Biomass from Hay and Pasture Land

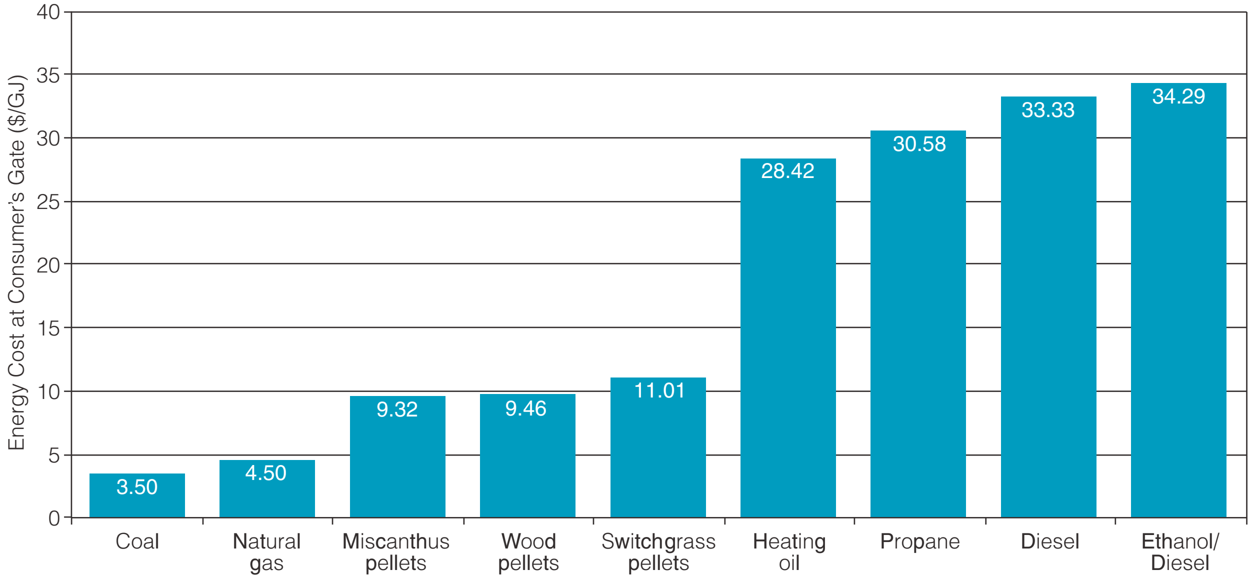

Figure 4.2 Comparison of Biomass Pellets with Other Energy Sources in Ontario

space heating applications could be reduced by approximately 65% by switching to biomass pellets. The conversion of heating systems needs to coincide with furnace replacement cycles.

The consumption of heating oil and propane in selected sectors, mainly for space heating applications, in Ontario is given in Table 4.1. The biomass equivalent in million tonne/yr is also estimated. The commercial and institutional sector is the largest consumer of heating oil and propane, representing over 50% of the provincial total. As shown in Table 4.1, the potential demand of biomass, replacing heating oil and propane, is approximately 3 million tonnes annually. For space heating applications, biomass grown on surplus hay acreage and pasture land has to compete with other biomass resources such as urban wood waste.

Electricity generated from biomass and other renewable sources can be sold to the grid at premium prices offered by the Feed-in-Tariff (FIT) program in Ontario. The majority of renewable electricity in Ontario comes from solar and wind sources. There has been no significant development in electricity generation from biomass except biogas electricity through anaerobic digestion of manure. At present, there is no regulatory support for heat generated from biomass in Ontario. The return on investment for generating electricity from biomass is estimated for different generation capacities, price of

Table 4.1 Potential Biomass Space Heating Markets in Ontario

Energy Source	Consumption (TJ/yr)	Biomass Equivalent (million tonne/yr)
Agricultural Sector		
Propane	3,245	0.18
Heating oil	1,339	0.07
Residential Sector		
Propane	8,446	0.46
Heating oil	12,765	0.69
Commercial and Institutional		
Propane	12,096	0.65
Heating Oil	17,573	0.95
Total	55,464	3.00

(Source of consumption data: Statistics Canada) electricity and biomass feedstock costs, and the results are shown in Figure 4.3. The price of electricity should be greater than \$0.17/kWh to make biomass electricity generation financially attractive.

The price and availability of natural gas and electricity demand in regions are important factors in considering bio-energy development. At the current FIT rate of \$0.13/kWh and the price of biomass, generating electricity is unlikely to be financially attractive. However, on-site biomass combined heat and power generation integrated with heat demand and other bio-processing industries could become a viable option since the price of electricity in Ontario has been gradually escalating. There are such models under development for ethanol production in the US. Additional revenue such as tipping fees for biomass waste could also improve the economics of biomass energy generation.

4.3 Bio-Fuels and Bio-Chemicals

As indicated in Figure 4.2, liquid transportation fuels, diesel and gasoline/ethanol are the highest cost energy sources if compared in unit energy content. Production of ethanol from sugar/starch crops has been technically proven and commercially viable around the world at current regulatory support levels. Approximately 30-35% of grain corn produced in Ontario is used to produce ethanol (Grier et al., 2012); however, residual DDGs are returned to the animal sector as feed. Cellulosic ethanol technologies which use non-food feedstocks such as wheat straw, grasses, wood chips, etc. are being commercialized. In 2012, DuPont, Abengoa and Poet have started the commercialization of cellulosic ethanol plant in Iowa, USA. These plants are expected to begin production in 2013-14 using corn crop residues as feedstock. There are also a number of Canadian cellulosic

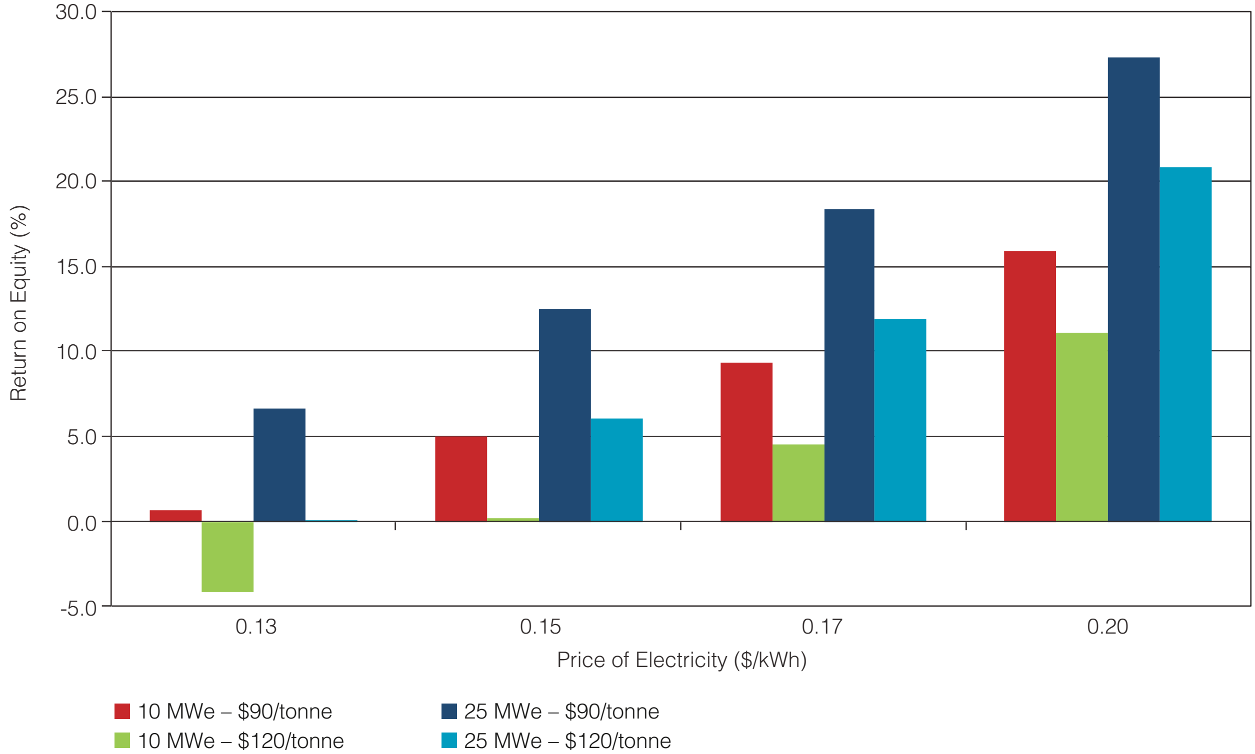

Figure 4.3 Economics of Biomass Electricity Generation

firms such as Shell/Iogen Corporation and KmX Biofuels commercializing their technologies.

For the economic production of ethanol from perennial biomass potentially produced from surplus hay acreage and pasture land, cellulosic ethanol technologies need to be improved to achieve greater efficiencies which will increase their competitiveness in the marketplace. The basic steps of cellulosic ethanol production are shown in Figure 4.4. Biomass pre-treatment usually involves washing, size reduction, grinding, etc. A chemical reaction using acids or an enzymatic reaction takes place in the hydrolysis process. Once the sugar molecules are extracted, they can be fermented to produce ethanol. The last two steps, fermentation and ethanol recovery, as depicted in Figure 4.4 are also common to the ethanol production from grain corn or other sugar/starch crops.

Further improvements in terms of costs and yields in the hydrolysis process are key to the commercialization of cellulosic ethanol technologies. Sugar from cellulosic materials is relatively more expensive than that from sugar/starch crops at current technologies. Once the cellulosic ethanol production is commercially viable, the stable markets for biomass from surplus hay acreage and pasture land in Ontario could be created. The cellulosic bio-fuels are expected to receive continued regulatory support around the world, especially in the US and countries with significant biomass resources.

A number of high-value chemicals could also be produced from biomass. Bio-chemicals could be either replacements for petroleum-based chemicals or new molecules with new functionality. Bio-chemicals can be used to produce diverse consumer products such as tire, glue, building and textile materials, flavors and fragrances, and cosmetic and personal care products. Top chemicals produced from biomass include succinic acid, lactic acid, butadiene, alcohol, and furfural. The production of bio-chemicals from sugar/starch crops has been technically proven and commercially viable for selected chemicals in some countries. In Ontario, BioAmber (http://www.bio-amber.com) is building a commercial plant in Sarnia to produce bio-succinic acid from plant sugar.

Producing chemicals from sugar/starch crops is relatively easier than that from cellulosic materials, including potential perennial biomass from surplus hay acreage and pasture land. The three most common routes of producing chemicals from cellulosic biomass are shown in Figure 4.5. The first route includes the extraction of sugar molecules from cellulosic materials through hydrolysis and the subsequent fermentation of sugar for the desired chemicals. Biomass can be gasified to produce syngas, and the syngas molecules can be synthesized to form required chemicals. Pyrolysis platforms are also available where biomass is heated in absence of air to approximately 500 °C to produce bio-oil and bio-char. Bio-oil can be further refined to produce different chemicals. Bio-char, which is a co-product of pyrolysis, has a number of potential applications such as soil amendment for greenhouses and mushroom production as

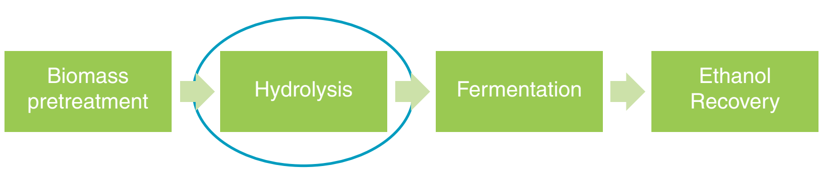

Figure 4.4 Basic Steps of Cellulosic Ethanol Production from Biomass

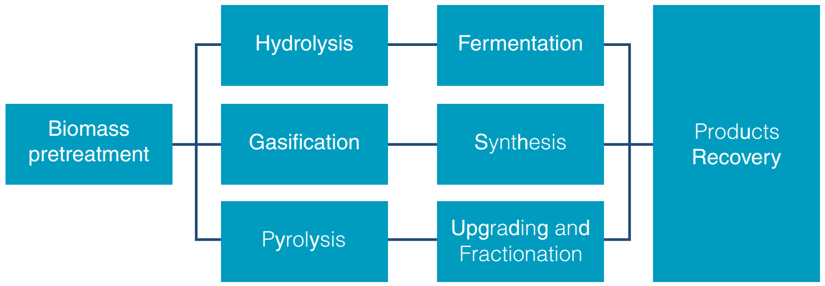

Figure 4.5 Producing Chemicals from Cellulosic Biomass

the bio-char material has superior water retention capacity. Its filtering properties are well documented in the alcohol distilling sector and for use in waste water treatment.

Technologies to produce chemicals from cellulosic biomass are at pilot to demonstration stages in North America. The prices and availability of natural gas and crude oil are important factors in the development of bio-chemicals industries. Certain chemicals could be manufactured more cost effectively from biomass than from fossil hydrocarbons, not to mention the beneficial environmental impact from lower GHGs. The commercialization of bio-chemicals production from cellulosic biomass would create a market for the perennial biomass and offer higher value adding to agricultural products in Ontario. The existence of petroleum refining sector and the well-established supply chain for chemicals in Ontario could attract emerging bio-chemical industries to the province. Therefore, the potential economic development from producing bio-chemicals using perennial biomass as feedstock is significant in Ontario.

4.4 Bio-Materials

Bio-composites and bio-plastics/polymers are materials which could be produced from biomass. In general, bio-composites are the combination of two phases with biomass fibre as one phase. Another phase could be either fossil-derived plastic/polymer or renewable bio-plastic/polymer. Vegetable oils or starches are common feedstocks used to produce renewable bio-plastics/polymers. Bio-composites commercially available today are mostly straw or woody fibre as reinforcement embedded in fossil-derived plastics due to their relatively lower cost of production. Sample bio-composites are shown in Figure 4.6.

Bio-composites have a wide range of applications and could replace almost all materials made from plastics and wood. Consumer products such as gardening tools, flower pots, ash trays, etc. could be made of bio-composites. Building materials such as insulation, furniture and flooring are also potential markets for bio-composites. A number of products are commercially available, and bio-composites have cost advantages over plastics or wood in many cases. In Ontario, Nott Farms and New Energy Farms has been supplying its switchgrass to bio-composites manufacturers.

The superior properties of bio-composites derived from agricultural biomass include better insulation and light weight. The application of bio-composites in the automotive industry is very promising since light weight materials with better insulation property could help meet higher fuel economy standards. Ontario, which is the home of the largest automotive industry in Canada, is well positioned to develop agricultural-based

Figure 4.6 Sample Bio-Composites

(Sources: www.kireiusa.com, www.en.wikipedia.org/wiki/Biocomposite, www.pliantplastics.com, www.biocom.iastate.edu)

bio-composites for automotive applications. Bio-based materials have been tested and deployed in a number of automotive components (Hill et al., 2012), and organizations like Ontario Bioauto Council (http://www.bioautocouncil.com) have been instrumental in this development. Bioproducts Discovery & Development Centre (BDDC) at the University of Guelph directed by Dr. Mohanty is a prominent research centre for bio-composites in Ontario. Figure 4.7 shows the use of wheat straw bio-composites in one of the Ford vehicle.

Agricultural bio-composites require some improvement and issues need to be addressed for a wider application in the automotive industry. Feedstock inconsistency due to seasonal and regional differences should be addressed. The odor and susceptibility to moisture and heat damage require more research and development work. Automotive manufactures have concern about the supply disruption of agricultural bio-composites due to abnormal weather. The costs of bio-composites are currently higher than that of regular plastics in most cases due to the current low volume production. The automotive industry offers the niche market for agricultural bio-composites in Ontario. Greater regulatory and institutional supports would accelerate the development of bio-composites industry for automotive applications.

Perennial biomass potentially produced from the surplus hay and pasture land could be

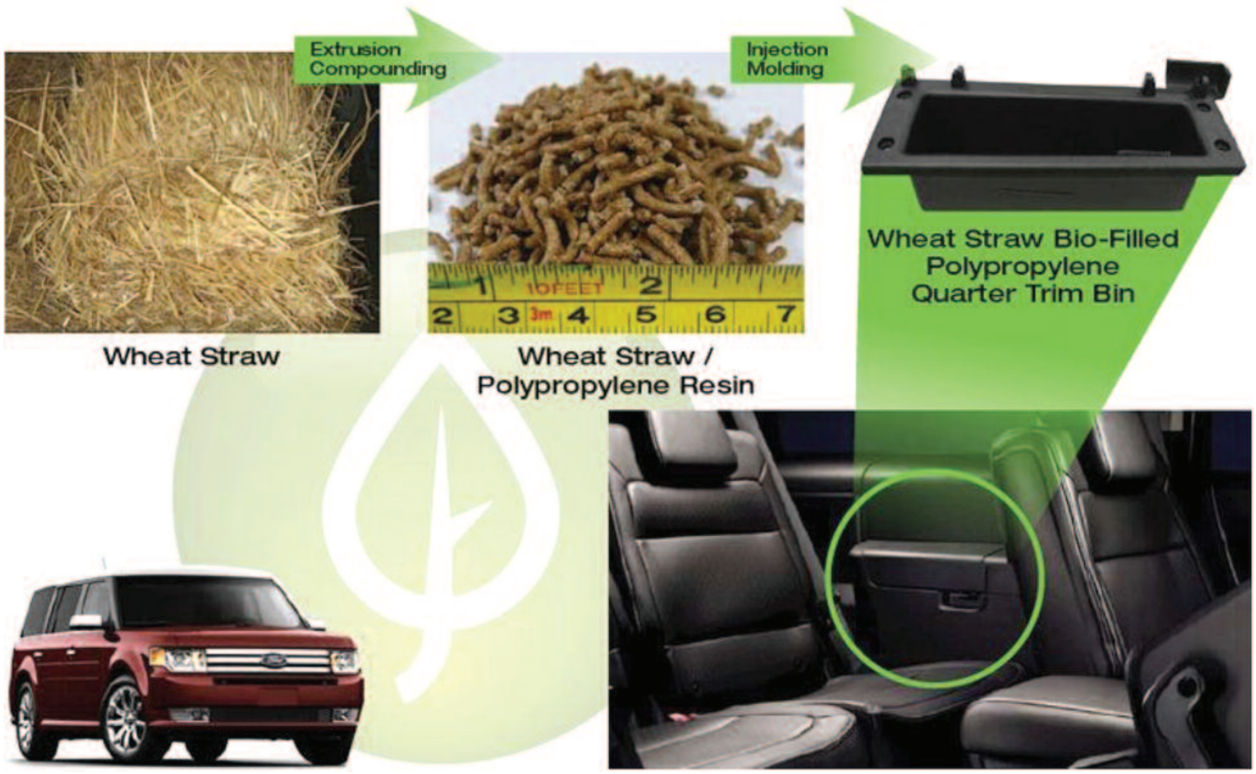

Figure 4.7 Wheat Straw Bio-Composites for Automotive Application
(http://media.ford.com)

feedstocks for the production of bio-plastics/polymers. PHA (Polyhydroxyalkanoate) polymers can be produced through the fermentation of cellulosic biomass (www.biorefine.org/prod/pha.pdf). At present, bio-plastics/polymers produced from sugar, starch and vegetable oils are commercially available, especially in Europe. Sample bio-plastic products are shown in Figure 4.8. The cellulosic bio-plastics/polymers have higher production costs in comparison with bio-plastics/polymers derived from sugar, starch and

Figure 4.8 Bio-Plastics/Polymers Materials
(en.wikipedia.org/wiki/Bioplastic)

vegetable oils. Competition from petroleum-based plastics/polymers should also be an important factor in the development of this industry. Global research and development and the commercialization efforts are expected to reduce production costs and make cellulosic bio-plastics/polymers competitive in the future.

4.5 Evaluation of Emerging Bio-Processing Industries

The emerging bio-processing industries discussed in previous sections are evaluated for potential perennial biomass feedstocks from the surplus hay acreage and pasture land. The evaluation parameters are technological maturity, profitability at current economic conditions, economic development potential for Ontario, competition with substitutes such as natural gas, crude oil, forestry biomass, etc., niche market existence, regulatory and institutional support, and existing value chain infrastructure. Weightings are assigned to these parameters, and each emerging bio-processing industry considered in this study is scored. The results are given in Table 4.2.

Bio-composites, bio-chemicals, and liquid bio-fuels are the most promising emerging bio-processing industries for the perennial biomass based on the total score of the evaluation. The major strengths of bio-composites industry are technological maturity, economic development potential, competition with substitutes, and the niche market existence. Demand from the building construction in the most populated province and the largest automotive industry could make Ontario attractive to bio-composites industry. The superior properties of light weight and better insulation offered by agricultural biomass have competitive advantages over other substitutes. The value-adding offered by bio-composites industry is also significant for the economic development potential in Ontario.

The major strengths of bio-chemicals and liquid bio-fuels sectors are its economic development

Table 4.2 Evaluation of Bio-Processing Industries for Perennial Biomass Feedstock

	Technology Maturity	Profitability	Economic Developmen t Potential	Competition with Substitutes	Niche Market Existence	Regulatory & Institutional Support	Existing Value Chain Infrastructure	Total Score (Max. 135)
Weighting	4	4	5	4	3	3	4	
Bio-Energy								
Space Heating	4	2	2	1	2	1	1	51
Combined Heat and Power	4	1	2	1	2	3	1	53
Bio-Fuels/ Chemicals								
Liquid Fuels	2	2	3	1	3	3	5	73
Chemicals	2	1	4	1	3	3	5	74
Bio-Materials								
Bio-Composites	4	3	4	3	4	2	1	82
Bio-Plastics/ Polymers	2	1	3	1	4	2	1	53

5 - Most favourable for biomass from hay/pasture land
1 - Least favourable for biomass from hay/pasture land

potential, niche market existence, regulatory and institutional support, and the existing value chain infrastructure from producer to market. The bio-chemicals and liquid bio-fuels industries require considerable initial capital investments. The well-established petro-chemicals industry in Ontario could reduce the required capital investments and operating expenses substantially by integrating these emerging bio-processing industries into the brown fields and other existing value chain infrastructure. The BioAmber plant being built at the LANXESS site in Sarnia, Ontario will produce bio-succinic acid from plant sugar and LANXESS' interest in butadiene from cellulosic sugar sources are examples of taking the advantage of existing value chain infrastructure.

Nova Institut estimated that jobs created by bio-materials or bio-fuels/chemicals industries are 5-10 times higher than that by bio-energy generation for the same quantity of biomass feedstocks. The value-adding offered by bio-materials or bio-fuels/chemicals industries are also 4-9 times higher than that by bio-energy generation for the same biomass input (Carus et al., 2010). There is a potential of integrating biomass combined heat and power generation or bio-digestion with bio-materials or bio-fuels/chemicals industries. This integration could not only improve the economics of energy generation from biomass but also allow the cascade use of biomass (higher value products from primary feedstock and energy generation from by-product/recycled biomass).

Due to their infancy, all emerging bio-processing industries require a certain level of regulatory and institutional support to accelerate the commercialization. Regulatory support can include government procurement initiatives for bio-base products, risk-sharing mechanisms, and research and development grants for the emerging industries. Partnership between the industries and universities/research institutions is essential in the development of bio-processing industries. The creation of knowledge and industry clusters in Ontario for emerging bio-processing industries would be of paramount importance for the bio-economy development in the province. This would maximize the economic value of surplus hay acreage and pasture land in Ontario by producing perennial biomass and by adding value at the related bio-processing industries. Farmers would also be interested in retaining a greater share of the value chain by participating in cooperative models to supply these potential industrial applications.

Chapter 5 - Summary, Conclusion and Recommendations

The surplus hay crop acreage and pasture land due to the declining cattle industry are estimated for Ontario agricultural regions in this study. Some hay acreage and pasture land have been converted to cash crops such as grain corn, soybeans and winter wheat. Hay crop acreage and pasture land are under utilized in some Ontario regions since the conversion to cash crops are economically unfavourable in those areas. The estimation of surplus hay acreage and pasture land is based on the land use comparison for the cattle industry in Ontario regions. The economics of biomass crop production, miscanthus and switchgrass are also investigated in this study. The net margins of traditional cash crops in Ontario are then compared with that of biomass crops for different grain price scenarios and land classes. Major applications for biomass from surplus hay acreage and pasture land are explored. Emerging bio-processing industries are reviewed and evaluated as potential users of biomass from hay acreage and pasture land.

5.1 Summary of Findings and Conclusion

The total number of cattle in Ontario has decreased from 2.29 million in 1996 to 1.74 million in 2011. This decline of 23.8% in 15 years has considerable effects on crop rotation, management of hay acreage and pasture land, and the crop mix in the province. Hay, which used to be the largest crop in Ontario, is usually grown as a perennial crop for 3-4 years. Farmers prefer to include hay in crop rotation since the perennial nature of hay crops improves soil quality significantly. However, inclusion of hay in crop rotation is no longer feasible in some areas due to the decreasing number of cattle.

Ontario farmers have been experiencing a gradual improvement in grain prices in recent years, starting from 2005-2006. This has led to the conversion of hay and pasture land to annual cash crops. In 2006-2011, approximately 485,000 acres of hay crops were converted to cash crops. The grain corn experienced an increase of 455,000 acres, the largest in 2006-2011. Soybeans and winter wheat acreages also increased during the same period. The most productive hay acreage and pasture land have been converted to cash crops due to favourable economics, especially in Southern and Western Ontario agricultural regions. Perennial crops have better environmental attributes such as improving soil, preventing erosion, using fewer chemicals, etc.

An option to keep the perennial hay crops in the crop mix in Ontario is to expand hay export markets. Canada is one of the largest forage exporters. Although Ontario farms produce approximately 25% of Canadian forage, the majority of forage products are consumed in the province. Canadian forage exports are mainly from Alberta and Saskatchewan to the US and Asian markets. Since Japan and Korea are the largest importers of forage products, Canadian western provinces are geographically better positioned for the hay export markets. Additionally, the economies of scales are favourable for the farm lands in the western provinces. One of the challenges in exporting Ontario forage products is the higher moisture content of hay harvested in humid Ontario climate. Moisture levels higher than 14% are considered as hazardous materials by most shipping companies. Drying hay to a moisture content of 10-12% would increase the production cost and reduce the competitiveness of Ontario forage producers in the global markets.

The surplus hay acreage and pasture land in Ontario which resulted from the declining cattle industry can be used to grow perennial biomass crops such as miscanthus and switchgrass. Biomass could also be supplied to traditional markets of animal beddings and feed. Biomass markets are emerging for bio-processing industries. Emerging biomass applications include bio-materials, cellulosic bio-fuels, bio-chemicals, and bio-energy generation. In addition to maintaining the perennial crops in the crop mix, these bio-processing industries offer the creation of value-adding activities in Ontario. Bio-processing industries would also provide business diversification to both the agricultural sector and the manufacturing industries.

Productivity of farm land in Ontario regions is compared by estimating farm cash receipts per acre. Farm cash receipts per acre in the southern region in 2011 were $1,241/acre, which is the highest in the province. It was followed by the western region with the average farm cash receipts per farm land of $910/acre. Based on farm cash receipts per acre, the most productive farm land in Ontario is located in the southern and western regions. Farm cash receipts per farm land in the central and eastern regions are comparable and lower than that of the western region. The northern region, which is the least agriculturally active area in the province, has the lowest farm cash receipts per acre. The average farm cash receipts of Ontario farms are $812/acre. The higher the productivity of farm land in the region, the lower the percentage of hay acreages in the total crop land. The southern region has the lowest hay acreage percentage; only 8.6% of total crop land is used to grow hay crops. In the northern region, hay acreages represent 57% of total crop land and hence offers a great potential for growing biomass crops.

Comparisons of hay and pasture land use per cattle for Ontario regions are made. For a similar beef to dairy cow ratio, producers in the western region use 0.83 acres to grow hay crops for each cow, while hay acreage per cattle in the central region is 1.82. The average yields of hay crops in the western region and the central region are not that different in order of magnitude, according to the OMAF statistics. The pasture land acreage per cattle in the central region is 1.77, which is 3.54 times higher than that of the western region. Similar differences are observed for the southern and eastern regions, which have approximately the same beef to dairy cow ratio. The comparisons suggest that hay crops and pasture land in the central and eastern regions are underutilized. The higher land use per cattle in the northern region could be caused by the shorter growing season and the lower productivity of agricultural land in the area.

Surplus hay crop acreage and pasture land are estimated for Ontario regions. The hay acreage and pasture land per cattle in the central and eastern regions are assumed to be reduced to the current provincial average. Due to the shorter growing season and the lower productivity of agricultural land, the hay acreage and pasture land per cattle in the northern region is assumed at 1.5 times of current provincial averages. The estimated surplus hay acreage and pasture land in Ontario is 864,000 acres, and the largest acreage is located in the central and eastern region with approximately 323,000 acres and 298,000 acres, respectively. The northern region also offers considerable acreages of surplus hay and pasture land. However, more research and field data are required for the agronomic practices and yield of biomass crops in the northern region. Surplus hay crop acreage and pasture land in the southern and western regions are relatively less than in comparison with the central and eastern regions. However, the continued high grain prices could further accentuate the move of cattle from the southern and western regions to others. Provincially, an additional 10% drop in the number of cattle would make 40,000 acres in the southern region and 113,000 acres in the western region available for conversion to cash crops or biomass crops. If the average yield of hay crops increases by 10% due to better crop management, an additional 200,000 acres of hay acreage and pasture land could be available for biomass crops in Ontario.

Potential biomass production from surplus hay crops and pasture land in Ontario regions are estimated. The largest biomass production potential from the surplus hay crops and pasture land is in the central Ontario region with an annual biomass quantity of 1.29 million tonne. Approximately 1.19 million tonne/yr of biomass can be produced from surplus hay crops and pasture land in the eastern region. The northern region also has a potential of producing 0.65 million tonne/yr of biomass; however, an assessment would be required on the feasibility of growing biomass crops in the area. Total annual biomass production potential from the surplus hay crops and pasture land in Ontario is estimated at 3.3 million tonne.

The net margins of perennial biomass crops, miscanthus and switchgrass are estimated for different land classes and biomass prices using the spreadsheet models developed. The net margins of miscanthus are positive for all biomass prices considered on all land classes; however, miscanthus production is likely geographically limited to the southernmost part of the province where snowfall is lower. For class 3 land, the net margins of miscanthus are $174.6/acre and $34.6/acre for the farm gate biomass price of $120/tonne and $100/tonne, respectively. The biomass price of over $120/tonne is required to achieve a positive net margin for switchgrass. For class 4 & 5 land, the net margins of switchgrass are $115.5/acre and $43.3/acre for the farm gate biomass price of $140/tonne and $120/tonne, respectively. For Ontario agricultural producers to grow perennial biomass crops on a large scale, net margins of biomass crops should be comparable to that of major field crops. At the grain corn price of $6/bushel, the approximate acceptable price of biomass is $120/tonne for class 1-3 land. If the price of grain corn improves to $7/bushel, the price of biomass should be about $140/tonne.

Emerging bio-processing industries are evaluated for the potential perennial biomass feedstocks from the surplus hay and pasture land in Ontario. The evaluation parameters are technological maturity, profitability, economic development potential, competition with substitutes, niche and established industrial market existence, regulatory and institutional support, and existing value chain infrastructure. Weightings are assigned to these parameters, and each emerging bio-processing industry is scored in consultation with industry experts. Bio-composites, bio-chemicals, and liquid bio-fuels are the most promising emerging bio-processing industries for the perennial biomass based on the total scores of the evaluation.

The major strengths of bio-composites industry are technological maturity, economic development potential, competition with substitutes, and the niche and industrial market existence. The demand from the building construction in the most populated province and the largest automotive industry could make Ontario attractive to bio-composites industry. The superior properties of light weight and better insulation offered by agricultural biomass have competitive advantages over other substitutes. The major strengths of bio-chemicals and liquid bio-fuels are economic development potential, niche market existence, regulatory and institutional support, and the most especially existing value chain infrastructure. The bio-chemicals and liquid bio-fuels industries require considerable initial capital investments. The well-established petro-chemicals industry in Ontario could reduce the required capital investments and operating expenses substantially by integrating these emerging bio-processing industries into existing value chain infrastructure. There is a potential of integrating biomass combined heat and power generation with bio-materials or bio-fuels/chemicals industries. This integration could not only improve the economics of energy generation from biomass but also allow the cascade use of biomass.

5.2 General Recommendations

Growing biomass crops on the surplus hay acreage and pasture land would maintain the perennial crops in the total crop mix in Ontario. In addition to the soil improvement benefits, the perennial biomass crops offer increased biodiversity, little or no use of chemicals, erosion prevention, and minimum crop maintenance requirement. The development of bio-processing industries, which would use the potential biomass from the surplus hay acreage and pasture land, would create an agriculture-based value adding activities in Ontario. The following general recommendations are provided to OFA and its affiliates:

- The net margins of annual cash crops are higher than that of perennial biomass crops for the most productive farm land at current grain and biomass prices. However, the economics of perennial biomass crops could be relatively better on the farm land with lower productivity. A comprehensive field research on the agronomic practices and the yields of biomass crops should be performed for low productivity farm land in Ontario regions.

- Communication with Ontario agricultural producers and industry experts during this study suggest that the yields of hay crops could be significantly improved if the hay crops are better managed. Although the economic incentives to increase the yields of hay crops could be limited in some areas, the potential productivity improvement in hay crops should be investigated. This improvement in yield would increase surplus hay acreage availability and pasture land for biomass production.

- The most productive hay and pasture land have been converted to cash crops due to favourable economics, especially in Southern and Western Ontario agricultural regions. When compared to annual cash crops, the perennial nature of hay and pasture land offer better environmental attributes such as improving soil, preventing erosion, using fewer chemicals, etc. A comprehensive study should be performed to investigate the social and environmental impacts of this significant land use change.

- Bio-composites, bio-chemicals, and liquid bio-fuels are the most promising emerging industries for the perennial biomass from the surplus hay acreage and pasture land. Job creation and value-adding offered by these industries are significantly better than most other bio-processing industries. The establishment of knowledge through reports like this one for industry clusters in Ontario is important and recommended to attract these bio-processing industries to the province.

- Due to their infancy, all emerging bio-processing industries require a certain level of regulatory and institutional support to accelerate commercialization. Regulatory support can include government procurement initiatives for bio-base products, risk-sharing mechanisms, and research and development grants for the emerging industries. Partnership between industries and universities/research institutions is essential in the development of bio-processing industries. Such support is recommended to maximize the economic value of surplus hay acreage and pasture land in Ontario by producing perennial biomass and by adding value at the related bio-processing industries.

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Appendix A – Ontario Agricultural Regions and Constituents

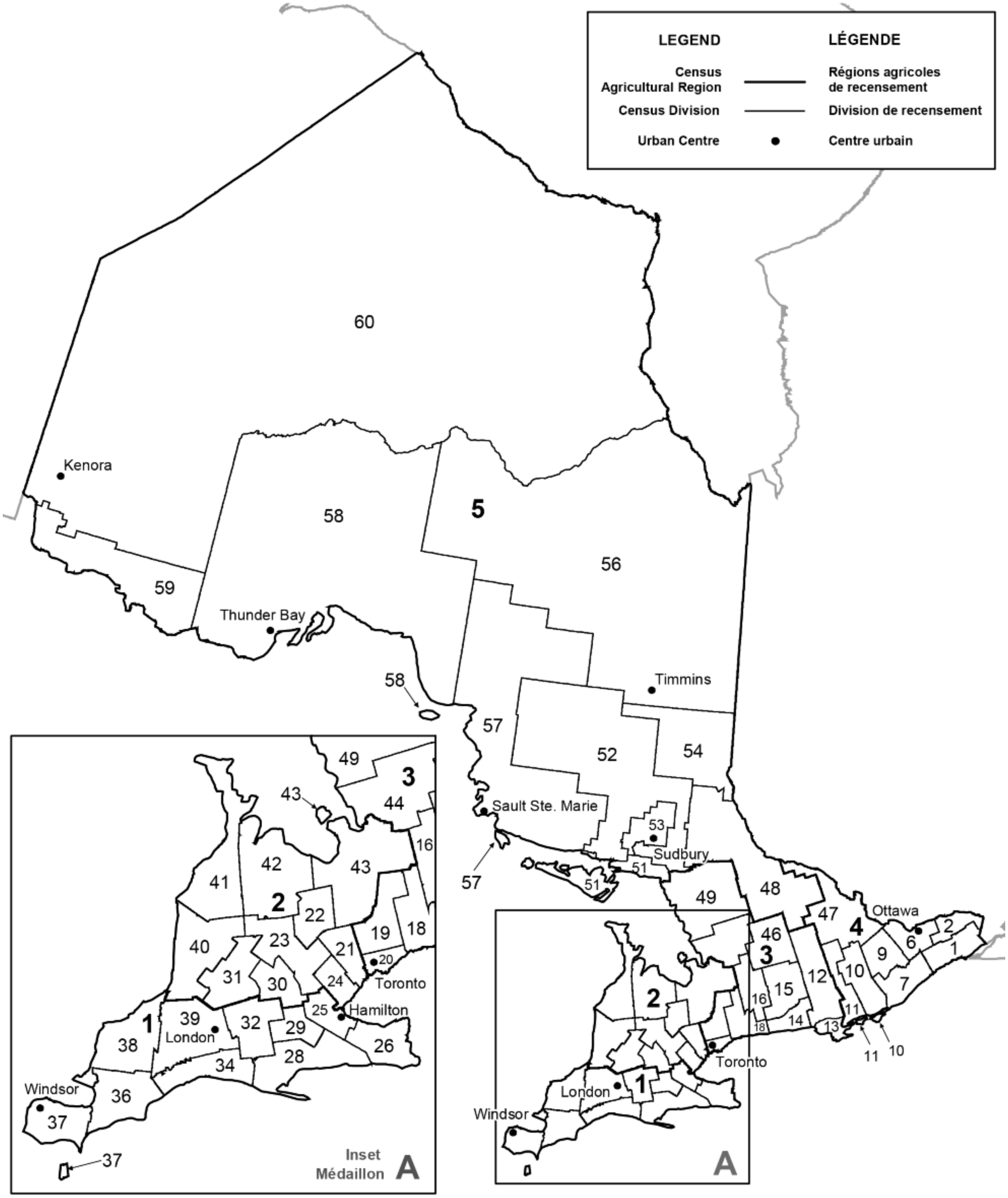


Figure A1 Agricultural Census Regions in Ontario

(http://www.omafra.gov.on.ca)

Table A1 Counties/Division/District/Municipality in Agricultural Census Regions

	Southern Ontario	Western Ontario	Central Ontario	Eastern Ontario	Northern Ontario
County/Division/District/Municipality	Brant (29)	Bruce (41)	Durham (18)	Frontenac (10)	Algoma (57)
	Chatham-Kent (36)	Dufferin (22)	Haliburton (46)	Lanark (9)	Cochrane (56)
	Elgin (34)	Grey (42)	Hastings (12)	Leeds & Grenville (7)	Greater Sudbury (53)
	Essex (37)	Halton (24)	Kawartha Lakes (16)	Lennox & Addington (11)	Kenora (60)
	Haldimand-Norfolk (28)	Huron (40)	Muskoka (44)	Ottawa (6)	Manitoulin (51)
	Hamilton (25)	Peel (21)	Northumberland (14)	Prescott & Russell (2)	Nipissing (48)
	Lambton (38)	Perth (31)	Parry Sound (49)	Renfrew (47)	Rainy River (59)
	Middlesex (39)	Simcoe (43)	Peterborough (15)	Stormont, Dundas & Glengarry (1)	Sudbury (52)
	Niagara (26)	Waterloo (30)	Prince Edward (13)		Thunder Bay (58)
	Oxford (32)	Wellington (23)	York (19)		Timiskaming (54)

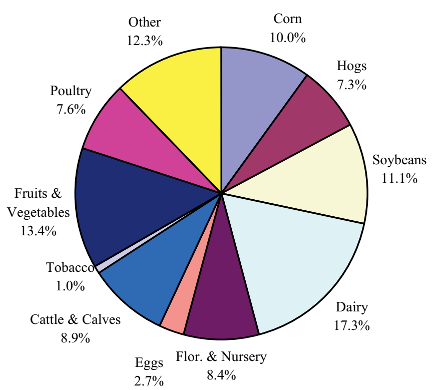
Note: Number in the bracket next to county/division/district/municipality refers to the region on the map (Figure A1)

Appendix B – Agricultural Summary of Ontario Regions

Southern Ontario Region at a Glance

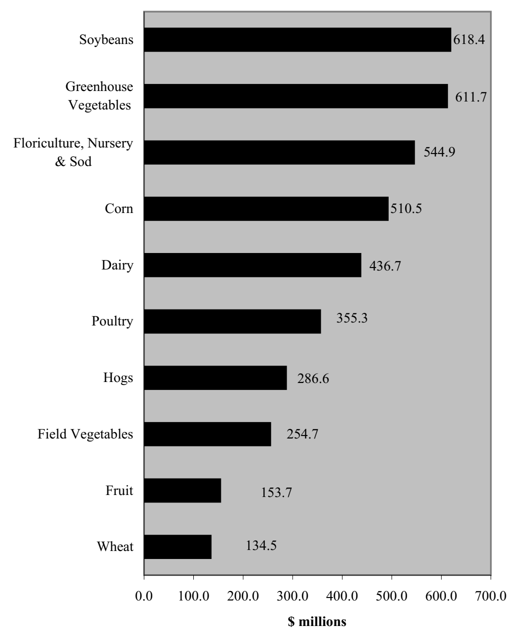
Item	Southern Ontario	Province	Percent of province
Farms, 2011 Census (number)			
Total	17,094	51,950	32.90
Reporting under 53 hectares	9,994	27,201	36.74
Reporting 53 to 161 hectares	4,547	16,230	28.02
Reporting 162 hectares and over	2,553	8,519	29.97
Land Use, 2011 Census (hectares)			
Land in crops..	1,337,269	3,613,821	37.00
Summerfallow land.................................	2,929	9,490	30.86
Tame or seeded pasture.........................	27,197	262,543	10.36
Natural land for pasture..........................	21,439	398,538	5.38
Christmas trees, woodland & wetland......	111,843	652,533	17.14
All other land...	48,436	189,728	25.53
Total area of farms..................................	1,549,113	5,126,653	30.22
Greenhouse Area, 2011 Census (square metres)			
Total area under glass or plastic	10,722,671	12,549,007	85.45
Hired Farm Labour, 2011 Census (weeks)			
Year round	705,863	1,405,252	50.23
Seasonal	517,172	812,057	63.69
Total	1,223,035	2,217,309	55.16
Farm Capital Value, 2011 Census (farms reporting)			
Under $200,000......................................	617	2,562	24.08
$200,000 to $499,999.............................	3,605	12,994	27.74
$500,000 to $999,999.............................	4,877	15,276	31.93
$1,000,000 and over...............................	7,995	21,118	37.86
Total Gross Farm Receipts, 2011 Census (farms reporting)			
Under $10,000...	2,688	12,263	21.92
$10,000 to $24,999.................................	2,621	9,098	28.81
$25,000 to $49,999.................................	2,469	6,720	36.74
$50,000 to $99,999.................................	2,417	6,189	39.05
$100,000 to $249,999.............................	2,674	6,985	38.28
$250,000 to $499,999.............................	1,774	5,086	34.88
$500,000 to $999,999.............................	1,319	3,248	40.61
$1,000,000 to $1,999,999.......................	729	1,558	46.79
$2,000,000 and over...............................	403	803	50.19
Farms by Industry Group, 2011 Census (number of farms)			
Dairy cattle and milk production..............	776	4,036	19.23
Beef cattle ranching and farming............	750	7,105	10.56
Hog and pig farming................................	467	1,235	37.81
Sheep and goat farming..........................	314	1,446	21.72
Poultry and egg production.....................	645	1,619	39.84
Other animal production..........................	1,579	6,966	22.67
Oilseed and grain farming.......................	8,628	15,818	54.55
Vegetable and melon farming.................	722	1,531	47.16
Fruit and tree nut farming........................	989	1,548	63.89
Greenhouse, nursery and floriculture......	1,036	2,372	43.68
Other crop farming..................................	1,188	8,274	14.36

Share of Farm Cash Receipts by Commodity, Ontario, 2010



Item	Southern Ontario	Province	Percent of province
Major Field Crops, 2011 Census (hectares)			
Winter wheat	217,976	445,155	48.97
Oats for grain	3,028	28,749	10.53
Barley for grain.......................................	1,758	51,347	3.42
Mixed grains	2,219	42,962	5.17
Corn for grain	370,025	822,465	44.99
Corn for silage	25,102	109,953	22.83
Hay	94,852	840,901	11.28
Soybeans	507,072	997,497	50.83
Dry white beans	3,013	16,283	18.50
Other dry beans	7,666	21,194	36.17
Potatoes	5,200	15,129	34.37
Major Fruit Crops, 2011 Census (hectares)			
Apples	3,161	6,406	49.34
Peaches	2,601	2,612	99.58
Sour Cherries	938	948	98.95
Raspberries	103	365	28.22
Strawberries	535	1,329	40.26
Grapes	7,015	7,439	94.30
Total fruit crops	16,165	21,343	75.74
Major Vegetable Crops, 2011 Census (hectares)			
Sweet corn	7,629	10,336	73.81
Tomatoes	6,321	6,701	94.33
Green peas	5,728	6,119	93.61
Green or wax beans	3,092	3,717	83.19
Total vegetables	38,265	52,445	72.96
Livestock Inventories, 2011 Census (number)			
Dairy cows	74,465	318,158	23.41
Beef cows	33,232	282,062	11.78
Steers	31,717	291,263	10.89
Total cattle and calves	290,600	1,741,381	16.69
Total pigs	1,383,068	3,088,646	44.78
Total sheep and lambs	60,661	352,807	17.19
Poultry Inventories, 2011 Census (number)			
Total hens and chickens	18,015,476	46,902,316	38.41
Total turkeys	2,083,683	3,483,828	59.81

Farm Cash Receipts for Main Commodities, Southern Ontario, 2010 (Total = $4.75 billion)



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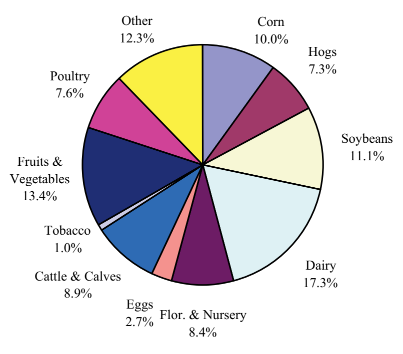
Sources: 2011 Census of Agriculture and Strategic Policy Branch, OMAFRA
28/08/2012

(http://www.omafra.gov.on.ca/english/stats/county/index.html)

Western Ontario Region at a Glance

Item	Western Ontario	Province	Percent of province
Farms, 2011 Census (number)			
Total	16,771	51,950	32.28
Reporting under 53 hectares	8,995	27,201	33.07
Reporting 53 to 161 hectares	5,449	16,230	33.57
Reporting 162 hectares and over	2,327	8,519	27.32
Land Use, 2011 Census (hectares)			
Land in crops	1,179,240	3,613,821	32.63
Summerfallow land	2,349	9,490	24.75
Tame or seeded pasture	96,319	262,543	36.69
Natural land for pasture	76,429	398,538	19.18
Christmas trees, woodland & wetland	161,650	652,533	24.77
All other land	55,159	189,728	29.07
Total area of farms	1,571,145	5,126,653	30.65
Greenhouse Area, 2011 Census (square metres)			
Total area under glass or plastic	863,923	12,549,007	6.88
Hired Farm Labour, 2011 Census (weeks)			
Year round	371,336	1,405,252	26.42
Seasonal	136,212	812,057	16.77
Total	507,548	2,217,309	22.89
Farm Capital Value, 2011 Census (farms reporting)			
Under $200,000	417	2,562	16.28
$200,000 to $499,999	3,070	12,994	23.63
$500,000 to $999,999	5,177	15,276	33.89
$1,000,000 and over	8,107	21,118	38.39
Total Gross Farm Receipts, 2011 Census (farms reporting)			
Under $10,000	3,104	12,263	25.31
$10,000 to $24,999	2,724	9,098	29.94
$25,000 to $49,999	2,162	6,720	32.17
$50,000 to $99,999	2,113	6,189	34.14
$100,000 to $249,999	2,695	6,985	38.58
$250,000 to $499,999	2,056	5,086	40.42
$500,000 to $999,999	1,126	3,248	34.67
$1,000,000 to $1,999,999	521	1,558	33.44
$2,000,000 and over	270	803	33.62
Farms by Industry Group, 2011 Census (number of farms)			
Dairy cattle and milk production	1,605	4,036	39.77
Beef cattle ranching and farming	3,096	7,105	43.57
Hog and pig farming	701	1,235	56.76
Sheep and goat farming	580	1,446	40.11
Poultry and egg production	674	1,619	41.63
Other animal production	2,499	6,966	35.87
Oilseed and grain farming	4,433	15,818	28.03
Vegetable and melon farming	306	1,531	19.99
Fruit and tree nut farming	226	1,548	14.60
Greenhouse, nursery and floriculture	535	2,372	22.55
Other crop farming	2,116	8,274	25.57

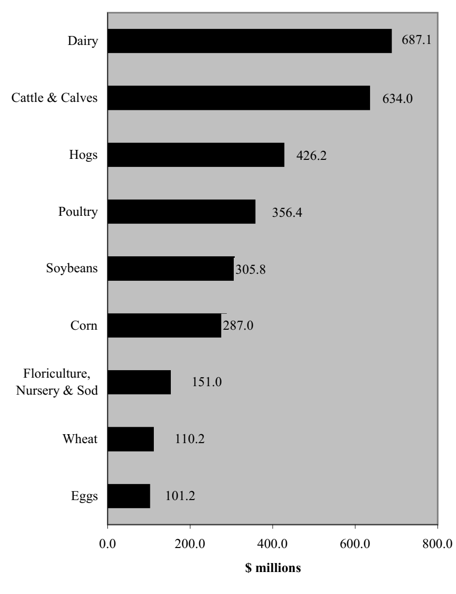
Share of Farm Cash Receipts by Commodity, Ontario, 2010



Total =$10.27 billion

Item	Western Ontario	Province	Percent of province
Major Field Crops, 2011 Census (hectares)			
Winter wheat	182,189	445,155	40.93
Oats for grain	6,895	28,749	23.98
Barley for grain	27,760	51,347	54.06
Mixed grains	27,891	42,962	64.92
Corn for grain	249,357	822,465	30.32
Corn for silage	53,437	109,953	48.60
Hay	269,463	840,901	32.04
Soybeans	273,978	997,497	27.47
Dry white beans	11,867	16,283	72.88
Other dry beans	11,648	21,194	54.96
Potatoes	7,711	15,129	50.97
Major Fruit Crops, 2011 Census (hectares)			
Apples	2,010	6,406	31.38
Peaches	9	2,612	0.34
Sour Cherries	4	948	0.42
Raspberries	67	365	18.36
Strawberries	248	1,329	18.66
Grapes	66	7,439	0.89
Total fruit crops	2,587	21,343	12.12
Major Vegetable Crops, 2011 Census (hectares)			
Sweet corn	940	10,336	9.09
Tomatoes	103	6,701	1.54
Green peas	173	6,119	2.83
Green or wax beans	440	3,717	11.84
Total vegetables	5,944	52,445	11.33
Livestock Inventories, 2011 Census (number)			
Dairy cows	120,256	318,158	37.80
Beef cows	103,086	282,062	36.55
Steers	222,712	291,263	76.46
Total cattle and calves	848,639	1,741,381	48.73
Total pigs	1,561,912	3,088,646	50.57
Total sheep and lambs	162,238	352,807	45.98
Poultry Inventories, 2011 Census (number)			
Total hens and chickens	21,084,855	46,902,316	44.95
Total turkeys	1,330,823	3,483,828	38.20

Farm Cash Receipts for Main Commodities, Western Ontario, 2010 (Total = $3.53 billion)



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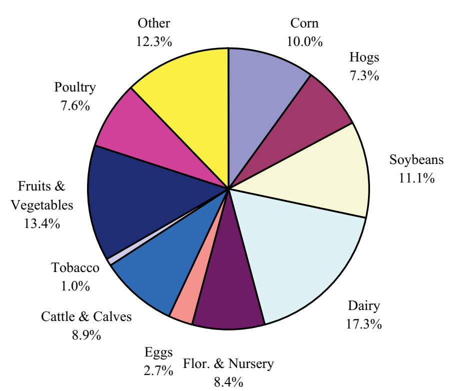
Sources: 2011 Census of Agriculture and Strategic Policy Branch, OMAFRA
28/08/2012

Appendix B

Central Ontario Region at a Glance

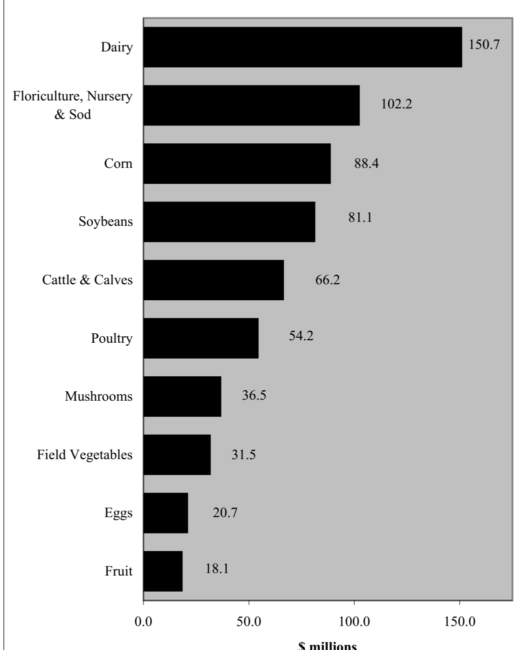
Item	Central Ontario	Province	Percent of province
Farms, 2011 Census (number)			
Total	7,817	51,950	15.05
Reporting under 53 hectares	4,243	27,201	15.60
Reporting 53 to 161 hectares	2,426	16,230	14.95
Reporting 162 hectares and over	1,148	8,519	13.48
Land Use, 2011 Census (hectares)			
Land in crops	411,327	3,613,821	11.38
Summerfallow land	1,824	9,490	19.22
Tame or seeded pasture	52,168	262,543	19.87
Natural land for pasture	98,239	398,538	24.65
Christmas trees, woodland & wetland	123,758	652,533	18.97
All other land	30,444	189,728	16.05
Total area of farms	717,760	5,126,653	14.00
Greenhouse Area, 2011 Census (square metres)			
Total area under glass or plastic	499,879	12,549,007	3.98
Hired Farm Labour, 2011 Census (weeks)			
Year round	160,550	1,405,252	11.42
Seasonal	99,624	812,057	12.27
Total	260,174	2,217,309	11.73
Farm Capital Value, 2011 Census (farms reporting)			
Under $200,000	453	2,562	17.68
$200,000 to $499,999	2,523	12,994	19.42
$500,000 to $999,999	2,558	15,276	16.75
$1,000,000 and over	2,283	21,118	10.81
Total Gross Farm Receipts, 2011 Census (farms reporting)			
Under $10,000	2,781	12,263	22.68
$10,000 to $24,999	1,720	9,098	18.91
$25,000 to $49,999	950	6,720	14.14
$50,000 to $99,999	736	6,189	11.89
$100,000 to $249,999	660	6,985	9.45
$250,000 to $499,999	484	5,086	9.52
$500,000 to $999,999	286	3,248	8.81
$1,000,000 to $1,999,999	132	1,558	8.47
$2,000,000 and over	68	803	8.47
Farms by Industry Group, 2011 Census (number of farms)			
Dairy cattle and milk production	459	4,036	11.37
Beef cattle ranching and farming	1,457	7,105	20.51
Hog and pig farming	26	1,235	2.11
Sheep and goat farming	273	1,446	18.88
Poultry and egg production	165	1,619	10.19
Other animal production	1,443	6,966	20.71
Oilseed and grain farming	1,141	15,818	7.21
Vegetable and melon farming	272	1,531	17.77
Fruit and tree nut farming	182	1,548	11.76
Greenhouse, nursery and floriculture	436	2,372	18.38
Other crop farming	1,963	8,274	23.72

Share of Farm Cash Receipts by Commodity, Ontario, 2010



Item	Central Ontario	Province	Percent of province
Major Field Crops, 2011 Census (hectares)			
Winter wheat	38,945	445,155	8.75
Oats for grain	5,106	28,749	17.76
Barley for grain	6,260	51,347	12.19
Mixed grains	7,038	42,962	16.38
Corn for grain	75,257	822,465	9.15
Corn for silage	10,309	109,953	9.38
Hay	165,250	840,901	19.65
Soybeans	78,596	997,497	7.88
Dry white beans	783	16,283	4.81
Other dry beans	958	21,194	4.52
Potatoes	753	15,129	4.98
Major Fruit Crops, 2011 Census (hectares)			
Apples	962	6,406	15.02
Peaches	X	2,612	-
Sour Cherries	1	948	0.11
Raspberries	76	365	20.82
Strawberries	242	1,329	18.21
Grapes	301	7,439	4.05
Total fruit crops	1,696	21,343	7.95
Major Vegetable Crops, 2011 Census (hectares)			
Sweet corn	1,157	10,336	11.19
Tomatoes	196	6,701	2.92
Green peas	178	6,119	2.91
Green or wax beans	69	3,717	1.86
Total vegetables	6,544	52,445	12.48
Livestock Inventories, 2011 Census (number)			
Dairy cows	29,973	318,158	9.42
Beef cows	56,214	282,062	19.93
Steers	18,318	291,263	6.29
Total cattle and calves	209,536	1,741,381	12.03
Total pigs	37,700	3,088,646	1.22
Total sheep and lambs	61,958	352,807	17.56
Poultry Inventories, 2011 Census (number)			
Total hens and chickens	3,116,786	46,902,316	6.65
Total turkeys	62,183	3,483,828	1.78

Farm Cash Receipts for Main Commodities, Central Ontario, 2010 (Total = $785.3 million)



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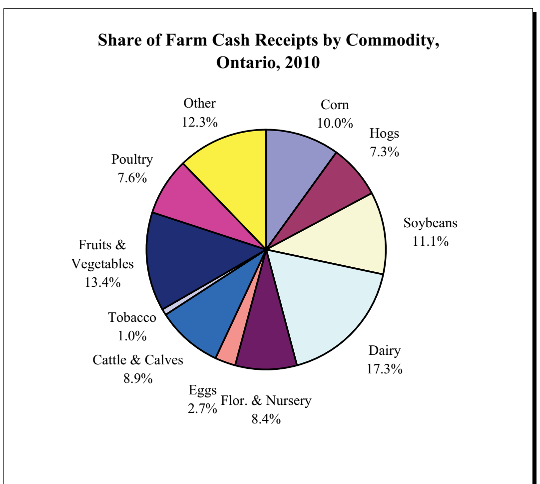
Sources: 2011 Census of Agriculture and Strategic Policy Branch, OMAFRA
28/08/2012

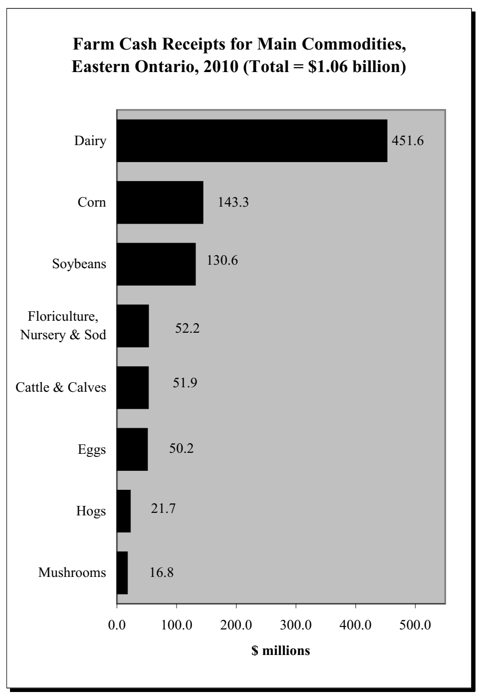
Appendix B

Eastern Ontario Region at a Glance

Item	Eastern Ontario	Province	Percent of province
Farms, 2011 Census (number)			
Total	8,007	51,950	15.41
Reporting under 53 hectares	3,302	27,201	12.14
Reporting 53 to 161 hectares	2,959	16,230	18.23
Reporting 162 hectares and over	1,746	8,519	20.50
Land Use, 2011 Census (hectares)			
Land in crops...	539,969	3,613,821	14.94
Summerfallow land................................	1,597	9,490	16.83
Tame or seeded pasture........................	52,799	262,543	20.11
Natural land for pasture.........................	115,158	398,538	28.90
Christmas trees, woodland & wetland.....	166,072	652,533	25.45
All other land..	38,237	189,728	20.15
Total area of farms.................................	913,832	5,126,653	17.83
Greenhouse Area, 2011 Census (square metres)			
Total area under glass or plastic............	265,916	12,549,007	2.12
Hired Farm Labour, 2011 Census (weeks)			
Year round	145,894	1,405,252	10.38
Seasonal	43,193	812,057	5.32
Total	189,087	2,217,309	8.53
Farm Capital Value, 2011 Census (farms reporting)			
Under $200,000.....................................	657	2,562	25.64
$200,000 to $499,999............................	2,798	12,994	21.53
$500,000 to $999,999............................	2,134	15,276	13.97
$1,000,000 and over..............................	2,418	21,118	11.45
Total Gross Farm Receipts, 2011 Census (farms reporting)			
Under $10,000.......................................	2,802	12,263	22.85
$10,000 to $24,999................................	1,507	9,098	16.56
$25,000 to $49,999................................	849	6,720	12.63
$50,000 to $99,999................................	716	6,189	11.57
$100,000 to $249,999............................	789	6,985	11.30
$250,000 to $499,999............................	668	5,086	13.13
$500,000 to $999,999............................	461	3,248	14.19
$1,000,000 to $1,999,999......................	160	1,558	10.27
$2,000,000 and over..............................	55	803	6.85
Farms by Industry Group, 2011 Census (number of farms)			
Dairy cattle and milk production.............	1,065	4,036	26.39
Beef cattle ranching and farming...........	1,322	7,105	18.61
Hog and pig farming...............................	34	1,235	2.75
Sheep and goat farming.........................	227	1,446	15.70
Poultry and egg production....................	115	1,619	7.10
Other animal production.........................	1,092	6,966	15.68
Oilseed and grain farming......................	1,501	15,818	9.49
Vegetable and melon farming................	166	1,531	10.84
Fruit and tree nut farming.......................	114	1,548	7.36
Greenhouse, nursery and floriculture......	257	2,372	10.83
Other crop farming.................................	2,114	8,274	25.55



Item	Eastern Ontario	Province	Percent of province
Major Field Crops, 2011 Census (hectares)			
Winter wheat	4,755	445,155	1.07
Oats for grain	4,807	28,749	16.72
Barley for grain.............................	9,222	51,347	17.96
Mixed grains	3,559	42,962	8.28
Corn for grain	126,427	822,465	15.37
Corn for silage	19,575	109,953	17.80
Hay	213,236	840,901	25.36
Soybeans	133,804	997,497	13.41
Dry white beans	X	16,283	-
Other dry beans	891	21,194	4.20
Potatoes	772	15,129	5.10
Major Fruit Crops, 2011 Census (hectares)			
Apples	249	6,406	3.89
Peaches	X	2,612	-
Sour Cherries	3	948	0.32
Raspberries	93	365	25.48
Strawberries	214	1,329	16.10
Grapes	56	7,439	0.75
Total fruit crops	701	21,343	3.28
Major Vegetable Crops, 2011 Census (hectares)			
Sweet corn	515	10,336	4.98
Tomatoes	74	6,701	1.10
Green peas	24	6,119	0.39
Green or wax beans	105	3,717	2.82
Total vegetables	1,416	52,445	2.70
Livestock Inventories, 2011 Census (number)			
Dairy cows	83,532	318,158	26.25
Beef cows	58,747	282,062	20.83
Steers	11,770	291,263	4.04
Total cattle and calves	300,358	1,741,381	17.25
Total pigs	99,859	3,088,646	3.23
Total sheep and lambs	53,509	352,807	15.17
Poultry Inventories, 2011 Census (number)			
Total hens and chickens	4,575,334	46,902,316	9.76
Total turkeys	6,195	3,483,828	0.18



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Sources: 2011 Census of Agriculture and Strategic Policy Branch, OMAFRA

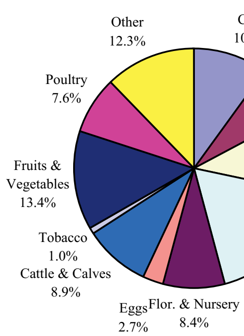
28/08/2012

Northern Ontario Region at a Glance

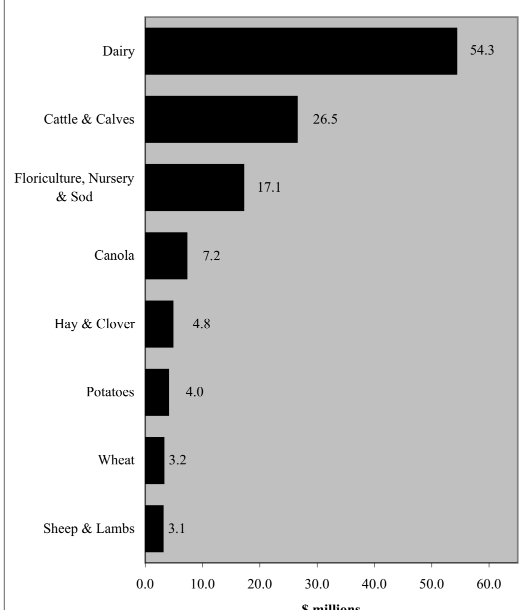
Item	Northern Ontario	Province	Percent of province
Farms, 2011 Census (number)			
Total	2,261	51,950	4.35
Reporting under 53 hectares	667	27,201	2.45
Reporting 53 to 161 hectares	849	16,230	5.23
Reporting 162 hectares and over	745	8,519	8.75
Land Use, 2011 Census (hectares)			
Land in crops	146,016	3,613,821	4.04
Summerfallow land	791	9,490	8.34
Tame or seeded pasture	34,060	262,543	12.97
Natural land for pasture	87,273	398,538	21.90
Christmas trees, woodland & wetland	89,211	652,533	13.67
All other land	17,452	189,728	9.20
Total area of farms	374,803	5,126,653	7.31
Greenhouse Area, 2011 Census (square metres)			
Total area under glass or plastic	196,618	12,549,007	1.57
Hired Farm Labour, 2011 Census (weeks)			
Year round	21,609	1,405,252	1.54
Seasonal	15,856	812,057	1.95
Total	37,465	2,217,309	1.69
Farm Capital Value, 2011 Census (farms reporting)			
Under $200,000	418	2,562	16.32
$200,000 to $499,999	998	12,994	7.68
$500,000 to $999,999	530	15,276	3.47
$1,000,000 and over	315	21,118	1.49
Total Gross Farm Receipts, 2011 Census (farms reporting)			
Under $10,000	888	12,263	7.24
$10,000 to $24,999	526	9,098	5.78
$25,000 to $49,999	290	6,720	4.32
$50,000 to $99,999	207	6,189	3.34
$100,000 to $249,999	167	6,985	2.39
$250,000 to $499,999	104	5,086	2.04
$500,000 to $999,999	56	3,248	1.72
$1,000,000 to $1,999,999	16	1,558	1.03
$2,000,000 and over	7	803	0.87
Farms by Industry Group, 2011 Census (number of farms)			
Dairy cattle and milk production	131	4,036	3.25
Beef cattle ranching and farming	480	7,105	6.76
Hog and pig farming	7	1,235	0.57
Sheep and goat farming	52	1,446	3.60
Poultry and egg production	20	1,619	1.24
Other animal production	353	6,966	5.07
Oilseed and grain farming	115	15,818	0.73
Vegetable and melon farming	65	1,531	4.25
Fruit and tree nut farming	37	1,548	2.39
Greenhouse, nursery and floriculture	108	2,372	4.55
Other crop farming	893	8,274	10.79

Item	Northern Ontario	Province	Percent of province
Major Field Crops, 2011 Census (hectares)			
Winter wheat	1,292	445,155	0.29
Oats for grain	8,913	28,749	31.00
Barley for grain	6,347	51,347	12.36
Mixed grains	2,255	42,962	5.25
Corn for grain	1,399	822,465	0.17
Corn for silage	1,531	109,953	1.39
Hay	98,099	840,901	11.67
Soybeans	4,047	997,497	0.41
Dry white beans	X	16,283	-
Other dry beans	31	21,194	0.15
Potatoes	694	15,129	4.59
Major Fruit Crops, 2011 Census (hectares)			
Apples	23	6,406	0.36
Peaches	0	2,612	0.00
Sour Cherries	2	948	0.21
Raspberries	25	365	6.85
Strawberries	89	1,329	6.70
Grapes	1	7,439	0.01
Total fruit crops	195	21,343	0.91
Major Vegetable Crops, 2011 Census (hectares)			
Sweet corn	96	10,336	0.93
Tomatoes	8	6,701	0.12
Green peas	17	6,119	0.28
Green or wax beans	11	3,717	0.30
Total vegetables	277	52,445	0.53
Livestock Inventories, 2011 Census (number)			
Dairy cows	9,932	318,158	3.12
Beef cows	30,783	282,062	10.91
Steers	6,746	291,263	2.32
Total cattle and calves	92,248	1,741,381	5.30
Total pigs	6,107	3,088,646	0.20
Total sheep and lambs	14,441	352,807	4.09
Poultry Inventories, 2011 Census (number)			
Total hens and chickens	109,865	46,902,316	0.23
Total turkeys	944	3,483,828	0.03

Share of Farm Cash Receipts by Commodity, Ontario, 2010



Farm Cash Receipts for Main Commodities, Northern Ontario, 2010 (Total = $151.2 million)



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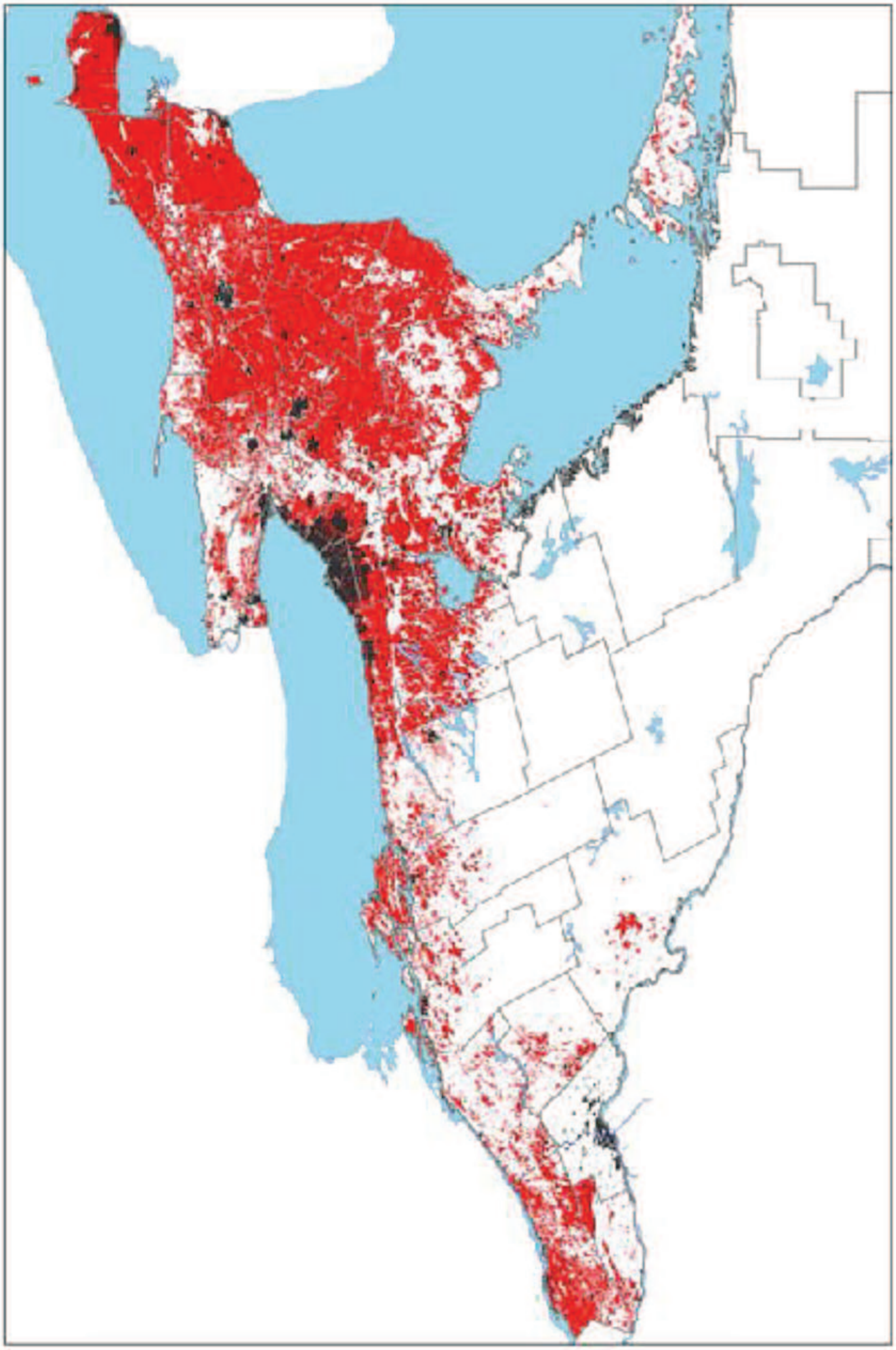
Sources: 2011 Census of Agriculture and Strategic Policy Branch, OMAFRA
28/08/2012

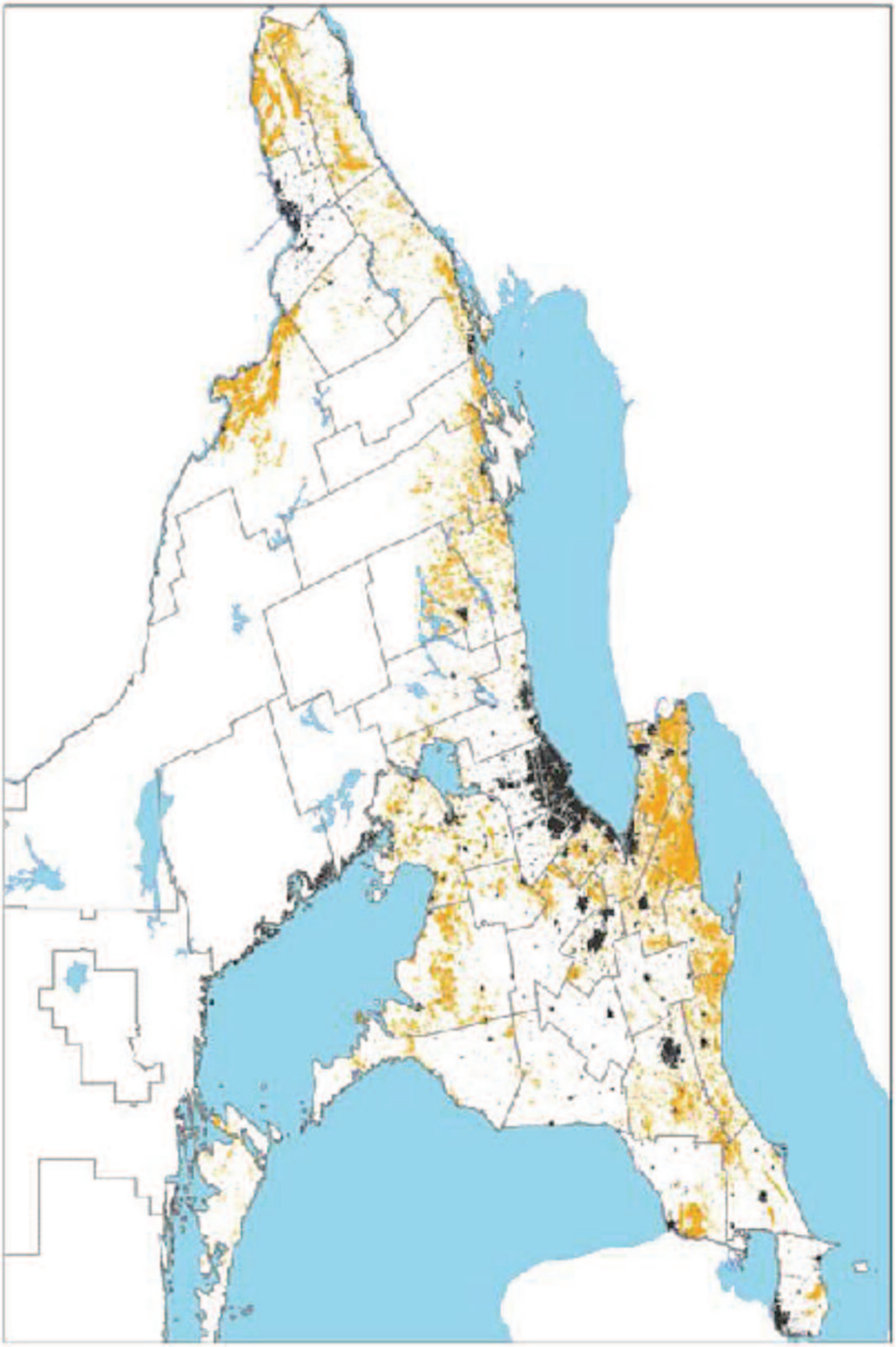
Appendix C - Selected Ontario Agricultural Land Classes Maps

Canada Land Inventory Capability Classes for Agriculture Class 1 & 2 Lands

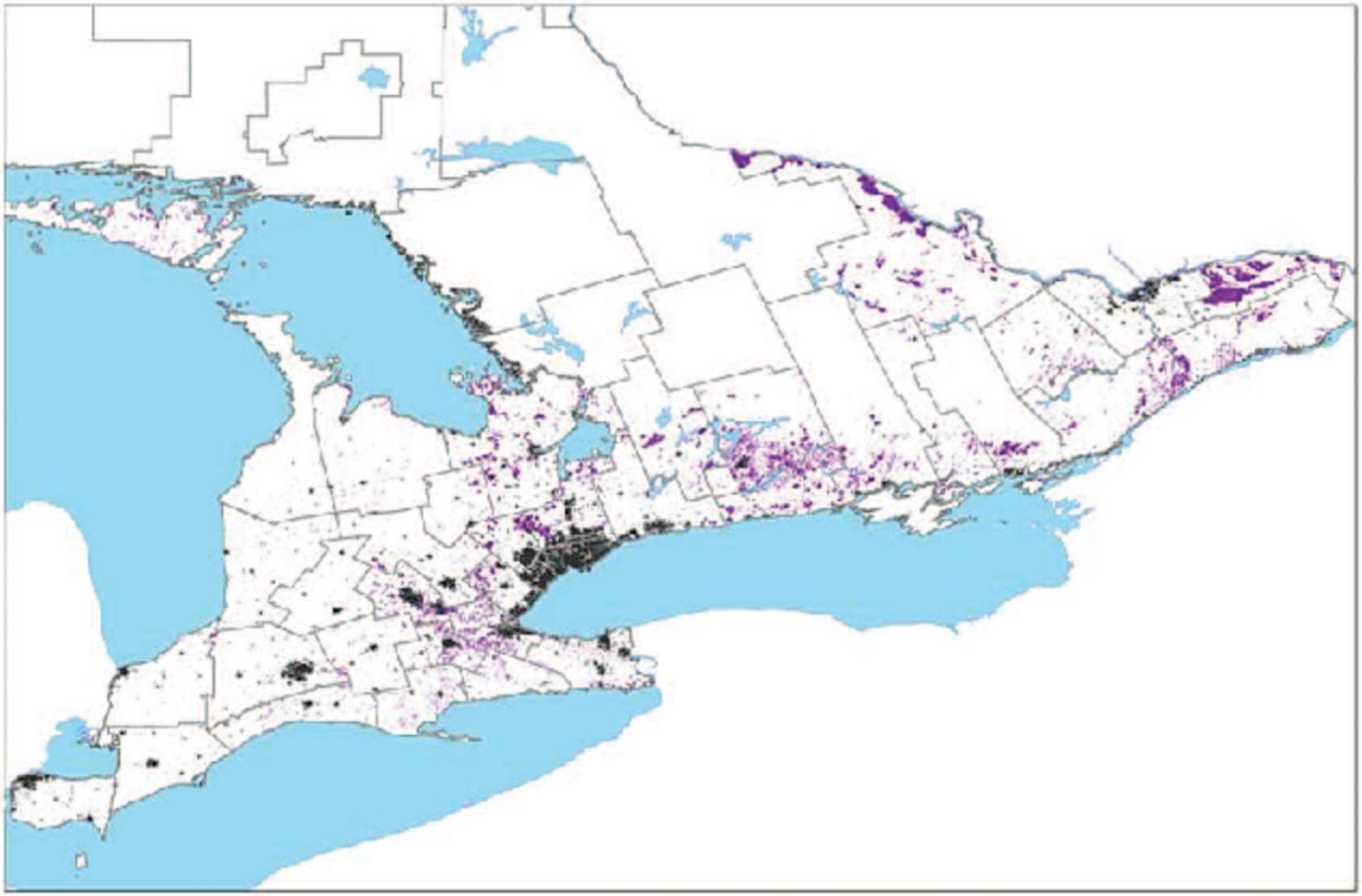


(Source: OMAF)

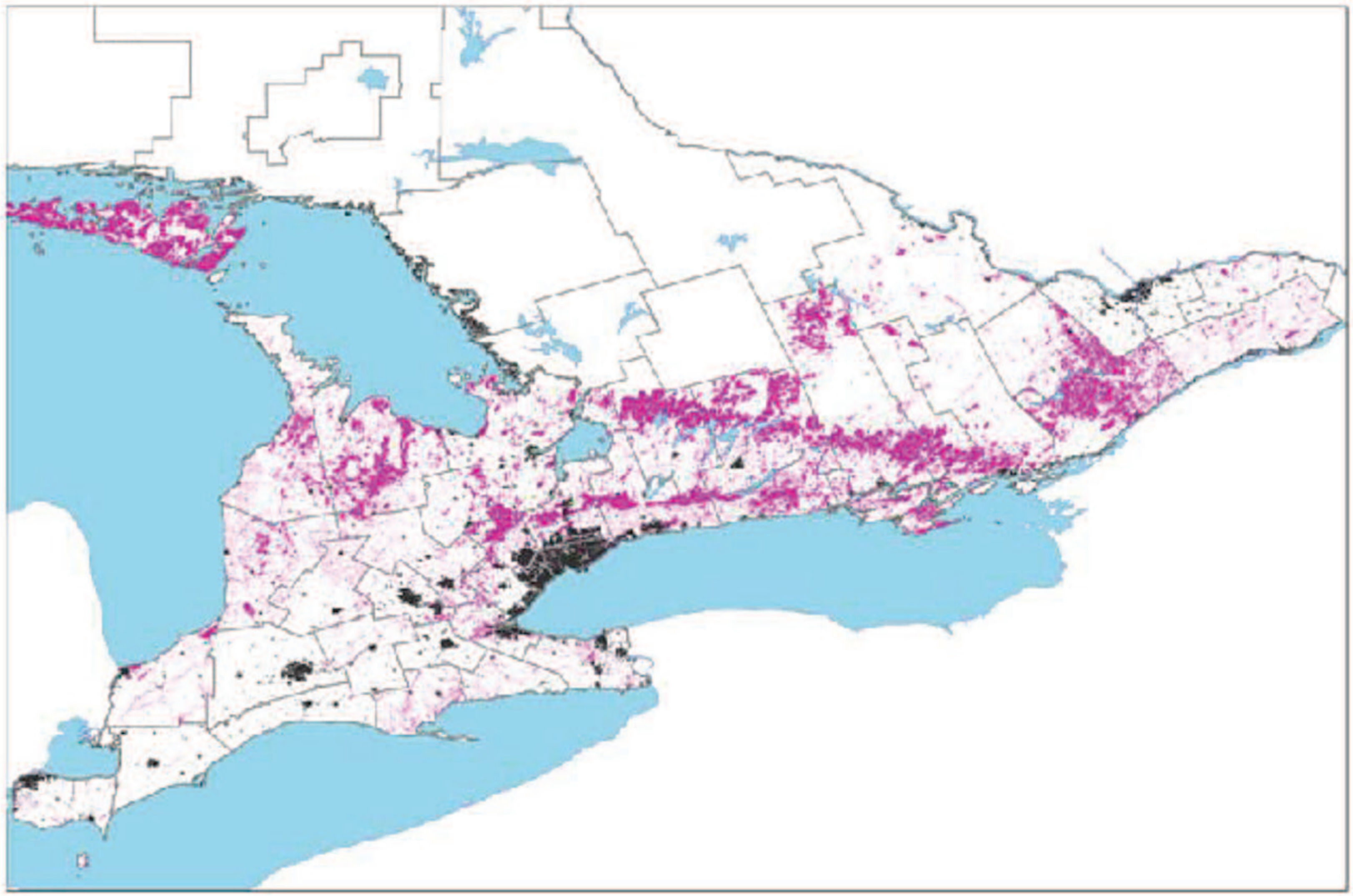
Canada Land Inventory
Capability Classes for Agriculture
Class 3 Lands



Canada Land Inventory Capability Classes for Agriculture Class 4 Lands



Canada Land Inventory
Capability Classes for Agriculture
Class 5 & 6 Lands



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