Biomass Crop Residues Availability for Bio-Processing in Ontario

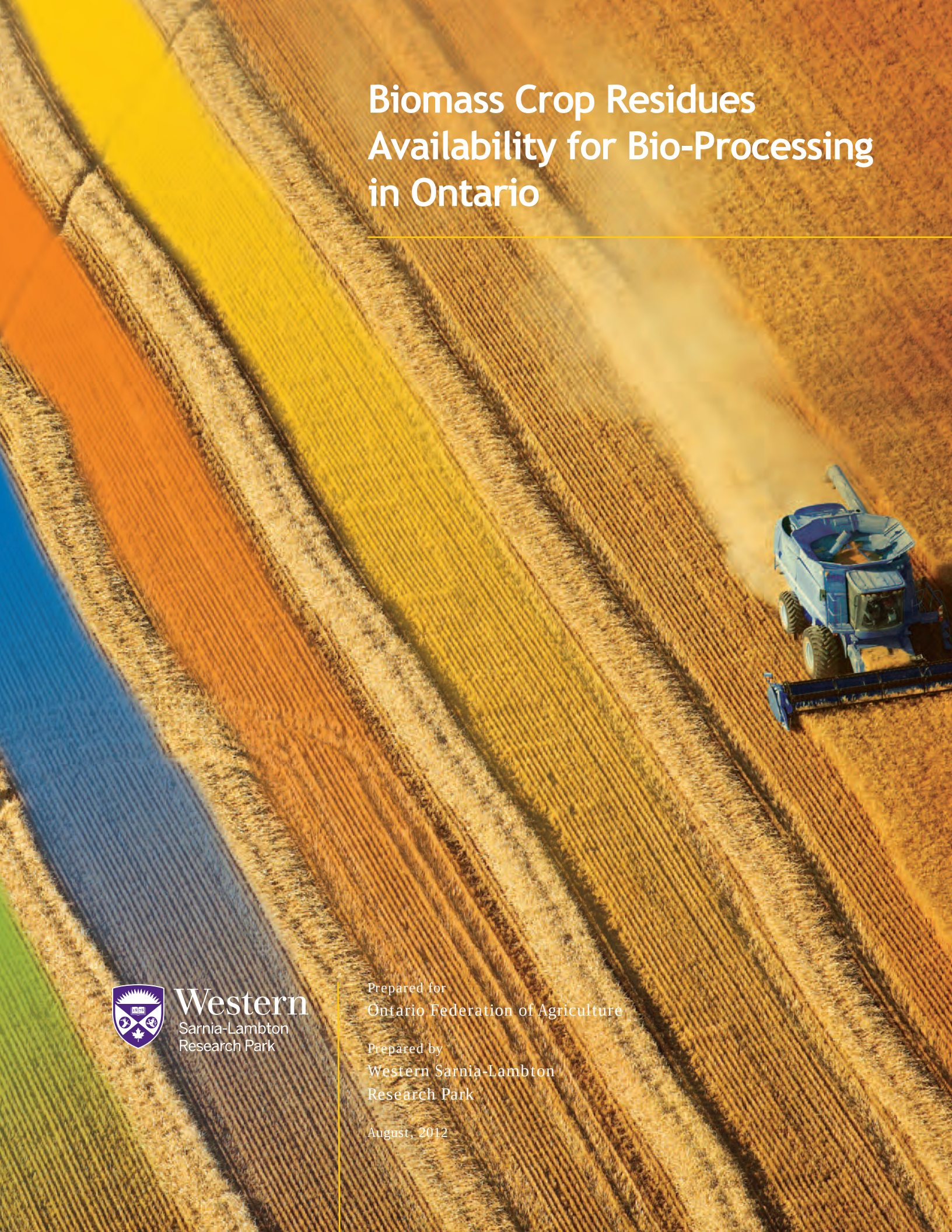

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Table of Contents

Preface

In 2010, the Ontario Federation of Agriculture (OFA) received Agriculture and Agri Food Canada (AAFC) funding through the Canadian Agricultural Adaptation Council (CAAP) to conduct producer level research and value chain determination, including this biomass crop residue report.

In earlier studies, the OFA examined the opportunities to use biomass as a substitution for coal and natural gas, including a business case for purpose-grown biomass as a combustion fuel. This report is available on the OFA website along with other biomass studies. Please visit www.ofa.on.ca/issues/overview/biomass to access these previous studies including this report.

As other jurisdictions have approached the use of biomass for combustion as an integrated market with bioprocessing opportunities, the OFA commissioned this study to examine the availability of crop residues that can be sustainably harvested in Ontario based on a snapshot of agricultural activities occurring in 2011. Using Statistics Canada livestock information and Ontario Crop Insurance information the environmentally sustainable biomass that can be harvested has been calculated. The information has been tabulated at a county level to facilitate its use. The methodologies used are consistent with those reported in literature and used by United States Department of Agriculture (USDA).

Information on crop residues complements previous information generated for the availability of purpose grown biomass. Together there is a formidable supply opportunity to support industrial and local uses of biomass in the future while generating new income for producers.

The OFA wishes to thank Dr. Aung Oo of Western Sarnia-Lambton Research Park for the preparation of this report.

Aung Oo

Charles Lalonde

Executive Summary

The quantities of sustainably harvestable crop residues available for bio-processing are estimated for counties in Ontario in this study. For this estimation, major crops in Ontario, crop rotation practices, livestock farming and its influence on soil quality, and current crop residues management are reviewed. A certain amount of crop residues must be left in the field to maintain soil SOM at a productive level. Therefore, the SOC budget model is employed to estimate the sustainably harvestable crop residues. The crop acreages are estimated from the crop insurance data from Agricorp and OMAFRA statistics. The size of cattle industry in each county is also obtained from the OMAFRA statistics. The spreadsheet model was developed to process the input data sets for each county to estimate the sustainably harvestable crop residues. The results of the counties are aggregated to the Ontario agricultural census regions and to the provincial level.

The total quantity of sustainably harvestable crop residue in Ontario is 3.12 million tonne/year, which is approximately 20% of total above-ground crop residues produced annually in the province. It should be noted, for a comparison, that approximately 2 million tonne/year of wood pellets are exported from British Columbia to Europe for energy applications. Western Ontario region offers the largest amount of crop residues, 1.26 million tonne/year, followed by Southern Ontario region, 0.85 million tonne/year. These two regions are the largest agricultural areas in Ontario. The sustainably harvestable crop residues in Central Ontario and Eastern Ontario are 0.39 million tonne/year and 0.55 million tonne/year, respectively. As the least agriculturally active region, Northern Ontario could provide the crop residues of 0.08 million tonne/year.

There are a total of 11 counties which can provide the crop residues of 500,000 tonne/year sustainably including the crop residues from the border-sharing neighbouring counties. They are Bruce, Grey, Huron, Perth, Waterloo and Wellington counties in Western Ontario region and Chatham-Kent, Elgin, Lambton, Middlesex and Oxford counties in Southern Ontario region. These counties are the likely locations of large-scale bio-processing industries. A 50 MW electricity generation plant at base load can consume approximately 300,000 tonnes of crop residues annually. A typical large biomass pellet mill in British Columbia produces 150,000 – 200,000 tonne/year. A cellulosic ethanol plant with 50 million litres annual capacity would require approximately 175,000 tonne/year of crop residues. Relatively small-scale bio-processing industries can be located in almost any county in Ontario.

The amount of agricultural residues which could be sustainably removed from farms is site-specific and depends on the crop rotation schedule and other farm practices of individual farmers. Hay, soybeans, grain corn and winter wheat are the top four field crops, collectively representing 89% of total field crops in Ontario. Grain corn, which is the highest biomass yielding food crop, offers the largest potential of residues for harvest followed by winter wheat. Growing hay, which has deep roots in comparison with annual crops, gives some theoretically harvestable residues; however, practically no residues would be available for harvesting. Soybeans, which are relatively small plants, need more plant or other organic materials to maintain the SOM of soil. The deficits of crop residues due to soybeans production are usually replenished by the residues' surplus from grain corn or winter wheat through crop rotation. Farmers also periodically add livestock manure to the soil to replenish the SOC.

The majority of sustainably harvestable crop residues in Ontario will be from grain corn and winter wheat. The preferred crop rotation in Ontario is soybeans-winter wheat-corn followed by 3-4 years of perennial hay crops. However, this rotation is unfeasible in some areas where there is no matching demand of hay products. Therefore, the most popular crop rotation is soybeans-winter wheat-corn. Wheat straw is the most widely used crop residue in Ontario and can be harvested using conventional farm equipment. Approximately 1.20 tonne/acre of wheat straw is harvested. Since total above-ground residues produced by winter wheat crop is about 3.53 tonne/acre, over 60% of crop residues are left in the field. It is not recommended to harvest soybeans residues due to the resulting SOC deficit. It may also be uneconomical to harvest soybean residues due to the relatively lower yield. However, if the demand for soybeans' residues exists for particular applications, harvesting can be done. Growing winter cover crops will likely be required to reduce soil erosion if soybeans residues are harvested. In general, the recommended harvest of corn residues is 1.26 tonne/acre, which would also leave over 60% of above-ground residues in the field for soybeans-winter wheat-corn rotation. Availability of manure and other organic materials would increase the recommended harvest of crop residues.

The crop mix and the numbers of cattle of a particular county define the sustainably harvestable crop residues. If soybeans represent a greater percentage of total crop land in the county, a lesser quantity of crop residues can be sustainably harvested. On the other hand, more crop residues are available for harvesting if grain corn and winter wheat dominate the crop land in the county. The numbers of cattle and calves also affect the sustainably harvestable residues in the county, since the manure provides organic materials and thus SOC for soil. In most cases in Ontario, the majority of hay produced in county is utilized by livestock farms in the county. The indigestible fibre in animal feed is returned to soil by spreading manure and used animal bedding. Therefore, the greater the cattle industry the county has, the more the sustainable harvestable residues.

The creation of bio-processing industries which use crop residues in Ontario would not only provide additional income to the producers but also offer better crop residues management. Crop residues, if sustainably harvested, are renewable feedstocks for bio-processing industries. The increasing crop yields will result in greater amount of crop residues in the future. A farm-specific assessment should be performed for individual producers who want to harvest some crop residues for bio-processing industries. Monitoring of soil health by regular soil tests is highly recommended for farms participating in crop residues harvesting. Beneficial soil management practices such as manure spreading and growing winter cover crop should be employed as required. Comprehensive field research on the effect of residue removal on soil is required in all regions of Ontario. Ontario producers and potential bio-processing industries should be educated on the sustainable harvesting of crop residues. Development of bio-processing industries in Ontario should be encouraged, and the use of crop residues as a sustainable source of biomass should be promoted. The use of crop residues for energy generation could be an immediate opportunity. Advanced bio-composite materials and bio-fuels and bio-chemicals could be long-term markets for crop residues. Monitoring the technology development in emerging bio-processing industries as well as collaborating with all stakeholders is recommended.

Chapter 1 - Overview of Agriculture and Residues Management in Ontario

The agricultural sector and related food and agricultural processing industries are important economic and social contributors to Ontario's economy while contributing positively to society's environmental goals. Farms in Ontario produce grains, beans and meat for human consumption, feeds for livestock, and feedstocks for various industries. Farm activities also produce significant amount of by-products such as manure and crop residues. These by-products are essential in farm management for conserving soil quality, and some of the by-products could be potentially used in other applications. In this chapter, an overview of major agricultural crops and typical crop rotation practices in Ontario are presented. Livestock farming in Ontario and its role in maintaining soil quality are also discussed. The current management of crop residues in Ontario is also reviewed.

1.1 Major Field Crops in Ontario

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). The four largest field crops in Ontario are hay, soybeans, grain corn and winter wheat, collectively representing approximately 89% of total field crop area. Ontario farmers also grow barley, fodder corn, spring wheat, beans, oats, rye, tobacco and canola. Table 1.1 gives the field crops grown in Ontario with their acreages, which are 2007-2011 five year average data compiled from Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Field Crop Statistics.

Hay is the largest crop in Ontario with 2.47 million acres representing 29% of the total field crops. Hay is mainly used for the livestock in Ontario, while some is exported to the USA and Asia markets. Due to the declining cattle industry in Ontario, some pasture land is being converted to other crops in recent years. About 2.32 million acres is used to grow soybeans, as the second largest crop in Ontario, which produces over 75% of Canadian supply. Grain corn is the third largest crop in Ontario with 1.86 million acres, producing about 65% of Canadian corn. Approximately 30-35% of grain corn produced in Ontario is used to make ethanol, and represents the agricultural sector's contribution to green energy with associated environmental benefits. Winter wheat, which accounts for 11% of the total, is the fourth largest crop, although the acreage of this crop fluctuates from year to year more than that of

Table 1.1 Acreages of Field Crops in Ontario

Field Crop	Acreage
Hay	2,472,000
Soybeans	2,316,400
Grain corn	1,857,000
Winter wheat	932,000
Fodder corn	276,000
Barley	153,400
Spring wheat	131,000
Dry field beans	121,600
Mixed grain	102,000
Oats	69,200
Canola	57,000
Fall rye	38,000
Tobacco	12,100
Total	8,537,700

other major crops. Other field crops occupy about 11% of total field crop area in Ontario. Over 70% of Ontario agricultural products are processed in the province, creating the second largest food processing region, after Chicago area in North America (OASC, 2010).

1.2 Crop Rotation Practices

Crops are grown in rotation largely for two reasons: to control pests and to maintain soil quality and hence productivity. 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 the growth cycle of weeds. Crop rotation improves the health of soil by adding nutrients. For instance, soybeans, which have a nitrogen fixing mechanism, would provide fertilizers to the subsequent crop in the rotation. Fast-growing crops, such as grain corn, leave a significant amount of crop residues to improve Soil Organic Matter (SOM) of agricultural land.

To understand the typical crop rotation practices of Ontario's producers, the composition of major field crops are given in Figure 1.1. Hay, the largest crop in Ontario, is usually grown as a perennial crop for 3-4 years. Farm operators prefer to include hay in the crop rotation, since the perennial nature of hay crops improves soil. However, in some areas, where the livestock is not a large part of farming, inclusion of hay is not always feasible. The preferred crop rotation by farm operators is soybeans-winter wheat-corn followed by 3-4 years of hay crops. Due to the declining cattle industry in Ontario, the most popular crop rotation is soybeans-winter wheat-corn. As seen in Figure 1.1, winter wheat represents only 11% of total field crops while soybeans and grain corn are 27% and 22%, respectively, of total field crops. This suggests that the field crops, other than winter wheat, are also rotated with soybeans and corn. There are some areas in Ontario where soybeans-corn is a common crop rotation.

The four largest crops in Ontario, namely hay, soybeans, grain corn and winter wheat, contribute in different ways to the health of the agricultural lands in the province. As mentioned earlier, the perennial hay crops improve soil quality with their living roots. Soybeans fix nitrogen to provide natural fertilizer to the other crops in rotation. Grain corn, the fast growing crop, replenishes SOM by leaving a large amount of crop residues. Winter wheat also leaves a

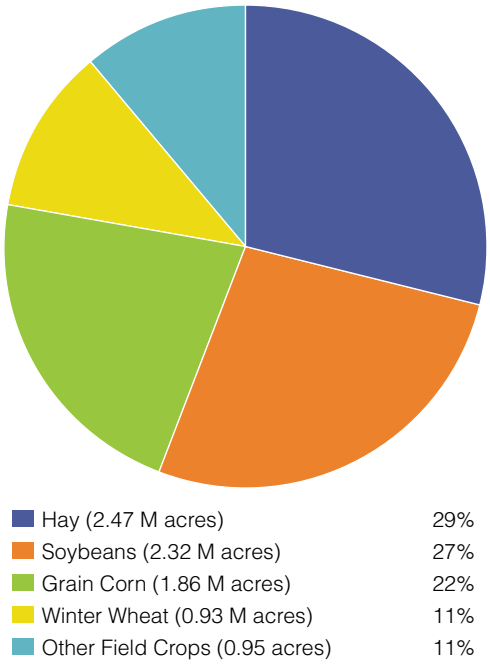

Figure 1.1 Ontario Major Crops in Rotation

significant quantity of crop residues and provides bedding materials, which are usually returned back to soil with manure, for livestock.

1.3 Livestock Farming

Livestock farming is an integral part of agricultural sector. An agricultural census in 2011 (http://www.omafra.gov.on.ca/english/stats/agriculture_summary.htm) suggested that total market receipts of top commodities from Ontario's farms was $ 10.2 billion, and approximately 50% of total market receipts was from livestock farming (see Figure 1.2). Dairy and beef farms are the largest livestock operations in the province, representing about 60% of total livestock market receipts. Dairy and beef farms can earn additional income by generating electricity through the Anaerobic Digestion (AD) of manure. There are about 15 AD electricity generation systems connected to the grid in Ontario, and a few more systems are under construction.

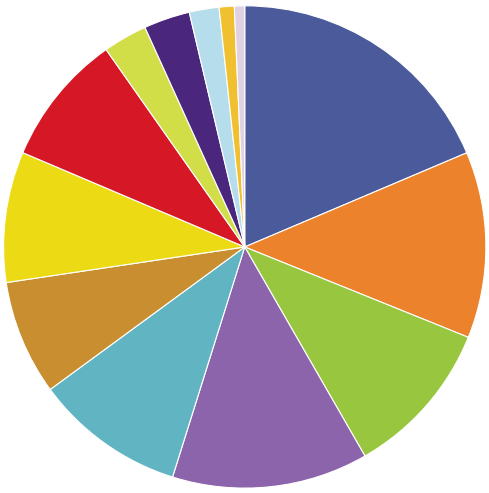

Figure 1.2 Shares of Top Commodities in Total Market Receipts in Ontario

(Source: http://www.omafra.gov.on.ca/english/stats/agriculture_summary.htm)

In addition to providing supplementary income for the farm operators and renewable electricity options to consumers, livestock farming significantly contributes to conservation of soil quality. Livestock, especially cattle, as a part of a farming operation, allow farmers to grow perennial hay crops, which have advantages over annual crops in improving soil. Manure is usually returned to the fields, along with the bedding materials from livestock farms. This provides nutrients to soil and replenishes SOM. This also offers some flexibility to crop rotation practices, since the SOM deficits resulted from some crop rotations can be rebalanced by spreading manure.

Among the livestock operations, cattle farms, as the largest consumers of hay products and the largest generators of organic materials rich manure, play a greater role in an integrated agricultural system. Unfortunately, the cattle industry has been declining in Ontario in recent years as shown in Figure 1.3. Industry experts suggest that the reasons of the decline are changing diets of people, increased competition from the Western Canada provinces, and rising feed costs. It is expected that local demand of dairy products and meat would support the current level of cattle industry in Ontario.

1.4 Crop Residues Management

Ontario farms generate approximately 13.7 million tonnes of above-ground crop residues annually (Oo et al., 2010). Only 1.5 million tonnes,

mainly cereal straws, are harvested for different applications, and the rest are incorporated back into soil. Cereal straws are mostly used as animal beddings. There are other applications of cereal straws as shown in Table 1.2.

One of the reasons cereal straws are the most widely used crop residues is the wide harvesting window. Winter wheat in Ontario is usually harvested in July with no pressure of snow coming or the need to plant a subsequent crop immediately. Most wheat straws in the regions where cattle population is the largest are harvested for bedding use. The straws, along with manure, are then returned from the livestock barns to the agricultural land. In the areas where cattle industry is not a large part of agriculture, cereal straws are left in the field, incorporated into the soil.

As a fast growing crop, grain corn generates a large quantity of residues. Most grain corn residues (stover and cobs) are left in the field. Grain corn residues are incorporated into soil by ploughing, no-till practices, or conservation tillage. Relatively small amounts of grain corn residues are harvested in some areas for animal beddings when there is a shortage of cereal straws in certain years. Grain corn residues play an important role in replenishing SOM of soil in Ontario, which is the largest grower of grain corn in Canada.

Figure 1.4 shows the increasing yield of grain corn over the past 100 years. To support this increased yields, grain corn plants have also been getting taller and stronger. The grain corn fields are significantly denser with more biomass in comparison with corn fields 30 years ago. Personal communication with farm operators

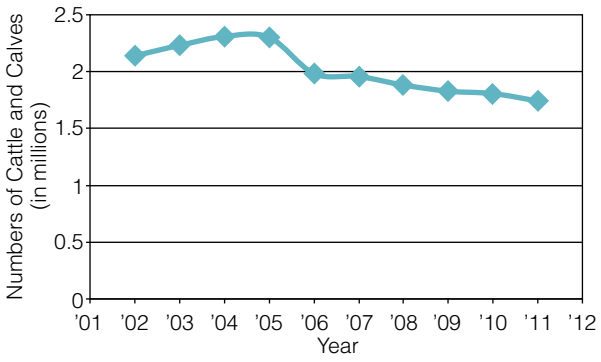

Figure 1.3 Numbers of Cattle and Calves in Ontario

(Source: OMAFRA Statistics)

Table 1.2 Crop Residues Applications and Demand in Ontario

Application	Demand (tonne/year)
Livestock	
Cattle bedding	1,154,200
Horse bedding	248,600
Cattle feed	48,800
Sheep feed	1,300
Agriculture and Horticulture	
Ginseng production	51,500
Strawberry production	11,500
Mushroom production	2,400
Biofuels	
Cellulosic ethanol	9,125
Total	1,527,425

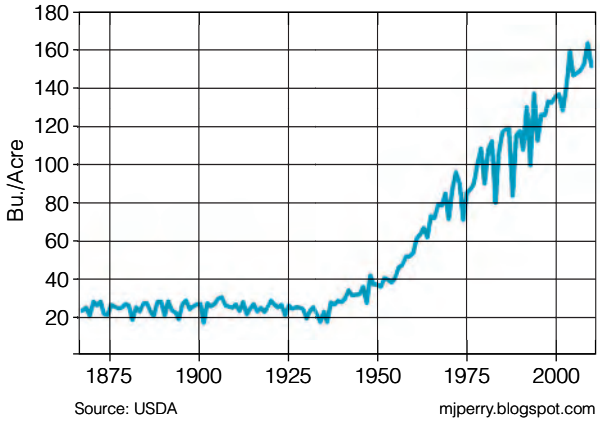

Figure 1.4 Grain Corn Yields 1866 – 2010

(Source: United States Department of Agriculture)

suggests that it is increasingly difficult to manage grain corn crop residues. Corn cobs, which take more than a couple of years to fully decompose, are especially problematic in the following planting season. Farm operators express the desire to harvest some grain corn residues if there is a market.

Soybeans, which are relatively small plants, produce the smallest amount of crop residues among the major field crops in Ontario. Current farming practices incorporate soybeans crop residues back into soil by chopping and spreading on the field during combining. Soybean residues are only harvested in some area for bedding applications when there is a shortage of cereal straws. Due to the lower yield and brittle nature of soybean residues, it may be uneconomical to harvest the residues for other applications such as energy generation.

Hay, which is the largest crop of Ontario, does not generate significant above-ground crop residues. However, its living roots produce considerable below-ground residues, replenishing SOM and offering other soil improvements. Indigestible portions of hay products are usually returned to soil as manure. Spreading manure and other available organic residues on farms is an important activity of soil management and allows integrating livestock, crop residues and overall farm management.

Chapter 2 – Sustainable Harvesting of Crop Residues

Crop residues—when left in the field—perform a number of important functions such as maintaining soil moisture, accommodating beneficial microbes, increasing soil organic matter, and recycling plant nutrients. Therefore, agricultural land requires a certain amount of crop residues to maintain the soil quality. On the other hand, excessive residues, which could potentially occur with improved crop yields would lead to slower soil warming in the planting season, difficulties in operating planting machinery, and increased emissions of greenhouse gases from the decay of residues. The optimum removal of crop residues is very site-specific depending on crop rotation and the soil management practices of individual farmers. Sustainable harvesting of crop residues is discussed in this chapter.

2.1 Soil Organic Matter

Soil is a dynamic and complex living eco-system. Healthy soil is a fundamental requirement for the food supply chain. Plants obtain nutrients from two natural sources: organic matter and minerals. Soil Organic Matter (SOM), however, has many more functions than only providing nutrients to plants. SOM defines the chemical and physical structures of the soil and its overall health. Maintaining SOM at an appropriate level is, therefore, of critical importance to increase the productivity of the agricultural lands.

Three pools (passive, active and slow with different potential decomposition rates), as shown in Figure 2.1, are collectively called soil organic matter. Above and below-ground plant residues, animal manures and compost organic materials in the passive pool help reduce the surface wind speed and water runoff, maintain the soil moisture, and provide food to microbes.

The materials in the passive pool are gradually broken down by microbes and when combined with partially decomposed materials form the active pool of SOM. The microorganisms in this dynamic, living and rapidly changing active pool are also responsible for binding small soil particles into larger aggregates. Aggregation is important for good soil structure, aeration, water infiltration and resistance to erosion and crusting.

Microorganisms in the active pool increase soil porosity, which is one of the most important natural activities to prepare the soil for seeding in the next growing season. Microbial activity also releases both large quantities of plant available nutrients and the stable fraction of Soil Organic Carbon (SOC), collectively termed the slow pool as shown in Figure 2.1. This pool decays at a very slow rate with a turnover time of several decades to over a century, if not disturbed by human activities such as ploughing. Well-decomposed SOC and recycled nutrients are collectively named humus which gives a dark colour to the surface soil. In general, the darker the colour of the soil, the higher the SOM level. SOC is generally considered to be 58% by mass of total SOM (McConkey et al., 2005), and SOM is usually estimated by measuring SOC in the soil.

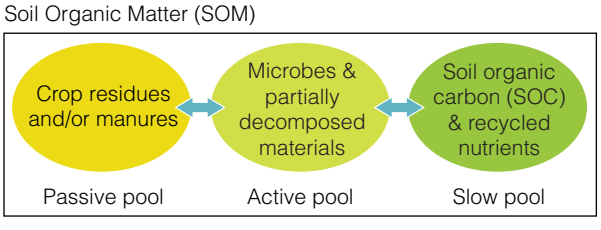

Figure 2.1 Three Pools of Soil Organic Matter

SOM is closely related to the health of the soil. Healthy soils produce healthy crops to nourish people. Nutrient replenishing through fertilizer application is not a replacement for SOM. As stated earlier, SOM has a number of functions, some of which are listed below, related to soil health and crop production:

- Supplies nutrients to plants
- Provides the primary food sources necessary for maintaining a large, diverse, and active microbial population
- Aggregates soil particles which increases the porosity of the soil
- Increases water infiltration thus reduces water runoff
- Defines the chemical and physical properties of the soil
- Increases the water and nutrient holding capacity of the soil
- Acts as a buffer for farmers to postpone fertilizer applications by a few years
- Recycles nutrients from crop residuals

2.2 Soil Organic Carbon Budget Model

Carbon compounds contained in plant residues, above and below-ground, are rapidly decomposed by microbes during the first couple of years following growth, as shown in Figure 2.2. The actual decomposition rate of carbon compounds in plant residues may differ slightly from the curve shown in Figure 2.2 depending on the soil temperature, soil moisture, soil type and other environmental factors. Within 5-10 years, the percentage of carbon left in the ground will reach 14-15%, which is generally accepted as the stable form of carbon or SOC (Kong et al., 2005). After this value has been reached, the decay rate slows significantly, if the soil is not disturbed by farming activities such as ploughing.

Soil loses its SOC through the normal decay of carbon even in the absence of farming activities. That rate of decay can be estimated from the equation developed by Voroney et al. (1989) shown in Figure 2.2. Soil erosion due to wind and water run-off also contributes to the SOC losses. If the tolerable limit, or "T value", of 2.67 tonne/acre of soil erosion recommended by OMAFRA is used in this equation, the associated SOC loss is 0.05 tonne/ha. Tillage activities also promote SOC loss due to exposure of soil carbon to the air which results in oxidation. Conventional tillage practices such as fall ploughing increase the SOC losses in comparison with no-till or other conservation tillage methods. On average, SOC losses due to conservation tillage may be assumed at 0.11 tonne/acre based on models developed by Gollany et al. (2010). The three major routes of SOC loss per acre of typical agricultural land using conservation tillage practices are shown in Figure 2.3.

Total SOC losses (normal decomposition + erosion + tillage) from an acre of typical

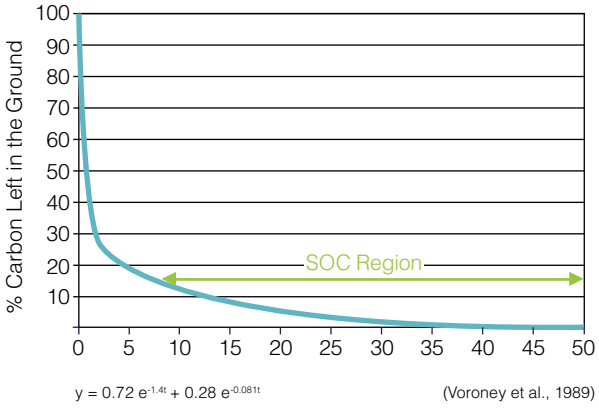

Figure 2.2 Decomposition of Carbons in Plant Residuals

agricultural land using conservation tillage practices are approximately 0.22 tonne/year. As shown in Figure 2.3, nearly 3.88 tonnes of plant residues and other organic materials at 15% moisture content are required to replenish the SOC losses to maintain the SOM of the land at 3.4%. Both above and below-ground residues contribute to the replacement of SOC in the soil. The estimated amount is determined based on the assumption that 45% of dry plant residues are carbon and 15% of this carbon is converted into the stable form or SOC. Total SOC content of the land in Figure 2.3 is for the top 30 cm of soil. Field crops which produce more than 3.88 tonne/acre of plant residues provide surplus biomass that are available for harvesting. However, field crops with less than 3.88 tonne/acre of plant residues present SOC deficits which should be made up by surplus residues from other crops through rotations or other organic materials such as livestock manure or compost.

2.3 Sustainable Harvesting for Typical Crop Rotation

Table 2.1 provides the theoretical harvestable amount of residues for the top four major field crops, which represent about 89% of the total field crops in Ontario. The estimation of root biomass materials are based on Voroney (2010) and personal communication with personnel from the Ontario Soil and Crop Improvement Association (OSCIA). Actual required residues to maintain 3.4% SOM will vary slightly from crop to crop, year to year, and farm to farm. However, the average quantity of 3.88 tonne/acre is conservatively assumed for all crops as explained in Section 2.2.

Grain corn, the highest biomass yielding crop, offers the largest potential of residues for harvest followed by winter wheat. Growing hay, which has deep roots in comparison with annual crops, gives some theoretically harvestable residue, however, practically no residues would be available for harvesting. Soybeans, which are relatively small plants, need more plant or other organic materials to maintain the SOM of soil. The deficits of crop residues due to soybean production are usually replenished by the

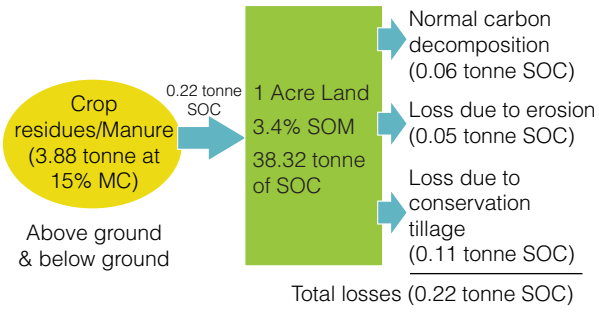

Figure 2.3 SOC Balance for an Acre of Agricultural Land

Table 2.1 Theoretically Harvestable Plant Residues (@ 15% Moisture) for Top Field Crops in Ontario

Crop	Grain Corn	Winter Wheat	Soybeans	Hay
Roots (tonne/acre)	2.38	2.11	1.33	3.97
Above-ground (tonne/acre)	3.57	3.53	1.18	0.08
Total residues (tonne/acre)	5.95	5.64	2.51	4.05
Required residues (tonne/acre) to maintain 3.4% SOM	3.88	3.88	3.88	3.88
Theoretical harvestable residues (tonne/acre)	2.07	1.76	-1.37	0.17

Note: Theoretical harvestable residues in this table do not consider the addition of manure/organic materials

residues surplus from grain corn or winter wheat through crop rotation. Farmers also periodically add livestock manure to the soil to replenish the SOC. Therefore, the amount of agricultural residues, which could be sustainably removed from the farms depends on the crop rotation schedule and other farm practices of individual farmers. If a particular farm is on a steep slope, soil erosion due to water run-off may be an issue and the theoretically harvestable amount may also be reduced.

The preferred crop rotation in Ontario is soybeans-winter wheat-corn followed by 3-4 years of perennial hay crops. However, this rotation is unfeasible in some areas where there is no matching demand of hay products. Therefore, the most popular crop rotation is soybeans-winter wheat-corn. Based on the SOC budget model for sustainable harvesting of crop residues, Table 2.2 gives the estimates of harvestable crop residues and recommended harvesting for the soybeans-winter wheat-corn rotation. The harvestable quantity would increase if manure or other organic materials are available to spread on farms. The estimates of residues harvest are based on maintaining 3.4% SOM level of soil.

Table 2.2 Recommended Residue Harvest for Soybeans-Winter Wheat-Corn Rotation

Year	Crop in Rotation	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.07	1.26
2	Soybeans	-1.37	0.00
3	Winter wheat	1.76	1.20
Total (tonne/rotation/acre)		2.46	2.46
Note: Harvestable residues in this table do not consider the addition of manure/organic materials			

Wheat straw is the most used crop residue in Ontario and can be harvested using conventional farm equipment. Approximately 1.20 tonne/acre of wheat straw is harvested. Since total above-ground residues produced by a winter wheat crop is about 3.53 tonne/acre, over 60% of crop residues are left in the field after the straw harvest. The lower portion of the wheat plant left in the field after straw harvest is approximately 10-12 inch high, protecting soil from erosion and providing nutrients and SOM for next crops. Harvesting more wheat straw per acre would not only lower those soil improvement benefits but also significantly slow down the harvesting operation.

As shown in Table 2.2, the harvest of soybeans residues is not recommended due to the SOC deficits. It may also be uneconomical to harvest soybeans residues due to the relatively lower yield. However, if the demand for soybean residues exists for particular applications, harvesting can be done. The crucial factor to ensure is that total residues' harvest does not exceed 2.46 tonne/rotation/acre to maintain the soil SOM. Growing winter cover crops will likely be required to reduce soil erosion, if soybeans residues are harvested. The recommended harvest of corn residues is 1.26 tonne/acre, which would also leave over 60% of above-ground residues in the field. Corn residues harvesting could require specialized farm equipment so that residues' harvest can be completed before snow falls.

2.4 Residues Harvesting Model at County Level

As discussed in the previous section, growing small plant crops such as soybeans can result in SOC deficits. Fast growing crops such as grain corn and dense crops such as winter wheat produce surplus SOC for soil. Therefore, the crop mix of a particular county would define the

sustainably harvestable crop residues. If soybeans represent a greater percentage of total crop land in the county, lesser quantity of crop residues can be sustainably harvested. On the other hand, more crop residues are available for harvesting if grain corn and winter wheat dominate the crop land in the county.

The number of cattle and calves also affect the sustainably harvestable residues in a given county, since manure provides organic materials and thus SOC for soil. Therefore, the greater the cattle industry the county has, the more the sustainable harvestable residues. In most cases in Ontario, the majority of hay produced in a county is utilized by livestock farms in the county. The indigestible fibre in animal feed is returned to the soil by spreading manure and used animal bedding. Conservatively, it is assumed that each cow, on an average per day, produces 35 kg of manure with 70% moisture content. When dried, the indigestible fibre content of this manure is 20%, and the rest are other nutrients contained in feeds (source: OMAFRA fact sheet on anaerobic digestion basics).

Table 2.3 gives a sample residues' harvesting model for a county. The crop mix of the year is given in the table, and there are 39,000 cattle and calves in the county. In this typical county in Ontario, soybeans, grain corn and winter wheat are major crops. As seen in Table 2.3, over 220,000 acres of soybeans result in approximately 300,000 tonnes of residues' deficit. However, that deficit is over-compensated by approximately 220,000 acres of grain corn and winter wheat combined, resulting in a moderate amount of residues surplus. The contributions from other crops to the residues' surplus/deficit are relatively small. Total surplus residues from the crops is the summation of the surplus/deficit of individual crops, and is 105.24 thousand tonnes in this example. The cattle industry in the county gives equivalent residues surplus of 29.89 thousand tonnes, resulting in 135.14 thousand tonnes of sustainably harvestable residues in the county.

Table 2.3 Sample Residues Harvesting Model for County

Crop	Acreage	Above-Ground Residues (tonne/acre)	Below-Ground Residues (tonne/acre)	Total Residues (tonne/acre)	Sustainably Harvestable Residues (tonne/acre)	Total Harvestable Residues ('000 tonne)
Hay	22,719	0.08	3.97	4.05	0.17	1.25
Soybeans	223,276	1.18	1.33	2.51	-1.37	-306.45
Grain corn	122,663	3.57	2.38	5.95	2.07	253.69
Winter wheat	100,309	3.53	2.12	5.65	1.76	176.75
Fodder corn	3,715	0.08	2.38	2.46	-1.42	-5.29
Barley	309	2.00	1.20	3.20	-0.69	-0.21
Mixed grain	126	1.43	0.86	2.28	-1.60	-0.20
Dry field beans	7,146	0.96	0.58	1.53	-2.35	-16.79
					Surplus residues from crops	105.24
					Organic material from manure (39,000 cattle and calves)	29.89
					Total sustainably harvestable residues	135.14

Other factors which could potentially increase the sustainably harvestable quantity of crop residues include availability of other organic materials such as compost and growing winter cover crops. While the residues' harvesting model at a county level gives the macro figure, the sustainably harvestable residues is, in fact, very site-specific.

Factors such as the slope of the farm land, other farm management practices, etc., should be considered at an individual farm level. Monitoring of SOM and other characteristics of farm land by regular soil testing is of paramount importance, if the crop residues are to be harvested for non-farm applications.

Chapter 3 – Estimation of Sustainably Harvestable Crop Residues

The quantity of sustainably harvestable crop residues at farm level depends on crop rotation, application of manure and other organic materials, cover crop practices, the topology of farm land, tillage methods, and other farm management practices. At a county level, the amount of sustainably harvestable crop residues can be estimated by the crop mix, the size of cattle industry, the level of soil SOM to be maintained, flow of manure and other organic materials to and from neighbouring counties, and local farm management practices. In this chapter, the agricultural regions and the counties of Ontario are described. The quantity of sustainably harvestable crop residues are estimated at county level, and aggregated to the provincial level. The counties with the greater potential of developing bio-processing industries using crop residues are highlighted.

3.1 Ontario Agricultural Regions and Counties

Ontario is divided into five agricultural census regions as shown in Figure 3.1. The constituents of agricultural regions are numbered in Figure 3.1, and given in Table 3.1. Western Ontario and Southern Ontario are the largest agricultural regions with over 3.8 million acres of farm land in each region. Central Ontario and Eastern Ontario regions approximately have 2.0 million acres of farm land in each. Northern Ontario is the smallest agricultural region in Ontario with about 1.0 million acres of farm land, since forestry sector dominates this region. Most farm lands in Northern Ontario are used to grow hay crops to support the cattle industry.

Table 3.1 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 3.1)

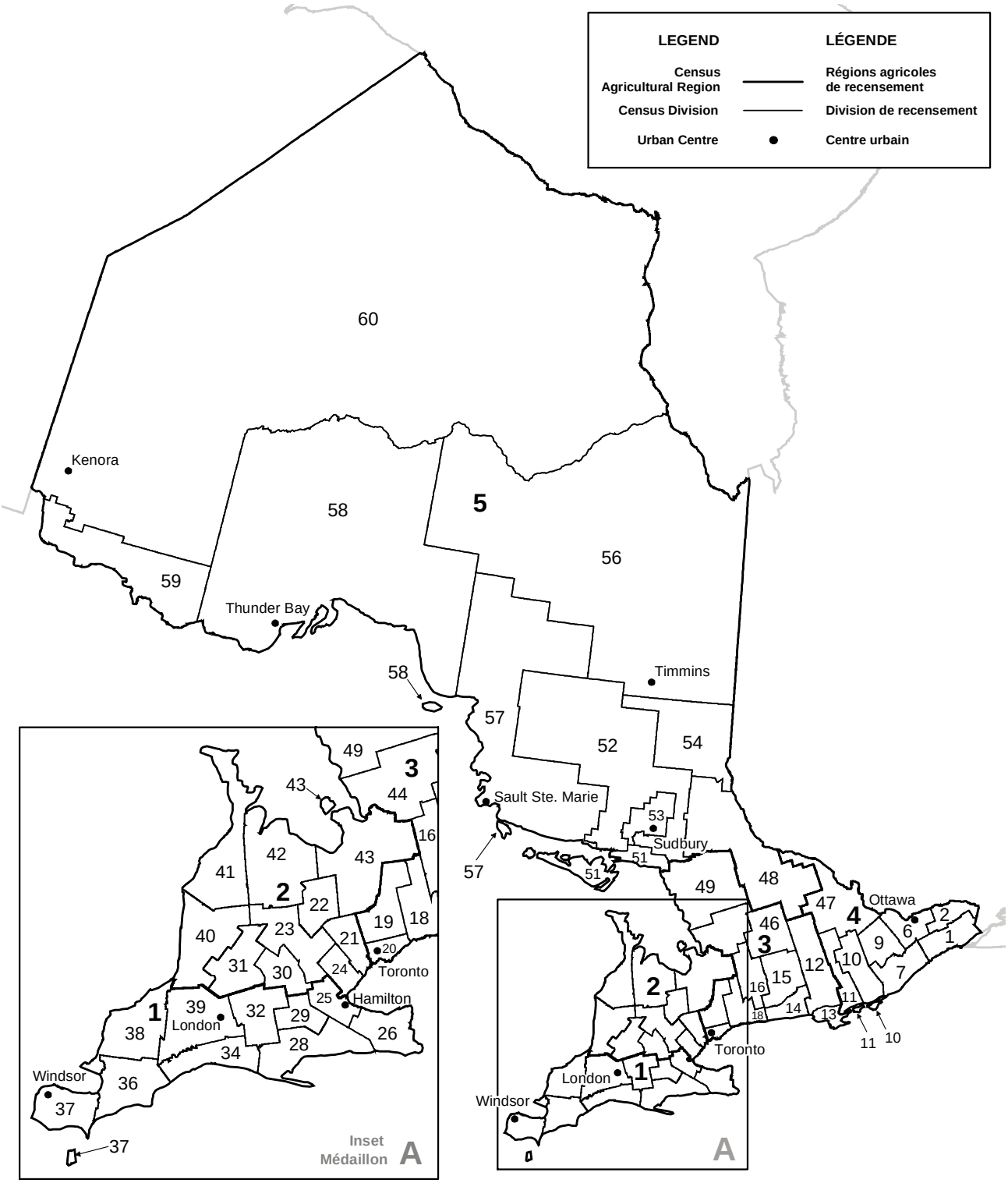

Figure 3.1 Agricultural Census Regions in Ontario

Total farm land area, numbers of cattle and total farm market receipts of agricultural regions in Ontario are shown in Figure 3.2. The Southern Ontario region has the highest farm market receipt of $ 4,750 million, followed by Western Ontario with $ 3,530 million in 2011 (Statistics Canada). Although total farm land area in Southern Ontario and Western Ontario are comparable, Western Ontario has over 845,000 cattle versus 295,000 cattle in Southern Ontario (OMAFRA Statistics). The Western region has the highest numbers of cattle per acre of farm land in Ontario. The most productive farm lands are located in Southern Ontario, where high value agricultural products, such as vegetable and fruits, are grown. It can be expected that the greater portion of sustainably harvestable crop residues would be in Southern and Western Ontario regions.

Central and Eastern Ontario regions have moderate agricultural activities in comparison with Southern and Western regions. Total farm market receipts of Central and Eastern Ontario regions in 2011 are $ 785 million and $ 1,060 million, respectively, in 2011 (Statistics Canada).

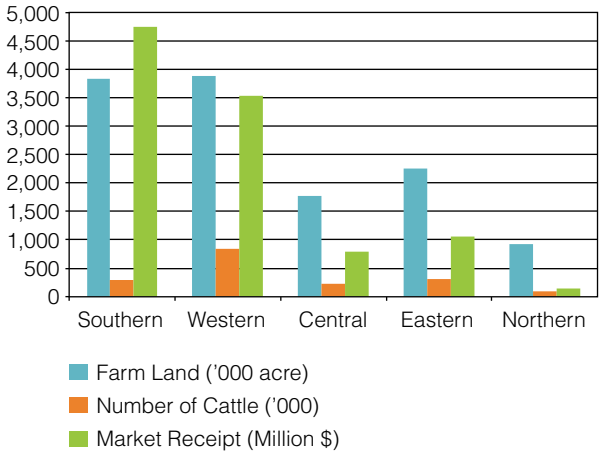

Figure 3.2 Farm Land Area, Numbers of Cattle and Market Receipts of Ontario Agricultural Regions

(Source: OMAFRA Statistics and Statistics Canada 2011 Agricultural Census)

Total numbers of cattle per acre of farm land in Central and Eastern Ontario regions are comparable, and similar to that in Northern Ontario region. Total farm market receipts of Northern Ontario region in 2011 are $ 151 million.

3.2 Harvestable Residues in Ontario Counties

As discussed earlier, the key sets of data required to estimate the sustainably harvestable crop residues in a county are the crop mix and the numbers of cattle. Figure 3.3 exhibits the approach in acquiring data sets in estimating sustainably harvestable crop residues in Ontario counties. The industry crop insurance data for each county for 2012 are courtesy of Agricorp, an agency of the government of Ontario (http://www.agricorp.com). The crop insurance data from Agricorp covers the major field crops of Ontario. It should be noted that not all crops are insured. To obtain the complete crop mix of a county, it is necessary to know the percentage of uninsured crops, which was estimated based on OMAFRA field crop statistics and consultation with farm operators and industry experts. The numbers of cattle and calves at county level from OMAFRA livestock statistics are then combined with the estimated crop mix as input data sets to the residues harvesting spreadsheet model. The sustainably harvestable crop residues for each county are estimated using the spreadsheet model, and the results are aggregated to the provincial level.

The residues harvesting spreadsheet include a worksheet for each county, and the complete spreadsheet is attached as Appendix A. The sample worksheet for Chatham-Kent county in Southern Ontario region is given in Figure 3.4. The average SOM level of farms in Chatham-Kent to be maintained is assumed at 3.5%. The OMAFRA livestock statistics suggests that there are 11,250 cattle and calves, which is relatively small for the given total crop acreages in this county. The SOC budget analysis suggests that farm lands in Chatham-Kent require 3.94 tonne/acre of below and above-ground residues to maintain the SOM level of 3.5%. Soybeans is the largest crop of Chatham-Kent, resulting in 342 thousand tonnes of crop residues deficit. The surplus crop residues from grain corn and winter wheat over-compensate the deficit from soybeans. The contributions from other crops and the cattle farms to the harvestable residues are relatively insignificant, in comparison with soybeans, grain corn and winter wheat. The sustainably harvestable crop residues in Chatham-Kent is estimated at 189 thousand tonnes for year 2012. The recommended harvest of crop residues for a typical crop rotation is also given in the model, assuming manure is evenly spread on all farm lands.

3.3 Total Estimates of Sustainably Harvestable Residues

The sustainably harvestable crop residues for most agriculturally active counties in Ontario are given in Appendix A. The counties with greater percentages of grain corn and winter wheat and relatively large cattle farms usually offer the higher amount of harvestable residues. The results from the counties are aggregated to the agricultural census region level and then to the provincial level. Total estimates of sustainably harvestable crop residues are summarized in Table 3.2.

Total quantity of sustainably harvestable crop residues in Ontario is 3.12 million tonne/year, which is approximately 20% of total above-ground crop residues produced annually in the province. It should be noted, for a comparison, that approximately 2 million tonne/year of wood pellets are exported from British Columbia to Europe for energy applications. Western Ontario region offers the largest amount of crop residues, 1.26 million tonne/year, followed by Southern Ontario region, 0.85 million tonne/year. As mentioned earlier, these two regions are the largest agricultural areas in Ontario. The sustainably harvestable crop residues in Central

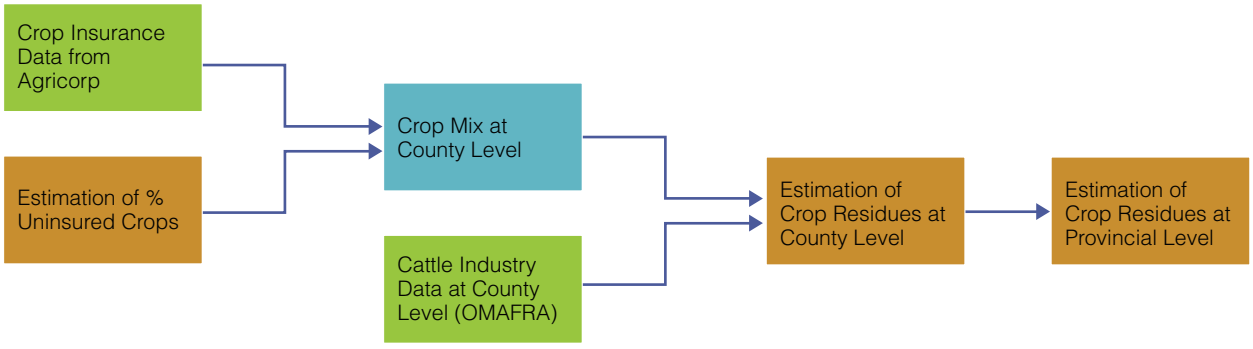

Figure 3.3 Data Sets and Approach for Estimation of Crop Residues in Ontario Counties

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	11,250	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	845	75	0.08	3.97	4.05	0.11	0.1	0.3	0.4
Forage-Standard	7,073	75	0.08	3.97	4.05	0.11	0.8	2.3	3.1
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	179,914	25	1.18	1.33	2.51	-1.43	-256.7	-85.6	-342.3
Grain corn	126,189	25	3.57	2.38	5.95	2.01	253.8	84.6	338.4
Seed corn	17,936	20	3.21	2.14	5.36	1.42	25.4	6.3	31.7
Winter wheat	83,319	10	3.53	2.12	5.65	1.71	142.2	15.8	158.0
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	1,250	40	0.96	0.58	1.54	-2.41	-3.0	-2.0	-5.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	1,391	10	1.05	0.63	1.68	-2.26	-3.1	-0.3	-3.5
								Surplus residues from major field crops	180.7
								Organic material from manure	8.6
								Total harvestable residues	189.3

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.11
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.31	2.31

Figure 3.4 Residues Harvesting Spreadsheet Model for Chatham-Kent County in Southern Ontario

Table 3.2 Summary of Sustainably Harvestable Crop Residues in Ontario

No.	County	Total Harvestable Residues in the County ('000 tonne)	Total Harvestable Residues in the County and Neighbouring Counties ('000 tonne)*	Names of Neighbouring Counties (sharing borders)
1	Algoma	12.8	28.1	Cochrane,Thunder Bay
2	Brant	42.0	362.2	Haldimand, Hamilton, Norfolk, Oxford, Waterloo
3	Bruce	178.4	756.7	Grey, Huron, Wellington
4	Chatham-Kent	189.3	636.8	Elgin, Essex, Lambton, Middlesex
5	Cochrane	7.0	35.7	Algoma, Thunder Bay, Timiskaming
6	Dufferin	36.7	423.0	Grey, Peel, Simcoe, Wellington
7	Durham	102.4	382.2	Kawartha Lakes, Northumberland, Peterborough, Simcoe, York
8	Elgin	140.4	855.4	Chatham-Kent, Middlesex, Norfolk, Oxford
9	Essex	-45.7	143.6	Chatham-Kent
10	Frontenac	20.8	221.0	Lanark, Leeds & Grenville, Lnnx & Addgton, Renfrew
11	Grey	115.6	589.3	Bruce, Dufferin, Simcoe, Wellington
12	Haldimand	-43.4	-10.3	Brant, Hamilton, Niagara, Norfolk
13	Halton	10.4	201.4	Hamilton, Peel, Wellington
14	Hamilton	9.3	244.6	Brant, Haldimand, Halton, Niagara, Waterloo, Wellington
15	Hastings	53.6	239.9	Lnnx & Addgton, Northumberland, Peterborough, Prince Edward
16	Huron	293.1	1240.4	Bruce, Lambton, Middlesex, Perth, Wellington
17	Kawartha Lakes	54.4	196.2	Durham, Peterborough
18	Lambton	77.4	835.1	Chatham-Kent, Huron, Middlesex
19	Lanark	25.6	246.6	Frontenac, Leeds & Grenville, Ottawa, Renfrew
20	Leeds & Grenville	43.3	331.5	Frontenac, Lanark, Ottawa, Stor, Dun & Glen'y
21	Lennox & Addington	34.5	151.5	Frontenac, Hastings, Prince Edward
22	Middlesex	275.3	1443.5	Chatham-Kent, Elgin, Huron, Lambton, Oxford, Perth
23	Niagara	-47.3	-81.4	Haldimand, Hamilton
24	Norfolk	29.0	389.3	Brant, Elgin, Haldimand, Oxford
25	Northumberland	69.9	307.9	Durham, Hastings, Peterborough, Prince Edward
26	Ottawa	60.0	498.5	Lanark, Leeds & Grenville, Prescott & Russel, Renfrew, Stor, Dun & Glen'y
27	Oxford	221.3	1058.7	Brant, Elgin, Middlesex, Norfolk, Perth, Waterloo
28	Peel	12.1	344.8	Dufferin, Halton, Simcoe, Wellington, York
29	Perth	246.6	1309.9	Huron, Middlesex, Oxford, Waterloo, Wellington
30	Peterborough	39.4	319.8	Durham, Hastings, Kawartha Lakes, Northumberland
31	Prescott & Russel	91.0	332.8	Ottawa, Stor, Dun & Glen'y
32	Prince Edward	42.5	200.6	Hastings, Lnnx & Addgton, Northumberland
33	Rainy River	41.0	49.3	Thunder Bay
34	Renfrew	96.8	203.3	Frontenac, Lanark, Ottawa
35	Simcoe	88.9	382.9	Dufferin, Durham, Grey, Peel, York
36	Stormont, Dundas & Glengarry	181.7	376.1	Leeds & Grenville, Ottawa, Prescott & Russel
37	Thunder Bay	8.2	69.1	Algoma, Cochrane, Rainy River
38	Timiskaming	7.6	14.6	Cochrane
39	Waterloo	104.0	792.9	Brant, Hamilton, Oxford, Perth, Wellington
40	Wellington	169.6	1175.9	Bruce, Dufferin, Grey, Halton, Hamilton, Huron, Peel, Perth, Waterloo
41	York	27.1	230.6	Durham, Peel, Simcoe
Sub-total (Southern Ontario)		847.7		
Sub-total (Western Ontario)		1,255.5		
Sub-total (Central Ontario)		389.3		
Sub-total (Eastern Ontario)		553.8		
Sub-total (Northern Ontario)		76.7		
Grand Total		**3,123.1**		

*Mostly in less than 100 km radius

Ontario and Eastern Ontario are 0.39 million tonne/year and 0.55 million tonne/year, respectively. As the least agriculturally active region, Northern Ontario could provide crop residues of 0.08 million tonne/year. The results of Ontario agricultural regions are plotted in Figure 3.5 for visual comparison.

While the analysis is reported by county boundaries, in practice industries using crop residues as feedstock source their materials across county lines. There is a flow of hay and manure across counties, allowing the replenishment of SOM to the farms with the SOM deficit resulted from some crop rotations. Table 3.2, therefore, also provides total crop residues from the county and the border-sharing neighbouring counties. For a particular county, the names of neighbouring counties are given. In most cases in Ontario, the neighbouring counties are within 100 km of the county considered.

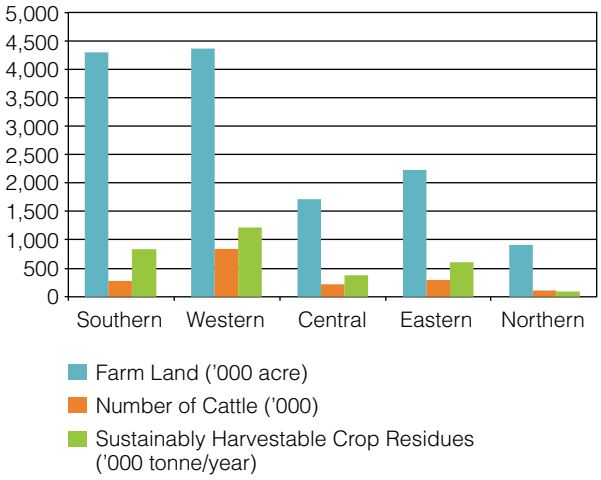

Figure 3.5 Farm Land, Numbers of Cattle and Sustainably Harvestable Residues on Ontario Regions

3.4 Ontario Counties with Greater Residues Potential

Feedstock availability is one of the major risk factors in locating an industry which utilizes biomass as an input in producing goods or energy. The county where the crop residues supply would exceed the biomass demand would be an ideal location for industry developers. Energy generation from crop residues could potentially be the large-scale biomass consumers. A 50 MW electricity generation plant, which can meet the electricity demand of 37,500 home, at base load can consume approximately 300,000 tonnes of crop residues annually. A typical large biomass pellet mill in British Columbia produces 150,000 – 200,000 tonne/year. A cellulosic ethanol plant with 50 million liters annual capacity would require approximately 175,000 tonne/year of crop residues.

Large-scale industries discussed above will likely consider those counties where over 500,000 tonnes/year of crop residues could be sourced from within the county and the neighbouring counties. Based on this consideration, Table 3.3 shortlists Ontario counties with over 500,000 tonne/year of crop residues supply. There are a total of 11 counties qualified for this shortlist, and all are in Southern Ontario and Western Ontario regions. Relatively small biomass industries, such as composite materials, can be located in any county with positive harvestable crop residues, depending on the demand. It should also be noted that there are other considerations, such as close to the markets, transportation infrastructures, existence of complementary industries, availability of skill labours, support from local community, etc., in locating an industry.

It should be noted that increasing crop yields, especially grain corn, will result in greater

amounts of crop residues in the future. The creation of bio-processing industries which will use crop residues, in Ontario would not only provide additional income to the producers but also offer better crop residues management.

These bio-processing industries would also create jobs in rural areas and re-balance the income gap between urban and rural communities.

Table 3.3 Ontario Counties with Over 500,000 tonne/year of Crop Residues Supply[#]

No.	County	Total Harvestable Residues in the County ('000 tonne)	Total Harvestable Residues in the County and Neighbouring Counties ('000 tonne)*	Names of Neighbouring Counties (sharing borders)
1	Bruce	178.4	756.7	Grey, Huron, Wellington
2	Chatham-Kent	189.3	636.8	Elgin, Essex, Lambton, Middlesex
3	Elgin	140.4	855.4	Chatham-Kent, Middlesex, Norfolk, Oxford
4	Grey	115.6	589.3	Bruce, Dufferin, Simcoe, Wellington
5	Huron	293.1	1240.4	Bruce, Lambton, Middlesex, Perth, Wellington
6	Lambton	77.4	835.1	Chatham-Kent, Huron, Middlesex
7	Middlesex	275.3	1443.5	Chatham-Kent, Elgin, Huron, Lambton, Oxford, Perth
8	Oxford	221.3	1058.7	Brant, Elgin, Middlesex, Norfolk, Perth, Waterloo
9	Perth	246.6	1309.9	Huron, Middlesex, Oxford, Waterloo, Wellington
10	Waterloo	104.0	792.9	Brant, Hamilton, Oxford, Perth, Wellington
11	Wellington	169.6	1175.9	Bruce, Dufferin, Grey, Halton, Hamilton, Huron, Peel, Perth, Waterloo

*Mostly in less than 100 km radius

Southern Ontario, Western Ontario

[#]Total supply includes crop residues from neighbouring counties

Chapter 4 - Summary, Conclusions and Recommendations

The quantities of sustainably harvestable crop residues are estimated for counties in Ontario in this study. For this estimation, major crops in Ontario, crop rotation practices, livestock farming and its influence on soil quality, and current crop residues management are reviewed. A certain amount of crop residues must be left in the field to maintain soil SOM at a productive level. Therefore, the SOC budget model is employed to estimate the sustainably harvestable crop residues. The crop acreages are estimated from the crop insurance data from Agricorp and OMAFRA statistics. The size of cattle industry in each county is also obtained from the OMAFRA statistics. The spreadsheet model was developed to process the input data sets for each county to estimate the sustainably harvestable crop residues. The results of the counties are aggregated to the Ontario agricultural census regions and to the provincial level. The chapter summarizes the finding of the study, and provides conclusions and recommendations.

4.1 Summary of Findings and Conclusions

The total quantity of sustainably harvestable crop residues in Ontario is 3.12 million tonne/year, which is approximately 20% of total above-ground crop residues produced annually in the province. It should be noted for a comparison that approximately 2 million tonne/year of wood pellets are exported from British Columbia to Europe for energy applications. Western Ontario region offers the largest amount of crop residues, 1.26 million tonne/year, followed by Southern Ontario region, 0.85 million tonne/year. These two regions are the largest agricultural areas in Ontario. The sustainably harvestable crop residues in Central Ontario and Eastern Ontario are 0.39 million tonne/year and 0.55 million tonne/year, respectively. As the least agriculturally active region, Northern Ontario could provide the crop residues of 0.08 million tonne/year.

A certain amount of crop residues can be sustainably harvested in almost every county in Ontario, if combined with agricultural activities in border-sharing neighbouring counties. There are a total of 11 counties which can provide crop residues of 500,000 tonne/year sustainably, including the crop residues from the border-sharing neighbouring counties. They are Bruce, Grey, Huron, Perth, Waterloo and Wellington counties in Western Ontario region and Chatham-Kent, Elgin, Lambton, Middlesex and Oxford counties in Southern Ontario region. These counties are the likely locations of large-scale bio-processing industries. A 50 MW electricity generation plant at base load, which can meet the electricity demand of 37,500 homes, consumes approximately 300,000 tonnes of crop residues annually. A typical large biomass pellet mill in British Columbia produces 150,000 – 200,000 tonne/year. A cellulosic ethanol plant with 50 million liters annual capacity would require approximately 175,000 tonne/year of crop residues. Relatively small-scale bio-processing industries can be located in almost any county in Ontario.

Hay, soybeans, grain corn and winter wheat are the top four field crops, collectively representing 89% of total field crops in Ontario. Grain corn, which is the highest biomass yielding crop, offers the largest potential of residues for harvest followed by winter wheat. Growing hay, which has deep roots in comparison with annual crops, gives some theoretically harvestable residues', however, practically no residues would be

available for harvesting. Soybeans, which are relatively small plants, need more plant or other organic materials to maintain the SOM of soil. The deficits of crop residues due to soybeans production are usually replenished by the residues surplus from grain corn or winter wheat through crop rotation. Farmers also periodically add livestock manure to the soil to replenish the SOC. Therefore, the amount of agricultural residues, which could be sustainably removed from the farms, is site-specific, and depends on the crop rotation schedule and other farm practices of individual farmers.

The preferred crop rotation in Ontario is soybeans-winter wheat-corn followed by 3-4 years of perennial hay crops. However, this rotation is unfeasible in some areas where there is no matching demand of hay products. Therefore, the most popular crop rotation is soybeans-winter wheat-corn. Wheat straw is the most widely used crop residue in Ontario and can be harvested using conventional farm equipment. Approximately 1.20 tonne/acre of wheat straw is harvested. Since total above-ground residues produced by winter wheat crop is about 3.53 tonne/acre, over 60% of crop residues are left in the field. It is not recommended to harvest soybeans residues due to the resulting SOC deficit. It may also be uneconomical to harvest soybeans residues due to the relatively lower yield. However, if the demand for soybeans residues exists for particular applications, harvesting can be done. Growing winter cover crops will likely be required to reduce soil erosion, if soybeans residues are harvested. In general, the recommended harvest of corn residues is 1.26 tonne/acre, which would also leave over 60% of above-ground residues in the field for soybeans-winter wheat-corn rotation. Availability of manure and other organic materials would increase the recommended harvest of crop residues.

The crop mix of a particular county defines the sustainably harvestable crop residues. If soybeans represent a greater percentage of total crop land in the county, lesser quantity of crop residues can be sustainably harvested. On the other hand, more crop residues are available for harvesting, if grain corn and winter wheat dominate the crop land in the county. The numbers of cattle and calves also affect the sustainably harvestable residues in the county, since the manure provides organic materials and thus SOC for soil. In most cases in Ontario, the majority of hay produced in a county is utilized by livestock farms in the county. The indigestible fibre in animal feed is returned to soil by spreading manure and used animal bedding. Therefore, the greater the cattle industry the county has, the more the sustainable harvestable residues.

4.2 General Recommendations

Crop residues, if sustainably harvested, are renewable feedstocks for bio-processing industries. The increasing crop yields will result in greater amount of crop residues in the future. The creation of bio-processing industries which use crop residues in Ontario would not only provide additional income to the producers but also offer better crop residues management. These bio-processing industries would also create jobs in rural areas and rebalance the income gap between urban and rural communities. The following general recommendations are provided to OFA and its affiliates:

- The quantity of sustainably harvestable crop residues is farm-specific, depending on crop rotation, application of manure and other organic materials, cover crop practices, the topology of farm land, tillage methods, and other farm management. A farm-specific assessment should be performed for individual producers who want to harvest some crop

residues for bio-processing industries. For instance, if a particular farm is on a steep slope, soil erosion due to water run-off may be an issue and crop residues harvesting may not be feasible.

- Monitoring of soil health by regular soil tests is highly recommended for farms participating in crop residues harvesting. Beneficial soil management practices such as manure spreading and growing winter cover crop should be employed as required.
- A comprehensive field studies investigating the current SOM levels in Ontario regions and the effects of residue harvest on soil should be performed. These field data should be used to develop a model to estimate the sustainably harvestable residues at a farm level.
- Ontario producers and potential bio-processing industries should be educated on the sustainable harvesting of crop residues.
- Development of bio-processing industries in Ontario should be encouraged, and the use of crop residues as a sustainable source of biomass should be promoted.
- The use of crop residues for energy generation could be an immediate opportunity. Advanced bio-composite materials and bio-fuels and bio-chemicals could be long-term markets for crop residues. It is recommended to monitor the technology development in emerging bio-processing industries and to collaborate with all stakeholders.

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Spreadsheet Model for Sustainably Harvestable Crop Residues in Ontario's Counties

Table A.1 Summary of Sustainably Harvestable Crop Residues in Ontario

No.	County	Total Harvestable Residues in the County ('000 tonne)	Total Harvestable Residues in the County and Neighbouring Counties ('000 tonne)*	Names of Neighbouring Counties (sharing borders)
1	Algoma	12.8	28.1	Cochrane,Thunder Bay
2	Brant	42.0	362.2	Haldimand, Hamilton, Norfolk, Oxford, Waterloo
3	Bruce	178.4	756.7	Grey, Huron, Wellington
4	Chatham-Kent	189.3	636.8	Elgin, Essex, Lambton, Middlesex
5	Cochrane	7.0	35.7	Algoma, Thunder Bay, Timiskaming
6	Dufferin	36.7	423.0	Grey, Peel, Simcoe, Wellington
7	Durham	102.4	382.2	Kawartha Lakes, Northumberland, Peterborough, Simcoe, York
8	Elgin	140.4	855.4	Chatham-Kent, Middlesex, Norfolk, Oxford
9	Essex	-45.7	143.6	Chatham-Kent
10	Frontenac	20.8	221.0	Lanark, Leeds & Grenville, Lnnx & Addgton, Renfrew
11	Grey	115.6	589.3	Bruce, Dufferin, Simcoe, Wellington
12	Haldimand	-43.4	-10.3	Brant, Hamilton, Niagara, Norfolk
13	Halton	10.4	201.4	Hamilton, Peel, Wellington
14	Hamilton	9.3	244.6	Brant, Haldimand, Halton, Niagara, Waterloo, Wellington
15	Hastings	53.6	239.9	Lnnx & Addgton, Northumberland, Peterborough, Prince Edward
16	Huron	293.1	1240.4	Bruce, Lambton, Middlesex, Perth, Wellington
17	Kawartha Lakes	54.4	196.2	Durham, Peterborough
18	Lambton	77.4	835.1	Chatham-Kent, Huron, Middlesex
19	Lanark	25.6	246.6	Frontenac, Leeds & Grenville, Ottawa, Renfrew
20	Leeds & Grenville	43.3	331.5	Frontenac, Lanark, Ottawa, Stor, Dun & Glen'y
21	Lennox & Addington	34.5	151.5	Frontenac, Hastings, Prince Edward
22	Middlesex	275.3	1443.5	Chatham-Kent, Elgin, Huron, Lambton, Oxford, Perth
23	Niagara	-47.3	-81.4	Haldimand, Hamilton
24	Norfolk	29.0	389.3	Brant, Elgin, Haldimand, Oxford
25	Northumberland	69.9	307.9	Durham, Hastings, Peterborough, Prince Edward
26	Ottawa	60.0	498.5	Lanark, Leeds & Grenville, Prescott & Russel, Renfrew, Stor, Dun & Glen'y
27	Oxford	221.3	1058.7	Brant, Elgin, Middlesex, Norfolk, Perth, Waterloo
28	Peel	12.1	344.8	Dufferin, Halton, Simcoe, Wellington, York
29	Perth	246.6	1309.9	Huron, Middlesex, Oxford, Waterloo, Wellington
30	Peterborough	39.4	319.8	Durham, Hastings, Kawartha Lakes, Northumberland
31	Prescott & Russel	91.0	332.8	Ottawa, Stor, Dun & Glen'y
32	Prince Edward	42.5	200.6	Hastings, Lnnx & Addgton, Northumberland
33	Rainy River	41.0	49.3	Thunder Bay
34	Renfrew	96.8	203.3	Frontenac, Lanark, Ottawa
35	Simcoe	88.9	382.9	Dufferin, Durham, Grey, Peel, York
36	Stormont, Dundas & Glengarry	181.7	376.1	Leeds & Grenville, Ottawa, Prescott & Russel
37	Thunder Bay	8.2	69.1	Algoma, Cochrane, Rainy River
38	Timiskaming	7.6	14.6	Cochrane
39	Waterloo	104.0	792.9	Brant, Hamilton, Oxford, Perth, Wellington
40	Wellington	169.6	1175.9	Bruce, Dufferin, Grey, Halton, Hamilton, Huron, Peel, Perth, Waterloo
41	York	27.1	230.6	Durham, Peel, Simcoe
Sub-total (Southern Ontario)		847.7		
Sub-total (Western Ontario)		1,255.5		
Sub-total (Central Ontario)		389.3		
Sub-total (Eastern Ontario)		553.8		
Sub-total (Northern Ontario)		76.7		
Grand Total		**3,123.1**		

*Mostly in less than 100 km radius

Note: Worksheets for all counties are shown in the following pages in an alphabetical order of county names.

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.4	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	9,600	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	38.32	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.49	tonne/acre
Input residues at 15% MC required to balance SOC	3.88	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	8,313	75	0.08	3.97	4.05	0.17	1.4	4.1	5.5
Forage-Standard	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Soybeans	0	25	1.18	1.33	2.51	-1.37	0.0	0.0	0.0
Grain corn	0	25	3.57	2.38	5.95	2.07	0.0	0.0	0.0
Seed corn	0	20	3.21	2.14	5.36	1.47	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.76	0.0	0.0	0.0
Spring wheat	0	40	2.82	1.59	4.41	0.53	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.60	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.35	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.28	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.20	0.0	0.0	0.0
								Surplus residues from major field crops	5.5
								Organic material from manure	7.4
								Total harvestable residues	12.8

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.07	1.48
2	Soybeans	-1.37	0.00
3	Winter wheat	1.76	1.20
Total (tonne/rotation/acre)		2.68	2.68

Figure A.1 Residues Harvesting Spreadsheet Model for Algoma County in Northern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	14,450	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	1,462	75	0.08	3.97	4.05	0.11	0.2	0.5	0.6
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	35,019	25	1.18	1.33	2.51	-1.43	-50.0	-16.7	-66.6
Grain corn	30,265	25	3.57	2.38	5.95	2.01	60.9	20.3	81.1
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	12,082	10	3.53	2.12	5.65	1.71	20.6	2.3	22.9
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	2,833	10	1.05	0.63	1.68	-2.26	-6.4	-0.7	-7.1
								Surplus residues from major field crops	31.0
								Organic material from manure	11.1
								Total harvestable residues	42.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.19
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.39	2.39

Figure A.2 Residues Harvesting Spreadsheet Model for Brant County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	159,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	33,496	75	0.08	3.97	4.05	0.11	3.6	10.9	14.6
Forage-Standard	3,367	75	0.08	3.97	4.05	0.11	0.4	1.1	1.5
Forage-Premium	898	75	0.08	3.97	4.05	0.11	0.1	0.3	0.4
Soybeans	65,797	25	1.18	1.33	2.51	-1.43	-93.9	-31.3	-125.2
Grain corn	42,878	25	3.57	2.38	5.95	2.01	86.2	28.7	115.0
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	35,984	10	3.53	2.12	5.65	1.71	61.4	6.8	68.2
Spring wheat	3,407	40	2.82	1.59	4.41	0.47	1.6	1.1	2.7
Spring grain	3,650	35	1.43	0.86	2.29	-1.66	-6.0	-3.3	-9.3
Beans	3,073	40	0.96	0.58	1.54	-2.41	-7.4	-4.9	-12.3
Canola	3,115	10	2.89	1.27	4.16	0.22	0.7	0.1	0.8
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	56.3
								Organic material from manure	122.2
								Total harvestable residues	178.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.43
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.63	2.63

Figure A.3 Residues Harvesting Spreadsheet Model for Bruce County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	11,250	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	845	75	0.08	3.97	4.05	0.11	0.1	0.3	0.4
Forage-Standard	7,073	75	0.08	3.97	4.05	0.11	0.8	2.3	3.1
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	179,914	25	1.18	1.33	2.51	-1.43	-256.7	-85.6	-342.3
Grain corn	126,189	25	3.57	2.38	5.95	2.01	253.8	84.6	338.4
Seed corn	17,936	20	3.21	2.14	5.36	1.42	25.4	6.3	31.7
Winter wheat	83,319	10	3.53	2.12	5.65	1.71	142.2	15.8	158.0
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	1,250	40	0.96	0.58	1.54	-2.41	-3.0	-2.0	-5.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	1,391	10	1.05	0.63	1.68	-2.26	-3.1	-0.3	-3.5
								Surplus residues from major field crops	180.7
								Organic material from manure	8.6
								Total harvestable residues	189.3

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.11
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.31	2.31

Figure A.4 Residues Harvesting Spreadsheet Model for Chatham-Kent County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.4	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	5,300	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	38.32	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.49	tonne/acre
Input residues at 15% MC required to balance SOC	3.88	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	4,441	75	0.08	3.97	4.05	0.17	0.7	2.2	2.9
Forage-Standard	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Soybeans	0	25	1.18	1.33	2.51	-1.37	0.0	0.0	0.0
Grain corn	0	25	3.57	2.38	5.95	2.07	0.0	0.0	0.0
Seed corn	0	20	3.21	2.14	5.36	1.47	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.76	0.0	0.0	0.0
Spring wheat	0	40	2.82	1.59	4.41	0.53	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.60	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.35	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.28	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.20	0.0	0.0	0.0
								Surplus residues from major field crops	2.9
								Organic material from manure	4.1
								Total harvestable residues	7.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.07	1.49
2	Soybeans	-1.37	0.00
3	Winter wheat	1.76	1.20
Total (tonne/rotation/acre)		2.69	2.69

Figure A.5 Residues Harvesting Spreadsheet Model for Cochrane County in Northern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	30,700	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	4,662	75	0.08	3.97	4.05	0.11	0.5	1.5	2.0
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	323	75	0.08	3.97	4.05	0.11	0.0	0.1	0.1
Soybeans	12,966	25	1.18	1.33	2.51	-1.43	-18.5	-6.2	-24.7
Grain corn	7,839	25	3.57	2.38	5.95	2.01	15.8	5.3	21.0
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	9,094	10	3.53	2.12	5.65	1.71	15.5	1.7	17.2
Spring wheat	1,167	40	2.82	1.59	4.41	0.47	0.5	0.4	0.9
Spring grain	1,960	35	1.43	0.86	2.29	-1.66	-3.2	-1.7	-5.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	6,188	10	2.89	1.27	4.16	0.22	1.4	0.2	1.5
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	13.2
								Organic material from manure	23.5
								Total harvestable residues	36.7

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.43
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.63	2.63

Figure A.6 Residues Harvesting Spreadsheet Model for Dufferin County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	42,450	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	451	75	0.08	3.97	4.05	0.22	0.1	0.3	0.4
Soybeans	27,124	25	1.18	1.33	2.51	-1.31	-35.6	-11.9	-47.5
Grain corn	35,414	25	3.57	2.38	5.95	2.12	75.2	25.1	100.3
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	14,660	10	3.53	2.12	5.65	1.82	26.7	3.0	29.6
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	1,608	35	1.43	0.86	2.29	-1.54	-2.5	-1.3	-3.8
Beans	2,377	40	0.96	0.58	1.54	-2.29	-5.4	-3.6	-9.1
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	69.9
								Organic material from manure	32.5
								Total harvestable residues	102.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.73
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.93	2.93

Figure A.7 Residues Harvesting Spreadsheet Model for Durham County in Central Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	29,350	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	3,518	75	0.08	3.97	4.05	0.11	0.4	1.1	1.5
Forage-Standard	1,722	75	0.08	3.97	4.05	0.11	0.2	0.6	0.7
Forage-Premium	314	75	0.08	3.97	4.05	0.11	0.0	0.1	0.1
Soybeans	84,559	25	1.18	1.33	2.51	-1.43	-120.7	-40.2	-160.9
Grain corn	88,579	25	3.57	2.38	5.95	2.01	178.1	59.4	237.5
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	29,359	10	3.53	2.12	5.65	1.71	50.1	5.6	55.7
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	2,691	40	0.96	0.58	1.54	-2.41	-6.5	-4.3	-10.8
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	2,381	10	1.05	0.63	1.68	-2.26	-5.4	-0.6	-6.0
								Surplus residues from major field crops	117.9
								Organic material from manure	22.5
								Total harvestable residues	140.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.17
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.37	2.37

Figure A.8 Residues Harvesting Spreadsheet Model for Elgin County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	5,450	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Standard	2,255	75	0.08	3.97	4.05	0.11	0.2	0.7	1.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	144,904	25	1.18	1.33	2.51	-1.43	-206.8	-68.9	-275.7
Grain corn	39,793	25	3.57	2.38	5.95	2.01	80.0	26.7	106.7
Seed corn	2,532	20	3.21	2.14	5.36	1.42	3.6	0.9	4.5
Winter wheat	59,937	10	3.53	2.12	5.65	1.71	102.3	11.4	113.6
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	-49.9
								Organic material from manure	4.2
								Total harvestable residues	-45.7

Figure A.9 Residues Harvesting Spreadsheet Model for Essex County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	20,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	5,311	75	0.08	3.97	4.05	0.22	1.2	3.5	4.7
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Soybeans	5,451	25	1.18	1.33	2.51	-1.31	-7.2	-2.4	-9.6
Grain corn	3,543	25	3.57	2.38	5.95	2.12	7.5	2.5	10.0
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.82	0.0	0.0	0.0
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.54	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	5.2
								Organic material from manure	15.6
								Total harvestable residues	20.8

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.90
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		3.10	3.10

Figure A.10 Residues Harvesting Spreadsheet Model for Frontenac County in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	129,150	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	17,089	75	0.08	3.97	4.05	0.11	1.9	5.6	7.4
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	509	75	0.08	3.97	4.05	0.11	0.1	0.2	0.2
Soybeans	17,870	25	1.18	1.33	2.51	-1.43	-25.5	-8.5	-34.0
Grain corn	13,878	25	3.57	2.38	5.95	2.01	27.9	9.3	37.2
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	9,573	10	3.53	2.12	5.65	1.71	16.3	1.8	18.2
Spring wheat	1,981	40	2.82	1.59	4.41	0.47	0.9	0.6	1.6
Spring grain	6,154	35	1.43	0.86	2.29	-1.66	-10.2	-5.5	-15.7
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	7,019	10	2.89	1.27	4.16	0.22	1.5	0.2	1.7
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	16.6
								Organic material from manure	99.0
								Total harvestable residues	115.6

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.78
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.98	2.98

Figure A.11 Residues Harvesting Spreadsheet Model for Grey County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	14,650	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	9,240	75	0.08	3.97	4.05	0.11	1.0	3.0	4.0
Forage-Standard	1,936	75	0.08	3.97	4.05	0.11	0.2	0.6	0.8
Forage-Premium	738	75	0.08	3.97	4.05	0.11	0.1	0.2	0.3
Soybeans	71,111	25	1.18	1.33	2.51	-1.43	-101.5	-33.8	-135.3
Grain corn	16,262	25	3.57	2.38	5.95	2.01	32.7	10.9	43.6
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	16,796	10	3.53	2.12	5.65	1.71	28.7	3.2	31.8
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	-54.7
								Organic material from manure	11.2
								Total harvestable residues	-43.4

Figure A.12 Residues Harvesting Spreadsheet Model for Haldimand County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	8,300	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	15,829	25	1.18	1.33	2.51	-1.43	-22.6	-7.5	-30.1
Grain corn	7,976	25	3.57	2.38	5.95	2.01	16.0	5.3	21.4
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	6,710	10	3.53	2.12	5.65	1.71	11.4	1.3	12.7
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	4.0
								Organic material from manure	6.4
								Total harvestable residues	10.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.25
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.45	2.45

Figure A.13 Residues Harvesting Spreadsheet Model for Halton County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	11,500	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	24,047	25	1.18	1.33	2.51	-1.43	-34.3	-11.4	-45.7
Grain corn	13,305	25	3.57	2.38	5.95	2.01	26.8	8.9	35.7
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	5,590	10	3.53	2.12	5.65	1.71	9.5	1.1	10.6
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	0.5
								Organic material from manure	8.8
								Total harvestable residues	9.3

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.25
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.45	2.45

Figure A.14 Residues Harvesting Spreadsheet Model for Hamilton County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	33,450	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	14,336	75	0.08	3.97	4.05	0.22	3.2	9.5	12.7
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	527	75	0.08	3.97	4.05	0.22	0.1	0.4	0.5
Soybeans	10,428	25	1.18	1.33	2.51	-1.31	-13.7	-4.6	-18.3
Grain corn	10,417	25	3.57	2.38	5.95	2.12	22.1	7.4	29.5
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	2,545	10	3.53	2.12	5.65	1.82	4.6	0.5	5.1
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	666	35	1.43	0.86	2.29	-1.54	-1.0	-0.6	-1.6
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	28.0
								Organic material from manure	25.6
								Total harvestable residues	53.6

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.71
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.91	2.91

Figure A.15 Residues Harvesting Spreadsheet Model for Hastings County in Central Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	123,300	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	9,221	75	0.08	3.97	4.05	0.11	1.0	3.0	4.0
Forage-Standard	10,643	75	0.08	3.97	4.05	0.11	1.2	3.5	4.6
Forage-Premium	1,467	75	0.08	3.97	4.05	0.11	0.2	0.5	0.6
Soybeans	136,458	25	1.18	1.33	2.51	-1.43	-194.7	-64.9	-259.6
Grain corn	143,809	25	3.57	2.38	5.95	2.01	289.2	96.4	385.6
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	94,366	10	3.53	2.12	5.65	1.71	161.0	17.9	178.9
Spring wheat	909	40	2.82	1.59	4.41	0.47	0.4	0.3	0.7
Spring grain	2,824	35	1.43	0.86	2.29	-1.66	-4.7	-2.5	-7.2
Beans	27,224	40	0.96	0.58	1.54	-2.41	-65.5	-43.7	-109.1
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	198.6
								Organic material from manure	94.5
								Total harvestable residues	293.1

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.24
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.44	2.44

Figure A.16 Residues Harvesting Spreadsheet Model for Huron County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	50,950	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	4,446	75	0.08	3.97	4.05	0.22	1.0	3.0	3.9
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Soybeans	19,679	25	1.18	1.33	2.51	-1.31	-25.9	-8.6	-34.5
Grain corn	10,098	25	3.57	2.38	5.95	2.12	21.4	7.1	28.6
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	10,178	10	3.53	2.12	5.65	1.82	18.5	2.1	20.6
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	1,582	35	1.43	0.86	2.29	-1.54	-2.4	-1.3	-3.8
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	1,251	10	2.89	1.27	4.16	0.33	0.4	0.0	0.5
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	15.3
								Organic material from manure	39.1
								Total harvestable residues	54.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.97
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		3.17	3.17

Figure A.17 Residues Harvesting Spreadsheet Model for Kawartha Lakes County in Central Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	37,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	4,577	75	0.08	3.97	4.05	0.11	0.5	1.5	2.0
Forage-Standard	9,175	75	0.08	3.97	4.05	0.11	1.0	3.0	4.0
Forage-Premium	455	75	0.08	3.97	4.05	0.11	0.0	0.1	0.2
Soybeans	194,610	25	1.18	1.33	2.51	-1.43	-277.7	-92.6	-370.2
Grain corn	82,530	25	3.57	2.38	5.95	2.01	166.0	55.3	221.3
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	101,716	10	3.53	2.12	5.65	1.71	173.6	19.3	192.9
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	532	35	1.43	0.86	2.29	-1.66	-0.9	-0.5	-1.4
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	48.7
								Organic material from manure	28.7
								Total harvestable residues	77.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.14
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.34	2.34

Figure A.18 Residues Harvesting Spreadsheet Model for Lambton County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	22,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	7,161	75	0.08	3.97	4.05	0.22	1.6	4.8	6.3
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	161	75	0.08	3.97	4.05	0.22	0.0	0.1	0.1
Soybeans	6,614	25	1.18	1.33	2.51	-1.31	-8.7	-2.9	-11.6
Grain corn	4,631	25	3.57	2.38	5.95	2.12	9.8	3.3	13.1
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.82	0.0	0.0	0.0
Spring wheat	1,208	40	2.82	1.59	4.41	0.58	0.7	0.5	1.2
Spring grain	326	35	1.43	0.86	2.29	-1.54	-0.5	-0.3	-0.8
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	8.4
								Organic material from manure	17.2
								Total harvestable residues	25.6

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.80
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		3.00	3.00

Figure A.19 Residues Harvesting Spreadsheet Model for Lanark County in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	38,950	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	5,899	75	0.08	3.97	4.05	0.22	1.3	3.9	5.2
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	268	75	0.08	3.97	4.05	0.22	0.1	0.2	0.2
Soybeans	12,302	25	1.18	1.33	2.51	-1.31	-16.2	-5.4	-21.6
Grain corn	11,107	25	3.57	2.38	5.95	2.12	23.6	7.9	31.5
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.82	0.0	0.0	0.0
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	828	35	1.43	0.86	2.29	-1.54	-1.3	-0.7	-2.0
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	13.4
								Organic material from manure	29.9
								Total harvestable residues	43.3

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.95
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		3.15	3.15

Figure A.20 Residues Harvesting Spreadsheet Model for Leeds & Grenville in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	20,050	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	9,504	75	0.08	3.97	4.05	0.22	2.1	6.3	8.4
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Soybeans	9,458	25	1.18	1.33	2.51	-1.31	-12.4	-4.1	-16.6
Grain corn	7,731	25	3.57	2.38	5.95	2.12	16.4	5.5	21.9
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	2,673	10	3.53	2.12	5.65	1.82	4.9	0.5	5.4
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.54	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	19.1
								Organic material from manure	15.4
								Total harvestable residues	34.5

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.67
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.87	2.87

Figure A.21 Residues Harvesting Spreadsheet Model for Lennox & Addington in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	79,750	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	5,489	75	0.08	3.97	4.05	0.11	0.6	1.8	2.4
Forage-Standard	5,876	75	0.08	3.97	4.05	0.11	0.6	1.9	2.6
Forage-Premium	812	75	0.08	3.97	4.05	0.11	0.1	0.3	0.4
Soybeans	127,630	25	1.18	1.33	2.51	-1.43	-182.1	-60.7	-242.8
Grain corn	135,181	25	3.57	2.38	5.95	2.01	271.8	90.6	362.5
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	71,745	10	3.53	2.12	5.65	1.71	122.4	13.6	136.0
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	693	35	1.43	0.86	2.29	-1.66	-1.1	-0.6	-1.8
Beans	10,706	40	0.96	0.58	1.54	-2.41	-25.7	-17.2	-42.9
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	838	10	1.05	0.63	1.68	-2.26	-1.9	-0.2	-2.1
								Surplus residues from major field crops	214.2
								Organic material from manure	61.1
								Total harvestable residues	275.3

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.21
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.41	2.41

Figure A.22 Residues Harvesting Spreadsheet Model for Middlesex County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	11,700	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	3,991	75	0.08	3.97	4.05	0.11	0.4	1.3	1.7
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	63,809	25	1.18	1.33	2.51	-1.43	-91.0	-30.3	-121.4
Grain corn	15,534	25	3.57	2.38	5.95	2.01	31.2	10.4	41.7
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	11,477	10	3.53	2.12	5.65	1.71	19.6	2.2	21.8
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	-56.3
								Organic material from manure	9.0
								Total harvestable residues	-47.3

Figure A.23 Residues Harvesting Spreadsheet Model for Niagara County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	14,650	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	44,131	25	1.18	1.33	2.51	-1.43	-63.0	-21.0	-84.0
Grain corn	44,429	25	3.57	2.38	5.95	2.01	89.3	29.8	119.1
Seed corn	389	20	3.21	2.14	5.36	1.42	0.6	0.1	0.7
Winter wheat	5,866	10	3.53	2.12	5.65	1.71	10.0	1.1	11.1
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.66	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	11,624	10	1.05	0.63	1.68	-2.26	-26.3	-2.9	-29.2
								Surplus residues from major field crops	17.8
								Organic material from manure	11.2
								Total harvestable residues	29.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.17
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.37	2.37

Figure A.24 Residues Harvesting Spreadsheet Model for Norfolk County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	30,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	8,447	75	0.08	3.97	4.05	0.22	1.9	5.6	7.5
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	410	75	0.08	3.97	4.05	0.22	0.1	0.3	0.4
Soybeans	25,942	25	1.18	1.33	2.51	-1.31	-34.1	-11.4	-45.4
Grain corn	24,014	25	3.57	2.38	5.95	2.12	51.0	17.0	68.0
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	8,816	10	3.53	2.12	5.65	1.82	16.0	1.8	17.8
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	672	35	1.43	0.86	2.29	-1.54	-1.0	-0.6	-1.6
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	46.6
								Organic material from manure	23.3
								Total harvestable residues	69.9

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.64
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.84	2.84

Figure A.25 Residues Harvesting Spreadsheet Model for Northumberland County in Central Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	37,050	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	3,096	75	0.08	3.97	4.05	0.22	0.7	2.1	2.7
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	690	75	0.08	3.97	4.05	0.22	0.2	0.5	0.6
Soybeans	34,428	25	1.18	1.33	2.51	-1.31	-45.2	-15.1	-60.3
Grain corn	29,349	25	3.57	2.38	5.95	2.12	62.3	20.8	83.1
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	1,409	10	3.53	2.12	5.65	1.82	2.6	0.3	2.8
Spring wheat	4,061	40	2.82	1.59	4.41	0.58	2.4	1.6	4.0
Spring grain	553	35	1.43	0.86	2.29	-1.54	-0.9	-0.5	-1.3
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	31.6
								Organic material from manure	28.4
								Total harvestable residues	60.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.69
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.89	2.89

Figure A.26 Residues Harvesting Spreadsheet Model for Ottawa County in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	79,150	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	1,774	75	0.08	3.97	4.05	0.11	0.2	0.6	0.8
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	618	75	0.08	3.97	4.05	0.11	0.1	0.2	0.3
Soybeans	55,303	25	1.18	1.33	2.51	-1.43	-78.9	-26.3	-105.2
Grain corn	90,928	25	3.57	2.38	5.95	2.01	182.9	61.0	243.8
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	30,227	10	3.53	2.12	5.65	1.71	51.6	5.7	57.3
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	576	35	1.43	0.86	2.29	-1.66	-1.0	-0.5	-1.5
Beans	8,166	40	0.96	0.58	1.54	-2.41	-19.6	-13.1	-32.7
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	848	10	1.05	0.63	1.68	-2.26	-1.9	-0.2	-2.1
								Surplus residues from major field crops	160.6
								Organic material from manure	60.7
								Total harvestable residues	221.3

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.33
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.53	2.53

Figure A.27 Residues Harvesting Spreadsheet Model for Oxford County in Southern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	14,350	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	3,940	75	0.08	3.97	4.05	0.11	0.4	1.3	1.7
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	14,816	25	1.18	1.33	2.51	-1.43	-21.1	-7.0	-28.2
Grain corn	6,387	25	3.57	2.38	5.95	2.01	12.8	4.3	17.1
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	6,392	10	3.53	2.12	5.65	1.71	10.9	1.2	12.1
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	644	35	1.43	0.86	2.29	-1.66	-1.1	-0.6	-1.6
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	1.1
								Organic material from manure	11.0
								Total harvestable residues	12.1

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.30
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.50	2.50

Figure A.28 Residues Harvesting Spreadsheet Model for Peel County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	116,300	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	2,568	75	0.08	3.97	4.05	0.11	0.3	0.8	1.1
Forage-Standard	5,409	75	0.08	3.97	4.05	0.11	0.6	1.8	2.4
Forage-Premium	1,013	75	0.08	3.97	4.05	0.11	0.1	0.3	0.4
Soybeans	78,153	25	1.18	1.33	2.51	-1.43	-111.5	-37.2	-148.7
Grain corn	99,764	25	3.57	2.38	5.95	2.01	200.6	66.9	267.5
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	57,989	10	3.53	2.12	5.65	1.71	99.0	11.0	109.9
Spring wheat	1,155	40	2.82	1.59	4.41	0.47	0.5	0.4	0.9
Spring grain	2,535	35	1.43	0.86	2.29	-1.66	-4.2	-2.3	-6.5
Beans	17,377	40	0.96	0.58	1.54	-2.41	-41.8	-27.9	-69.7
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	157.5
								Organic material from manure	89.1
								Total harvestable residues	246.6

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.33
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.53	2.53

Figure A.29 Residues Harvesting Spreadsheet Model for Perth County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	33,700	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	5,707	75	0.08	3.97	4.05	0.22	1.3	3.8	5.1
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Soybeans	10,211	25	1.18	1.33	2.51	-1.31	-13.4	-4.5	-17.9
Grain corn	6,671	25	3.57	2.38	5.95	2.12	14.2	4.7	18.9
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	4,920	10	3.53	2.12	5.65	1.82	9.0	1.0	9.9
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	1,035	35	1.43	0.86	2.29	-1.54	-1.6	-0.9	-2.5
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	13.6
								Organic material from manure	25.8
								Total harvestable residues	39.4

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.92
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		3.12	3.12

Figure A.30 Residues Harvesting Spreadsheet Model for Peterborough County in Central Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	48,300	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	18,618	75	0.08	3.97	4.05	0.22	4.1	12.4	16.5
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	2,321	75	0.08	3.97	4.05	0.22	0.5	1.5	2.1
Soybeans	64,998	25	1.18	1.33	2.51	-1.31	-85.4	-28.5	-113.9
Grain corn	52,616	25	3.57	2.38	5.95	2.12	111.8	37.3	149.0
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.82	0.0	0.0	0.0
Spring wheat	5,568	40	2.82	1.59	4.41	0.58	3.3	2.2	5.4
Spring grain	2,157	35	1.43	0.86	2.29	-1.54	-3.3	-1.8	-5.1
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	54.0
								Organic material from manure	37.0
								Total harvestable residues	91.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.58
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.78	2.78

Figure A.31 Residues Harvesting Spreadsheet Model for Prescott & Russel in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	11,150	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	11,026	75	0.08	3.97	4.05	0.22	2.4	7.3	9.8
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Soybeans	14,778	25	1.18	1.33	2.51	-1.31	-19.4	-6.5	-25.9
Grain corn	12,791	25	3.57	2.38	5.95	2.12	27.2	9.1	36.2
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	9,320	10	3.53	2.12	5.65	1.82	17.0	1.9	18.8
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	387	35	1.43	0.86	2.29	-1.54	-0.6	-0.3	-0.9
Beans	1,065	40	0.96	0.58	1.54	-2.29	-2.4	-1.6	-4.1
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	34.0
								Organic material from manure	8.5
								Total harvestable residues	42.5

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.52
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.72	2.72

Figure A.32 Residues Harvesting Spreadsheet Model for Prince Edward County in Central Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.4	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	19,800	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	38.32	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.49	tonne/acre
Input residues at 15% MC required to balance SOC	3.88	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	43,131	75	0.08	3.97	4.05	0.17	7.1	21.4	28.5
Forage-Standard	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Soybeans	0	25	1.18	1.33	2.51	-1.37	0.0	0.0	0.0
Grain corn	0	25	3.57	2.38	5.95	2.07	0.0	0.0	0.0
Seed corn	0	20	3.21	2.14	5.36	1.47	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.76	0.0	0.0	0.0
Spring wheat	0	40	2.82	1.59	4.41	0.53	0.0	0.0	0.0
Spring grain	1,070	35	1.43	0.86	2.29	-1.60	-1.7	-0.9	-2.6
Beans	0	40	0.96	0.58	1.54	-2.35	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.28	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.20	0.0	0.0	0.0
								Surplus residues from major field crops	25.9
								Organic material from manure	15.2
								Total harvestable residues	41.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.07	1.35
2	Soybeans	-1.37	0.00
3	Winter wheat	1.76	1.20
Total (tonne/rotation/acre)		2.55	2.55

Figure A.33 Residues Harvesting Spreadsheet Model for Rainy River County in Northern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	54,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	54,673	75	0.08	3.97	4.05	0.22	12.1	36.3	48.5
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	1,108	75	0.08	3.97	4.05	0.22	0.2	0.7	1.0
Soybeans	12,834	25	1.18	1.33	2.51	-1.31	-16.9	-5.6	-22.5
Grain corn	10,524	25	3.57	2.38	5.95	2.12	22.4	7.5	29.8
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.82	0.0	0.0	0.0
Spring wheat	2,085	40	2.82	1.59	4.41	0.58	1.2	0.8	2.0
Spring grain	1,536	35	1.43	0.86	2.29	-1.54	-2.4	-1.3	-3.6
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	55.1
								Organic material from manure	41.7
								Total harvestable residues	96.8

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.59
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.79	2.79

Figure A.34 Residues Harvesting Spreadsheet Model for Renfrew County in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	56,400	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	3,555	75	0.08	3.97	4.05	0.11	0.4	1.2	1.5
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	283	75	0.08	3.97	4.05	0.11	0.0	0.1	0.1
Soybeans	53,549	25	1.18	1.33	2.51	-1.43	-76.4	-25.5	-101.9
Grain corn	31,549	25	3.57	2.38	5.95	2.01	63.4	21.1	84.6
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	38,632	10	3.53	2.12	5.65	1.71	65.9	7.3	73.2
Spring wheat	1,873	40	2.82	1.59	4.41	0.47	0.9	0.6	1.5
Spring grain	1,675	35	1.43	0.86	2.29	-1.66	-2.8	-1.5	-4.3
Beans	2,627	40	0.96	0.58	1.54	-2.41	-6.3	-4.2	-10.5
Canola	5,798	10	2.89	1.27	4.16	0.22	1.3	0.1	1.4
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	45.7
								Organic material from manure	43.2
								Total harvestable residues	88.9

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.32
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.52	2.52

Figure A.35 Residues Harvesting Spreadsheet Model for Simcoe County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	77,600	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	7,936	75	0.08	3.97	4.05	0.22	1.8	5.3	7.0
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	937	75	0.08	3.97	4.05	0.22	0.2	0.6	0.8
Soybeans	68,503	25	1.18	1.33	2.51	-1.31	-90.0	-30.0	-120.0
Grain corn	84,918	25	3.57	2.38	5.95	2.12	180.4	60.1	240.5
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.82	0.0	0.0	0.0
Spring wheat	4,914	40	2.82	1.59	4.41	0.58	2.9	1.9	4.8
Spring grain	2,034	35	1.43	0.86	2.29	-1.54	-3.1	-1.7	-4.8
Beans	1,576	40	0.96	0.58	1.54	-2.29	-3.6	-2.4	-6.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	122.3
								Organic material from manure	59.5
								Total harvestable residues	181.7

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.66
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		2.86	2.86

Figure A.36 Residues Harvesting Spreadsheet Model for Stormont, Dundas & Glengarry in Eastern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.4	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	7,000	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	38.32	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.49	tonne/acre
Input residues at 15% MC required to balance SOC	3.88	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	4,326	75	0.08	3.97	4.05	0.17	0.7	2.1	2.9
Forage-Standard	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Soybeans	0	25	1.18	1.33	2.51	-1.37	0.0	0.0	0.0
Grain corn	0	25	3.57	2.38	5.95	2.07	0.0	0.0	0.0
Seed corn	0	20	3.21	2.14	5.36	1.47	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.76	0.0	0.0	0.0
Spring wheat	0	40	2.82	1.59	4.41	0.53	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.60	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.35	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.28	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.20	0.0	0.0	0.0
								Surplus residues from major field crops	2.9
								Organic material from manure	5.4
								Total harvestable residues	8.2

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.07	1.57
2	Soybeans	-1.37	0.00
3	Winter wheat	1.76	1.20
Total (tonne/rotation/acre)		2.77	2.77

Figure A.37 Residues Harvesting Spreadsheet Model for Thunder Bay County in Northern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.4	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	21,450	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	38.32	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.49	tonne/acre
Input residues at 15% MC required to balance SOC	3.88	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	4,047	75	0.08	3.97	4.05	0.17	0.7	2.0	2.7
Forage-Standard	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.17	0.0	0.0	0.0
Soybeans	4,915	25	1.18	1.33	2.51	-1.37	-6.7	-2.2	-9.0
Grain corn	0	25	3.57	2.38	5.95	2.07	0.0	0.0	0.0
Seed corn	0	20	3.21	2.14	5.36	1.47	0.0	0.0	0.0
Winter wheat	0	10	3.53	2.12	5.65	1.76	0.0	0.0	0.0
Spring wheat	12,561	40	2.82	1.59	4.41	0.53	6.6	4.4	11.0
Spring grain	8,327	35	1.43	0.86	2.29	-1.60	-13.3	-7.2	-20.5
Beans	0	40	0.96	0.58	1.54	-2.35	0.0	0.0	0.0
Canola	22,499	10	2.89	1.27	4.16	0.28	6.2	0.7	6.9
Tobacco	0	10	1.05	0.63	1.68	-2.20	0.0	0.0	0.0
								Surplus residues from major field crops	-8.8
								Organic material from manure	16.4
								Total harvestable residues	7.6

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.07	1.46
2	Soybeans	-1.37	0.00
3	Winter wheat	1.76	1.20
Total (tonne/rotation/acre)		2.66	2.66

Figure A.38 Residues Harvesting Spreadsheet Model for Timiskaming County in Northern Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	91,550	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	2,202	75	0.08	3.97	4.05	0.11	0.2	0.7	1.0
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Soybeans	16,147	25	1.18	1.33	2.51	-1.43	-23.0	-7.7	-30.7
Grain corn	18,108	25	3.57	2.38	5.95	2.01	36.4	12.1	48.6
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	9,221	10	3.53	2.12	5.65	1.71	15.7	1.7	17.5
Spring wheat	0	40	2.82	1.59	4.41	0.47	0.0	0.0	0.0
Spring grain	964	35	1.43	0.86	2.29	-1.66	-1.6	-0.9	-2.5
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.22	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	33.8
								Organic material from manure	70.2
								Total harvestable residues	104.0

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	2.15
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		3.35	3.35

Figure A.39 Residues Harvesting Spreadsheet Model for Waterloo County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.5	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	130,050	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	39.45	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.23	tonne/acre
Input carbon required to balance SOC	1.51	tonne/acre
Input residues at 15% MC required to balance SOC	3.94	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	1,563	75	0.08	3.97	4.05	0.11	0.2	0.5	0.7
Forage-Standard	0	75	0.08	3.97	4.05	0.11	0.0	0.0	0.0
Forage-Premium	442	75	0.08	3.97	4.05	0.11	0.0	0.1	0.2
Soybeans	62,045	25	1.18	1.33	2.51	-1.43	-88.5	-29.5	-118.0
Grain corn	44,385	25	3.57	2.38	5.95	2.01	89.3	29.8	119.0
Seed corn	0	20	3.21	2.14	5.36	1.42	0.0	0.0	0.0
Winter wheat	37,517	10	3.53	2.12	5.65	1.71	64.0	7.1	71.1
Spring wheat	2,346	40	2.82	1.59	4.41	0.47	1.1	0.7	1.8
Spring grain	2,845	35	1.43	0.86	2.29	-1.66	-4.7	-2.5	-7.2
Beans	0	40	0.96	0.58	1.54	-2.41	0.0	0.0	0.0
Canola	9,694	10	2.89	1.27	4.16	0.22	2.1	0.2	2.4
Tobacco	0	10	1.05	0.63	1.68	-2.26	0.0	0.0	0.0
								Surplus residues from major field crops	69.9
								Organic material from manure	99.7
								Total harvestable residues	169.6

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.01	1.56
2	Soybeans	-1.43	0.00
3	Winter wheat	1.71	1.20
Total (tonne/rotation/acre)		2.76	2.76

Figure A.40 Residues Harvesting Spreadsheet Model for Wellington County in Western Ontario

Optimum Residues Removal by Soil Organic Carbon (SOC) Balance		
General Parameters	Value	Unit
Soil Organic Matter (SOM) level of agricultural land	3.3	%
Tolerable soil erosion	2.67	tonne/acre
Numbers of cattle and calves in county	16,200	head
Tillage practise (1 - conservation, 2- conventional)	1	
Residues to SOC conversion efficiency	15	%

Calculated parameters	Value	Unit
SOC in the soil (0-30 cm) to be maintained	37.20	tonne/acre
SOC loss due to erosion	0.05	tonne/acre
SOC loss due to normal carbon decomposition	0.06	tonne/acre
SOC loss due to tillage	0.11	tonne/acre
Total SOC losses	0.22	tonne/acre
Input carbon required to balance SOC	1.46	tonne/acre
Input residues at 15% MC required to balance SOC	3.83	tonne/acre

Sustainably Harvestable Residues in the County									
Field Crop	Acres Planted (Insured)	Un-insured Acres (% of Total)	Above Ground Residues (tonne/acre)	Roots Residues (tonne/acre)	Total Residues (tonne/acre)	Harvestable Residues (tonne/acre)	Harvestable Residues - Insured ('000 tonne)	Harvestable Residues - Un-insured ('000 tonne)	Total Harvestable Residues ('000 tonne)
Forage-Rainfall	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Standard	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Forage-Premium	0	75	0.08	3.97	4.05	0.22	0.0	0.0	0.0
Soybeans	11,238	25	1.18	1.33	2.51	-1.31	-14.8	-4.9	-19.7
Grain corn	9,250	25	3.57	2.38	5.95	2.12	19.6	6.5	26.2
Seed corn	0	20	3.21	2.14	5.36	1.53	0.0	0.0	0.0
Winter wheat	4,025	10	3.53	2.12	5.65	1.82	7.3	0.8	8.1
Spring wheat	0	40	2.82	1.59	4.41	0.58	0.0	0.0	0.0
Spring grain	0	35	1.43	0.86	2.29	-1.54	0.0	0.0	0.0
Beans	0	40	0.96	0.58	1.54	-2.29	0.0	0.0	0.0
Canola	0	10	2.89	1.27	4.16	0.33	0.0	0.0	0.0
Tobacco	0	10	1.05	0.63	1.68	-2.15	0.0	0.0	0.0
								Surplus residues from major field crops	14.6
								Organic material from manure	12.4
								Total harvestable residues	27.1

Recommended Residue Harvest for Typical Crop Rotation			
Year	Crop	Harvestable Residues (tonne/acre)	Recommended Residue Harvest (tonne/acre)
1	Corn	2.12	1.82
2	Soybeans	-1.31	0.00
3	Winter wheat	1.82	1.20
Total (tonne/rotation/acre)		3.02	3.02

Figure A.41 Residues Harvesting Spreadsheet Model for York County in Central Ontario

Notes

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