# An Organic Waste Inventory for Alberta's Agrifood Sector

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## Abstract

The agriculture and food-processing industries have always been important in Alberta and in 2015 they are as relevant as ever. Despite the positive growth of the agriculture and food manufacturing sector, there is limited understanding of the residues left behind. Do they present a missed opportunity? This study concludes that it does.

Using a diversity of methods ranging from literature review to telephone interviews and site visits the study compiled, aggregated, anonymized and (in some cases) extrapolated data on the organic waste streams from four subsectors that were identified as being of strategic importance: livestock, food processing, grocery and residential yards. **Figure E1** shows a breakdown of the almost 3.4 million dry tonnes of organic waste identified by subsector and **Figure E2** summarizes the same data geographically.

This report provides information that will be useful to future discussions on waste management in Alberta's Agrifood sector. The key conclusions are:

1. There are approximately 3.4 million tonnes of dry organic waste produced every year in Alberta including all four of the subsectors considered.
2. The most common disposal methods vary by subsector however putting waste in landfills, applying waste directly onto land, composting waste, rendering animal waste and feeding waste to animals are the five most commonly used disposal options.
3. Even where waste management practices offer benefits it may be possible to improve procedures to extract more value (for example diverting wastes from animal feed to high value food ingredients).
4. The majority of waste volumes tend to remain constant throughout the year although individual waste streams were reported as being highly seasonal.
5. The majority of the reported waste is still a liability where producers must pay to have it hauled and disposed.
6. Disposal fees vary greatly across the province and thus incentives for diverting waste also vary.
7. There is an opportunity for Albertans to more aggressively explore options to convert waste streams into higher value products.

The results of this study should be used with caution and there remains significant opportunity to improve the quality and quantity of the data that was used to reach the conclusions. It is hoped that having numbers on waste values for the various subsectors, even if they are inaccurate, can still be valuable as a means to catalyze discussion and inspire new efforts to improve data quality.

**Figure E1. Organic Waste Identified by Subsector**

| Sub-sector | tonnes per year (dry) |
|---|---|
| Livestock operation (manure) | 2,560,000 |
| Livestock operation (on-farm dead) | 70,000 |
| Food-processing Waste | 500,000 |
| Grocery Store Waste | 50,000 |
| Yard Waste | 200,000 |
| Total | 3,380,000 |

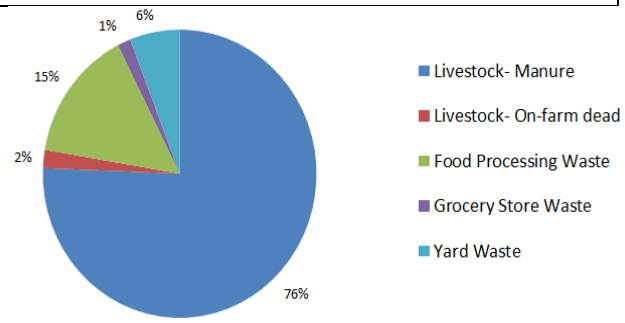
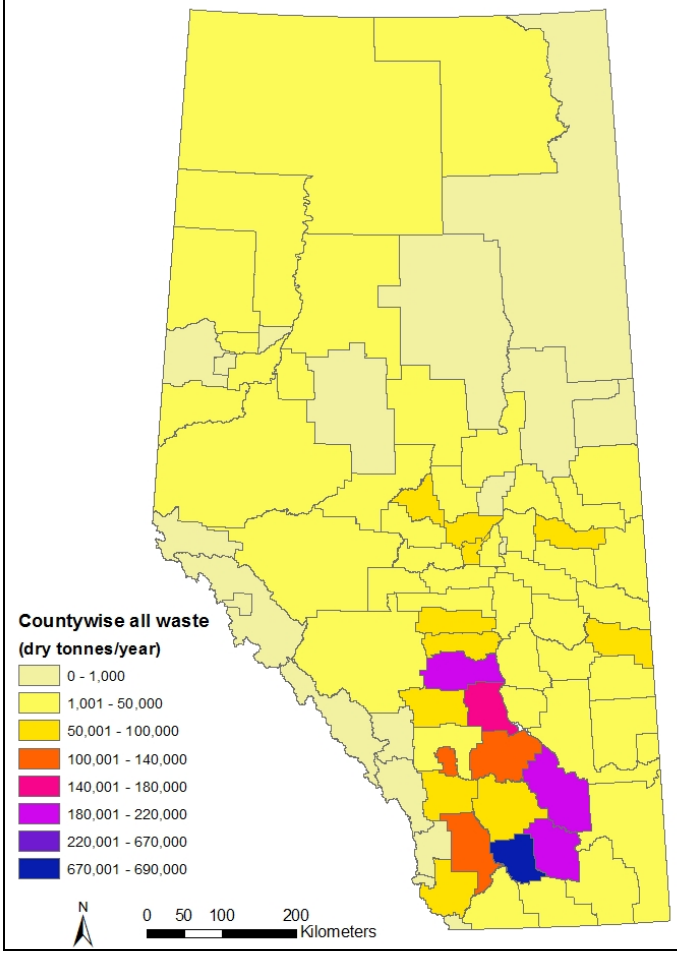



**Figure E2. County-level Availability of Select Organic Wastes in Alberta**



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## Introduction

The agriculture and food-processing industries have always been important in Alberta and in 2015 they are as relevant as ever. Agriculture and food remains Alberta's second largest export industry after the oil and gas sector.[1] In 2013, Alberta's food and beverage processing industries represented the second largest manufacturing sector in the province accounting for 16.8% or $12.6 billion of total manufactured goods ($74.8 billion).[2] Despite the positive growth of the agriculture and food manufacturing sector, there is limited understanding of the residues left behind. Do they present a missed opportunity? In order to answer this question a thorough understanding is needed of residues and wastes associated with the agriculture and food industry.

Prior to this study, anecdotal evidence suggested that much of the by-products and residues resulting from the food and agricultural sectors were considered liabilities- the producer had to pay for their hauling and disposal. In some cases producers made a modest income from selling the by-products to those that can make use of them but most of the time the material was sent to landfill, applied on the land, burned, used to supplement animal feed, etc. Only a small amount of the material found its way into products that demanded a premium price. This study set out to test these hypotheses.

The study hoped to contribute to answering the following underlying question. Is there an opportunity to improve the competitiveness of Alberta agricultural processors by:

i. Reducing the amount of waste that must be hauled and disposed of (thus reducing associated costs); or,
ii. Diverting residue and by-products from the disposal stream to new products, thereby increasing revenues.

Before the business case can be made to invest in waste diversion or reduction a company requires accurate information on the quantity and characteristics of available waste. Alberta's waste management and processing professionals have identified three major deficiencies in our current understanding of Alberta's organic waste. Lack of information on:

i. Waste composition;
ii. Seasonal variation;
iii. Geographic distribution.

The goal of this project was to create an organic waste inventory for Alberta that could help match waste products to end users as well as reveal opportunities for on-site waste reduction and diversion. Because the food and agriculture sector is so large in Alberta it was necessary to limit the scope of the study. Some subsectors were omitted because it was thought that some public information already existed; for example information on agricultural residues such as straw. Other sub-sectors were omitted for practical or methodological reasons, for example it was deemed that it would be difficult to gather data on food waste in the restaurant sector. The four sub-sectors that were considered of sufficient strategic importance to warrant focus in this study were:

i. Food-processing facilities;
ii. Livestock operations
iii. Grocery stores;
iv. Residential yard waste.

The project sought to gather information from these four subsectors on the quality and quantity and availability of organic waste streams and low-value by-products. The resultant data gathered in this study will complement existing information on other organic wastes and by-products including work that has previously been done with forestry residues, crop residues and municipal solid waste, etc.

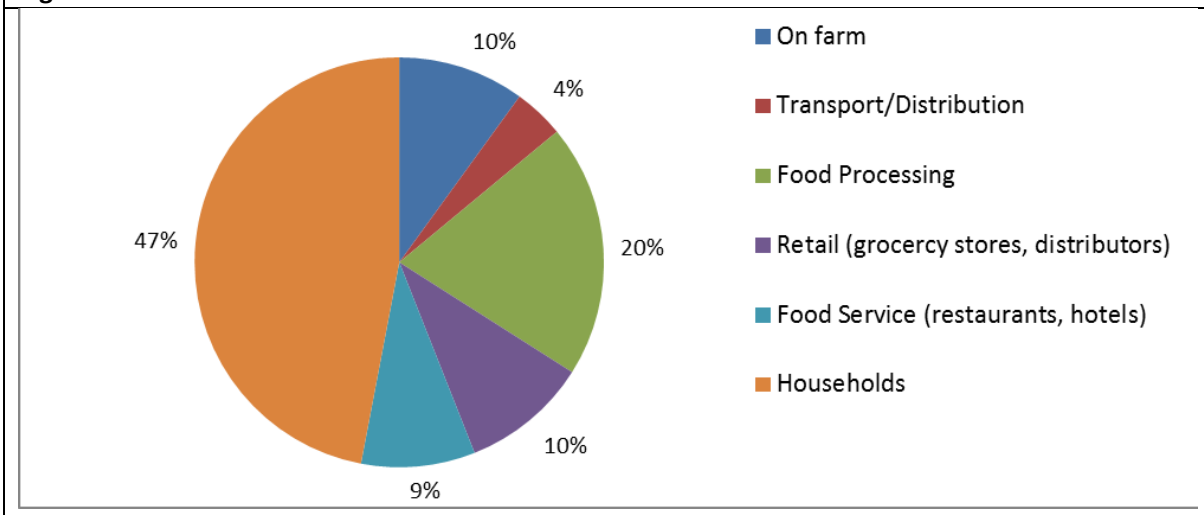
## Background

Around the world there is a growing recognition that existing management practices for organic waste are not optimal. Practices such as burying organic wastes in landfills, burning organic wastes, spreading organic wastes onto the land or even feeding organic wastes to livestock in many cases could be substituted with practices that capture more value from the organic materials. Not only do current practices not always capture full value from the waste but these existing practices can also cause problems. For example, in the case of landfills, burying large volumes of organic wastes can decrease the lifespan of the landfill, forcing local authorities to try to find expensive and unpopular new landfills. Burying organic wastes in landfills also traps valuable soil nutrients –making them unavailable for agriculture. In the case of land application, in the short term spreading organic wastes to soil can act as a fertilizer and improve soil fertility. But in many cases, prolonged spreading of organic wastes on land can destroy soil productivity by overloading the soil with nutrients[3] (resulting in eutrophication of surrounding water bodies)[4] salts, or heavy metals.

Organic waste in the broadest sense can include any organic material including forest residues, portions of household garbage, etc. but no matter how it is defined, agrifood waste is an important component. Beyond the reasons mentioned above, food waste is problematic for a host of additional reasons, including obvious problems such food being landfilled rather than feeding hungry Albertans as well as less obvious problems such as the vast amount of energy and water used to produce the food or the money and investment required to produce food also going to waste. Three of the four waste streams considered in this report relate directly to food and food-processing. Food waste in particular is attracting growing international attention as a problem needing addressing. According to the Food and Agriculture Organization of the United Nations, globally about a third of all food produced for human consumption is wasted somewhere along the supply chain.[5] A 2012 study concluded that in the United States total waste is closer to 40%.[6] A study by the Organization for Economic Co-operation and Development found that Canada is among the nations with the poorest data on food waste. “Very little is known about food waste in the primary, the manufacturing and related services sectors (covering both distribution and out-of-home eating)[7].” The data which is available suggests that Canada also has a problem. In Canada, according to a 2014 study, an astounding 47% of all food produced is never eaten.[8] This translates into $31 billion in wasted food each year.[9] In developing countries most food is lost

during the earlier stages of the supply chain, such as at the farm or food processor; whereas, North American food waste occurs mainly once it leaves the grocery store.[10] Studies show that there are losses at every step of the supply chain which means edible food is being wasted everywhere from before when it leaves Alberta farms all the way to after it reaches Alberta kitchens. **Figure 1** shows the breakdown of where food is wasted in Canada. Retail and food-processing, two sectors included within the scope of this report, together account for a third of food waste in Canada which translates into roughly $10 billion worth of value lost. So, in theory this study should capture about a third of the food waste in Alberta.

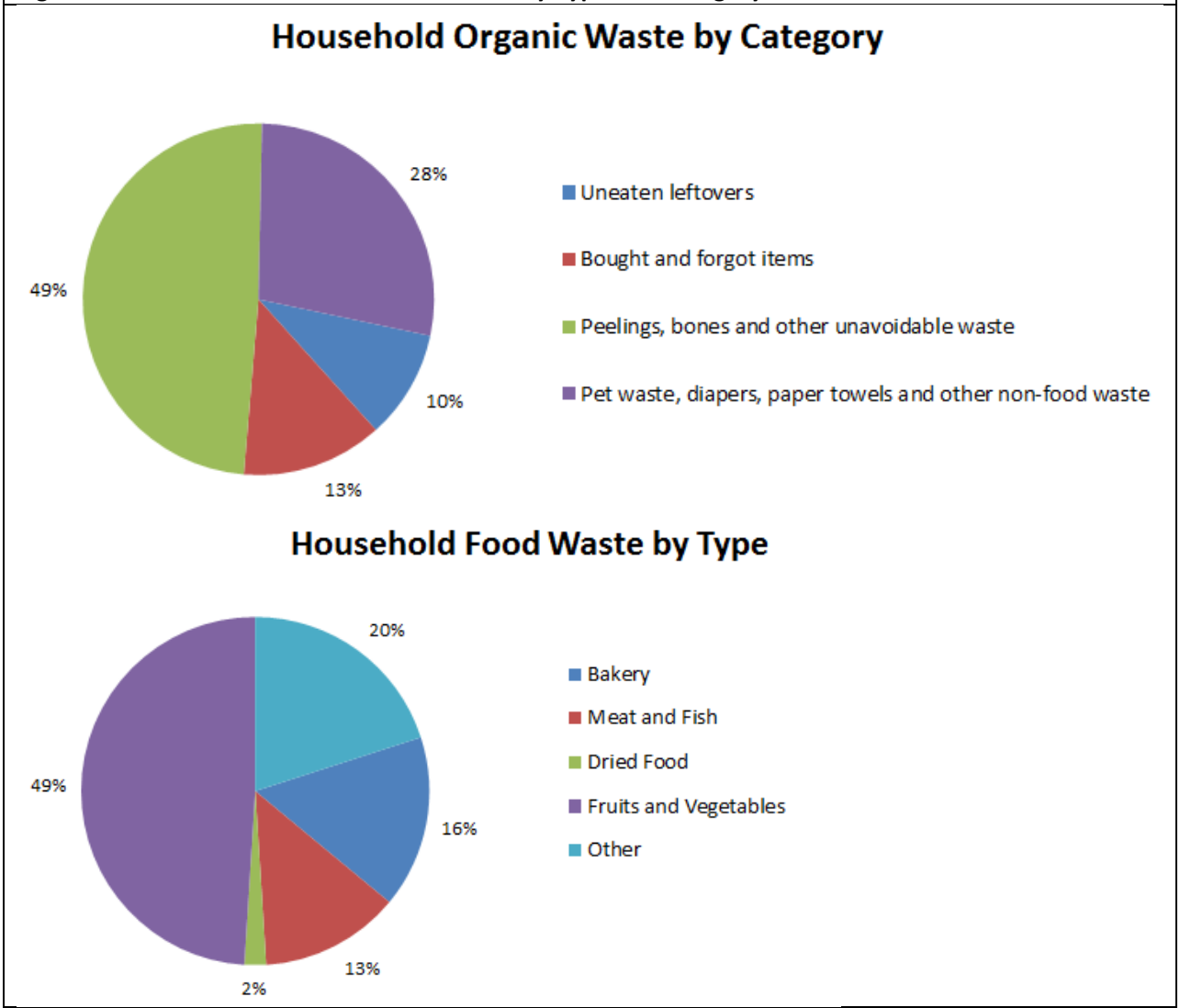
**Figure 1. Where Food Waste Occurs in Canada's Value Chain**




**Source:** Value Chain Management, 2014

**Figure 2** shows that at a household level much of the food waste is avoidable and that fruits and vegetables account for about half of food wasted in homes.

**Figure 2. Food Waste at the Household Level by Type and Category**




**Source:** *Value Chain Management, 2014*

Beyond the fact that there are common sense reasons for diverting organic waste to higher value uses, there may soon be legal reasons as well. An increasing number of jurisdictions are banning organic waste from landfills effectively forcing producers of organic waste to find alternative waste disposal methods. In Europe there have been regulations requiring organics to be diverted from landfills since at least 1999 when the European Commission published a directive requiring Member States to reduce biodegradable municipal waste that goes to landfill to 35% of 1995 levels[11]. In many European jurisdictions sending organics to the landfill has been illegal since at least 2010. In the United States, a growing number of jurisdictions are also banning organics in landfills including: Boston, Seattle, San Francisco, Portland, New York State, Rhode Island, Connecticut and Vermont.[12] Canadian examples include Vancouver,[13] Halifax, Toronto and Calgary. For example, in 2011 Vancouver implemented a 70% diversion target by 2015 and 80% by 2020, including banning all residential commercial and institutional

waste generators from disposing of any organic materials in landfills.[14] Here in Alberta the City of Calgary has approved a ban of paper and cardboard going to landfills as of 2018 and a ban on food and residential yard waste going to landfill starting in 2019.[15]

Some provinces have also begun to introduce "waste stewardship" programs, which have forced commercial producers of waste to both track their waste more carefully and reduce the waste produced because of the additional fees/tax paid per unit of waste generated. France recently introduced a law to ban supermarkets from producing food waste, forcing them to instead to either donate the food to charities or transform it into animal feed, energy or compost.[16] It is likely more and more jurisdictions will actively be pursuing diversion of organic wastes from landfills.

## The Livestock Sector

For the purposes of this study the livestock sector included the whole range of animals that are raised in the province, everything from common beef cattle to dairies, swine operations and even less common animals such as goats or elk. There are over 1,500 livestock raising operations in the province- an important part of Alberta's agricultural economy by any measure. In 2013, meat and poultry represented about 45% of total food and beverage sales,[17] illustrating the relative importance of this subsector. It is important for the province to develop a better appreciation of the waste produced by this sizable industry. The types of waste examined in this study included manure and animals that died before processing. According to Statistics Canada, in Alberta, 60.2% of all farms with livestock store manure in some way.[18] Composting is the most common treatment for stored manure in Alberta, followed by drying.[19] The "downstream" livestock industry (meat, eggs, dairy and feed production) also represents significant portions of waste in the food-processing and grocery sectors (see below).

## The Food-processing Sector

There are over 500 food and agricultural processing facilities in Alberta[20] which take a wide variety of agricultural raw materials as inputs and transform them into higher value products- for both domestic use and export. The diverse sector produces fruits and vegetables, cereal products, fish, meat, baked goods, confections, herbs and spices and unique specialty foods, among others. This wide assortment of products results in an equally wide range of waste products which require better understanding. According to research by the consulting group Value Chain Management, the food-processing sector in Canada generates about 20% of total food waste.[21] Not all food waste may be created equally from an environmental perspective. For example, one study found that efforts might be better spent to reduce meat and dairy waste rather than vegetable waste due to their relatively higher carbon footprint.[22]

## The Grocery Sector

There are approximately 40 major supermarket brands or "banners" in Alberta (e.g. Safeway, Real Canadian Superstore, etc.) owned by at least 15 companies (e.g. Sobeys, Loblaw, etc.). Overall there are more than 580 grocery store locations. This does not include a wide range of gas stations, liquor stores, and convenience stores that sometimes also sell groceries. In some cases a brand can have locations that are managed and operated privately under franchise while also having locations with the same brand name managed and operated by the central brand owner. The sector includes smaller stores serving rural areas and massive supercenters serving major urban centers. Some companies only deal

with retail, others only with wholesale or distribution. Some companies are vertically integrated with their own distribution warehouses; others rely on third party distributors. Frequent mergers, acquisitions and divestitures further complicate a clear understanding of the sector. The waste produced by this sector may offer a significant opportunity if its output can be better characterized.

Waste can be generated from various factors including natural deterioration and "shrinkage", goods damaged during handling, improper packaging, improper storage (e.g. too cold or too hot), expired goods, mold or pest infestations, overstocking, improper stock rotation, or simply food that does not meet the retailer's specifications for quality or appearance.[23] Interestingly, new products that fail was also cited as a source of waste in retail food, for example "new" foods that no one wants to buy because of new, unfamiliar packaging.[24] When possible some wastes are diverted to other uses but for the most part food discarded ends up in a landfill.

A number of companies in the grocery sector have come out with public statements or policies that state a desire to reduce waste. For example, Loblaw Companies limited has stated its desire to: "…strive to incorporate in its environmental practices the best available technology…and will promote source reduction initiatives as a means of reducing waste".[25] Sobeys has publicly stated a goal to reduce waste production by 30% including a reduction in kilograms of waste to landfill per square foot from retail stores and a reduction of waste at distribution centers per 100 cases shipped.[26]

### Residential Yard Waste

Although not an industry sector per se, residential yard waste represents an important source of organic waste in the province and thus was included in the scope of this study. Organics including leaf and yard waste are approximately 40 per cent of residential and up to 25 of commercial and institutional waste streams[27]. Residential yard waste includes a broad selection of materials originating in residential and commercial gardens, landscapes boulevards, etc. Things like leaves, grass, prunings, trimmings, compost etc. are included under this heading. There are over 1.3 million households in the province in addition to commercial and industrial facilities with landscaping that may generate yard waste. Many of the organic waste bans referred to above also affect residential yard waste.

## Methodology

The study combined a compilation of existing information available in the literature with new primary research in the form of telephone interviews and site visits. Given the unique characteristics of the four sub-sectors considered in this study, slightly different methodologies were used, as described in the below sections.

### Livestock

Alberta's diverse livestock industry produces a variety of organic waste materials which could potentially be repurposed to higher value streams. For this reason the livestock sector was one of the four strategic focus areas looked at in this study. Examples of waste materials in the livestock sector include manure, used bedding, spoiled feed, dead animals, feathers, etc.

The Natural Resources Conservation Board (NRCB) is responsible for the regulation of confined feeding operations in Alberta and thus has access to some of the best data on livestock operations in the province. Although the data is not collected for the purpose of estimating organic waste production it was used for that function is this study. In order to make it useable for our purposes some manipulation of the data was necessary.

The starting point was the raw data consisting of a list of all registered livestock operations in the province from the categories as listed in **Table 1**:

**Table 1. Types of Alberta Livestock for Which Organic Waste Production was Estimated**

| | | | |
|---|---|---|---|
| Cattle | Cows/Finishers (900+ lbs) | Poultry | Chicken - Breeders |
| | Feeder Calves (<550 lbs) | | Chicken - Layers (inc. pullets) |
| | Feeders (450 - 900 lbs) | | Chicken - Pullets/Broilers |
| | Dairy - Lactating Cows Only | | Ducks |
| Swine | Farrow Only | | Geese |
| | Farrow To Finish | | Turkey - Broilers |
| | Farrow to Wean | | Turkey - Hens - Light |
| | Feeders/Boars | | Turkey - Toms/Breeders |
| | Roasters | Other | Bison |
| | Weaners | | Deer |
| Sheep | Ewes with Lambs | | Elk |
| | Ewes/rams | Horses | Feeders > 750 lbs |
| | Feeders | | PMU |
| | Lambs | Goat | Meat/Milk (per Ewe) |
| | | | Nannies/Billies |

**Source:** *Agriculture and Forestry Compilation based on Natural Resources and Conservation Board, 2014*.
**Note:** Cow calf operations (representing an important portion of cattle in Alberta) are not included here because the organic waste produced by this livestock category is distributed widely on pasture lands.

### Estimate of Manure production

Manure is the most abundant organic waste from livestock operations so it was decided to look at it first. The first thing that was done once the data was received was to categorize each operation by county and sort the data by geographic area. Although data was provided for all livestock operations in the province for which there are records, it is important to note that not all operations in Alberta are currently registered with the NRCB. Therefore the data could potentially underestimate the volume of organic waste significantly. Keeping this in mind, the next step was to assign corresponding manure production factors and moisture content values to the data set for each livestock operation type. These values were taken from the *Manure Characteristics and Land Base Code* which is part of the *Agriculture Operations Practices Act.*[28]

Out of necessity and to keep things simple a few assumptions were made:

- In the NRCB dataset "Livestock Number" represents the maximum number of livestock allowed based on the permit issued. It was assumed that the actual number of animals present on the operation was the maximum permitted. In reality the actual number of animals could be less, in some cases significantly less. This will result in an overestimation of animals. However, this is balanced by the fact, mentioned above, that many operations not currently permitted are not captured in the data at all.
- Dairy cows and swine operations were assumed to be 100% liquid manure. All other livestock types were assumed to produce solid manure.
- For every milking cow there is also 0.5 of a replacement cow and 0.5 of a dry cow. To capture these extra animals (that are not reported in the NRCB data) the manure factors for producing, replacement and dry dairy cattle were combined, effectively doubling the number of animals.
- Manure factors for chickens are reported "per 100" animal so the factors were divided by 100 to make them appropriate for single animals.
- A liter of liquid manure was assumed to convert to 1kg of solid manure.
- The estimate does not include manure that is not easily recovered (for example manure from cow/calf operations where animals are dispersed in pastures).

The resulting factors (as per **Table 2** below) were then multiplied to the number of livestock of each type in the NRCB dataset to calculate the total manure per operation accounting for moisture.

| Table 2. Manure Production Factors by Livestock Category | | | |
|---|---|---|---|
| **Category** | **Livestock Type** | **% solid factor** | **Values (tonnes/year) per animal (solid)** |
| Cattle | Cows/Finishers (900+ lbs) | 0.5 | 1.08 |
| | Feeder Calves (<550 lbs) | 0.5 | 0.30 |
| | Feeders (450 - 900 lbs) | 0.5 | 0.66 |
| | Lactating Cows Only | 0.08 and 0.2 | 5.02 |
| Swine | Farrow Only | 0.04 | 0.24 |
| | Farrow To Finish | 0.04 | 0.94 |
| | Farrow to Wean | 0.04 | 0.28 |
| | Feeders/Boars | 0.04 | 0.11 |
| | Roasters | 0.04 | 0.06 |
| | Weaners | 0.04 | 0.04 |
| Poultry | Chicken - Breeders | 0.65 | 0.02 |
| | Chicken - Layers (inc. pullets) | 0.6 | 0.01 |
| | Chicken - Pullets/Broilers | 0.65 | 0.01 |
| | Ducks | 0.37 | 0.01 |
| | Geese | 0.37 | 0.01 |
| | Turkey - Broilers | 0.65 | 0.01 |
| | Turkey - Hens Light | 0.65 | 0.01 |
| | Turkey - Toms/Breeders | 0.65 | 0.02 |
| Sheep | Ewes with Lambs | 0.5 | 0.33 |
| | Ewes/rams | 0.5 | 0.25 |
| | Feeders | 0.5 | 0.14 |
| | Lambs | 0.5 | 0.07 |
| Horses | Feeders > 750 lbs | 0.5 | 1.26 |
| | PMU | 0.25 | 1.86 |
| Goats | Meat/Milk (per Ewe) | 0.5 | 0.48 |
| | Nannies/Billies | 0.5 | 0.24 |
| Other | Bison | 0.65 | 0.78 |
| | Deer | 0.65 | 0.31 |
| | Elk | 0.65 | 0.60 |
| **Source:** *Agriculture and Forestry Compilation based on Manure Characteristics and Land Base Code, 2006.* | | | |

Finally, the anonymized data were aggregated at a county level to generate total volumes by geographic region (see Results Section).

### Estimate of other wastes from the livestock sector

In addition to manure, other forms of organic wastes were also considered. It was determined, for example, that bedding materials such as straw or sawdust, as well as spilled or wasted feed are typically included in the manure production factors for livestock and thus will be captured in the total manure number. Feathers shed in poultry barns would be similarly captured. One major source of organic waste that is not captured in the manure number, are the animals that die in livestock operations from illness or accidents. An estimate of total tonnes biomass from on-farm mortality was thus calculated. A literature review provided typical mortality rates of livestock operations for the most common livestock types as well as the typical mass of an individual animal (See **Table 3**). The factor was then calculated by multiplying the mortality rate by the individual mass per animal by an assumed moisture factor. It was assumed that all livestock types have the same moisture content as a cow (80%).[29] The final factors that were determined for each livestock type were then multiplied by the total number of livestock reported in the NRCB dataset. Factors were not calculated for less common livestock types due to lack of information.

**Table 3. Mortality Production Factors by Livestock Category**

| Category of Livestock | Typical Mortality (%) | typical mass of individual animal (kg) | biomass from mortality/animal (tonnes/year dry) |
|---|---|---|---|
| Dairy - Lactating Cows Only | 10.80 | 544.00 | 0.1410 |
| Cattle - Cows/Finishers (900+ lbs) | 2.00 | 544.00 | 0.0261 |
| Cattle - Feeder Calves (<550 lbs) | 2.50 | 125.00 | 0.0075 |
| Cattle - Feeders (450 - 900 lbs) | 2.50 | 306.82 | 0.0184 |
| Poultry - Chicken - Breeders | 4.20 | 2.82 | 0.0003 |
| Poultry - Chicken - Layers (inc. pullets) | 4.20 | 1.54 | 0.0002 |
| Poultry - Chicken - Pullets/Broilers | 5.85 | 3.60 | 0.0005 |
| Swine - Farrow Only | 11.00 | 2.73 | 0.0007 |
| Swine - Farrow to Wean | 3.00 | 10.91 | 0.0008 |
| Swine - Farrow To Finish | 3.00 | 119.00 | 0.0086 |
| Swine - Feeders/Boars | 3.50 | 125.00 | 0.0105 |
| Swine - Roasters | 3.00 | 50.00 | 0.0036 |
| Swine - Weaners | 3.00 | 10.91 | 0.0008 |

**Source:** *Agriculture Forestry Compilation based on various sources*

## Food-processing

Collecting data for the food-processing sector was the most involved process compared to the other sectors. The diversity of food-processing facilities in the province made it impossible to try to go through a central trade association so the only option was to attempt to gather information directly from the diverse Alberta companies themselves. Although not all Alberta companies are listed, the existing Agricultural Processing Industry Directory[30] maintained by Alberta Agriculture and Forestry provided a good starting point for identifying potential companies to interview. Because there are more than 500 food-processing companies in Alberta it was apparent that contacting every company would be overly

ambitious. A goal was set to contact 200 companies. Thus the first step was to prioritize the companies that should be contacted. Criteria were developed to try to target, geographically diverse companies, companies involved in a diversity of products as well as a mix of smaller and larger companies. Once priority companies were identified the next step was to identify the correct point of contact at the company. A combination of cold calling, personal references and trial and error was used to narrow the list down to find the correct individuals. Once the correct individual was identified a letter was sent which outlined the goals of the project, explained how it was hoped the company would participate and attempted to address any possible concerns about confidentiality (see **Appendix B**). Sample questions were also sent at the same time (see **Appendix C**). Each individual was then contacted by phone and asked to provide answers to the survey questions over the phone. In some cases interviewees were re-contacted multiple times until it was possible to provide information.

The data received was then converted into the consistent unit of tonnes/year. For example, if the amount of waste was reported in volume/day, density was estimated based on the type of waste and it was converted to tonnes/year. If the amount of waste was reported in dumpsters/week, the volume of waste was determined from estimated dumpster size, and then multiplied by density to calculate the value in tonnes/year. Third party sources were used to estimate density of various materials.[31] We primarily sought information of solid waste however in some cases companies also volunteered information on liquid and gaseous wastes. Because the types of waste were so diverse it was also necessary to try to normalize the moisture level so the amounts of waste from facility to facility could be compared. In attempt to address this all of the reported volumes were converted to a "dry basis" before being compiled. To determine the dry tonnes/year first the moisture content for each waste stream was determined. In some cases it was derived from the interviews and in other cases literature was relied upon. For example, a moisture content of 90% for vegetable waste, 79% for potato waste, 60% for meat waste and 5% for cardboard waste, etc. was assumed. In some cases, the waste that was reported was mixed and it was not possible to determine which type of waste was dominant in the mix. In those cases it was assumed moisture content was 70% since it is considered the typical moisture content for food waste. The dry tonnes/year for each waste stream was calculated as below:

*Dry tonnes per year = Wet tonnes per year x (1 - moisture content)*

Finally, the anonymized data were aggregated at a county level to generate total volumes by geographic region (see Results section).

## Grocery

The grocery sector in many ways proved the most challenging sector from which to gather information. Not only was the sector unexpectedly complex in organization; but, compared to the food-processing industry, grocery store representatives on average seemed more cautious about sharing information.

The first step of the research was to try to derive a list of all the grocery store brands that have a presence in Alberta that would need to be contacted. This was done by a combination of internet research, team member brainstorming and literature review. The *Who's Who Annual Directory of Chains and Groups in Canada*[32] published by the Canadian Grocer proved a useful starting point despite the fact

that Alberta data is aggregated with Saskatchewan and Manitoba in the "prairies" category. Further clarity around the relationship between the various brands was gained during the stakeholder interview stage. Additional brands were also identified. In the end, the list in **Table 4** was the one that was used.

| **Table 4. Grocery Store Brands Present in Alberta** | | | |
|---|---|---|---|
| 1 | AG Stores | 16 | M&M Meats |
| 2 | AM Foodfare | 17 | No Frills |
| 3 | Bigway Foods | 18 | Northern |
| 4 | Buy-Low | 19 | Northmart |
| 5 | Calgary Coop | 20 | Real Canadian Superstore |
| 6 | Costco Canada Inc | 21 | Real Canadian Wholesale Club |
| 7 | Extra Foods | 22 | Safeway |
| 8 | Family Foods | 23 | Save on Foods |
| 9 | Federated Co-op | 24 | Shop Easy |
| 10 | Fine Food Stores | 25 | Sobeys |
| 11 | Freson IGA | 26 | Super A |
| 12 | Giant Tiger Stores | 27 | Super Valu |
| 13 | Grocery People | 28 | T&T Supermarket |
| 14 | IGA | 29 | Walmart Canada |
| 15 | Lucky Dollar | 30 | Your Independent Grocer |
| **Source:** *Alberta Agriculture and Forestry* | | | |

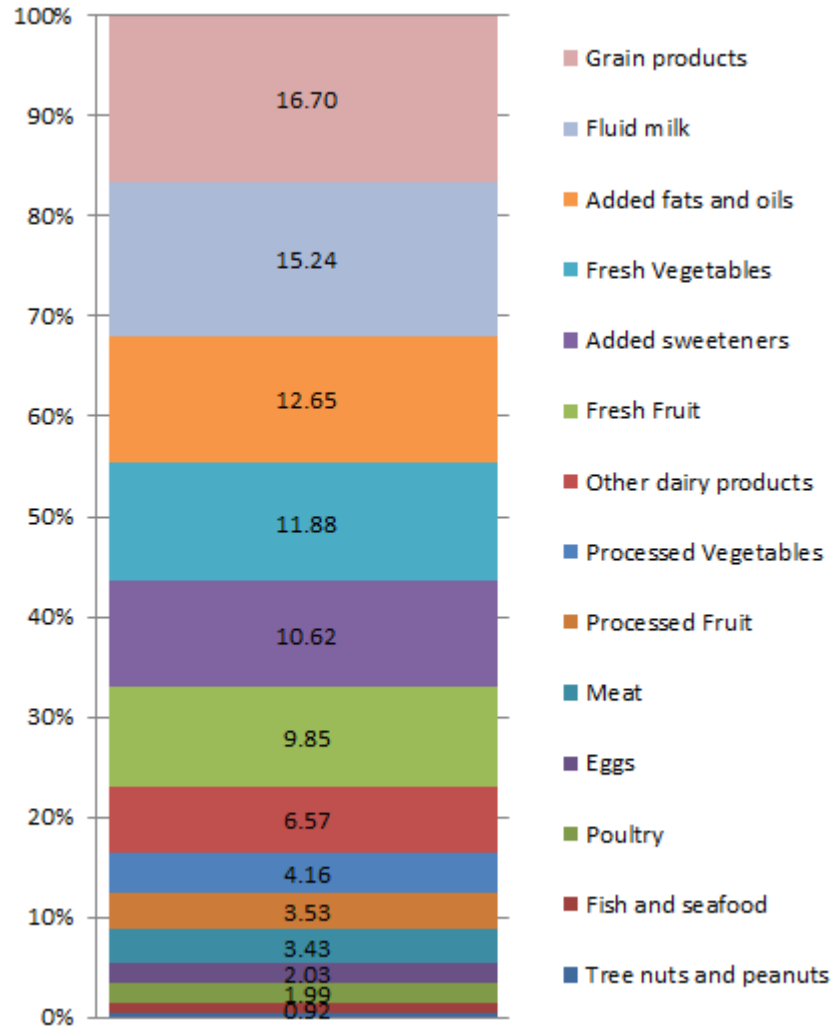
Once companies were identified the next step was to identify to the correct individual at each company to interview. A combination of cold calling, personal references and trial and error was used to narrow the list down to find the correct individual. In some cases an individual was never identified or the individual that was identified was unable to provide any useful data. For the smaller grocery store chains the correct individual tended to be either the CEO or a lead involved in purchasing/logistics. The larger organizations tended to have dedicated staff working on waste reduction issues. Once a contact was established the contact was asked to provide information on the location of each store as well as detailed information on the amount and type of waste the stores disposed of. A template (see **Appendix C**) was provided to each contact and they were asked to share information on the volume of food waste, cardboard waste, plastic waste and inert waste and what proportion of each category was sent to landfill or diverted.

Almost all the various grocery store chains that were contacted provided information but some were much more willing to share than others. Because the data that was received was inconsistent from organization to organization (both in terms of quantity and quality) some subsequent data processing was required. In some cases it was necessary to extrapolate or interpolate data or manipulate data (for example if information on total organic waste was received it was necessary to subtract out cardboard or plastic to arrive at a number for food waste). All the data was converted to the consistent unit of metric tonnes per year. In some cases data was only provided for a few stores in which case the average number was assumed for the other stores that had been identified under that banner. In other cases no

data was provided for the chain and the overall average was applied to all their stores. Certain chains tend to have only large stores (for example Walmart) whereas other stores tend to have only smaller stores (for example Coop). Using a single factor will thus result in imperfect results. Another factor that was not considered (because of an inability to access data) was the impact sales have on waste generation. Several companies indicated that urban grocery stores have more sales and that this correlates to higher amounts of organic waste that requires diversion or disposal. Since not all companies were willing to share information about all their stores, extrapolation using a single average was unavoidable.

Once data for each store was determined the next step was to try to account for moisture. Again some important assumptions were made. According to some literature the moisture value typical of "food waste" is around 70% or higher.[33] Based on the interviews it was known that the waste going to landfill was diverse and included not only organic waste but also packaging and other drier wastes. So first an attempt to get a breakdown of typical grocery store waste was required. A 2011 study in the Journal of Consumer Affairs provided a breakdown of typical food wasted at a retail level by type based on USDA data (**Figure 3**).[34] It was assumed that although the information was based on the food waste in the United States that the breakdown would be similar for Alberta.

**Figure 3. Total Food Waste at a Retail Level by Type (%)**




**Source:** *Journal of Consumer Affairs, 2011*

Next an attempt was made to determine a realistic typical moisture estimate for each category. An appendix in the book *Water Activity in Foods: Fundamentals and Applications*[35] provided moisture related data for more than 500 commonly available grocery store products. Each of the 500+ items were categorized based on best judgement into one of the 14 categories of retail waste outlaid in the Journal of Consumer Affairs study. The average moisture was then calculated for each category as illustrated in **Table 5**.

| Table 5. Estimated Moisture for Grocery Waste Categories | |
|---|---|
| **Retail Food Category** | **Calculated Average Moisture** |
| Tree nuts and peanuts | 2.19 |
| Fish and seafood | 68.30 |
| Poultry | 74.60 |
| Eggs | 75.00 |
| Meat | 50.43 |
| Processed Fruit | 43.25 |
| Processed Vegetables | 11.57 |
| Other dairy products | 60.53 |
| Fresh Fruit | 69.21 |
| Added sweeteners | 13.95 |
| Fresh Vegetables | 89.64 |
| Added fats and oils | 60.23 |
| Fluid milk | 89.40 |
| Grain products | 13.65 |
| **Source:** *Alberta Agriculture and Forestry based on Schmidt et al, 2007 and Consumer Affairs, 2011* | |

A pro-rated moisture value for total grocery waste was then determined by applying these category specific values to the proportions in **Figure 3**. The final moisture number for typical grocery waste was thus determined to be about 54%. The results of this exercise suggested that the typical moisture value for "food waste" of ~70% may not be appropriate for Alberta grocery store waste; thus the lower value of 54% was applied. Packaging, grain products, processed fruits and vegetables and products high in sweeteners, common in retail food waste streams, have lower moisture content so this makes logical sense.

The final step of the process was to determine the county of each store and roll up the moisture-corrected total waste for all brands names within each county. The results are discussed in the Grocery Sector section below.

## Residential yard waste

Residential yard waste was not originally in the scope of the study but it was included once it was discovered an existing data set was available. Underlying data from the *Leaf and Yard Waste Diversion Strategy Feasibility Study*[36] was taken and county information was added from each municipality for which data was available. So as to be easily comparable with the other waste streams of interest in this study the data was then converted to tonnes/year and converted to a dry basis by assuming a factor of 60%. Institutional, commercial and industrial yard/landscaping waste does not appear to be included in the data set.

## Mapping

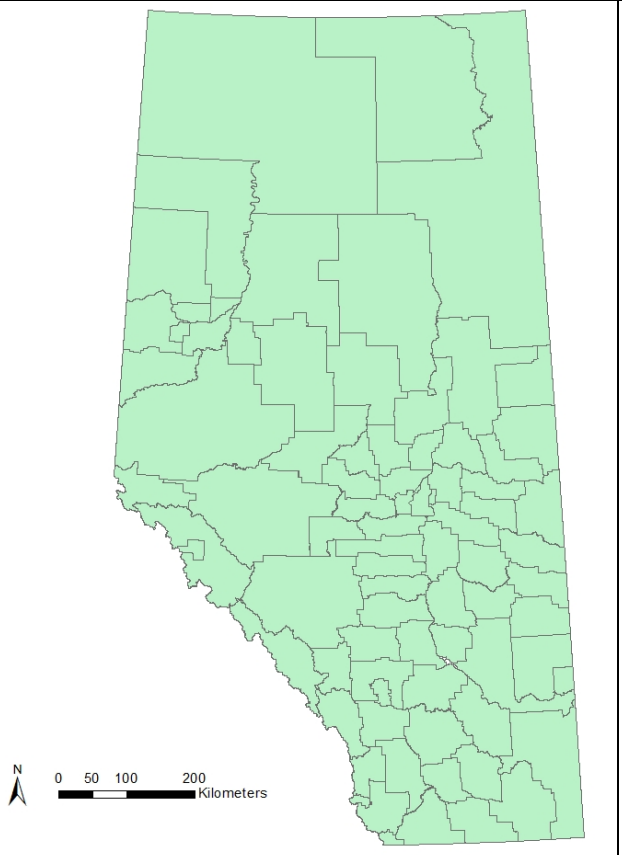
In total nine maps are included, as shown in **Table 6**, List of Maps.

| **Table 6. List of Maps** | | |
|---|---|---|
| | **Map title** | **Figure Number** |
| 1. | Counties and Municipal Districts of Alberta | Figure 4 |
| 2. | Land-use Regions of Alberta | Figure 4 |
| 3. | County-level Availability of Select Organic Wastes in Alberta | Figure 5 |
| 4. | Region-wise livestock waste | Figure 8 |
| 5. | Region-wise livestock waste, normalized | Figure 8 |
| 6. | Region-wise food processor waste | Figure 9 |
| 7. | Region-wise food processor waste, normalized | Figure 9 |
| 8. | Region-wise grocery waste | Figure 14 |
| 9. | Region-wise grocery waste, normalized | Figure 14 |
| 10. | Region-wise residential yard waste | Figure 16 |
| 11. | Region-wise residential yard waste, normalized | Figure 16 |
| **Source:** *Alberta Agriculture and Forestry* | | |

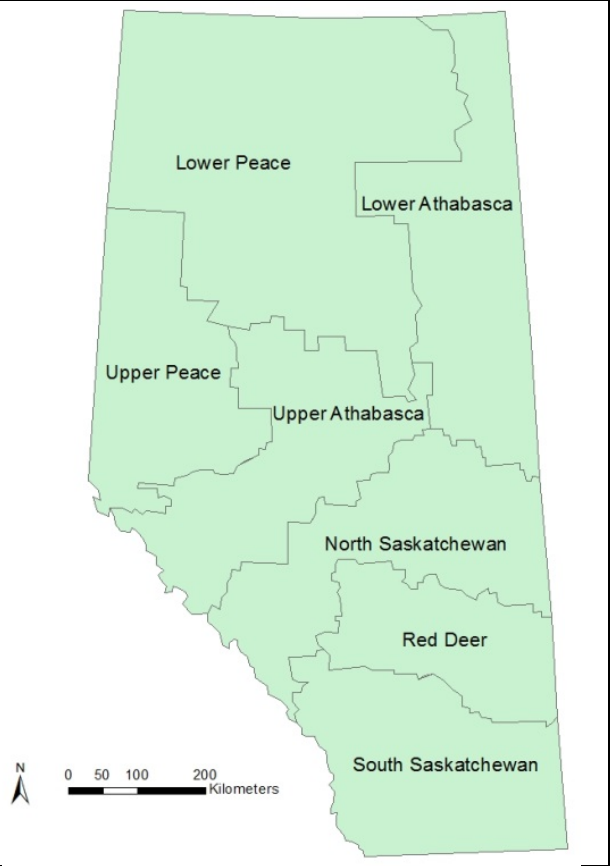
ArcGIS software (version 10.1) was used to develop the maps. The standard county and municipal boundaries shape files are publically available and were obtained through AltaLIS.[37] The standard regional land use planning boundaries, as used in the provincial Landuse-Framework,[38] also publically available, were obtained via the Alberta Environment and Parks website.[39] **Figure 4** shows the boundaries used for mapping purposes.

**Figure 4. Land-use Boundaries Used for Mapping Purposes**

Counties and Municipal Districts of Alberta




Land-use Regions of Alberta




**Source:** *AltaLIS, 2014*[40] and *Alberta Environment and Parks, 2014*[41]

In order to make use of the downloaded shape files it was first necessary to define the correct projection coordinate system for Alberta. For this purpose the georeferencing standard adopted by most federal and provincial agencies in Canada was chosen (North American Datum of 1983 (NAD83)).

A new field was then added in the attribute table of the ArcGIS software for each subsector and the name and type of the field was defined. The corresponding values for waste from each county or for each region were manually added into each field.

Two sets of graduated color maps were then produced for each subsector by altering the legend categories. The “normalized” set of maps all share the same legend definitions. The “normalized” maps are therefore best for comparing organic waste volumes between categories: for example, if you wanted to compare the amount of livestock waste to the amount food-processing waste in a single land use planning region. The other set of maps (the “non-normalized” series) have employed legend definitions that best illustrate the geographic diversity in a single subsector. This set of maps is best if, for example, you wanted to know which land use regions had the most grocery waste. Both sets of maps are based on the same data and are only showing the data in a different way.

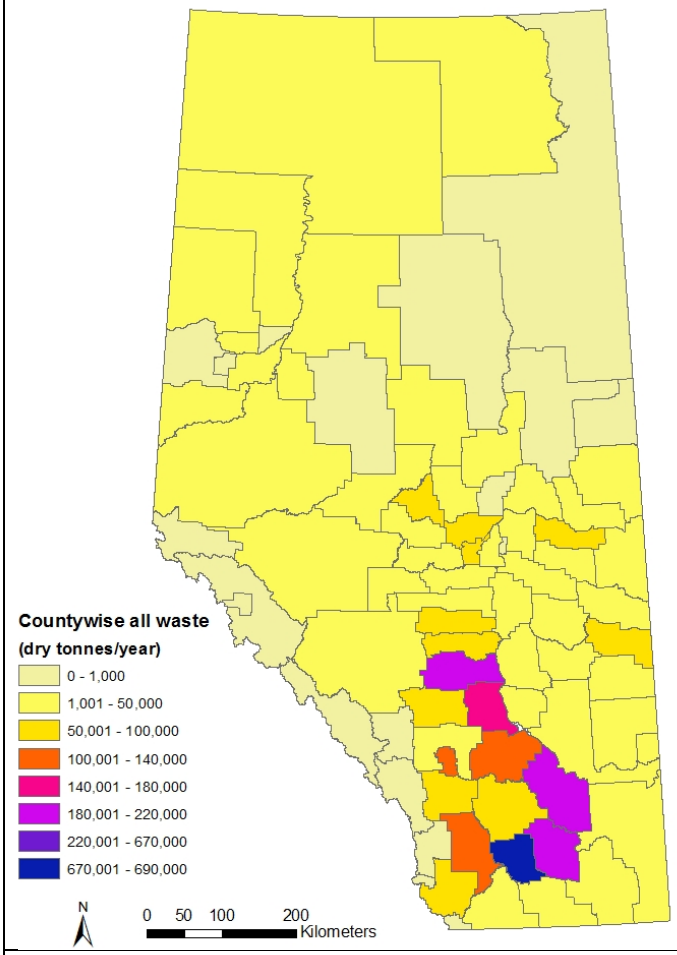
# Results

## Overall Results

After compiling information from primary research and telephone interviews it was determined that there are significant volumes of organic waste and under-utilized by-products available in Alberta. In total an estimated 3.38 million tonnes of dry organic waste per year (282 thousand tonnes per month) were identified province wide. All organic wastes were normalized for moisture thus the total mass is reported dry. **Figure 5** illustrates the total organic waste identified by county. Although specific volumes and compositions varied by county, every county was found to possess volumes sufficient to warrant a re-examination of possible opportunities. There appears to be a concentration of organic wastes in the south half of the province which is unsurprising given the study focused on agriculture and food wastes and that region is home to Alberta's agrifood sector (with the forestry sector- which was out of scope of this study -dominating the north half of the province). The county identified with the most organic waste was Lethbridge County with counties in the north having the lowest concentration. Other counties with significant volumes of organic waste include Willow Creek, Taber, Newell, Wheatland, Kneehill, and Red Deer as well as the city of Calgary.

Livestock manure represented the single largest source of organic waste in absolute terms in almost every county with the exception of Red Deer County and the cities of Edmonton and Calgary (where food-processing waste and residential yard waste were more significant). More than 2.56 million tonnes of dry manure per year were identified as well as an additional 70 thousand tonnes per year of on-farm dead. The food-processing sector produced 500 thousand tonnes of dry food waste per year with concentrations in the City of Calgary, Red Deer County, along the Highway 2 corridor, Barrhead County, Vermillion River County, Lethbridge County and Taber County. 50 thousand tonnes of dry food waste per year was identified in the grocery sector. 200 thousand tonnes of dry residential yard waste per year were identified. The grocery waste and residential yard waste that was produced was fairly evenly distributed throughout the province though correlated to population centers. There were thus higher concentrations in urban areas, especially Edmonton and Calgary.

**Figure 5. County-level Availability of Select Organic Wastes in Alberta**

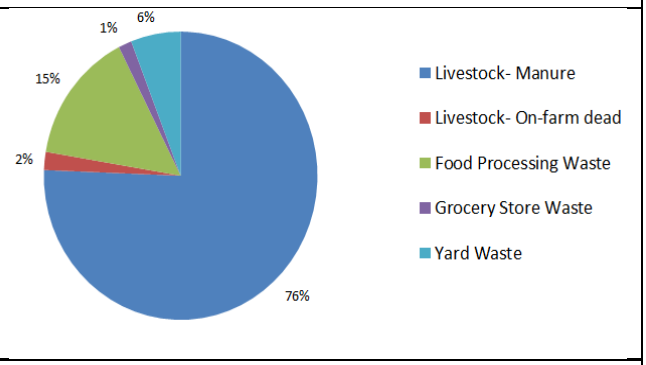



**Source:** *Alberta Agriculture and Forestry*
**Note:** Includes Grocery Waste, Livestock Waste, Food-processing Waste and Residential yard waste.

Error! Reference source not found.Error! Reference source not found. shows the breakdown of organic waste identified in the study by subsector. By far the largest volumes of waste identified in this project were wastes from livestock operations although it is important to note that the proportion may evolve as more data becomes available (for example if better data was obtained from the grocery sector or food-processing sector). Also the grocery sector, food-processing sector and residential yard waste sectors may still present significant opportunities despite the relatively lower volumes of waste.

**Figure 6. Organic Waste Identified by Subsector**

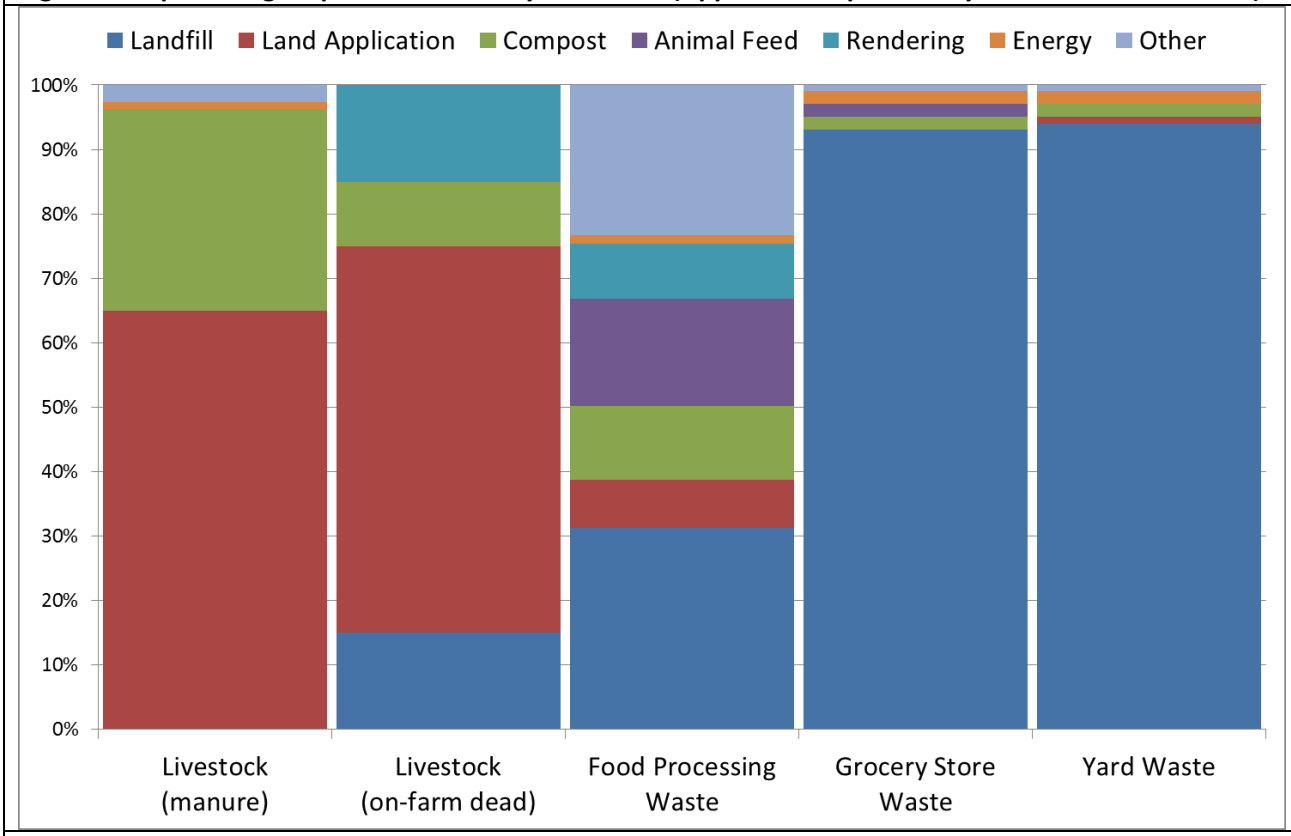
| Sub-sector | tonnes per year (dry) |
|---|---|
| Livestock operation (manure) | 2,560,000 |
| Livestock operation (on-farm dead) | 70,000 |
| Food-processing Waste | 500,000 |
| Grocery Store Waste | 50,000 |
| Yard Waste | 200,000 |
| Total | 3,380,000 |




**Source:** *Alberta Agriculture and Forestry*
**Note:** Figure includes extrapolated data for the food processing and grocery sectors. Grocery store data only includes food waste (not cardboard or plastics).

The most common means of disposing of organic wastes currently vary greatly by subsector. **Figure 7** attempts to summarize the findings according to the best available information available for each subsector. Returning the waste to the land as a form of nutrients is the most common practice in the livestock sector whereas most grocery, yard and food processing wastes are destined for landfill. Note this data is likely to evolve as better information becomes available.

**Figure 7. Top Existing Disposal Methods by Subsector (Approximate percent by number of times cited)**




Source: *Alberta Agriculture and Forestry* based on various
Note: "Land application" in the case of on-farm dead means on-farm burial

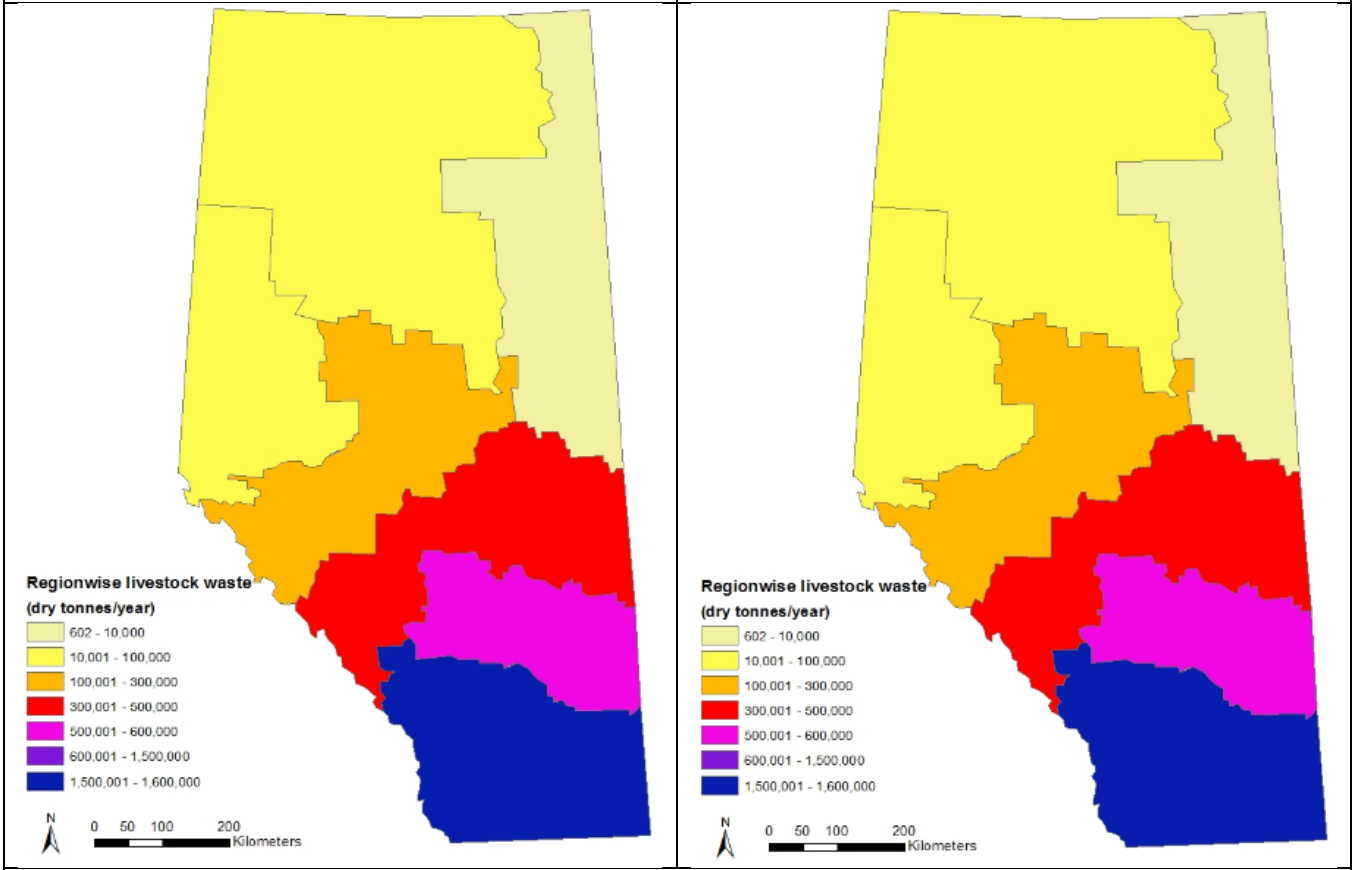
As explained in the *Understanding the Results* section below, the results of this study should be used with caution and there remains significant opportunity to improve the quality and quantity of the data that was used to reach the conclusions. It is hoped that having numbers on waste values for the various subsectors, even if they are inaccurate, can still be valuable as a means to catalyze discussion and inspire new efforts to improve data quality. As such, it may be more useful to think of the *Organic Waste Inventory for Alberta's Agrifood Sector* as a preliminary inventory which will be convenient to build upon. The authors invite review and criticism that leads to refinement of results and improvement of publicly available information.

## Results Livestock

**Figure 8,** below, illustrates geographically the results obtained from the livestock portion of the research. The main conclusion that can be reached is that more than 2.56 million tonnes manure per year were identified. This is not including additional organic wastes from eggshells, deadstock, etc. This represents over 76% of the total waste identified. Note that because the volumes for livestock manure represented the largest source of organic waste the normalized and non-normalized maps are the same (i.e. the manure map set the scale for the other normalized maps). Geographically, Lethbridge County is the hotspot of manure concentration which is unsurprising given the high concentration of feedlots located there. Other counties of note, in order of decreasing volumes are: Newell, Willow Creek, Taber, Kneehill, Wheatland and Two Hills.

**Figure 8. Region-level Availability of Livestock Sector Wastes in Alberta (2014)**

| Regionwise livestock waste, non-normalized (dry tonnes/year) | Regionwise livestock waste, normalized (dry tonnes/year) |
|---|---|




**Source:** *Alberta Agriculture and Forestry*

**Note:** See mapping methodology section for explanation between normalized and non-normalized. In the case of the livestock-operation waste maps the normalized and non-normalized maps are the same. The maps in this Figure include waste in the form of both manure and on-farm dead.

### Disposal practices

Depending on the context manure is either a valuable asset or a liability. Although no interviews were conducted with livestock operators as part of the this study, industry experts did confirm that spreading manure on the land is by far the most common management practice or disposal method. Although no detailed information is available, **Table 7** illustrates a best-estimate of what is currently being done with Alberta's abundant manure resources.

**Table 7. Estimated Existing Manure management practices**

| Practice | ~% manure |
|---|---|
| Direct land application | 36.10 |
| Stockpiling> land application | 14.50 |
| Stockpiling> Aeration> land application | 1.80 |
| Stockpiling> Compost> land application | 31.40 |
| Stockpiling> Drying> land application | 9.50 |
| Stockpiling> Other treatment> land application | 3.00 |
| Stockpiling>Energy | 1.00 |
| Stockpiling>Retail (compost) | 2.50 |
| Stockpiling>Other (e.g. panel board) | 0.10 |

**Source:** *Compiled by Agriculture and Forestry based on various*

Although the Statistics Canada data (see **Table 8**) does not speak to total volume it corroborates the above estimate based on approximate proportion of farms which are applying manure to land. The number of farms applying manure (including those that manure bought and sold and rented land) is about 96% of the total, which is comparable to the total of the six categories applying land in **Table 7**.

| Table 8. Manure and Manure Application Methods in Alberta (2010) | | |
|---|---|---|
| | **Number of farms reporting** | **Hectares** |
| Area for manure spread naturally by grazing animals | 17,661 | 4,123,955 |
| Area for solid or composted manure, incorporated into soil | 6,835 | 275,724 |
| Area for solid or composted manure, not incorporated | 4,049 | 129,813 |
| Area for liquid manure injected or incorporated into soil | 721 | 80,602 |
| Area for liquid manure not incorporated | 249 | 20,179 |
| Farms producing or using manure (20) | 24,482 | |
| Manure applied on the agricultural operation | 21,494 | |
| Manure applied on land that was rented to others | 599 | |
| Manure sold or given to others | 1,064 | |
| Manure bought or received from others | 448 | |
| Other manure (composted, processed, dried, stored, etc.) | 5,611 | |

**Source:** *Statistics Canada, 2011*[42]
**Note:** Although included here "manure spread naturally by grazing animals" was not within scope of this study. The data is from the 2011 census but since it is labeled "in the year prior to the census" the actual data is for 2010.

### Seasonality

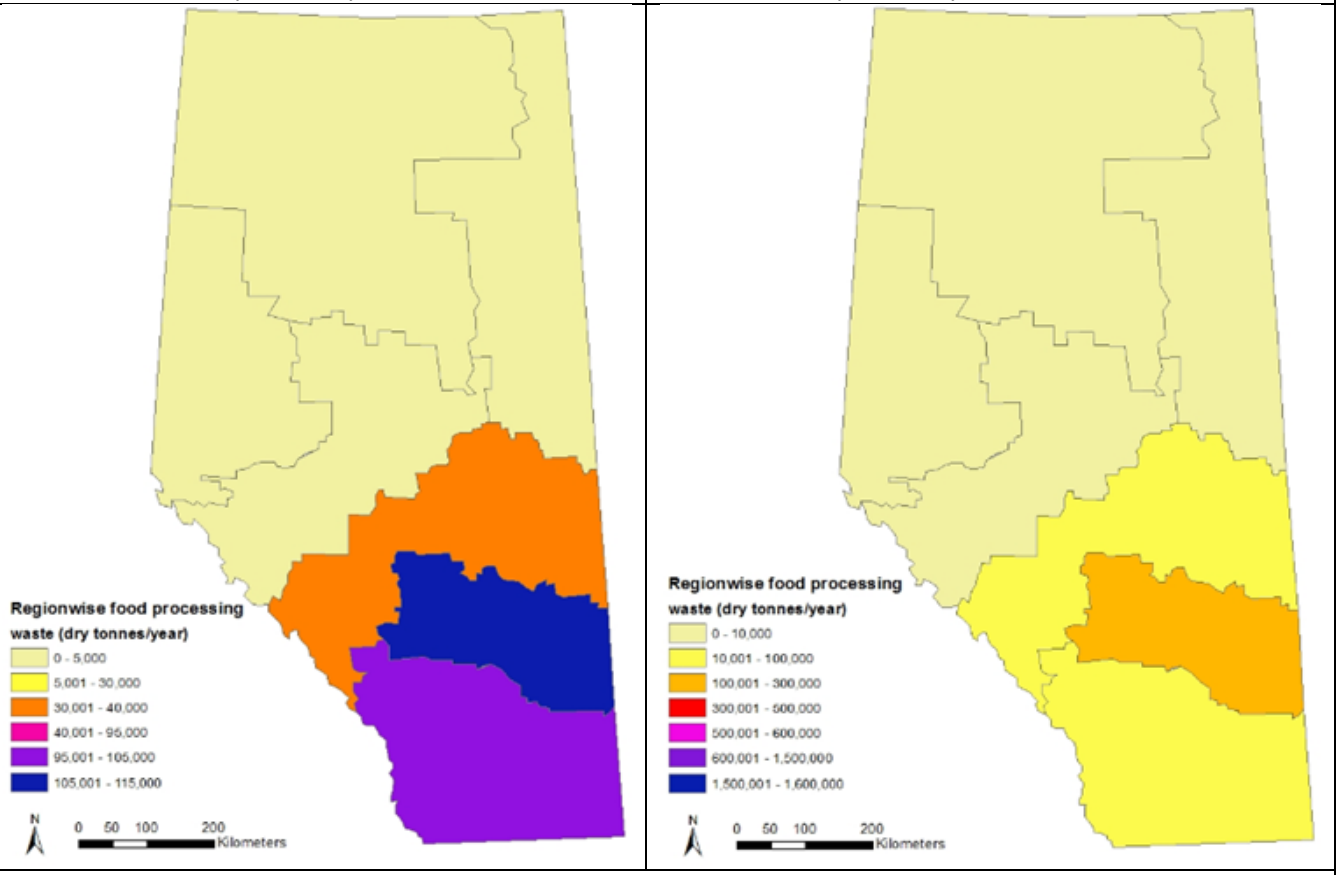
Provincial manure production correlates directly with the age of the individual animals and is a function of the total number of animals in the Alberta herd at any given time. As the size of the herd evolves throughout the year so too will the manure production. As animals mature they produce more manure. Although no studies were encountered during the course of the research, anecdotally it was suggested that collectable manure production may be at its maximum in the fall (when calves born the previous spring are taken to feedlots). Overall, experts suggested that manure production is fairly constant throughout the year.

## Food-processing

The overall results from the phone interviews with food-processing companies are summarized geographically in **Figure 9**, below.

**Figure 9. Region-level Availability of Food-processing Wastes in Alberta (2014)**

| Regionwise Food-processing waste, non-normalized (dry tonnes/year) | Regionwise Food-processing waste, normalized (dry tonnes/year) |
|---|---|




**Source:** *Alberta Agriculture and Forestry*
**Note:** See mapping methodology section for explanation between normalized and non-normalized. Maps in this Figure only include collected data not extrapolated data.

There are over 500 food processors in the province and they generate a significant amount of organic waste. Over 200 Alberta-based food processors were contacted and data was obtained from about 180 companies. This represents only about 40% of known food processors in Alberta. The 181 companies for which data was collected collectively reported over 250,000 tonnes per year of organic waste. In order to extrapolate the data to other known food-processing facilities (a combination of those listed in the Agriculture Processing Industry Directory and others identified during the course of the research) the companies were first grouped in categories based on one of three "number of employee" categories: "1-25", "26-100" and "100+". The number-of-employees category was used as an imperfect proxy to estimate the size of the company based on an assumption that larger facilities will have more employees. There was a further assumption that companies of a similar size will have a similar amount of waste.

The survey data that had been collected was thus first broken into three samples by subcategory and an average tonnes of waste per year was calculated for each sample. Those three simple averages were

then assumed to be the waste volume generated for all the facilities for which no data had been collected in each of three the corresponding sub-categories. There were some outliers in each category (companies that reported significantly above average amounts of waste). The simple average extrapolation approach thus assumes that there will be at least one additional outlier in each subcategory (which may or may not be realistic). Finally the total tonnage for each of the three sub-categories was summed (see **Table 9**).

**Table 9. Total Organic Waste from Alberta Food Processors By Company Size**

| | Collected data (tonnes/year)* | Extrapolated data (tonnes/year) | TOTAL (tonnes/year) | # companies sampled | # companies extrapolated | TOTAL # companies |
|---|---|---|---|---|---|---|
| Small Companies | 28,874 | 85,603 | 114,478 | 85 | 252 | 337 |
| Medium Companies | 135,287 | 90,191 | 225,479 | 69 | 46 | 115 |
| Large Companies | 86,408 | 76,807 | 163,215 | 27 | 24 | 51 |
| TOTAL | 250,569 | 252,602 | 503,171 | 181 | 322 | 503 |

**Note:** * In some cases companies provided partial information. Data is not included here unless the interviews were deemed complete (thus some volumes are material that were identified are not included here)

Information was gathered on the types of waste they produce, the amount of each type and the default disposal method for each type of waste. Some companies also shared information on the cost associated with disposing of each waste or the revenue received, as well as some information on the seasonal nature of waste generation. Overall 250 thousand tonnes of food waste per year were identified in the food-processing sector from a mixture of very large companies and very small companies. Once the survey data were extrapolated to the other food processor companies in the province the total estimate amount of food-processing waste rises to over 500 thousand tonnes per year. Some companies produced very large amounts of homogeneous materials that were costing them hundreds of thousands of dollars to dispose of whereas others had only small amounts of very heterogeneous materials that cost only a few dollars a month. Interestingly, larger amounts tended to be more homogeneous. The total amount of waste reported varied widely by company. Twenty-four companies reported more than 1,000 tonnes of dry tonnes of waste per year (see **Table 10**). Efforts to repurpose waste will probably be easier for those companies that reported larger amounts.

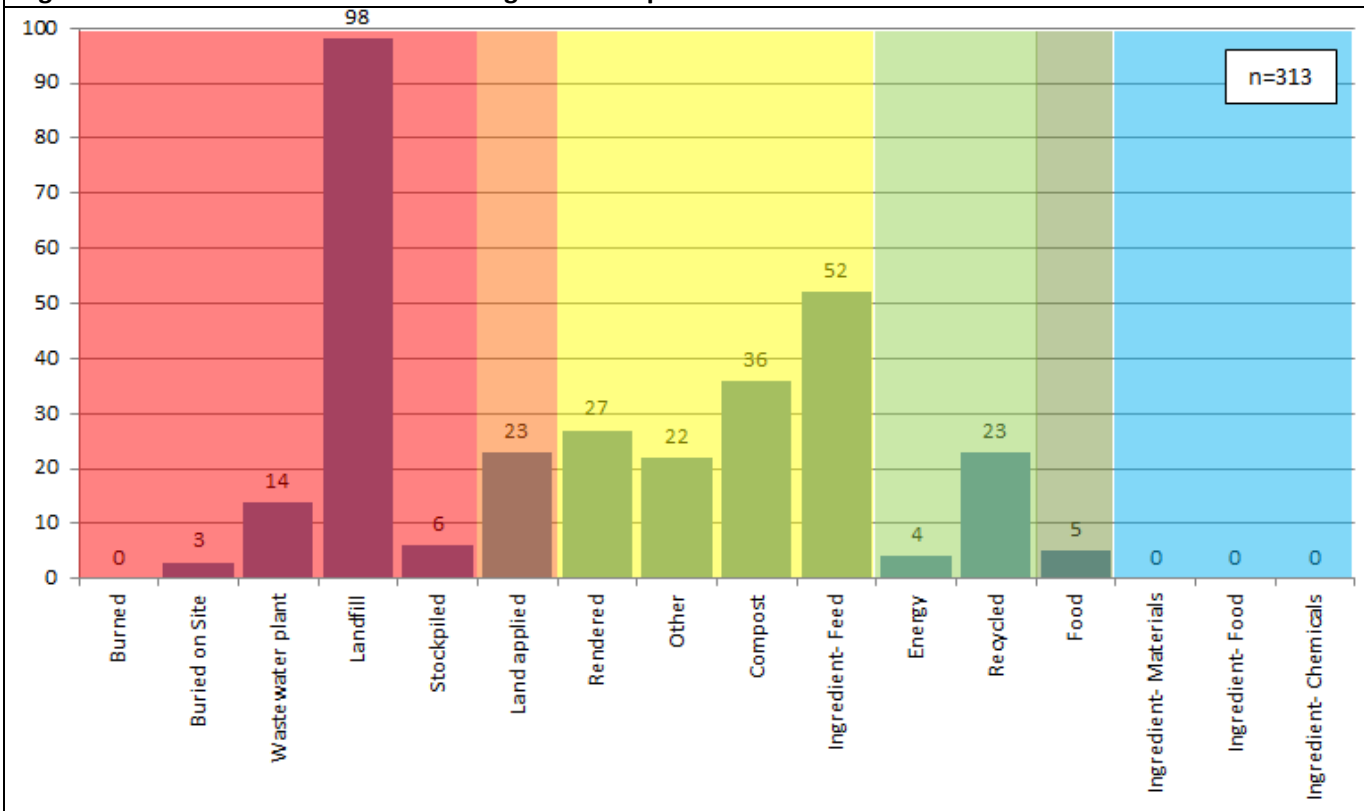
| Table 10. Range of Reported Amounts of Waste by Number of Companies Reporting | | |
|---|---|---|
| Reported Waste Amount Range (dry tonnes per year ) | Number of companies reporting | |
| 0-100 | 91 | |
| 100-1000 | 42 | |
| 1000-10,000 | 21 | |
| 10,000-100,000 | 2 | |
| +100,000 | 1 | |
| **Source:** *Alberta Agriculture and Forestry* | | |

### Disposal practices

**Figure 9** shows that overall the food-processing waste (identified in this study- remember only about 40% of food processors in the province were actually contacted) was concentrated in the south of the province. Concentrations of food waste were identified in the City of Calgary, Red Deer County, along the Highway 2 corridor, Barrhead County, Vermillion River County, Lethbridge County and Taber County.

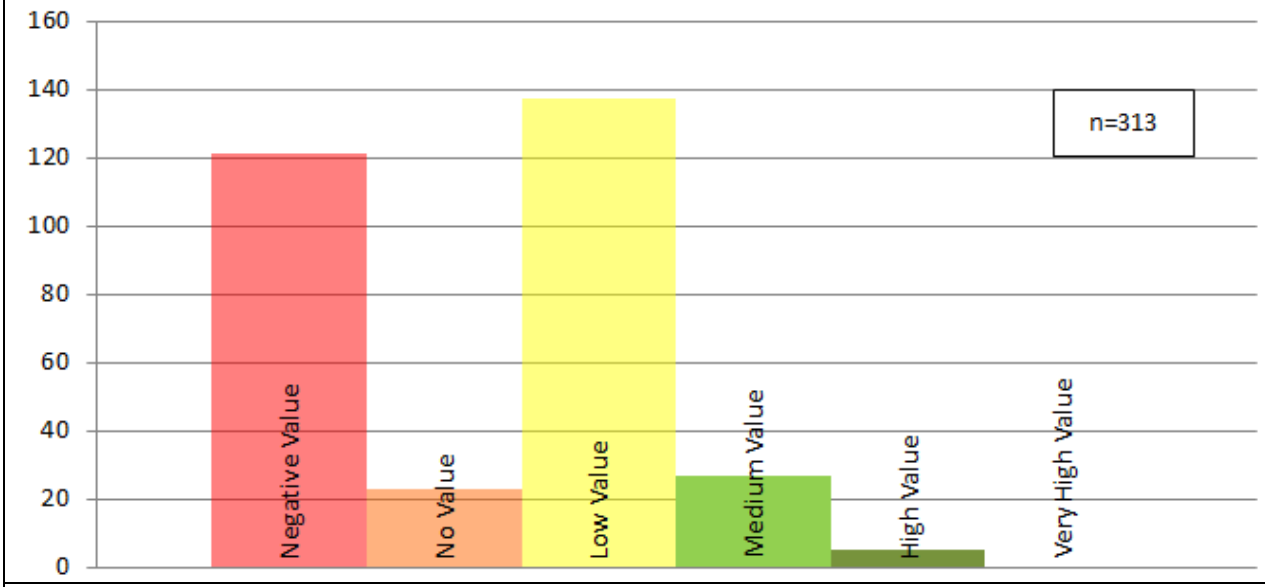
**Figure 10** was built based on responses from phone interviews and the number of times each disposal method was cited as existing practice. The main conclusion here (as illustrated in **Figure 11**) is that the evidence shows organic waste disposal practices overwhelmingly capture little or no value. Those citing landfills and land application are typically obtaining no value and, in many cases, are also paying both hauling fees and tipping fees (or fees to hire a third party waste management company). Those citing compost and animal feed as a disposal method in some cases are receiving a small compensation for the organic materials from the farmers but in other cases are paying the farmers a fee for taking the materials off their hands. There were no examples of companies diverting wastes or by-products arising from the production of a core product to other high value uses however this could be because what was once considered a waste product is now just considered another core product and so did not arise in the context of discussions of wastes or by-products. See **Table 11** for an overview of assumptions used to assign value category to disposal methods. Note there are more data points on waste disposal methods than the number of companies for which data was obtained because many companies reported multiple waste streams.

**Figure 10. Number of Times Each Existing Waste Disposal Practice Was Cited**




**Source:** *Alberta Agriculture and Forestry*
**Note:** Color coding corresponds to the value categories as defined in **Table 11**.

**Figure 11. Existing Waste Disposal Practices (# of times Cited), by Value to Food Processor**




**Source:** *Alberta Agriculture and Forestry*
**Note:** Color coding corresponds to the value categories as defined in **Table 11**.

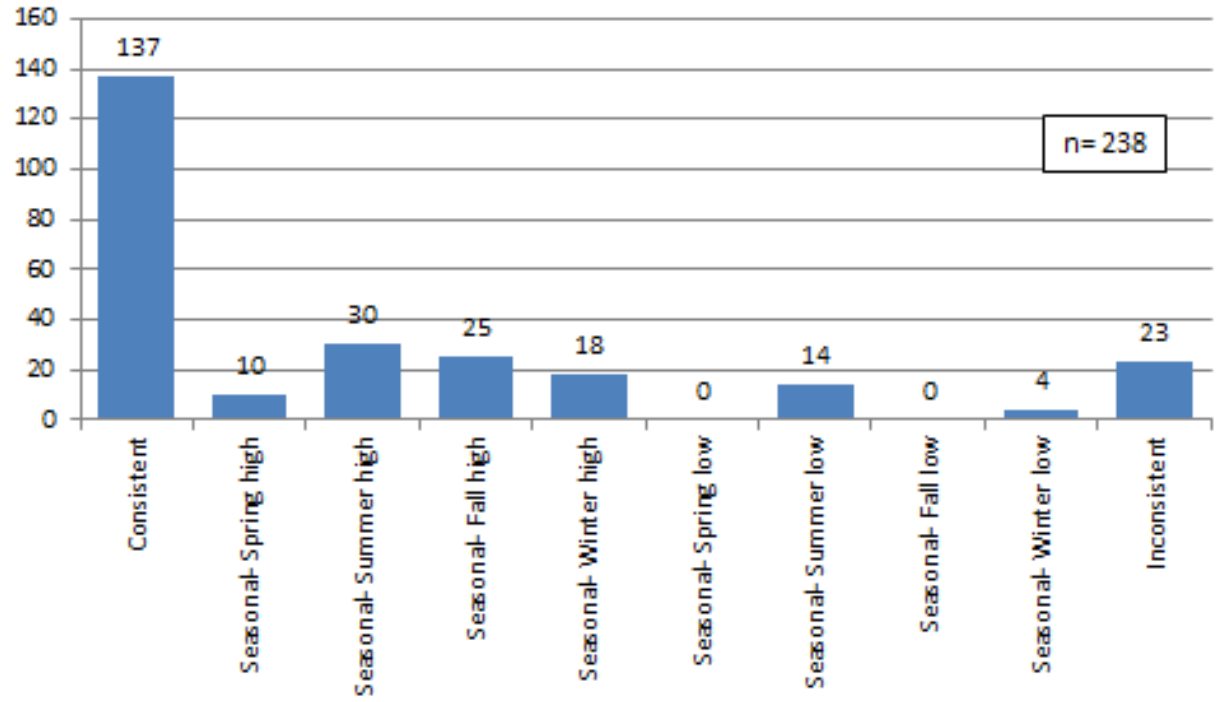
| Table 11. Assumptions Used to Assign Value Category to Disposal Methods | | | |
|---|---|---|---|
| **Cited Disposal Method** | **Assumptions** | **Resultant Value Category Assumed** | **Color** |
| Burned | Hauling costs and staff time | Negative Value | Red |
| Buried on Site | Hauling costs and staff time | Negative Value | Red |
| Wastewater plant | Hauling costs, staff time, fees | Negative Value | Red |
| Landfill | Hauling costs and staff time, fees | Negative Value | Red |
| Stockpiled | Staff time, land opportunity cost | Negative Value | Red |
| Land applied | Hauled at someone else's cost | No Value | Orange |
| Rendered | May or may not have to pay for material, pay for hauling; may or may not receive payment | Low Value | Yellow |
| Other | May or may not have to pay for material, pay for hauling; may or may not receive payment | Low Value | Yellow |
| Compost | May or may not have to pay for material, pay for hauling; may or may not receive payment | Low Value | Yellow |
| Ingredient- Feed | May or may not have to pay for material, pay for hauling; may or may not receive payment | Low Value | Yellow |
| Energy | Slightly more valuable commodity | Medium Value | Light Green |
| Recycled | Slightly more valuable commodity | Medium Value | Light Green |
| Food | Valuable commodity | High Value | Dark Green |
| Ingredient- Materials | Low volume high value | High Value | Dark Green |
| Ingredient- Food | Low volume high value | High Value | Dark Green |
| Ingredient- Chemicals | Low volume high value | Very High Value | Blue |
| **Source:** *Agriculture and Forestry* | | | |

### Seasonality

Every interviewee was asked to share information on seasonality. Although many did share valuable information on what time of year various organic waste streams were produced, the overall finding was that although most interviewees may have a general idea of when more or less waste is produced they did not track in detail the production of waste by time of year. As a result most of the information collected was either qualitative e.g. “slower in summer” or only roughly quantitative e.g. “15% increase in November and December”. Based on general descriptions attached to each waste volume reported, each stream was sorted into general categories as illustrated in **Figure 12,** below. The overall conclusion is that most food-processing facilities have relatively consistent supplies of organic wastes. Although some individual facilities reported some seasonal variation, if you look at the province as a whole some

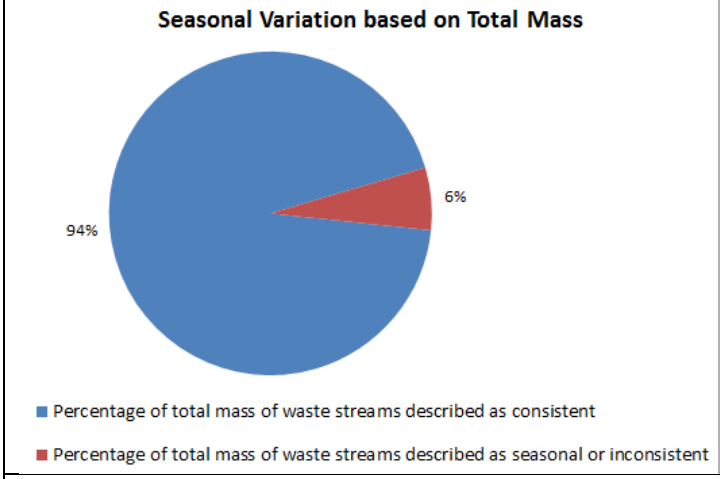
of this variation is cancelled out between companies. Another conclusion that can be reached is illustrated in **Figure 13**: on a mass basis by far the majority of waste was reported as "consistent".

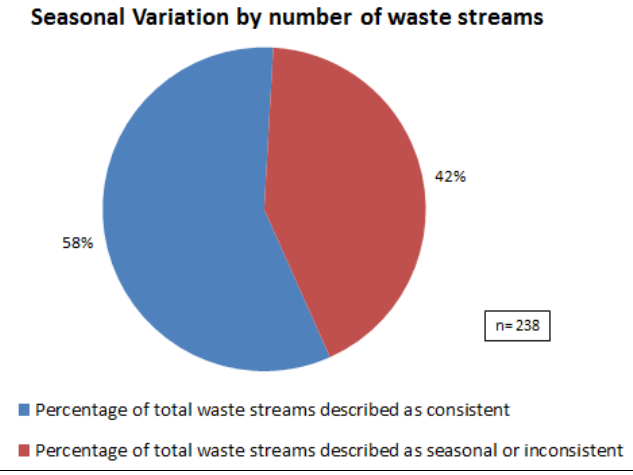
**Figure 12. Number of Waste Streams Reported Sorted by Seasonality Category**




**Source:** *Agriculture and Forestry*
**Note:** Number of data points differs from Figure 10 and Figure 11 because information on seasonality was not reported for each waste stream.

**Figure 13. Seasonal Variation of Waste Comparing Number of Waste Streams to Total Mass**




**Source:** *Agriculture and Forestry*
**Note:** Number of data points differs from Figure 10 and Figure 11 because information on seasonality was not reported for each waste stream.

## Grocery Sector

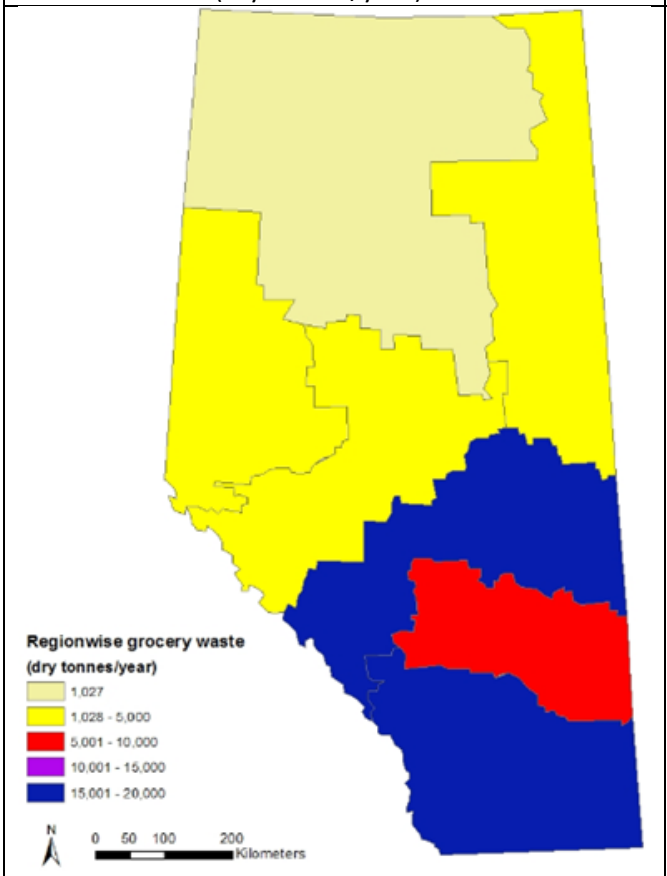
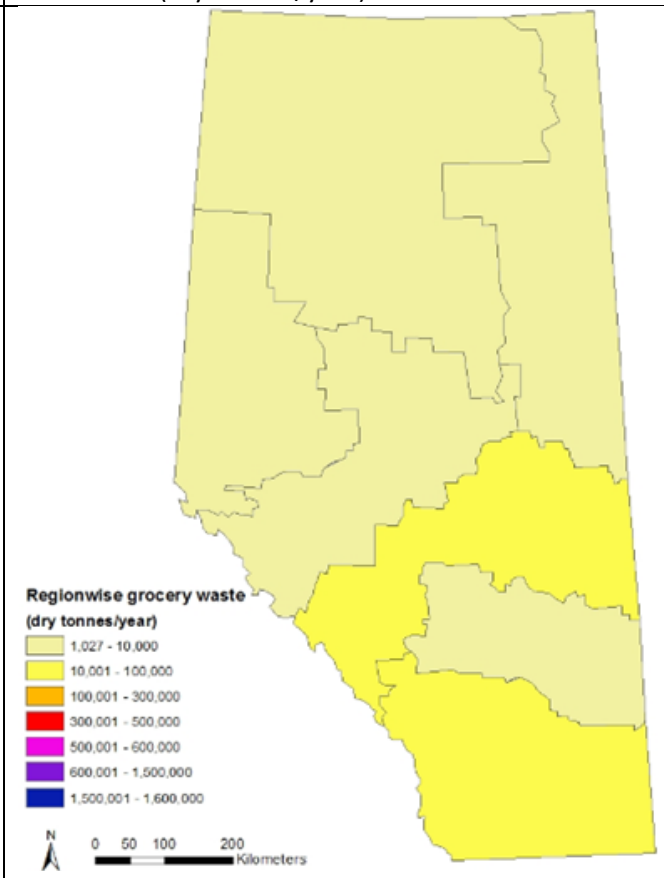
**Figure 14** below summarizes the geographic results compiled from the phone interviews for the grocery sector. Data from 30 of the approximate 35 brands in Alberta are included, representing 504 locations. It was assumed that the grocery sector has access to very detailed information about waste- that grocery representatives should be able to generate very detailed reports that itemize waste by grocery store category, subcategory or even individual products. It was thought the detailed reports could total the amount of food brought into inventory- subtract that which was never sold and the difference would be the amount wasted. Another approach of generating highly detailed information on waste it was thought would be available to grocery sector representatives would be to generate reports on volumes hauled by third party waste haulers (who typically charge by total weight or volume). If indeed these means of generating data on industry waste are available none of the interviewees were willing to share that level of detail.

Based on the results that were received, it can be concluded that, unsurprisingly, the food waste volume correlates quite closely to the population centers. According to the data the average grocery store produced about 210 tonnes of food waste per year in Alberta. The number should be used with caution however as there was a wide range between smaller stores and large box stores and even stores of similar size had a wide standard deviation. Not all companies broke down their waste volumes into categories and those that did, did not do so consistently. Data on separated cardboard and plastic and well as total waste was also collected (see **Figure 15**) but only waste identified as "food waste" is include in the maps. Reported tonnage of source separated cardboard and plastic was not included in the maps because it is already being recycled. Likewise "other" waste (any waste reported that was not food waste or recyclables) was not included in the maps. It is primarily composed of inert packaging such as metal and glass as well as non- recyclable/recycled plastic or cardboard packaging. In reality, there is some overlap between "food waste" and "other" waste. Waste that is mostly food but contained some packaging was included in the "food waste" category whereas waste that was mostly metal or glass but might still contain some organic material, was included in the "other" category. Some grocery store companies separated food from its packaging in order to optimize disposal of the organic and inorganic fractions but this practice remains the exception as opposed to the rule.

### Disposal practices

More detailed analysis and more statistically defensible conclusions may be possible in the future if the grocery sector is willing to share more data around store specific waste tonnage, monthly hauling costs, store sales, etc. Many of the grocery stores that were interviewed contracted third party haulers to dispose of their waste so the grocery stores themselves did not always have perfect information about the disposal method being used after it had been hauled away from their site. That said, most interviewees seemed to think that the majority of the waste was being taken to landfill with some also citing composting of organic waste as a disposal method. There were also a few interesting disposal methods cited with one company saying their waste was already being hauled to a biogas facility to be produced into energy and fertilizer whereas another company cited there were working with researchers to feed waste to insects and harvest the insects for biofuels.

**Figure 14. Region-level Availability of Grocery Sector Wastes in Alberta (2014)**

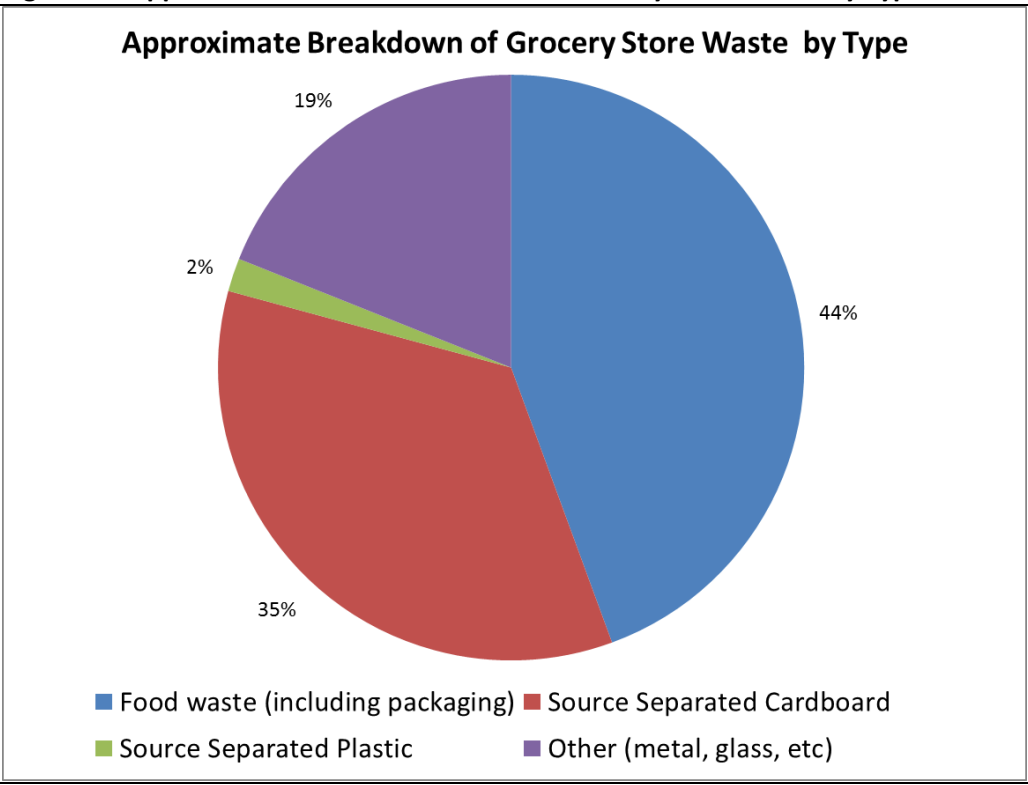
| Regionwise grocery waste, non-normalized (dry tonnes/year) | Regionwise grocery waste, normalized (dry tonnes/year) |
|---|---|
|  |  |



**Source:** *Alberta Agriculture and Forestry*

**Note:** See mapping methodology section for explanation between normalized and non-normalized. Maps in this Figure only include collected data, not extrapolated data and only include food waste (not source separated cardboard, source separated plastic or "other" waste).

**Figure 15. Approximate Breakdown of Alberta Grocery Store Waste by Type**




**Source:** *Alberta Agriculture and Forestry*

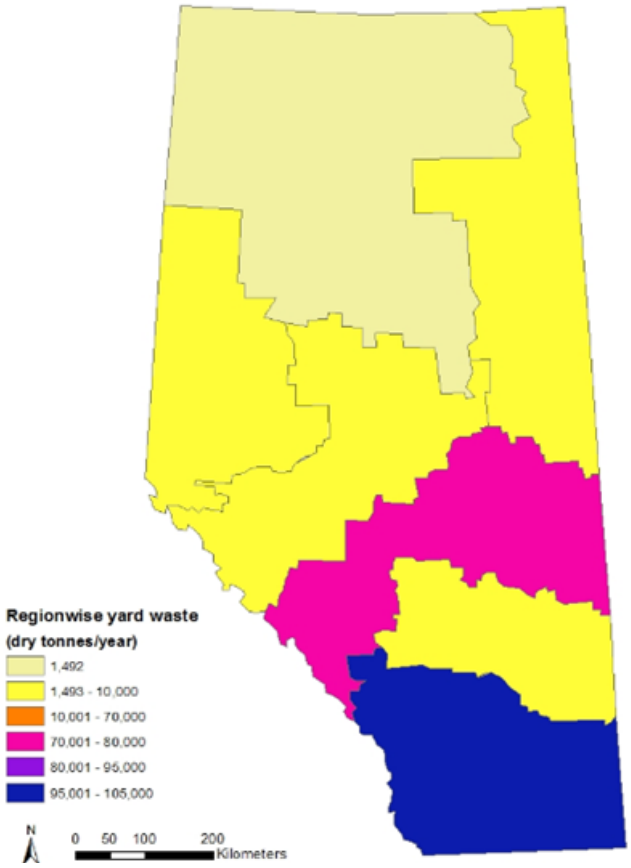
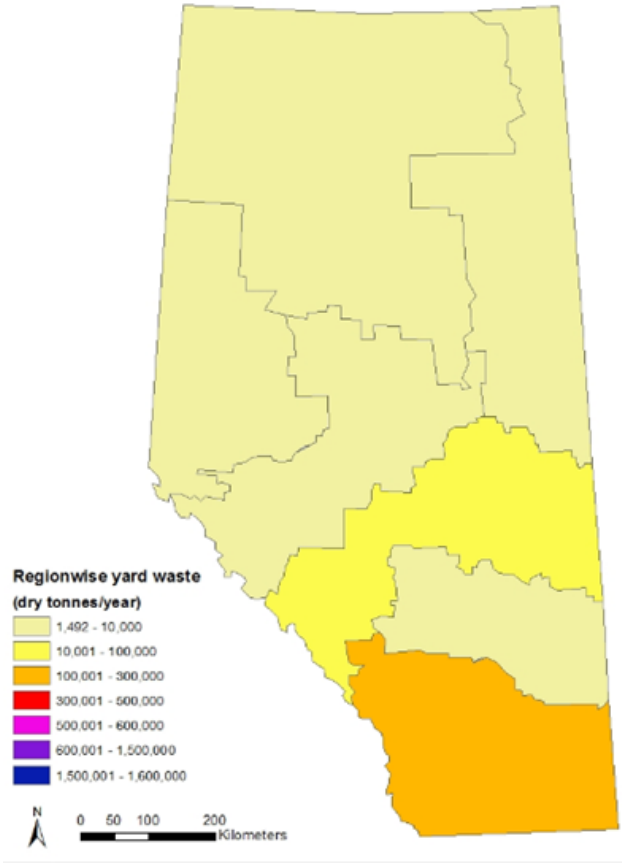
### Seasonality

Interviewees were asked about the seasonal variation of waste production. Although insufficient data was provided by enough parties to make any data public, organic waste in the grocery sector appears to correlate with holidays. For example, there are spikes in organic waste around Halloween (pumpkins, candy) Canadian thanksgiving and Christmas (general food waste, Christmas trees, etc.).

## Residential Yard Waste

The geographic distribution of the residential yard waste data obtained for this study is illustrated below in **Figure 16.** Unsurprisingly, the concentrations correlate closely with population centers, with notably large volumes in the cities of Edmonton and Calgary.

**Figure 16. Region-level Availability of Residential yard wastes in Alberta (2014)**

| Regionwise yard waste, non-normalized (dry tonnes/year) | Regionwise yard waste, normalized (dry tonnes/year) |
|---|---|
|  |  |



**Source:** *Alberta Agriculture and Forestry*
**Note:** See mapping methodology section for explanation between normalized and non-normalized.

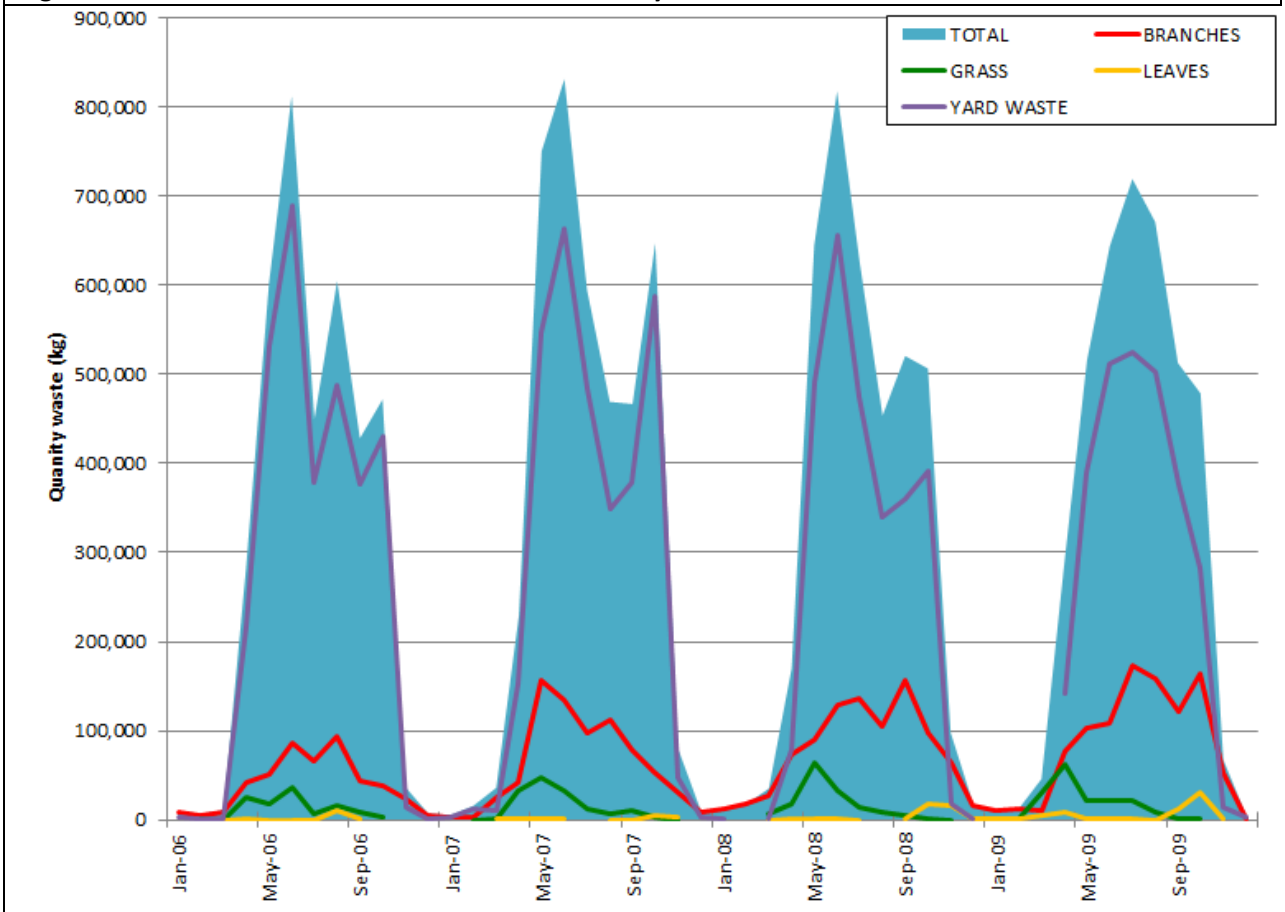
## Disposal practices

Residential yard waste is typically collected by or on behalf of municipalities. The majority of residential yard waste in Alberta is currently sent for disposal in landfills; smaller volumes are composted, applied to land as a source of nutrients or fed to anaerobic digesters for energy production. [43]

## Seasonality

Residential yard waste is highly seasonal with the biggest spikes in spring (when gardeners do their spring clean-up) and fall (when leaves are raked and bagged). Volumes remain high throughout the summer and drop to almost nothing in the winter. **Figure 17** illustrates this phenomenon using real data from the city of Red Deer. The trend would be very similar for other jurisdictions.

**Figure 17. Seasonal Nature of Yard Waste for the City of Red Deer**




**Source:** *Alberta Agriculture and Forestry based on City of Red Deer data*

## Understanding the Results

Some notes of caution are required to put the results in context.

### Geography

With regards to geographical groupings illustrated in **Figure 4** it is important to understand that county information was added to data records for all four categories of waste of interest in this study: waste in livestock, grocery, food-processing and yard sub-sectors. For the purposes of categorizing waste streams by county, geographic areas that do not officially form part of the county (examples cities, towns, first nation reserves, etc.) were included in the adjacent county. For example, organic waste that was identified as originating from within the city of Lethbridge was included in the number for Lethbridge County even though the municipality is not officially part of the county. Similarly, the organic waste from the city of Camrose was included in Camrose County, etc. This was done to protect confidential information and to simplify mapping. In some cases a municipality fell on the border of two or more counties. In such cases an arbitrary decision was made to determine which county to include it in (for example, the town of Drumheller was included in Starland County- though an argument could have been made to include it instead in Kneehill county). Because of the abundance of organic materials identified

within their city limits the cities of Edmonton and Calgary were considered their own areas and were not rolled into an adjacent county. Although the information was gathered at a county-level, it could only be shared at a broader regional level due to concerns about privacy. The exception to this was **Figure 5** where the four data sets (livestock, grocery, food-processing and yard) were aggregated for each county.

### Incomplete Data

Another important note which is especially relevant to the food-processing sector but to a lesser extent also the grocery sector is that some counties may show lower tonnage not because they don't have waste but because no/not enough companies were surveyed in that area (or those that were surveyed were not able to provide data). Additional research may reveal that a region with low waste in this study actually has considerable volumes of organic waste available. This will be less of an issue for the livestock and residential yard waste data sets because the data sets are more complete. As explained above, data were extrapolated in the case of grocery waste and food-processing waste. For the food-processing sector, both the collected data and the extrapolated data are presented in **Table 9**. Because it could be misleading to assign assumed volumes to specific geographic regions the maps only illustrate the waste actually identified via the surveys (i.e. the maps do not include extrapolated data).

### Waste Availability

Although some consideration has been given to what waste is being produced that may be available for other, higher value uses, it is important to note that just because the volumes are reported in this study as being produced does not necessarily mean that they are available, or that higher value options are economic. Some volumes are already being diverted post-collection to other uses (see **Figure 10**). This is largely the case in Edmonton where the city is already diverting 60% of all wastes that are collected (which would include things like grocery store waste) and will shortly be diverting 90% of waste as more residuals are diverted to make fuel ethanol.[44] A few other key examples include manure and slaughterhouse waste. Manure is almost universally being land applied which is returning important nutrients to the soil. In areas where there are already sufficient nutrients in the soil it might be worth exploring other uses for manure. No study was identified that estimated the proportion of Alberta soils which might have met or exceeded acceptable nutrient thresholds; however, industry experts estimated that a reasonable expectation might be 10%. Even where the nutrients are required, options like biogas may be worth exploring as extra energy value could be captured while retaining the nutrients for field application. Likewise, slaughter houses are currently sending wastes to rendering facilities and there may not be higher value options. In cases where even a small income is being realized it may be very difficult to convince producers of the waste that other, higher value, options may be worth considering.

### Moisture

Comparing data on materials with widely different moisture content is difficult. In an attempt to normalize the data to allow for comparison of waste amounts between sectors, all reported volumes were converted to a dry basis. The benefit of this approach is that it makes it possible to compare the amount of waste between neighbouring jurisdictions or widely diverse waste streams. This approach does however create some risks around data interpretation. In some cases individuals may be used to seeing waste volumes reported "as is" whereas in this report they are reported dry. For example,

manure amounts are often reported on a wet basis. In this study they are reported on a dry basis so the amounts may not be comparable to other studies (even liquid manure is assumed to be dry- the mass of the manure that is water is not reported here). For all four subsectors assumptions were made around what percentage of the waste was water and factors were applied accordingly to discount the mass of the waste. Those wishing to use the data in this report in business planning should use caution as significant drying may be required and the actual volumes of waste may be much larger than dry-basis data may suggest (which may affect transportability or transport cost, for example).

As explained in the methodology sections of each subsector the moisture numbers were assumed as per the **Table 12** below:

| **Table 12. Moisture Assumptions by Sub-sector** | |
|---|---|
| **Waste Type** | **Assumed Moisture** |
| Livestock (manure) | By species (see **Table 2**) |
| Livestock (on-farm dead) | 80% |
| Food Processors | By facility |
| Grocery Stores | 54% |
| Yard Waste | 60% |
| **Source:** *Alberta Agriculture and Forestry*<br>**Note:** See methodology section for details | |

### Confidentiality

Although data was gathered at a county level for each of the four subsectors only aggregated data at a county level could be made public (See **Figure 5**) due to concerns around confidentiality. Certain companies were only comfortable with sharing data if this assurance was provided.

### Data Comparison

As explained in the methodology section, two sets of maps were created that show the same data in two different ways. One set of maps was produced with a "normalized" legend so that total volumes on one map were directly comparable with any other normalized map. The advantage of this series is that it is easy to look at the livestock map and the grocery map side by side and notice immediately that the livestock sub-sector has more total volume. In contrast, the legends on the other set of maps vary to best fit the natural separations of scale unique to that subsector. The advantage of this series is that one can look at any individual "non-normalized" map and easily conclude which jurisdiction has the most grocery waste or food-processing waste.

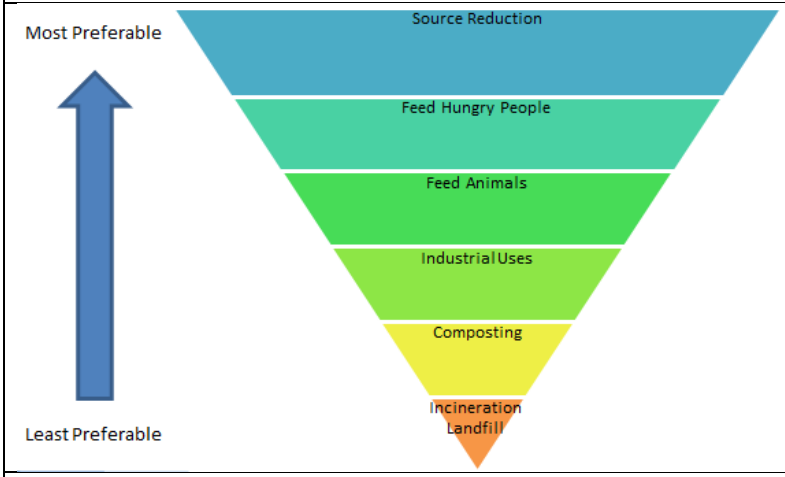
### Seasonality

This study sought to uncover new information or trends on the seasonal availability of organic waste. Every interviewee was asked to share information on seasonality. Although the overall findings seemed to indicate that waste volumes tended to remain constant throughout the year, individual waste streams were reported as being highly seasonal. As a result, some caution should be exercised if new uses for organic wastes require constant supplies of waste.

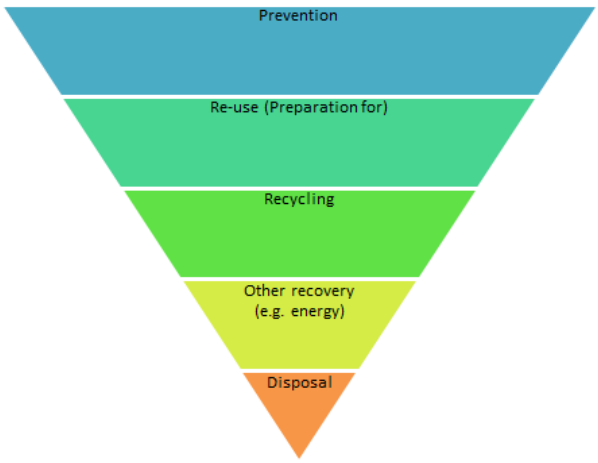
## Discussion

This study confirmed that Albertans are doing a lot of things with their waste (see **Figure 7**, **Figure 10, Figure 11**), everything from landfilling or stockpiling to applying on the land or feeding it to animals. As explained in the background section, an increasing number of jurisdictions are requiring producers of waste to explore options allowing more value to be captured from waste. Although there is still some debate around exactly the order, there is general consensus that it is possible to categorize waste disposal options into better and worse options. **Figure 18** shows a selection of examples of some thinking about the order or hierarchy of waste disposal options. The examples are from the United States Environmental Protection Agency, the European Commission and some draft thinking by Alberta Agriculture and Forestry for discussion purposes (there are many more examples of "waste hierarchies" that have not been included). All examples agree that landfilling waste, at the orange end of the inverted pyramid, is among the worst things that can be done with it. After that there is some disagreement around the specific order but there is general agreement that as you go towards the practices at the blue end of the pyramid the jurisdiction captures more value from the waste product.

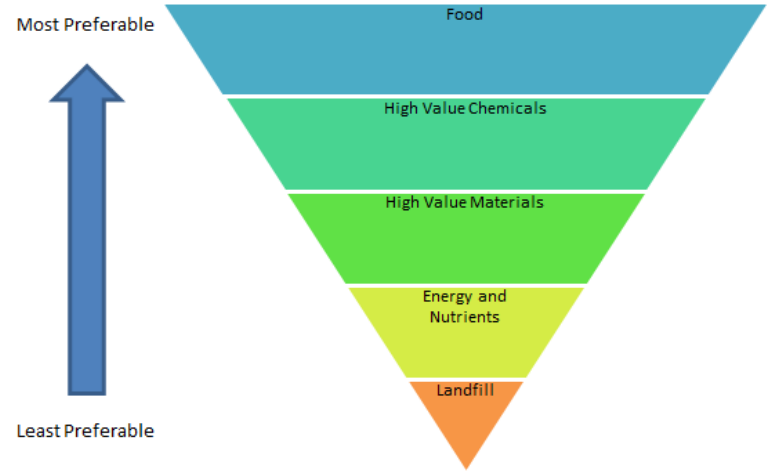
**Figure 18. Examples of Possible Waste Hierarchies**



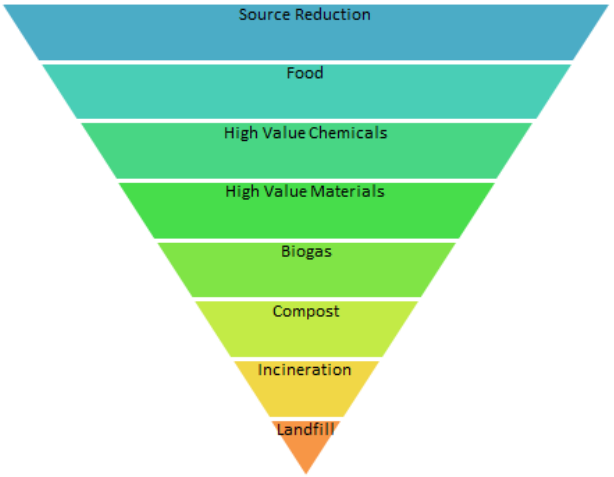

**Source:** *US Environmental Protection Agency, 2007*




**Source:** *European Commission, 2008*




**Source:** *Author*

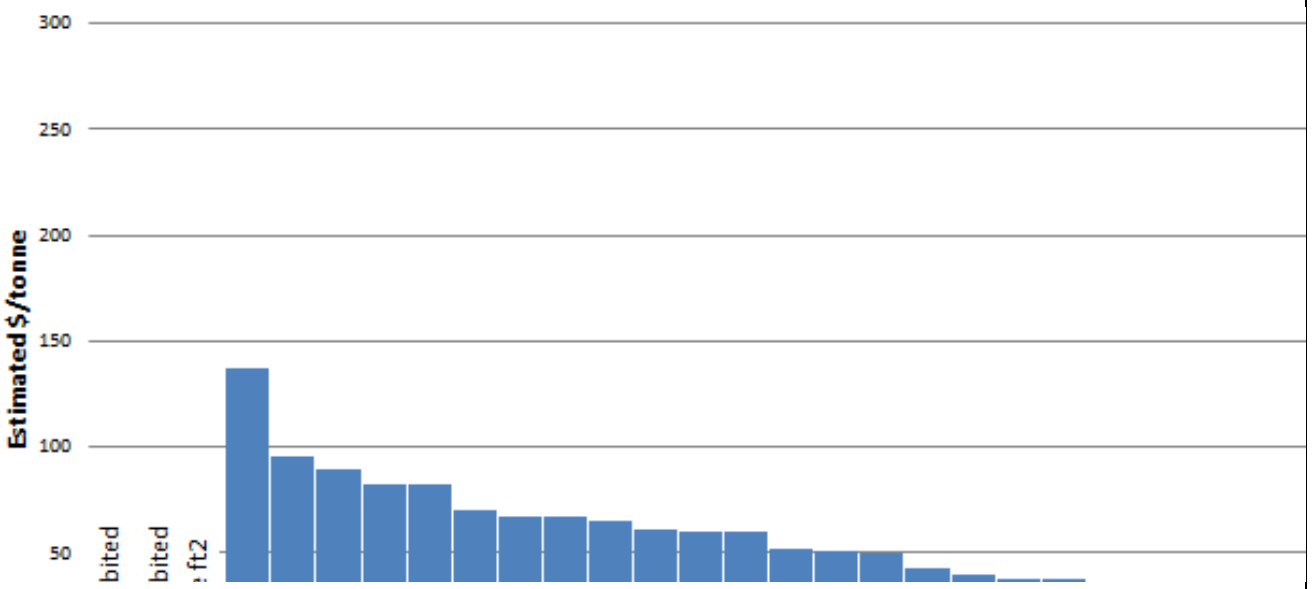



**Source:** *Author*

Despite the fact that there is almost universal consensus that there may be better options available to Albertans for dealing with waste than putting it in a landfill, landfill remains the most common means of disposing of certain organic wastes (see **Figure 7**). An increasing number of communities are taking an interest in other potential approaches. Below are a series of graphs (**Figure 19Figure 22)** which attempt to compare the disposal fees associated with landfills (sometimes referred to as tipping fees) in various communities across Alberta for four categories of waste.

The information was gathered by an informal search of the waste management portions of websites of municipalities or waste management authorities, many of which list the prices charged to people who want to dispose of various materials. The categories below do not always exactly match the materials listed on the waste management websites but were created to try to compare prices between facilities. Four categories were defined based on the most common waste streams identified in the various price lists: “Residential yard waste”, “Mixed Organic Waste”, “Construction and Demolition” and “Animal Carcasses”. For each facility, assumptions were made about what categories listed on the various waste management websites would best fit within each of the four defined categories. In some case it was fairly straight forward; for example, it was assumed that "Segregated Bagged Grass and Leaves" best fits in the “residential yard waste” category or “dead animal” corresponds to “animal carcasses”. In other cases it was less clear. For example, it was assumed "Household garbage" and “refuse” were best categorized as “Mixed Organic Waste”. The assumptions may or may not have been accurate. The complete list of assumptions is included in **Error! Reference source not found.Error! Reference source not found.** Although the list is only a partial list of Alberta landfills there is a wide range between charges per tonne for similar materials among the various municipalities for which information was obtained. Information was obtained for 35 waste management facilities; and, according to Alberta Environment and Sustainable Resource Development’s Regional Waste Management Authority Contact List,[45] there are at least 74. Note that because the standardized categories (“construction and demolition”, “mixed waste” “yard waste” and “animal carcasses”) were invented for the purposes of comparison, the various facilities should be contacted directly to confirm actual costs for disposing of specific materials. Of note is the fact that various facilities state that they already do not accept construction and demolition waste, animal carcasses or mixed organic wastes. The city of Calgary has banned organic waste starting in 2019.[46]

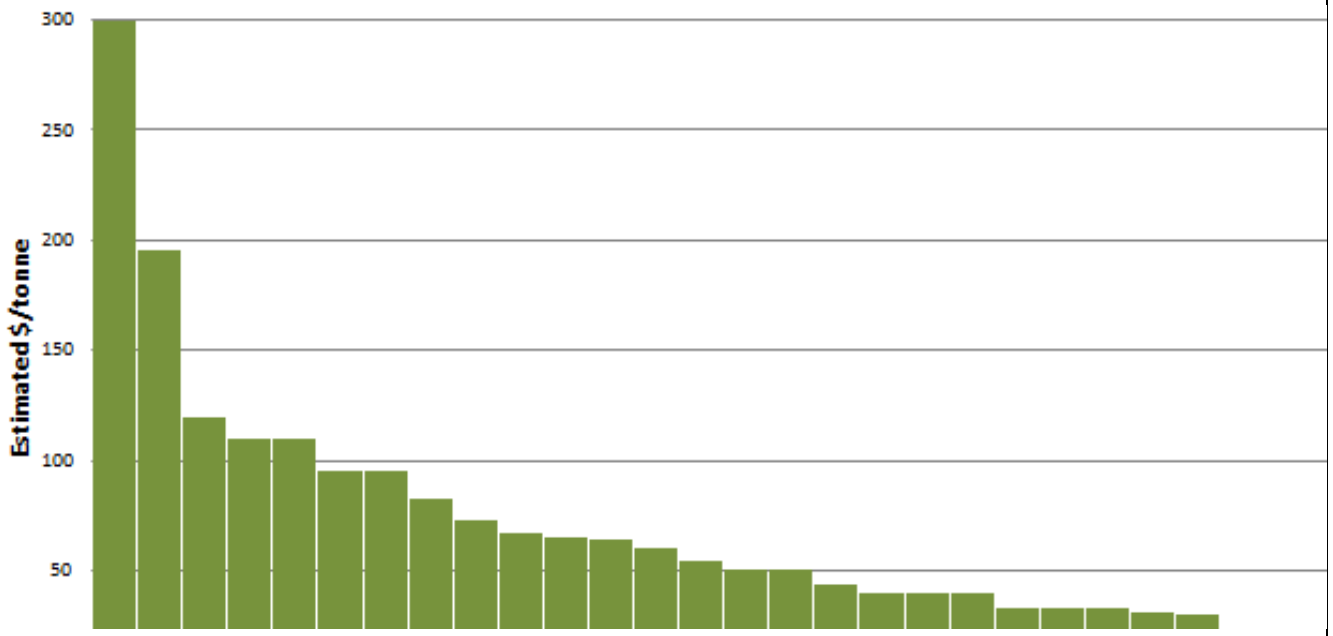
**Figure 19. Estimated Disposal Fees for Construction & Demolition Waste by Select Alberta Jurisdiction**




**Source: Compiled by Alberta Agriculture and Forestry**

**Note:** See "Understanding the Results" Section for explanation of geographic groupings.
There may be more than one facility per county, not all of which will be captured here.

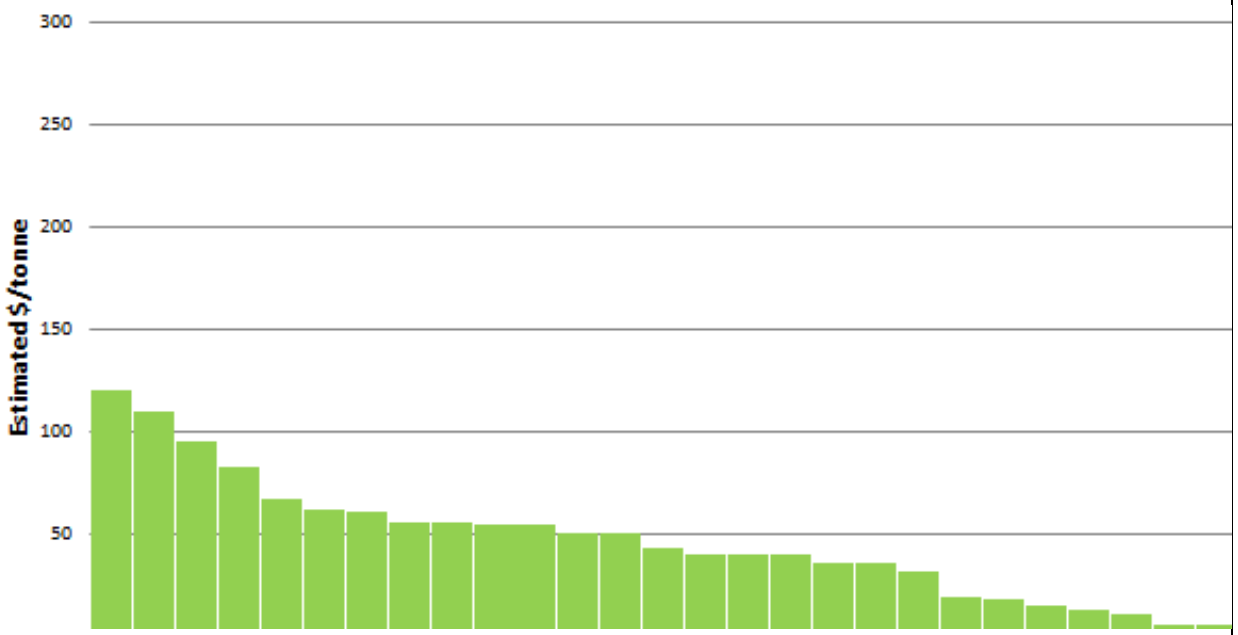
**Figure 20. Estimated Disposal Fees for Mixed Waste by Select Alberta Jurisdictions**




**Source: Compiled by Alberta Agriculture and Forestry**

**Note:** See "Understanding the Results" Section for explanation of geographic groupings.
There may be more than one facility per county, not all of which will be captured here.

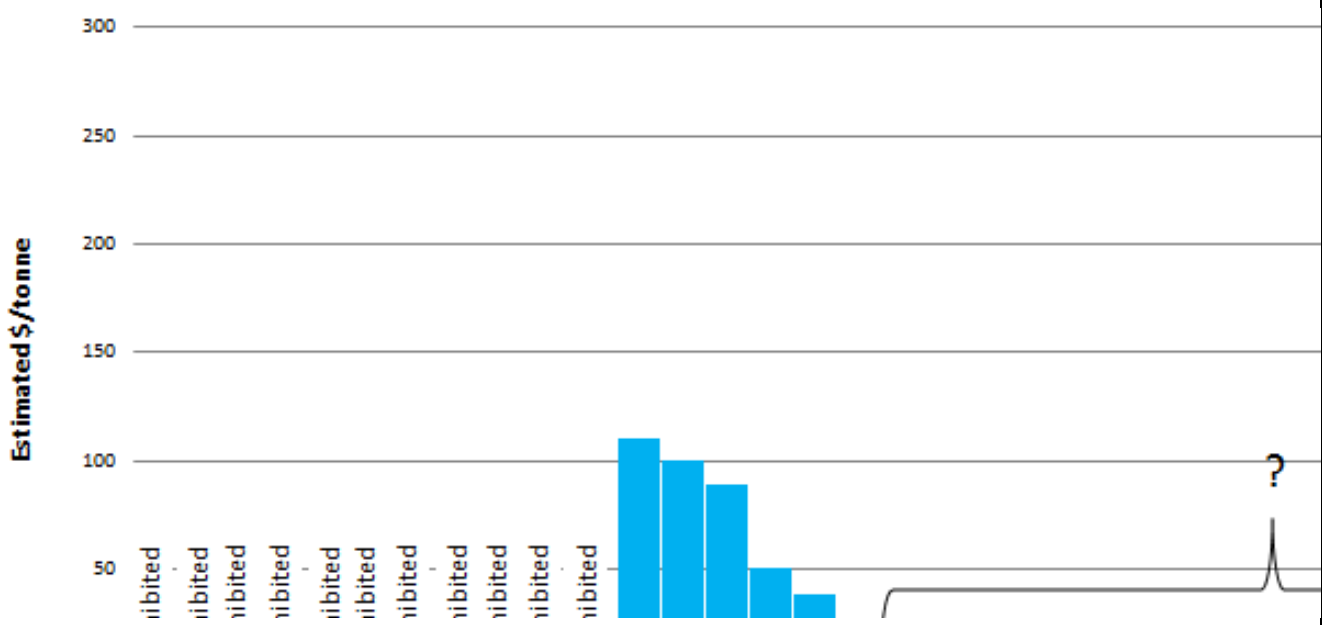
**Figure 21. Estimated Disposal Fees for Yard Waste by Select Alberta Jurisdictions**




**Source: Compiled by Alberta Agriculture and Forestry**

**Note:** See "Understanding the Results" Section for explanation of geographic groupings.
There may be more than one facility per county, not all of which will be captured here.

**Figure 22. Estimated Disposal Fees for Animal Carcasses by Select Alberta Jurisdictions**




**Source: Compiled by Alberta Agriculture and Forestry**

**Note:** See "Understanding the Results" Section for explanation of geographic groupings.
There may be more than one facility per county, not all of which will be captured here.

## Relevance

So the results from this research show that there are abundant volumes of organic material that are currently being disposed of that may be available for higher value applications. So what could Albertans be doing with their waste instead? Of course the first piece of homework for any organization trying to reduce the amount of waste they are disposing of would be to try to eliminate or reduce the production of the waste in the first place. In some cases this may be possible by improving the efficiency of the production process or supply chain. For example, grocery stores may be able to reduce wasted food by improving the efficiency of automatic ordering systems to ensure only as much product as is likely to be sold is stocked at any given time.[47] In other cases the production of the waste may be an unavoidable fact of manufacturing the product in question. For example, as long as there is a meat industry there will be production of paunch manure (the stomach contents of animals at the time of slaughter). Likewise, in milling operations the hull or chaff by-product stream will always be produced so long as the grain in question is the main product of interest.

If complete waste elimination is not possible there are a wide variety of options available for adding value to waste, many of which are already being explored or have already been implemented in Alberta.

### Food/Feed

In some cases "waste" products are fit for human consumption and can be diverted from landfill to feed hungry people. Working to improve the efficiency of supply chains could decrease the amount of food waste and transform food destined for disposal into meals for those who need it. Food that is not fit for human consumption might be fit for animal feed.

For example, the Edmonton Food Bank salvages edible food and distributes it to people in need through a variety of programs. Over 80% of the food it distributes is surplus food from local food processors and grocery stores. In 2014, it rescued more than 2,400 tonnes of food from going to landfill and was able to distribute this to hungry people. Any food that it receives that it is not able to use (for example food that is spoiled or past its expiry date) is either picked up by local farmers to be used as animal feed or is composted at the city of Edmonton's compost facility. *The Charitable Donation of Food Act* offers some protection from liability to organizations for damages caused by the consumption of donated food.[48]

### Bio-nutrients

Organic wastes can be converted to nutrients and amendments for improving soil using various technologies including composting, aerobic digestion, anaerobic digestion, aquaponics, pyrolysis, etc. Examples of possible products include: biochar, compost, refined organic fertilizers, digestate, fertilizer pellets, etc. One local company already producing commercial nutrients from agrifood waste is Calgary's Hop. Hop provides a service to collect organic wastes from local restaurants and grocery stores and produces premium compost using proprietary technology. The compost is then sold in small batches to local gardeners. According to Hop they will divert more than two million pounds of organic waste from landfills in 2015.[49]

### Bio-energy

In the context of this study bio-energy includes any means of using agrifood waste to create energy. The energy produced could be used on site to displace natural gas or electricity that needs to be purchased or could be sold as a commodity to others. Potential technologies in this category include anaerobic digesters, fermentation operations, pyrolysis or gasification units or pelletizers. End products would include, electricity, renewable natural gas, biodiesel, fuel ethanol, bio-coal or energy pellets. There are a number of existing examples in Alberta of Agrifood waste being diverted for bioenergy. **Appendix E** presents a compilation of research conducted in Alberta on the ability of various organic wastes to produce energy-rich biogas.

Lethbridge biogas has been collecting organic waste from confined feeding operations, food processors and local grocery stores since 2013.[50] The wastes are converted via an anaerobic digestion process into renewable natural gas which it then burns to generate electricity. The electricity is sold to the grid and the remaining residue, high in nutrients, is returned to land as fertilizer. The suppliers of the organic waste also benefit from reduced hauling fees, reduced tipping fees and improved public perception.

### Bio-materials

Certain organic wastes lend themselves well to be repurposed as materials for markets such as construction, erosion control, packaging and automotive parts. Some of the types of organic waste that may be useful in the production of bio-materials include: starches, oils and low-moisture fibers. Drier, more homogenous sources of these wastes tend to be better suited for material applications. The adoption of organic-waste-based materials in construction and manufacturing may offer many benefits, including increased performance, reduced environmental footprint and improved health.

Edmonton-based ATI Composites Canada Inc. has developed a number of advanced products for the construction industry incorporating locally available agriculture-processing waste. For example, their award winning Fire Resistant Composite Panels are made of oat hulls and/or flax and hemp fines from the AITF pilot scale processing facility in Vegreville. These precast wall panels are being developed to offer a cost-effective alternative to concrete block construction in commercial projects requiring fire resistance ratings of 2 or more hours and have generated substantial commercial interest.

### Bio-chemicals

Other organic-waste materials are ideal raw materials for high value chemicals in markets as diverse as personal care products, polymers or industrial chemicals. Renewable resources such as organic wastes can be used to produce a wide variety of chemicals that are currently produced using petroleum. Potential benefits to entrepreneurs pursuing these opportunities may include functional improvements, reduced environmental impact and access to new markets or customers. Waste products and by-products can be ingredients for large volume commodity chemicals but their value can be maximized if small-volume-high-value applications can be identified.

Enerkem is a local company using municipal solid waste as a feedstock to produce biochemicals as a complement to recycling and composting. At their Edmonton plant, one of the first commercial advanced biorefineries in the world, they are taking those organic wastes which are not recycled or composted and converting them to renewable methanol. Methanol is primarily used as a chemical

building block to produce secondary chemicals, such as ethanol, acrylic acid, n-Propanol, olefins, etc. These and other chemicals produced from methanol are then used to produce thousands of products consumers use every day. Methanol can also be used directly in applications such as solvents, antifreezes or windshield washer fluids.

Botaneco is another Alberta-based company, focusing on developing ingredients for the international personal care industry. Their core products are made from unique extracts from oilseeds (e.g. oleosomes), but they recently realized that the aqueous waste stream resulting from their process presented an opportunity to diversify into new product lines. Using a solvent free process they were able to extract the protein from their waste water; which is also commercially valuable as an ingredient in other personal care applications. This provided the opportunity to produce a new line of products from the same feedstock simply by looking at their by-product as another resource rather than a liability.

## Conclusions and Next Steps

This project has successfully contributed baseline data on waste generation and management for selected subsectors of Alberta's Agrifood industry for which information was not previously available publicly. Such reference information is required to have meaningful discussions around improving waste management practices and exploring opportunities to transform liabilities into economic opportunities for the province. Despite the required cautions explained in the "Understanding the Results" section the new information compiled in this study should be useful to entrepreneurs as they pursue prospects to capture value from "waste" streams. The findings should be relevant to municipalities and third party waste management companies as they look for innovative waste management opportunities. Finally, the findings should be of interest to the industries examined in the study. Hopefully food processors, livestock operations and grocery stores themselves will benefit from this new public information. Perhaps the information may serve to help match sources of waste with those who require organic materials for their own business- thus offering alternative disposal methods. Having aggregated information for regional waste availability may also create opportunities even for operations that themselves generate insufficient volumes of organic material to be of interest to a project developer.

### Conclusions

This report can thus make an important contribution to future discussions on waste management in Alberta's Agrifood sector. The key conclusions are:

1. There are approximately 3.4 million tonnes of dry organic waste produced every year in Alberta including all four of the subsectors considered:
    a. Livestock waste
    b. Food-processing waste
    c. Grocery waste
    d. Residential yard waste
2. Waste from the livestock sector (including livestock operations, and wasted meat, dairy and eggs at the processing and retail level) is the source of more than 80% of the waste identified.

3. The most common disposal methods vary by subsector (see **Figure 7**) however putting waste in landfills, applying waste directly onto land, composting waste, rendering animal waste and feeding waste to animals and are the five most commonly used disposal options.
4. In some cases "disposal" options offer important benefits (such as returning nutrients to the soil). In other cases waste disposal practices have neutral or even damaging impacts, for example eutrophication of water bodies or release of methane into the atmosphere.
5. Even where waste management practices offer benefits it may be possible to improve procedures to extract more value (for example diverting wastes from animal feed to high value food ingredients).
6. The majority of waste volumes tend to remain constant throughout the year although individual waste streams were reported as being highly seasonal.
7. The majority of the reported waste is still a liability where producers must pay to have it hauled and disposed.
8. Disposal fees vary greatly across the province and thus incentives for diverting waste also vary.
9. Feedstock limitation is unlikely to be the limiting factor preventing Albertans from getting more value from their organic wastes.
10. There is an opportunity for Albertans to more aggressively explore options to:
    a. Reduce the amount of waste that must be hauled and disposed of (thus reducing associated costs);
    b. Divert residue and by-products from the disposal stream to new products, thereby increasing revenues.
11. There are many individual companies that were identified that reported large volumes of organic waste (see **Table 10**). These companies may have the most to gain from looking at waste to value-add opportunities.

### Next Steps

Even though the study generated information that will be useful by itself, a number of other opportunities for future research were also identified. A number of possible follow up pieces of work fall naturally out of this project:

1. The results of this study should be considered a preliminary inventory on which to build. It is recommended that interested parties try to leverage the data collection framework assembled in this study to further improve the quality and quantity of publically available data. Using a life cycle assessment approach will identify opportunities to increase efficiencies, decrease waste, reduce emissions and capture value from residual materials.
2. Refine the data collected in this study and build on the results:
    a. Work to develop better information on the seasonality of waste;
    b. Interview livestock operations to ask about disposal methods, costs and revenues;
    c. Work with the food-processing sector to improve data quality and integrate collection and publication of waste data into industry best practice;
    d. Work with the grocery sector to improve data quality and integrate collection and publication of waste data into industry best practice;
    e. Work with industry to voluntarily harmonize data categories for reporting purposes across grocery store chains and food processors;

    f. Work to get data shared publically at a county level, including annual public reporting of waste by industry;
3. Set up a program to provide resources to companies who wish to divert their wastes and by-products to higher value uses and/or adapt existing programs to better accommodate waste reduction initiatives;
4. Set up information sharing service to help match waste volumes to those who may be able to use them.
5. Conduct detailed research on opportunities for upgrading specific wastes and underutilized bi-products into higher value products (ingredients for food, feed, chemicals, nutrients, materials or energy). For example: pinpointing the best sites where a biogas plant would have the strongest business case.
6. Work with regional waste authorities to explore coordinated approaches for reducing the organic waste that goes to landfill including examining coordinated tipping fees and harmonizing definitions of the various waste categories. For example: develop a voluntary waste reporting template.
7. Work with industry and provincial and municipal government stakeholders to agree upon a common waste hierarchy framework (see. **Figure 18**) that can guide allocation of organic materials to end uses.

## Appendix A- Project Abstract

## Appendix B- Participant Letter

## Appendix C- Sample Questions

## Appendix D- Select Information on Tipping Fees

## Appendix E- Compilation of Methane Potential Information

## Appendix F- References and Bibliography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