

EVALUATION OF AGRICULTURAL PLASTICS WASTE MANAGEMENT IN
NOVA SCOTIA: IDENTIFYING BARRIERS TO AND OPPORTUNITIES FOR
IMPROVING DISPOSAL PRACTICES

by

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Amanda, mi amor, my monkos. Precision of language is unachievable when it comes to expressing how much I love you. Thank you for the encouragement, the help and support, and for being the reason that this is quite possibly the first thesis written in Canada, Egypt, and England.

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ABSTRACT

Progressive waste management directives, such as those in Europe, aim to achieve zero waste to landfill in the coming decades; plastics commonly account for an appreciable fraction of waste sent to landfill. Agricultural plastics waste (APW) is plastics waste generated on farms as part of normal agricultural production processes. APW is generated in varying types and quantities spatially and temporally. Additionally, APW is difficult to recycle as it is often contaminated and/or physically degraded; a small number of jurisdictions have implemented successful APW recycling programs. To investigate the issue of APW recycling and to identify key barriers to implementing effective, accessible APW recycling programs, Nova Scotia (NS) (Canada) was used as a case study. Plastics waste types generated on-farm were identified along with the agricultural commodity production groups that generate the most plastics waste. Farmers' attitudes to APW recycling and operational considerations of implementing a program were investigated and discussed. Data were collected using mail-out surveys to NS farmers as well as email surveys with waste management professionals in NS and other jurisdictions, namely Prince Edward Island, Germany, Ireland, Iceland, and Norway. Findings indicate that the majority of farmers in NS are willing to introduce on-farm activities to facilitate the collection of APW for recycling, and that the environmentally responsible disposal of APW is an important consideration. In NS very little low-value plastics waste, including APW, is diverted from landfill. It was seen that successful APW recycling programs are often managed by a government body which coordinates the participation of stakeholders, including municipal waste managers, and that funding is provided by the farming community and the plastics producers/suppliers/importers.

LIST OF ABBREVIATIONS USED

APW – agricultural plastics waste
C&D – construction & demolition
EOL – end-of-life
EPS – expanded polystyrene
EPR – extended producer responsibility
HDPE – high-density polyethylene
ICI – industrial, commercial, institutional
LDPE – low-density polyethylene
MRF – material recovery facility
NS – Nova Scotia
NSE – Nova Scotia Environment
NSFA – Nova Scotia Federation of Agriculture
RRFB – Resource Recovery Fund Board of Nova Scotia

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CHAPTER ONE: INTRODUCTION

1.1 PROBLEM STATEMENT

The use and disposal of plastics on farms has become increasingly problematic in recent years. In Nova Scotia, and in other parts of Canada and the world, disposal options beyond landfilling or on-farm disposal have not kept pace with the increasing amounts of plastics being used (Scarascia-Mugnozza et al., 2012; Briassoulis et al., 2010). There is a pressing need to improve the diversion rate of the approximately 700 tonnes (CleanFARMS¹, 2012) currently being generated annually in NS. Nova Scotia Environment (NSE) has set a waste disposal target of 300kg/person/year by 2015 (Nova Scotia Environment, 2011). To work toward this goal initiatives must be undertaken to identify and divert more waste streams from landfill.

1.2 STUDY PURPOSE

When diversion options exist for a waste stream but diversion from landfill is not taking place, solutions need to be developed to link the waste generators with entities that will be able to recycle the waste or dispose of it in some other environmentally superior manner. The primary purpose of this research was to engage with stakeholders (farmers and waste managers) to fill in the information gaps related to understanding the barriers to progress regarding the responsible disposal of agricultural end-of-life (EOL) plastics. The research sought information on the types and quantity of plastics being generated on farms across Nova Scotia, the current methods of disposal of these plastics, the attitudes and opinions of farmers in relation to EOL plastics management, the best practices of EOL farm plastics management in other jurisdictions, and the current state of off-farm EOL plastics management in NS. The study was undertaken to examine both the current infrastructure and behavioural challenges interfering with alternative disposal strategies for agricultural plastics. Additionally, the study sought information on plastics waste management in NS with the purpose of connecting on-

¹ CleanFARMS is a not-for-profit industry stewardship organization with programs to manage agricultural plastic and other inorganic waste from farms across Canada.

farm disposal practices and barriers to recycling with potential off-farm EOL solutions for APW.

1.3 RESEARCH QUESTIONS

1. What types and amounts of plastics are being generated on farms in Nova Scotia, and how are they currently being managed?
2. What are the barriers facing farmers to engage with recycling of agricultural plastics?
3. What are the broader institutional barriers to recycling of agricultural plastics in Nova Scotia and how can they be addressed?

1.4 OUTLINE OF THE THESIS

The thesis is divided into four chapters. Chapter one is an introduction to the research including a survey of the relevant literature.

Chapter two is primarily focused on interpreting the quantitative results of a mail-out survey sent to farmers in NS. Chapter two was written as a manuscript intended for publication in an academic journal and is narrowly focused on the results of the mail-out survey to farmers in NS. These results highlight the issues and opinions of respondents concerning EOL farm plastics management and are then connected back to relevant literature for contrast and comparison (Muise et al., 2016).

Chapter three is an exploration of the nature of plastics waste management in NS and in other jurisdictions. This chapter focuses on data from various waste management groups, waste management professionals, and APW recycling organizations, and will include insights into the off-site practices of plastics waste management and how those can be connected to EOL plastics on farms in NS.

Chapter four emphasizes highlights of the research findings as they relate specifically to policy recommendations and consideration to the feasibility of an efficient

waste management program in NS that addresses EOL agricultural plastics. Chapter four offers some concluding statements, suggests areas for further research, and discusses some of the limitations of the project.

1.5 BACKGROUND

1.5.1 MANAGEMENT METHODS OF END-OF-LIFE PLASTICS

1.5.1.1 GENERAL OVERVIEW

Plastics, or synthetic polymers, are usually derived from petrochemicals and require energy (often fossil-fuel based) for their production. Approximately 4% of world oil and gas production is converted to plastics and the production process for plastics consumes the energy equivalent to an additional 3-4% (Al-Salem et al., 2009). Industrial scale production of plastics began in the 1940's and has grown at an estimated rate of 10% per year since that time, with global production increasing from 1.3 million tonnes in 1950 to 300 million tonnes in 2014 (Plastics Europe, 2015; Panda et al., 2010; Al-Salem et al., 2009). While amounts vary depending on jurisdiction, the use of plastics for packaging represents upwards of 40% of plastics demand – much of it for single-use packaging (Plastics Europe, 2015; Brems et al., 2012; Al-Salem et al., 2010). Many plastics are discarded in the environment, resulting in a multitude of negative consequences (Pettipas et al., 2016), or disposed of in landfill because they are not easily recycled or do not generate profit when recycled. Brems et al. (2012) consider at length the reasons why certain plastics are difficult to recycle, including the high costs associated with transportation, storage, sorting, and processing, and the difficulties of implementing collection programs.

Difficult to recycle plastics are often contaminated and structurally degraded low-density polyethylene (LDPE) films, clam-shell packaging (usually made with polyvinyl chloride), polystyrene and other plastics that are mixed together with other waste streams. Additionally, the economies of scale necessary to profitably recycle these plastics are often such that operations are located in the developing world and are not

easily established in the jurisdictions where much of the plastics waste is generated. In 2013, Canada and the United States recovered 450,000 tonnes of low-value plastics (primarily film) for recycling (74% increase since 2005) but nearly 60% of these recovered plastics were shipped overseas (American Chemistry Council, 2015). China has become the primary recipient of the low-value plastics, importing 70% of the globally traded recovered plastics in 2012 (Brems et al., 2012). Since 2012, however, under the program commonly referred to as “Project Green Fence” the import of post-consumer plastics waste into China is strictly controlled and the material is thoroughly inspected, which has had a dramatic effect on the demand for these plastics, and is an initiative in China that has been reinforced in 2016 (Resource Recycling, 2016).

1.5.1.2 MANAGEMENT OF AGRICULTURAL END-OF-LIFE PLASTICS

Agricultural plastics are a category of low-value, post-consumer plastics waste, which have largely been ignored by recyclers. Global estimates of agricultural plastics disposal range from 2 to 6.5 million tonnes per year (Scarascia-Mugnozza et al. 2012; Briassoulis et al., 2010). Plastics have become an integral part of many agricultural operations, including horticultural mulch films, bale and silage plastic, and fertilizer storage. Some of these major uses allow for an extended growing season, reduced water use, and reduced herbicide and pesticide use; additionally, plastics used in livestock production improve the quality and storage life of feed. Diversion of these plastics from landfill is a challenge for many governments and waste management researchers (IFFPG, 2015; Urvinnslusjodur, 2015; Briassoulis et al., 2010; Levitan and Barros, 2003). In many jurisdictions, APW is discarded using one of four disposal methods, each with its own negative environmental consequence. These include: on-site burning of APW, on-site burial, disposal in municipal landfills, and illegal dumping. Briassoulis et al. (2010) identifies negative repercussions of burning plastics in an open environment including the release of numerous harmful substances into the broader environment (water, soil and air). Bio-accumulation of these harmful substances in plant materials may occur if adjacent fields are contaminated. Burying APW contributes to degradation of soil quality characteristics, and can result in soil contamination, which

poses possible threats to local ecosystems. Disposal of APW in terrestrial and aquatic environments also contributes to aesthetic pollution in the form of discarded trash, threats to domestic and wild animals due to ingestion and entanglement (Pettipas et al., 2016) and degraded habitat, and the loss of material resources and energy through the extraction, use and disposal of naturally occurring hydrocarbons; these issues are magnified when materials are disposed of illegally in unmanaged sites. Microplastics as contaminants in the marine environment are abundant and widespread, and found in the highest concentrations along coastlines and in mid-ocean gyres (Cole et al., 2011). Accumulation of plastics waste in terrestrial environments is less well documented, though it has been observed that plastics waste litters urban environments, contaminates soils, and is carried into streams and rivers in appreciable quantities by rain and flooding events (Thompson et al., 2009).

APW collection and recycling programs are well established in parts of Europe. Efforts to increase capture rates and better utilize the plastics waste being generated on farms are documented in the academic literature (Briassoulis et al., 2010; epro, 2012a).

1.5.2 WASTE MANAGEMENT IN NOVA SCOTIA

The Environment Act and the Environmental Goals and Sustainable Prosperity Act (2007) committed the NS Government to a waste diversion rate of 50% and a waste disposal target of no more than 300kg per person per year by the year 2015 (Nova Scotia Environment, 2011). This disposal target was not met, as in 2015 the per capita disposal in NS was 380kg/person (B. Gordon, personal communication, September 24, 2015). The Solid-Waste Resource Management Regulations of NS were first created under section 102 of the Environment Act in 1994-95. These regulations establish a Resource Recovery Fund which:

- develops and implements industry stewardship programs
- funds municipal or regional diversion programs
- develops and operates a deposit-refund system for beverage containers

- develops education and awareness of source reduction, reuse, recycling, and composting
- promotes the development of value-added manufacturing in the province

The fund is administered by a board known as the Resource Recovery Fund Board (RRFB) – which was incorporated as a not-for-profit organization under the laws of NS in 1996. The RRFB supports organizations and businesses that collect, manage, recycle, and dispose of post-consumer waste materials in the province.

The RRFB operates a number of programs that divert post-consumer materials from landfill - these are referred to as priority materials by the RRFB NS Diversion and Business Development Program and are materials that have proven difficult to recycle for a number of reasons. The plastics that the RRFB have identified as priority materials are:

- Plastic containers #3 to 7: dairy and food packaging, some automotive fluids, some cleaners
- Plastic film #4 and #2: shopping bags, packaging wrap (around toilet paper, tissue boxes, insulation wrap, etc.), dry cleaner bags, pallet wrap
- Plastic products #1 to 7: toys, furniture, household products (laundry baskets, buckets, etc.), electronic casings
- Expanded polystyrene (EPS) #6 (Styrofoam™): disposable cups, food trays, foam packaging around new products

Most of these plastics are banned from landfill (Province of Nova Scotia, 2009; D. MacQueen, personal communication, March 26, 2015), however, as they have been recognized by the RRFB as priority materials it is evident that they are still being disposed of in landfills in appreciable amounts.

Additionally, the RRFB has been responsible for administering the beverage container deposit-refund program since 1996. The deposit-refund system was established as part of the Solid-Waste Resource Management Regulations of NS, which

ban certain beverage containers from landfill and require beverage distributors or retailers to charge a recycling deposit fee, which can then be partially regained at a recycling depot. The program supports diversion efforts by paying recyclers by weight for designated materials they have diverted from landfill. Similar programs have been implemented for milk cartons, tires, and used oil - with other stewardship agreements being negotiated on an on-going basis (Province of Nova Scotia, 2014b).

The impetus and the success of the above described programs depend entirely on the legislative structure supporting them. The bans give the first right of refusal to waste collectors, therefore if the bans are enforced waste generators would be required to recycle appropriately. The RRFB acts to support these bans when they are not working by implementing programs that manage materials that are difficult to capture and/or recycle. Even if a material is not banned the RRFB supports research and projects that work towards establishing non-landfill disposal routes for the material, and paves the way for more bans in the future.

1.5.3 MANAGEMENT METHODS OF PLASTICS IN NOVA SCOTIA

1.5.3.1 GENERAL OVERVIEW

The most recent study of plastics waste in NS estimated that 13.8% of plastics were diverted from landfill and sold to plastics recyclers in 2006 (RRFB, 2008). This is comparable to those European countries who lag behind the European average (26%) such as Malta (12%) and Cyprus (15%). However, in Europe the amount going to landfill was 38%, while 36% of plastics were burned for energy recovery (Plastics Europe, 2015). Therefore, much less plastics are going to landfill in Europe, and the average plastics mechanical recycling rate of 26% is still almost double the Nova Scotia plastics recycling rate.

Waste audits were undertaken by the RRFB in NS in 2011 and 2012. Landfills in NS reported that ~20% of all incoming material was a plastic of some type, with 58,550 tonnes of plastics in 2011 and 60,600 tonnes in 2012 (Figure 1).

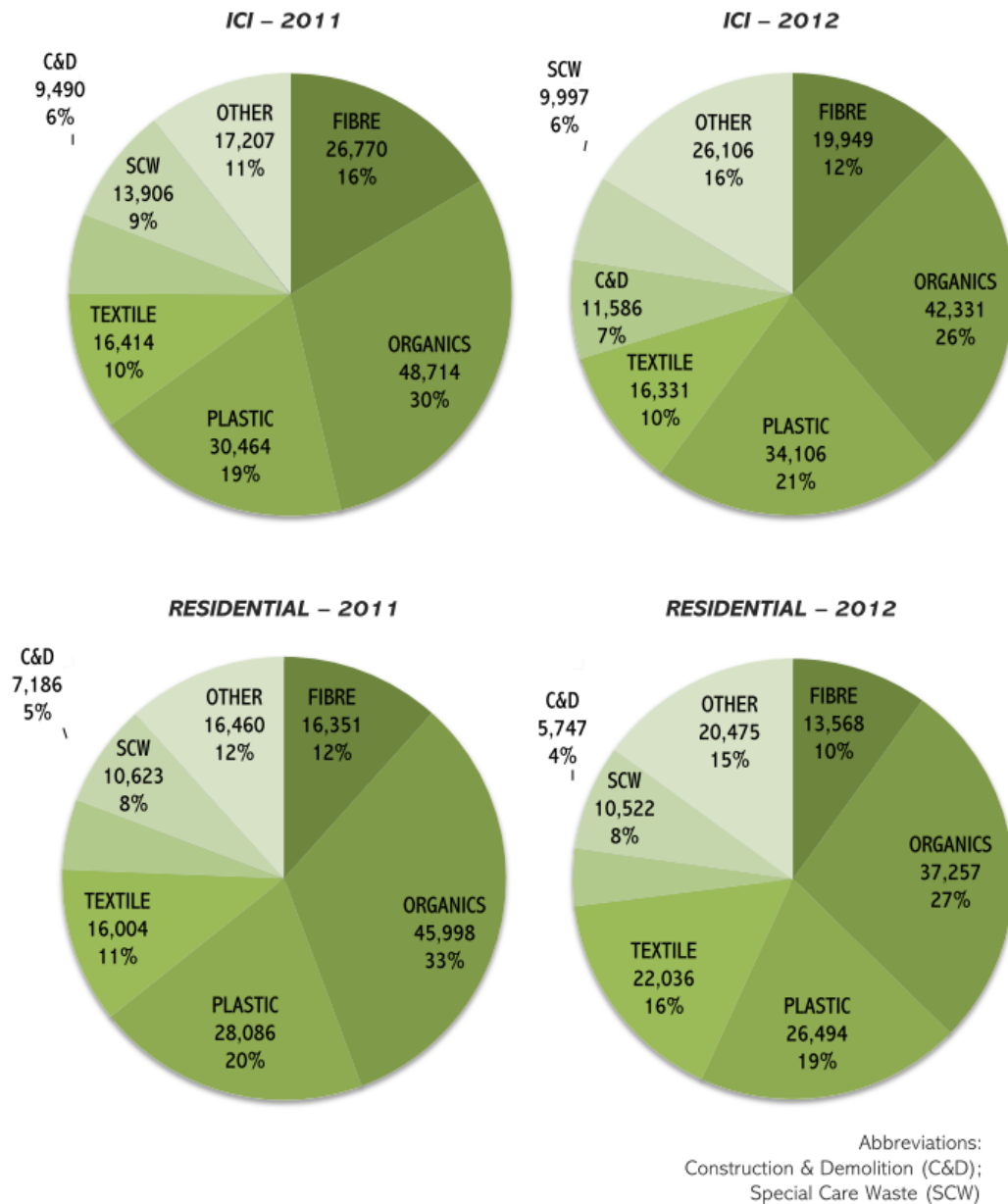


Figure 1: Amounts (t) and % of waste types entering Nova Scotia landfills (RRFB, 2012)

1.5.3.2 END-OF-LIFE AGRICULTURAL PLASTICS MANAGEMENT IN NOVA SCOTIA

Farm plastics generated in New Brunswick, Nova Scotia, and Prince Edward Island have been estimated at 2124 tonnes per year by CleanFARMS. Nova Scotia accounted for approximately 702 tonnes of this total (CleanFARMS, 2012). LDPE is the predominant plastic used on farms with silage film and bale wrap accounting for about 80%, followed by row covers and mulch film at 8% (CleanFARMS, 2012). CleanFARMS

reported that the majority of plastics waste generated on-farm are dumped, burned, or sent to landfill, a finding supported by data collected via the Nova Scotia Federation of Agriculture's *Environmental Farm Plan* (P. Brenton, personal communication, December 22, 2014).

1.5.3.3 DRIVERS FOR CHANGE IN NOVA SCOTIA

Mandate 1 of the RRFB of Nova Scotia is to fund municipal waste diversion programs across the province; Nova Scotia has made progress in reducing waste, having decreased the provincial disposal rate from 743 kg/person/year in 1990 to 380 kg/person per year in 2015 (Nova Scotia Environment, 2011; personal communication, B. Gordon, September 24, 2015). Our Path Forward: Building on the Success of Nova Scotia's Solid Waste Resource Management Strategy, published by the Government of Nova Scotia in 2011, recognizes that the stated disposal target of no more than 300 kg per person per year is ambitious, and will require new approaches to solid waste resource management (Nova Scotia Environment, 2011). By addressing the issue of APW management a large amount of plastics waste could be diverted from landfill, and from on-farm disposal.

1.5.4 MANAGEMENT OF LOW-VALUE WASTE STREAMS

There are many examples of waste streams that have progressed from landfill banes to valuable material sources, one of the most obvious being that of used tires. Stewardship programs such as the massive network in place for used tire recovery in Europe force the valorization of a waste stream, which in turn spurs innovative management strategies (Sienkiewicz et al., 2012). Programs for recycling used tires are now well established in many parts of the world because tires are disposed of in large quantities and are composed of energetically and materially valuable components. In recent years more attention has been paid to waste materials that are of such low economic and/or energetic value that they are being disposed of in unmanaged dumps or landfills - despite being produced in large quantities by industries such as

construction and demolition (C&D) and agriculture (Leiva et al., 2013; Tuttobene et al., 2009).

C&D waste management is a major issue globally. C&D waste is difficult to classify and is often mixed and/or contaminated with various materials; however, novel uses for these materials are being tested, and desirable physical properties (improved sound and fire insulation) have been observed in construction blocks made with recovered C&D waste (Leiva et al., 2013). Agricultural waste management is sensitive to the high economic costs associated with disposal of waste and the potential for negative environmental impacts on land used to produce food for human and non-human consumption. Many agricultural waste streams that are produced in large quantities are often disposed of in less than ideal methods, such as orange waste that is left to rot in the fields in some jurisdictions, with serious environmental consequences; in Italy it has been estimated that 350 000 to 450 000 tonnes of citrus waste is produced each year (Tuttobene et al., 2009). In Italy however, as in other industrial countries, citrus waste is used for energy recovery, flavor and fragrance enhancers, household cleaning supplies, and livestock feed (Braddock, 1999; Gentry et al., 2001).

One of the more ubiquitous low-value waste materials that is currently being addressed more widely in waste management is that of organics in municipal waste streams. Similar to APW and other low-value plastics municipal compost can be difficult to treat and process, and often yields products that are inferior to other options for similar uses (Farrell & Jones, 2009; Hargreaves et al., 2008). The organic fraction of municipal solid waste in Europe is as high as 40%, and the range of per capita biodegradable waste production globally is 10 to 115kg per year (Cesaro et al, 2016). Some European Union member states landfill 100% of the organic fraction of their waste streams, which speaks to the fact that difficult to recover low-value waste streams, no matter how ubiquitous, are often disposed of in landfill. However, states such as Denmark and Germany have reached less than 1% landfill rate for organic/biological waste (Jensen et al., 2016). Programs and processes that manage organic wastes and municipal compost have developed with the aid of legislation,

government management, and public funding (Environment Canada, 2013; Farrell & Jones, 2009)

The preceding examples of waste management initiatives are part of a shift in needs and mindset that require organizations to tackle waste streams that are more complicated to collect and process than other waste streams, and are therefore more difficult to reconcile economic and energetic outlay with the returns gained.

1.5.5 ENGAGING STAKEHOLDERS IN THE MANAGEMENT OF LOW-VALUE WASTE STREAMS

Literature on the development of recycling programs suggests that legislation provides the impetus for waste generators and waste managers to organize and fund diversion schemes, such as the case of C&D waste (Agamathu, 2008), and that waste generators need education and support to manage low-value waste streams such as plastics (Martin et al., 2006; Sidique et al., 2010; Sidique et al, 2010a). Examples of useful support to encourage plastics recycling would be the provision of storage options for EOL plastics (Martin et al., 2006), and convenient and affordable options for disposal (Sidique et al., 2010a). These enablers, combined with encouragement (e.g. penalties, rewards) and engagement (e.g. communication, feedback) tools are thought to help sustain any changes made (Timlett & Williams, 2008; Defra, 2006). Voluntary extended producer responsibility (EPR) programs have been seen to be at least as successful as mandatory programs, though it is likely that one of the primary incentives to participate in voluntary programs is to avoid punitive regulations (Nahman, 2010), and are often simply a desirable option for industry stakeholders as a way to avoid potentially harmful regulations (Widmer et al., 2005). EPR originated in Sweden and Germany in the early 1990's as a policy strategy with the potential to: 1. Spur innovation in packaging design; 2. Access private sector know-how to achieve public sector goals; 3. Include waste management costs in product prices; 4. Shift waste management costs to producers and consumers (Lifset et al., 2013).

In the specific case of farmers, the propensity of an individual to participate in any type of environmental stewardship program, such as appropriate waste disposal, is dependent on a number of factors including the prevalent socio-cultural context, the attitudes, and the values and beliefs of the individual in question (Ajzen, 1991; Beedell and Rehman, 1999). Ajzen (1991)'s Theory of Planned Behaviour describes the interplay between such factors and the likelihood that a person will choose to participate in or engage with a program. However, the socio-cultural context, attitudes, and values and beliefs of individuals (even those in ostensibly similar situations) will vary greatly. It is important to note, also, that the average person will not engage in a practice if they are not sufficiently knowledgeable in it and confident that the practice is beneficial and appropriate (Kennedy et al., 2009). Additionally, it has been suggested that voluntary measures are better received in the farming community than mandated or legislated measures as voluntary measures and stewardship programs speak to the personal ethic of farmers as independent and responsible land managers (Plummer et al., 2008). One of the largest and best known examples of an agricultural stewardship program is Australia's National Landcare Program, which has 120 000 volunteers and has been active for over 20 years (Plummer et al., 2008).

1.6 METHODS

1.6.1 RESEARCH APPROACH

This research used a mixed methods approach. A mail-out survey was sent to farmers in NS that sought quantitative and qualitative data. Additionally, data was collected from waste management organizations as well as industry and government representatives in NS and other jurisdictions. Survey questions and research methodologies were reviewed and approved by the Dalhousie University Research Ethics Board.

1.6.2 METHODOLOGY

1.6.2.1 MAIL-OUT SURVEYS TO FARMERS IN NOVA SCOTIA

Dillman's work (Dillman et al., 2008) support the notion that the best way to reach a large number of individuals is through the use of a mail-out survey. Therefore, to engage with NS farmers during this research surveys were sent out by the Nova Scotia Federation of Agriculture (NSFA) using their mailing list of 2374 farms, which represents approximately 61.5% of active farms in NS (P. Brenton, personal communication, December 22, 2014; Province of Nova Scotia, 2014). The surveys were accompanied by self-addressed and pre-paid postage envelopes. The survey consisted of a variety of question types including single choice, multiple choice, write-in answers, and 5 point Likert scale questions.

The Likert scale is employed ubiquitously as a measure for attitude and opinion (Boynton and Greenhalgh, 2004), the 5 point Likert scale was chosen as a satisfactory tool for gaining knowledge regarding the presence or absence of a selected attribute, while allowing for gradation of responses, and allowing for the answers to be analyzed quantitatively – which is more difficult to achieve with open-ended questions (Dawes, 2008; Dillman, 2009; Gliem and Gliem 2003). The two Likert scale questions were framed in opposite dispositions to ensure that the reader was carefully considering each question, as similar responses given for the two questions would have indicated a contradictory mindset (Bryman and Teevan, 2005). The responses to open-ended write-in questions were coded thematically and analyzed using Microsoft Excel software. The survey generally followed Dillman's method in structure and procedure, however, follow-up reminders were not sent due to budget constraints (Dillman et al., 2008). It was also made available online using Opinio software accessed through Dalhousie University. The online survey was designed to be exactly the same as the mail-out survey with one question added to determine whether or not the respondent was included in the original NSFA mailing list or if they should be added in addition.

The survey was designed to obtain data on the following:

1. Farmer demographics
2. Commodities produced on the farm
3. Types and amounts of farm plastics
4. Practices and needs of farmers related to:
 - a. Farm plastics management
 - b. Farm plastics recycling
5. Opinions of the farmer on:
 - a. Environmental aspects of farm plastics management
 - b. Willingness to support a farm plastics recycling program
 - c. Level of responsibility of different stakeholders to organize and manage a farm plastics recycling program

See Appendix A for sample questionnaire.

1.6.2.2 SURVEYS FOR ADDITIONAL STAKEHOLDERS

Three additional surveys were developed to gain insight from other stakeholder groups about the operational and management considerations related to plastic recycling from various perspectives. The surveys were developed and tested with the assistance of personnel within the different organizations and were administered primarily by email. This method was chosen as the most practical and cost-efficient way to contact the maximum number of stakeholders (Sinclair et al., 2012).

The first additional survey was developed to obtain information on the operational practices and capabilities of stakeholder groups that manage EOL low-value plastics. It was tailored for and administered to representatives of:

1. Regional waste management organizations in NS
2. Private waste management contractors in NS

3. Plastics buyers/recyclers in NS

The second additional survey was developed for municipal and provincial government representatives to identify current legislation pertaining to the management of EOL low-value plastics, as well as any expected changes to legislation or practices.

The third additional survey was developed for organizations that recycle APW in other jurisdictions. These organizations were identified and selected through internet searches and guidance from individuals knowledgeable in APW recycling.

See Appendices B, C and D for sample questionnaires.

1.6.2.3 DATA ANALYSIS

The mail-out survey was sent out to 2374 NS farmers representing approximately 61.5% of active farms in the province (P. Brenton, personal communication, December 22, 2014; NS Department of Agriculture, 2014); and was accompanied by self-addressed and pre-paid postage envelopes. It contained a series of questions, which included single choice, multiple choice, write-in answers, and Likert scale.

The remaining two surveys distributed in NS were done via email to waste management professionals. The surveys sought information on practices, policies, and legislation regarding plastics waste with emphasis on APW. The population of waste-generator facing waste managers was determined by consultation with the Resource Recovery Fund Board and individual municipalities, surveys were returned from all of the material recovery facilities (MRFs) in the province as well as a number of landfills and transfer stations. The population of waste managers working at the legislative and regional management levels was determined by contacting Nova Scotia Environment.

The survey questions and resultant answers were reviewed and approved by two employees of NSE.

The third survey that was distributed by email was sent to APW recycling organizations in Iceland, Ireland, Norway, Germany, and Prince Edward Island. These organizations were identified and chosen with assistance from Barry Friesen of CleanFARMS.

The responses from the surveys were recorded, tabulated, and tracked using Microsoft Excel software. Quantitative results, such as amount of plastic type generated on farm each year, were summed within the software and verified using multiple summation approaches. Sums were then extrapolated to the entire survey population, and to the entire population of farms in NS. The management and analysis of the survey data was completed using Microsoft Excel and Minitab 16. Microsoft Excel and Minitab 16 were used to generate basic descriptive statistics and to carry out analysis of variance statistical techniques (Bryman, 1996). The open-ended write-in answers were analyzed using thematic coding, and were organized, categorized, and summed using Microsoft Excel software. The thematic codes were developed by reviewing the responses holistically and using keyword searches to evaluate the prevalence of identified themes.

1.6.2.4 STATISTICAL ANALYSIS

The mail-out survey response population was assessed to be representative of the broader population of farmers in NS by considering a number of factors. Firstly, demographic and geographic comparisons were made between the response population and the general population of farmers in NS; it was observed that the balance of commodities produced was comparable between the groups (NS Department of Agriculture, 2014; Statistics Canada, 2015) and that every farming region of NS was represented. Secondly, using a confidence level of 95% (z -score = 1.96), a standard deviation of 0.5, and a margin of error/confidence interval of $\pm 5.91\%$ resulted in a

required a response population size of 275 returned surveys (Weiss & Weiss, 2012). The calculation was completed as:

Necessary sample size = $(Z\text{-score})^2 * StdDev * (1-StdDev) / (\text{margin of error})$

$((1.96)^2 * 0.5(0.5)) / (0.0591)^2$

$(3.8416 * 0.25) / 0.00349$

$0.9604 / 0.00349$

275.18

275 respondents are needed

The confidence level and margin of error gauge how well the results of the survey represent the greater population. For example, the confidence level and margin of error stated above mean that the data collected would be within a range of $\pm 5.91\%$ of the true value of the population 95 times out of 100 (Bartlett et al., 2001). As data were collected from 275 respondents we were further assured that the response population could be said to represent the general population of farmers (Bartlett et al., 2001).

Finally, the response rate of 12% was considered to be acceptable for a mail-out survey with no reminders or incentives – especially in that the farming community is considered to give low response rates and that the survey was not sent during the optimal time window for farmers, January and February (Pennings et al., 2002).

A primary intent of this study was to gather more direct estimates of plastics use in the agricultural sector of NS and to determine what primary producer perceptions were regarding disposal of these materials. Moreover, the study was designed to examine some of the social and practical barriers to implementing an agricultural plastics recycling program. As such, the design of the mail-out survey questionnaire only included two quantitative questions on a 5 point Likert scale, which allowed for testing

via analysis of variance statistical techniques. We attempted to statistically examine relationships between responses to these questions and other factors such as gender, years in operation, income derived directly from farming, and age. The survey used in our study is typically a first step to elucidate general patterns and trends within a population leading to follow up questionnaires designed to be more quantitative. The outcome of the study identified a number of trends in respondent perceptions and willingness to change which would be further explored in subsequent work.

CHAPTER 2: ATTITUDES TO THE RECOVERY AND RECYCLING OF AGRICULTURAL PLASTICS WASTE: A CASE STUDY OF NOVA SCOTIA, CANADA

The following chapter was published in *Resources, Conservation & Recycling* (doi.org/10.1016/j.resconrec.2016.02.011) and was authored by Isaac Muise, Michelle Adams, Ray Côté and G. W. Price; it has been modified to improve the flow for the reader and to integrate the writing into the broader document.

2.1 INTRODUCTION

Plastics, or synthetic polymers, are usually derived from petrochemicals and require energy (often fossil-fuel based) for their production. Approximately 4% of world oil and gas production is converted to plastics and the production process for plastics consumes the energy equivalent to an additional 3-4% (Al-Salem et al., 2009). Industrial scale production of plastics began in the 1940's and has grown at an estimated rate of 10% per year since that time, with global production increasing from 1.3 million tonnes in 1950 to 300 million tonnes in 2014 (Plastics Europe, 2015; Panda et al., 2010; Al-Salem et al., 2009). While amounts vary depending on jurisdiction, the use of plastics for packaging represents upwards of 40% of plastics demand – much of it for single-use packaging (Plastics Europe, 2015; Brems et al., 2012; Al-Salem et al., 2010). Many plastics are discarded in the environment or landfill because they are not easily recycled or do not generate profit when recycled. Brems et al. (2012) consider at length the reasons why certain plastics are difficult to recycle, including the high costs associated with transportation, storage, sorting, and processing, and the difficulties of implementing collection programs. Difficult to recycle plastics are often contaminated and structurally degraded LDPE, clam-shell packaging (usually made with poly-vinyl chloride), polystyrene and other plastics that are mixed together with other waste streams. Additionally, the necessary economies of scale necessary to profitably recycle these plastics are often such that operations are located in the developing world and are not easily established in the jurisdictions where much of the plastics waste is generated. In 2013, Canada and the United States recovered 450,000 tonnes of low-value plastics

(primarily film) for recycling (74% increase since 2005) but nearly 60% of these recovered plastics were shipped overseas (American Chemistry Council, 2015). China has become the primary recipient of the low-value plastics, importing 70% of the globally traded recovered plastics in 2012 (Brems et al., 2012).

Agricultural plastics are a category of low-value, post-consumer plastics waste, which in many jurisdictions have largely been ignored by recyclers. The estimates of agricultural plastics used and agricultural waste plastics generated in the literature vary widely; they range from 2 to 6.5 million tonnes of APW generated globally per year (Scarascia-Mugnozza et al., 2012; Briassoulis et al., 2013). Plastics have become an integral part of many agricultural operations, including horticultural mulch films, bale and silage plastic, and fertilizer storage. Some of these major uses allow for an extended growing season, reduced water use, and reduced herbicide and pesticide use (Picuno et al., 2012). Plastics used in livestock production improve the quality and storage life of feed. Diversion of these plastics is a challenge for many governments and waste management researchers (IFFPG, 2015; PolieCO, 2015; Urvinnslusjodur, 2015; Briassoulis et al., 2010; Levitan and Barros, 2003). APW diversion programs that exist in Europe are managed through the co-operation of governments and academic researchers (Award Project, 2015; AgroChePack, 2013). Programs and networks that recover and recycle plastics waste in jurisdictions of Europe have been active since at least the 1989 (Gront Punkt Norge AS, 2015; Birch Farm Plastics, 2016) and have recently been buttressed by the 2011 establishment of an APW working group in the European Association of Plastics Recycling & Recovery Organizations (epro), however, 45.2% of APW in Europe was sent to landfill in 2012 (epro, 2012).

In many jurisdictions, APW is discarded using one of four disposal methods, each with its own negative environmental consequence. These include: on-site burning of APW, on-site burial, disposal in municipal landfills, and illegal dumping (Scarascia-Mugnozza et al., 2008). Briassoulis et al. (2010) identifies negative repercussions of

burning plastics in an open environment including the release of numerous harmful substances into the broader environment (water, soil and air). Bio-accumulation of these harmful substances in plant materials may occur if adjacent fields are contaminated. Burying APW contributes to degradation of soil quality characteristics, and can result in soil contamination, which poses possible threats to local ecosystems. Disposal of APW in terrestrial and aquatic environments also contributes to aesthetic pollution, threats to domestic and wild animals, and the loss of material resources and energy; these issues are magnified when materials are disposed of illegally in unmanaged sites (Briassoulis et al., 2013).

The most recent study of plastics waste in Nova Scotia estimated that 13.8% of plastics were diverted from landfill and sold to plastics recyclers in 2006 (RRFB, 2008). This is comparable to those European countries who lag behind the European average (26%) such as Malta (12%) and Cyprus (15%); however, the amount going to landfill was only 38%, due to the fact that 36% of plastics were burned for energy recovery (Plastics Europe, 2015). Therefore, much less plastics are going to landfill in Europe, and the average plastics mechanical recycling rate of 26% is still almost double the Nova Scotia plastics recycling rate.

Farm plastics generated in the Atlantic Canadian provinces, including New Brunswick, Nova Scotia, and Prince Edward Island have been estimated at 2124 tonnes per year. Estimates suggested that Nova Scotia accounted for approximately 702 tonnes per year of the total (CleanFARMS, 2012). LDPE is the predominant plastic used on farms with silage film and bale wrap accounting for about 80%, followed by row covers and mulch film at 8% (CleanFARMS, 2012). CleanFARMS reported that the majority of plastics waste generated on-farm are dumped, burned, or sent to landfill, a finding supported by data collected via the Nova Scotia Federation of Agriculture's *Environmental Farm Plan* (P. Brenton, personal communication, December 22, 2014).

Beginning in the 1990's in North America the quantity of plastics waste on farms began to be documented in professional, government, and university reports. For example in 1997, a study completed by the Waste Management Institute at Cornell University found that waste management was the single most often cited issue with plastics use on farms. Moreover, eighty-five percent of the farmers surveyed (n = 77) said they would be interested in a recycling program if available, but would not be willing to pay for the program (Rollo, 1997). Another study completed in 2003 by Levitan and Barros noted that the management of farm plastics had significantly lagged behind other plastic waste streams, in large part because it was legal to burn/bury agricultural plastics on-site. The study also found that the economics of a recycling program was not well understood due to the low-value and the technical challenges associated with contamination and degradation of the materials (Levitan and Barros, 2003).

At that time, there were a number of initiatives undertaken in various jurisdictions to try and address this issue. These included: an industry-sponsored network for collecting HDPE pesticide containers; an industry-sponsored program based in Ontario, Canada, that picks up, pays for, and re-processes polystyrene nursery flats and trays; a LDPE nursery film collection program in New Jersey accessible to out-of-state producers; a plastic lumber re-processing technology based in Prince Edward Island, Canada, capable of handling contaminated LDPE plastics used in dairying; and a plan at Penn State University to develop a plastic fuel nugget that can be burned for energy recovery (Levitan and Barros, 2003). More recently, Briassoulis et al. (2013a) have proposed technical specifications for the best economic and environmental valorisation of APW in the context of European agriculture and plastics management. There is little evidence in literature to suggest whether or not farmer attitudes or challenges are markedly different today than they were in the 1990's and early 2000's.

The purpose of this study is to investigate the attitudes in the agricultural sector toward recycling and disposal of APW in order to identify the current barriers towards

implementation of a diversion and recycling program. The study takes a case study approach with a specific focus on Nova Scotia, Canada which has a strong legislative history of sustainable waste management, but yet does not have an ongoing management plan for the diversion of APW from the existing waste stream.

2.2 MATERIALS AND METHODS

2.2.1 SCOPE OF THE RESEARCH

The scope of the paper is to evaluate bottlenecks and challenges to implementing plastics diversion and recycling programs from dispersed generators, such as in agricultural contexts. The first step was to conduct a literature review of existing APW recycling programs and challenges associated with managing geographically dispersed plastics waste streams. The next step was to evaluate attitudes towards plastics use, generation, and disposal options by targeted APW generators. The final step was to survey waste management groups, as well as industry and government representatives to examine prevailing concerns related to implementation of APW diversion and recycling programs. This research used a mixed methods approach in order to determine how the attitudes of rural producers might impact development of an APW diversion and recycling program. Survey questions and research methodologies were reviewed and approved by Dalhousie University's Research Ethics Board.

2.2.2 ANALYTICAL APPROACH

2.2.2.1 MAIL-OUT SURVEYS TO FARMERS IN NOVA SCOTIA

Dillman et al. (2008) support the notion that the best way to reach and engage large numbers of representative participants is through the use of a mail-out survey. A questionnaire was developed to obtain a range of quantitative and qualitative data covering two categories (see Appendix A). The first category (questions 1 to 6) related to the agricultural production system such as: agricultural sector, farmer demographics, and commodities produced on farm. The second category (questions 7 to 15) more explicitly examined the types and amounts of farms plastics generated, current APW

practices on-farm, and a range of attitudes related to APW management and responsibility.

The survey was sent out to 100% of the 2374 NS farmers registered with the NSFA, representing approximately 61.5% of active farms in the province (P. Brenton personal communication, December 22, 2014; NS Department of Agriculture, 2014); and was accompanied by self-addressed and pre-paid postage envelopes. It contained a series of questions, which included single choice, multiple choice, write-in answers, and Likert scale (1 to 5) responses. The open-ended write-in answers were analyzed using thematic coding, which was organized, categorized and summed using Microsoft Excel software. The thematic codes were developed by reviewing the 275 responses holistically and using keyword searches to evaluate the prevalence of identified themes. The survey generally followed Dillman's method in structure and procedure, however, follow-up reminders were not sent due to budget restraints (Dillman et al., 2008). It was also made available online using Opinio software accessed through Dalhousie University. The online survey was designed to be exactly the same as the mail-out survey with one question added to determine whether or not the respondent was included in the original NSFA mailing list or if they should be added in addition.

A survey was also distributed - by email - to waste management professionals in NS. The survey sought information on practices and policies regarding plastics waste with emphasis on APW. The population of waste managers was determined by consultation with the RRFB and individual municipalities, surveys were returned from all of the material recovery facilities (MRFs) in the province as well as a number of landfills and transfer stations. It should be noted that the response to this survey was intended to elicit a better understanding of the operational barriers and opportunities for APW recycling in the region and will not be discussed as a specific research output. Instead these insights informed a better sense of 'the possible' in this context.

2.2.3 STATISTICAL ANALYSIS

Survey responses were recorded, tabulated, and tracked using Microsoft Excel software. Quantitative results, such as amount of plastic type generated on farm each year, were summed within the software and verified using multiple summation approaches. Sums were then extrapolated to the entire survey population, and to the entire population of farms in NS.

2.3 RESULTS

2.3.1 RESPONDENT DEMOGRAPHICS

The majority of survey respondents were male (78%) and aged 51 and over (72%). This is relatively consistent with the 2011 NS agricultural census statistics which show that 74% of farm operators are male and that 54% of farmers are aged 55 years and over (Statistics Canada, 2015). The majority of respondents have operated their farm for 21 years or more (57%) and about half earn a majority of their income from farm activities (49%). The top three commodity groups reported in the respondent population were *vegetables/fruits/plants* at 45% (the result of collapsing the categories *vegetables/fruits*, *hay/silage*, and *grains/cereals*), *beef cattle* at 17% and *dairy cattle* at 6%. This is consistent with the reported provincial agricultural statistics where *vegetables/fruits/plants* farms were reported to represent 60%, *beef cattle* at 11%, and *dairy cattle* at 7% (NS Department of Agriculture, 2014). *Vegetables/fruits/plants* farms are somewhat underrepresented in the respondent population which is attributed to the fact that certain plastics used on these farms were not addressed in the mail-out survey.

The demographics of the farm operators and the commodities produced on their farms are particularly important for policy-makers and planners. Demographics can greatly influence engagement strategies, so a clearer understanding of the stakeholder characteristics will improve the likelihood of positive farmer interaction and connection,

as well as better inform the development of effective farmer education programs related to APW management planning and implementation.

2.3.2 Current APW generation

Respondents were asked to estimate the amount of EOL plastics generated annually on-farm and were provided a list of typical products used on farm including: a) plastic baling twine, b) silage plastic, c) grain bags/tubes, d) bale plastic, e) plastic containers, and f) mixed agricultural plastics. They were instructed to select a weight category that represented the total amount of each type of plastic generated annually or to provide actual estimates (in kilograms). A total of approximately 62 tonnes of APW was reported by the 275 respondents. Figure 2 shows the reported waste amounts with upper and lower limits relating the size of the range of the weight categories that the respondents could choose from. When extrapolated to the broader population - based on factors such as commodity mix, size of farms, income reported from farming products – it was estimated that farms in NS generate 900 tonnes of APW annually. Plastics totals were extrapolated to the broader population of farms in order to provide an estimate to policy makers of the annual APW generation in NS. The calculated amount of 900 tonnes is significantly higher than previously reported estimates of APW generation rates at 702 tonnes per year (CleanFARMS, 2012). The CleanFARMS report relied on correlations between plastics use and farm productivity, where there was an average amount of APW associated with a specific unit of production for each commodity, and not on empirically derived data. Figures 3, 4, and 5 show absolute totals of respondent answers to questions as a percent of total responses and have not been extrapolated to the broader population of farms in NS.

2.3.3 Current on-farm APW management

The primary management pathways for APW were *transport to landfill* and *roadside collection for landfill*, representing 50% of responses (Figure 3). A number of

responses (~18%) indicated some kind of recycling activity took place, while 10% of responses indicated that plastics were burnt on-farm.

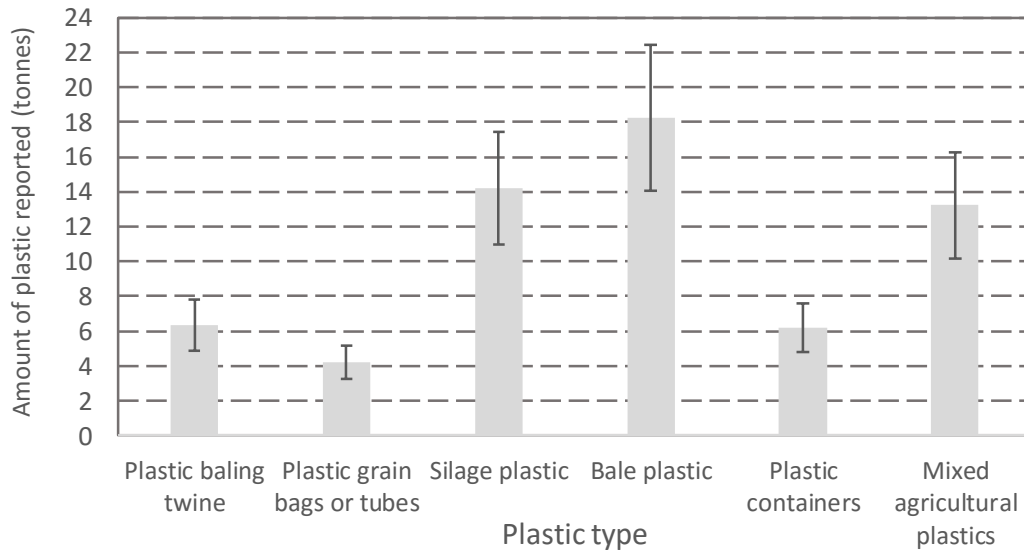


Figure 2: Reported amounts of agricultural plastic waste generated (tonnes) among respondents in Nova Scotia

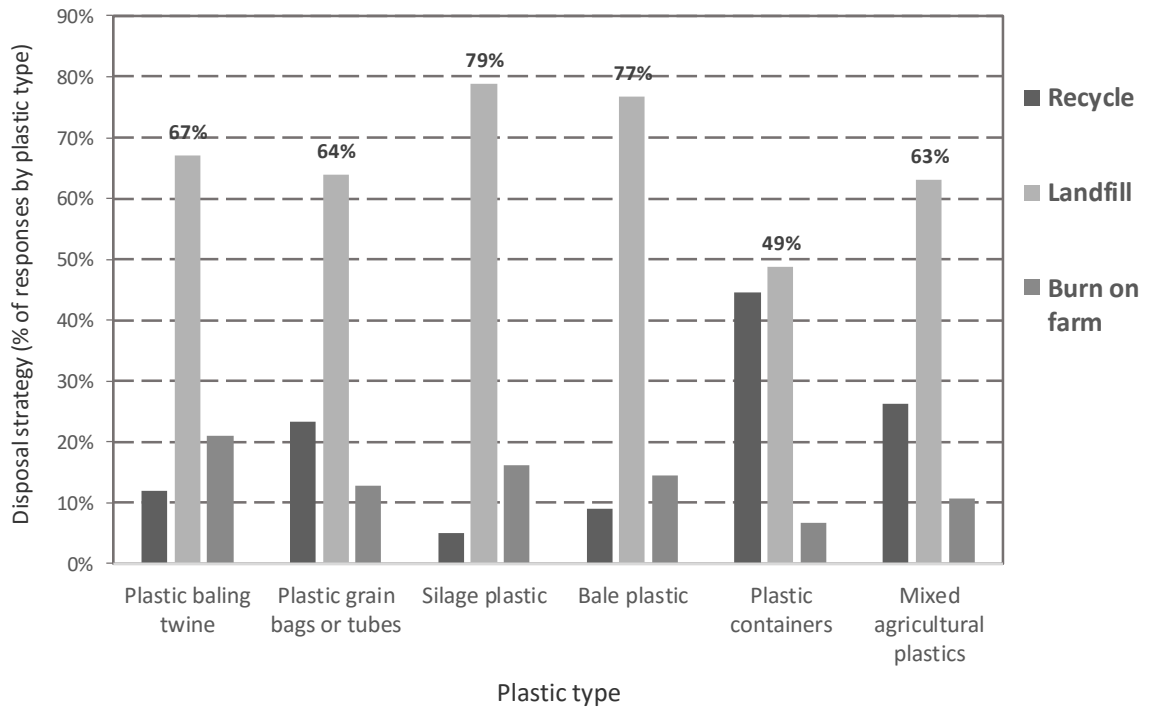


Figure 3: Management method chosen by agricultural respondents in Nova Scotia as a percent of the number of times chosen for each plastic type

2.3.4 RESPONDENT ATTITUDES TOWARD APW MANAGEMENT

Specific questions were designed to gain insight into the farmers' attitudes toward various elements of APW management. The questions explored farmer perspectives on various disposal/management options for APW, willingness to integrate various APW management options into their own on-farm operations, willingness to pay to support an APW recycling program, and opinions about the level of responsibility of various stakeholders for funding and administering an APW recycling program.

2.3.4.1 FARMER ENGAGEMENT

The respondents revealed a strong desire for *farm plastics waste to be recycled or disposed of in some other sustainable manner* (69%, n = 187), and that *disposal of farm plastics waste in a public landfill is not an adequate method* (50%, n = 134). Respondents overwhelmingly felt that sustainable recycling or disposal was required for APW (90% of all respondents) (Figure 4). Despite current on-farm disposal practices, landfilling was not viewed as an acceptable choice of APW management suggesting that, in principle, an APW recycling initiative might be accepted.

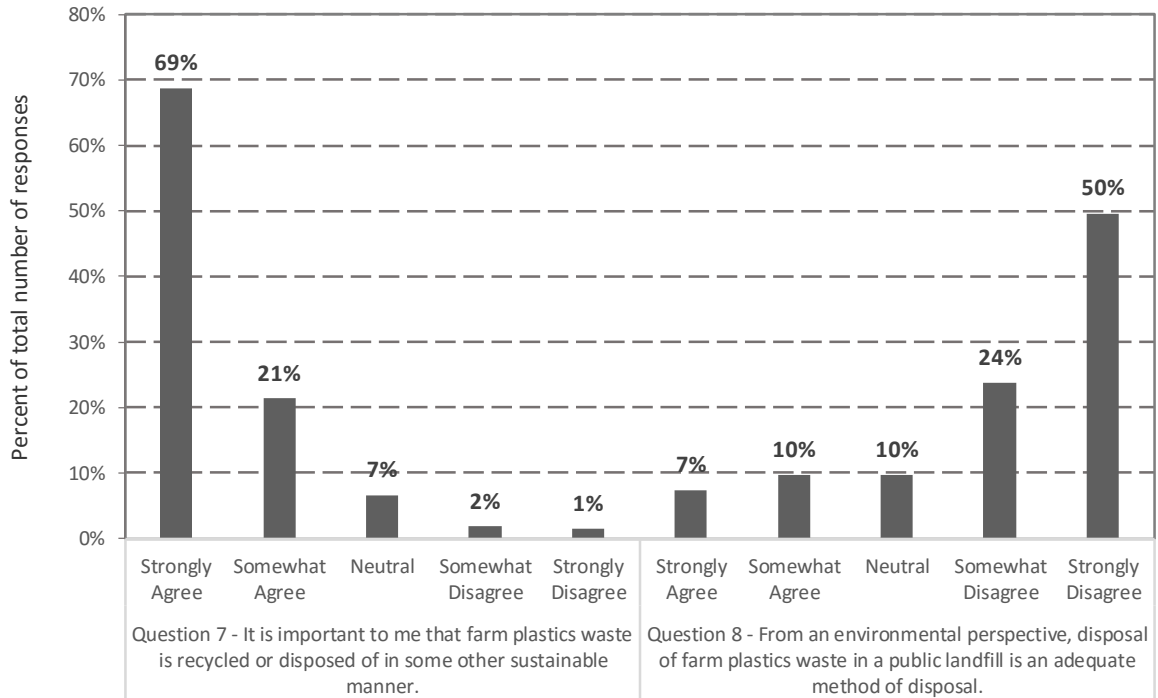


Figure 4: Attitudes of agricultural respondents in Nova Scotia towards APW management methods, collated from survey questions 7 and 8 and presented as a percent of total responses

The degree to which farmers would modify their behaviour and the barriers associated with this transition were also addressed through the questionnaire. Respondents were asked if they would undertake activities such as separating, delivering to a depot, or storing on-site for pickup (Figure 5).

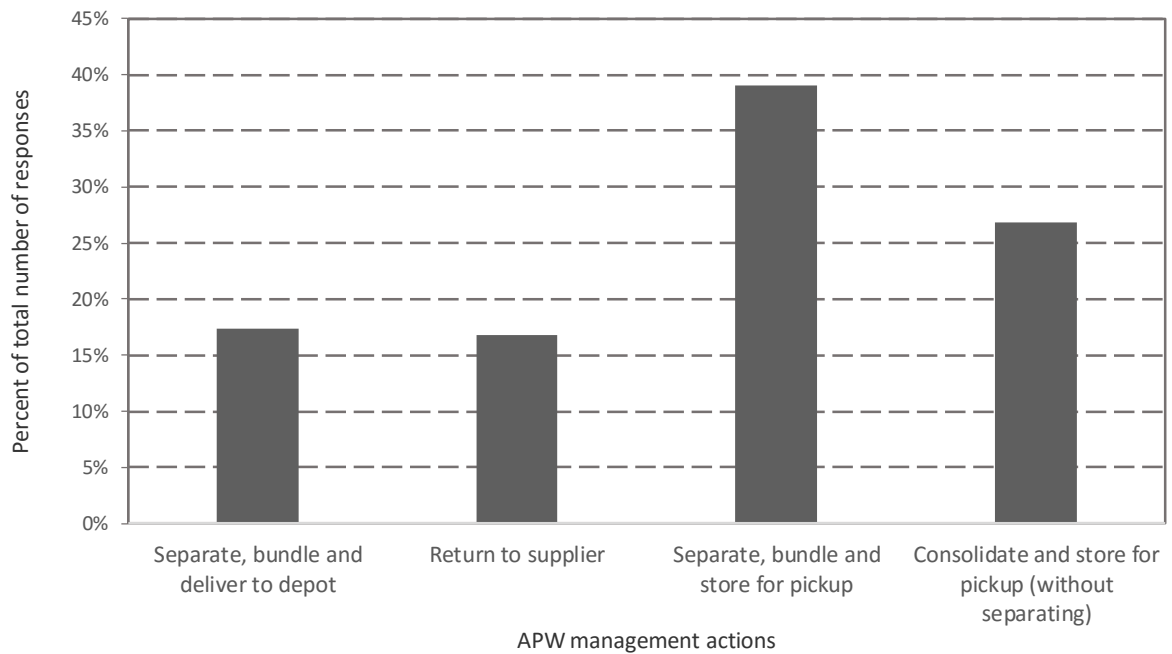


Figure 5: Actions agricultural respondents in Nova Scotia would choose in order to assist APW collection if a program was implemented

The option *separate, bundle, and store for pickup* was chosen 39% of the time, followed by *consolidate and store for pickup (without separating)* at 27%. Actions that required farmers to transport APW either to a depot or to a supplier return facility were less popular (with the exception of plastic containers). A majority of responses (66%) indicated a willingness to perform some kind of consolidation activities to make the material ready for pick up but only 34% indicated farmers would be willing to transport the APW in addition to any on-farm collection and preparation.

The survey also sought barriers impacting respondents' ability to undertake one of the above actions, specifically related to *consolidating plastics into one location on farm* to enable some kind of collection. The open-ended responses were coded thematically - analysis requires identifying, examining, and recording patterns and themes within the data - and from these, important phenomena related to the research questions were highlighted. Contrary to expectations, 45% of farmers stated clearly they did not perceive there to be any barriers to participating in a recycling program (by

collecting and consolidating the plastics for easy collection) while approximately 20% of respondents noted lack of storage space as a major barrier, and 14% pointed to problems such as time, convenience, and lack of motivation as barriers to collecting and consolidating APW. The idea that the plastics are too dirty or degraded to be recycled was often cited as a significant barrier by recyclers and municipal waste managers but only 10% of farm respondents mentioned it as a barrier to collecting and consolidating plastics on-farm for recycling.

Although respondents expressed reservations about various elements related to their participation in a new APW diversion program, the overall results suggest a positive engagement would be possible. For example, a program that requires farmers to transport APW to collection depots would be met with resistance but data suggest a curbside pickup option would be supported.

2.3.4.2 PROGRAM FUNDING AND DELIVERY

Respondents were asked to identify the financial amount they would be willing to contribute to support an APW management program. The amounts they could choose from were dollar amounts that would be paid on top of a stated theoretical amount being spent on a type of farm plastic (bale wrap). A majority of farm respondents (>56%) were prepared to pay between 1% and 4% of the amount already being spent on plastics, while 31% would not be willing to pay for such a program. Less than 5% of respondents would pay between 5% and 10% of the up-front cost of farm plastics. This establishes potential acceptable lower and upper limits for fees imposed on the farmer to support an APW recycling program.

Respondents were asked to prioritize the sources of funding and management of an APW recycling program from four groups. The groups included a) plastics producer/dealer/importers, b) farmers, c) municipal government, or d) provincial/federal governments. These four groups were included because they are

common stakeholders in waste management programs. Government agencies are often expected to facilitate waste management directly or indirectly, and the end users of materials are burdened with disposing of the wastes generated. In some instances, EPR legislation, where implemented, has obliged the producers/dealers/importers of materials to pay for the management of the waste they sell into the market (Sachs, 2006).

Respondents indicated that they prefer the *plastics producer/dealer/importer (s)* to bear the responsibility (financial and operational) of such programs, being selected 45% of the time. This was followed by the *farmer*, selected by 21%, *the provincial/federal government* at 19%, and the *municipal government* at 15%. Interestingly, more farmers place the responsibility of funding and managing a program on the *producer/dealer/importer* and the *farmer*, and less on the *municipal or provincial/federal governments*, despite the fact that waste diversion/recycling programs are typically operated by municipal operations and the legislation related to what is diverted and what is permitted to be landfilled falls under provincial jurisdiction. The respondent population of farmers theoretically assume a central role in the financial and operational management of an APW recycling program, an important consideration from a planning and policy perspective.

2.3.5 VARIATIONS IN FARMING COHORTS

The cost-efficiency and effectiveness of an APW recycling program may be increased by targeting sub-sets of the farming community who may represent a disproportionately high percentage of the total amount of APW generated in NS, or a more easily engaged cohort. Analysis of specific cohorts was undertaken to identify who produce the most plastics, and what idiosyncrasies exist that could have bearing on the effectiveness of a program. For example, a program that targets the *dairy cattle* and *vegetables/fruits* farmers would engage with the groups that produce the majority of APW in NS. The data show that *dairy cattle* farms produce much more plastics waste per

capita than *vegetables/fruits* farms, but because there are more of the latter represented in this study the total plastics generated per cohort are not disparate. Additionally, official NS statistics show that *vegetables/fruits* farms are underrepresented in this study, and so it can be assumed that the APW produced by this cohort is more than what is reported here. Interestingly, the data show that *beef cattle* farms report burning plastics twice as often as any other group. Highlights of the cohort analysis are shown in Table 1 below.

Table 1: Responses from survey respondents aggregated according to farming type.

	% of respondent population	Plastics waste generated		APW management practices	Willingness to act to facilitate an APW recycling program	Notes
		Respondent population	Extrapolated to NS farm population			
Dairy farmers	13%	26.2 tonnes	372 tonnes	Primarily send to landfill – burn as often as recycle	Consolidate on farm (without separating)	N/A
Fruits and vegetables farmers	30%	17 tonnes	242 tonnes	Primarily send to landfill – recycle more often than other cohorts	Consolidate on farm (without separating)	N/A
Full time farmers that generate >45 kg of bale and/or silage plastic	20%	24 tonnes	338 tonnes	Primarily send to landfill – burn plastics – do not recycle any bale or silage plastic	Consolidate on farm (without separating)	50% of these are dairy farmers
Age demographics and undesirable disposal practices	20% of respondents report burning plastic(s) on-farm - >80% of these farmers are age 51+ - 50% have operated their farm for >30 years – these farmers were more often than not satisfied with their current methods of plastics disposal					

2.4 DISCUSSION

2.4.1 ENGAGING THE FARMING COMMUNITY

It was found that the basic demographics and commodity mix do not vary excessively between this study and official NS statistics, with the noted underrepresentation of *vegetables/fruits/plants* farms, and the slight overrepresentation of *beef cattle* farms. This suggests that the survey responses can be seen as representative of the broader views of the NS farming community.

It appears that while some farmers are not sufficiently dissatisfied with the practices of landfilling and/or burning to warrant their own individual action to find alternative options, they did emphasize the need for a recycling program. However, the program needs to be easy to engage with and must not require the farmer to invest significant financial resources or time. Similar views were expressed by farmers during United States farm waste studies in both 1997 (Rollo, 1997) and 2003 (Levitan and Barros, 2003). The majority of farmers in this study reported that: a) farm plastics should be recycled or disposed of in some other sustainable manner; b) sending APW to landfill is not an ideal option; and c) they are willing to pay at least a small amount to support a recycling program. Most of the survey respondents are not willing to transport APW to disposal points themselves; curbside/on-site collection would be required for broader participation. They did not specify any insurmountable barriers preventing them participating in a plastics recycling program by collecting and consolidating plastics on-farm for ease of collection by a recycler. A minority of respondents cited a lack of storage space or a lack of education/understanding as barriers, but these problems could be solved with the implementation of a well-designed program. All of these results together paint a picture of a farming community that is ready and willing to contribute to and participate in a recycling program – however, it should be noted that stated attitudes, intentions, and willingness are considered at length in the academic literature as poor indicators of the real-life actions

a person will take (Husted et al., 2014; Kormos and Gifford, 2014; Markowitz and Bowerman, 2012). Strong institutional and peer support would be necessary to transition expressions of willingness into action. This is particularly important when one notes that despite finding similar attitudes regarding the recycling of APW among farmers in New York state 18 years ago (Rollo, 1997), a widespread management program has yet to be borne out.

2.4.2 COMPARISONS TO OTHER FARMING COMMUNITIES

Farmers in many jurisdictions, especially outside of Europe, are not furnished a comprehensive APW recycling program. This research, supported by Briassoulis et al. (2010), identifies that when confronted with limited options for APW management farmers are more likely to bury, burn, or landfill the material. The LabelAgriWaste (2009) program for tracking and recycling APW and directing non-recyclable APW to energy recovery facilities is being developed and documented by waste management researchers in Europe (Briassoulis et al., 2010). Research related to the LabelAgriWaste program has supported the notion that farmers around the world are disposing of plastics waste on-farm or in landfills - unless dedicated APW recycling programs are facilitating other actions. In countries such as Spain, Italy, and Greece, where horticulture farming takes place at large scales the LabelAgriWaste program makes provisions for the proper management of the agricultural plastics during their use and collection, followed by sorting, separation and consolidation in dedicated collection areas where there is provision for quality control and labeling depending on the quality of the APW with regard to recyclability or energy recovery. If collected APW is too contaminated to be considered for recycling it is directed to cement kilns to be used as fuel (Briassoulis et al., 2010). In a number of Northern European countries - notably Norway, Ireland, and Iceland - programs are in place that require/facilitate the recovery and recycling of APW. In these countries plastics producers/suppliers/importers and farmers have either been forced to recover and recycle APW through legislative action or are participating in voluntary APW recycling initiatives. The programs in these

countries focus on silage and bale wrap as those plastics are the most prevalent, such as the case in NS. The commodity mix in NS includes a significant amount of horticulture, and so lessons from Southern Europe are pertinent as well. This research has shown that in North America, in a Canadian province with ambitious waste management goals and a record of good waste management practices (Nova Scotia Environment, 2011; Wagner and Arnold, 2006), the APW recycling problem has not been addressed. It has been seen that a contemporary farming community, such as in NS, cares about the responsible disposal of APW and is generally willing to invest time, effort, and money to support an APW recycling program. In contrast, considerable progress has been made in Europe regarding APW recycling programs and rates of recovery, presumably because farmers were willing to participate in plastics recycling programs - and were provided them via ambitious waste diversion legislation such as the Framework Directive on waste 2008/98/EC; the Landfill Directive, 1999/31/EC; and the Packaging and Packaging Waste Directive, 94/62/EC (Institute for European Environmental Policy, 2011).

2.4.3 PROGRAM OPTIONS

Most APW is recyclable in principle and could enter recycling streams if kept relatively clean and dry by farmers and waste collectors. Municipalities in NS are not responsible for collecting commercial waste resources; therefore farmers are left to manage large amounts of plastics waste that is costly and effort-intensive to dispose of. As reported, many farmers resort to stockpiling and burning it on-farm, a situation that runs contradictory to legislation in place in NS that deals with plastics waste, as the majority of these plastics are banned from landfill and open burning of plastics is prohibited (Province of Nova Scotia, 2009). It is clear that given the low-value and management challenges associated with recycling APW, any program will need to be funded in some manner. Market-based financial incentives are not sufficient, i.e. recyclers do not get enough for the material to cover program operational costs. There are various mechanisms to generate the funding required to operate diversion programs, commonly originating with one or more of the relevant stakeholders – such

as local/regional governments, producers/dealers/importers, and end-users (Wagner and Arnold, 2006; Louis, 2004). Evidence gathered in this research suggests that two scenarios, common for 'low-value' material recycling programs, could be applied to an APW program: a) legislation that requires the producers/importers and the farmers to fund a program; and/or b) voluntary initiatives funded primarily by the plastics producers/dealers/importers, and to a lesser extent by the farmers (Gront Punkt Norge AS, 2015; IFFPG, 2015; Urvinnslusjodur, 2015).

Personnel within CleanFARMS suggested that approximately 5 to 7% of front-end plastic costs would be needed to fully fund an APW program in Nova Scotia (B. Friesen personal communication, May 8, 2015) and therefore, a better understanding of farmers' 'willingness to pay' is required. This would aid in developing a potential funding model for a new APW program with multiple stakeholders with a fiduciary role. As previously noted, the survey included questions that would query farmers' willingness to pay to support an APW recycling program and 4% of the front-end amount spent on plastics was the identified upper limit. While 4% of plastics costs is not sufficient to fully cover programmatic costs it could supply more than 50% of the required funding.

Functional APW programs do exist in some areas globally and are valuable sources of information for development of standardized best management practices. When implemented and operational it is possible that a farm plastics stewardship program would be able to capture most of the APW that is currently being sent to landfill or burned on-farm. The Gront Punkt AS program in Norway, is the only program investigated in-depth as part this research that is entirely voluntary and does not require the farmer to pay for disposing of the plastics (unless the plastic is dirty). The Gront Punkt program is not necessarily an ideal example for NS, as Norwegian farmers are required to arrange transport of the EOL plastics themselves, an unpopular management method according to results from the mail-out survey to farmers. However, the program in Norway accepts all plastics, has a nearly 100% recovery rate, reaches "most" of the farming community, and has been active since 1996 (R. Eibakk,

personal communication, January 7, 2014). Programs in Ireland and Iceland both operate under legislation that forces the organizations putting the plastics on the market, and the farmers, to pay to support collection and recycling efforts. Though the farmers pay to support the recycling programs in Iceland and Ireland the transportation of the plastics is incorporated in this price and does not require the farmers to transport the plastics themselves.

Alternatively, a less co-ordinated approach to APW recycling is possible using educational campaigns to inform farmers and waste collectors about APW recycling options, combined with the provision of drop-off locations. For example, this research has discovered that *plastic containers* are recycled almost as much as they are sent to landfill, which is a much higher recycling rate than any other APW in NS. This is due to the fact that a pesticide and fertilizer container recycling program has been active in NS since 1989 and has received a lot of attention and focus by the various farming associations and groups. The recovery rate of containers over the past five years has averaged about 30,000 containers per year (CleanFARMS, 2015). The CleanFARMS empty pesticide and fertilizer container collection program was suggested by a number of farmers as a successful model for addressing the general farm plastics problem in NS, and it is an excellent example of how recycling rates can be increased with education campaigns and drop-off locations for farm waste. However, pilot programs have been tested in Prince Edward Island and the Municipality of Colchester NS (Nova Scotia Environmental Farm Plan, 2015; Government of Prince Edward Island, 2012), both collected APW and received positive feedback from the farming community, but were limited in successfully gaining the buy-in of the broader farming community. This suggests that isolated programs with no obligatory participation divert small quantities of APW from landfill.

Literature on the development of recycling programs suggests that the farmers in question will need education and guidance on how to manage APW for recycling

(Sidique et al., 2010; Sidique et al., 2010a; Martin et al., 2006), storage options for the EOL plastics (Martin et al., 2006), and convenient and affordable options for transporting the plastics to MRFs (Sidique et al., 2010a). These three enablers, combined with encouragement (e.g. penalties, rewards) and engagement (e.g. communication, feedback) tools are thought to help sustain any changes made (Timlett and Williams, 2008; Defra, 2006). Voluntary EPR programs have been seen to be at least as successful as mandatory programs (Nahman, 2010), and are often simply a desirable option for industry stakeholders as a way to avoid potentially harmful regulations (Widmer et al., 2005).

Nova Scotia has a government agency that oversees the implementation and operation of many of the provinces waste diversion/recycling programs. The Resource Recovery Fund Board, which is largely funded through tipping fees and deposit mechanisms, could organize a *producer responsibility organization* to determine and levy an *advanced recycling fee* (Nahman, 2010) on the producers/importers/dealers of APW which would fund the provision of storage bins and educational programs for farmers, as well as incentives for waste collectors to undertake a collection program. Charges could be levied on farmers that are not properly managing plastics on farm, which would protect said waste collectors from incurring costs for participating in the program. This approach could be transferable to other jurisdictions, and mimics elements that have been successful with other waste streams, for example, the waste electronics management stewardship program administered by the Electronic Products Recycling Association. Implementation of EPR to play a role in the funding/management of APW programs poses some challenges but has been shown to be successful for other products. EPR principles require manufacturers to invest in the responsible EOL management of their products and materials. The growing ubiquity of EPR programs and legislation has theoretically set the stage for the producers/suppliers/importers of agricultural plastics in NS to voluntarily fund an EPR program. However, while EPR legislation is expected to be introduced in NS in the near future for some

materials/products, a large amount of time could pass before the creation of stewardship programs can be enforced.

Though concerns have been expressed about the difficulties farmers will encounter keeping the plastics clean and dry, literature demonstrates the feasibility in other jurisdictions (Briassoulis et al., 2010). Stewardship programs that levy the producers/suppliers/importers and the farmers have been seen to be effective as well and could be for many farmers achieved at no extra cost, as they are already paying for the transport and disposal of their plastics in landfill (Gront Punkt Norge AS, 2015; IFFPG, 2015). The farmers that are not paying for disposal now may incur extra costs but an effective stewardship program would minimize these and provide a much needed service. There are many examples of waste streams that have progressed from landfill banes to valuable sources of material, one of the most obvious being that of used tires. Stewardship programs such as the massive network in place for used tire recovery in Europe force the valorization of a waste stream, which in turn spurs innovative management strategies (Sienkiewicz et al., 2012).

2.5 CONCLUSIONS

The results of this research form a core of information that helps characterize the state of APW management in NS. A clear picture of the realities, attitudes, opinions, and systems in place here is an important first step in solving a resource and environmental dilemma being faced by the farming and waste management communities. Farmers, in general, have expressed how irreplaceable plastics have become in their daily operations – therefore such materials will continue to be used and disposed of in an unsustainable manner if ‘user-friendly’ diversion solutions are not available. As much as 900 tonnes of plastics waste is generated annually on farms in Nova Scotia and the majority is not recycled. In this study we have seen that the majority of Nova Scotia farmers are concerned about the proper disposal of farm plastics, are willing to take on-farm actions, and are willing to provide a small amount of

funding to support an APW recycling program. Jurisdictions that maintain successful APW recycling programs are most often funded by the plastics producers/suppliers/importers and the farmers, and are usually supported by legislation and administered by government agencies. The situation for farmers in NS and elsewhere is couched in the wider problem of managing EOL low-value plastics waste. These plastics are often difficult to recycle mechanically and are subsequently being landfilled in the many thousands of tonnes globally every year. The results of our study suggest a growing willingness within the agricultural community to alter on-farm activities to facilitate more sustainable management of such materials.

Future research should focus on elucidating better data associated with two aspects influencing the implementation of an APW recycling program. First, a practical hands-on audit can categorize the physical and chemical characteristics of the APW being generated on farms. Secondly, a more thorough understanding of the input requirements (physical, chemical and volumetric) of the various recycling alternatives and reinvestigation into alternative disposal routes for these plastics needs to be undertaken. While it is possible that much of the plastics waste generated on farms in NS is recyclable, it is likely that new routes need to be uncovered as well.

CHAPTER THREE: INSTITUTIONAL BARRIERS TO DEVELOPMENT AND IMPLEMENTATION OF AN APW MANAGEMENT SYSTEM IN NOVA SCOTIA

3.1 INTRODUCTION

As noted earlier, research was completed that investigated barriers to, and potential for, implementing an APW recycling program with a focus on gathering insight from policy makers and waste management professionals in Nova Scotia. This was undertaken through the completion of a series of e-mail surveys. Additionally, information was collected from organizations that are currently recycling APW in other jurisdictions.

The purpose of the work is a better understanding of potential APW recycling scenarios that could be applied in NS. Examples of APW recycling programs in other jurisdictions provide context for the practical application of an APW recycling program in NS. The scope of the work is to evaluate the operational landscape of APW recycling in NS and compare this information with APW recycling programs in other jurisdictions.

3.1.1 APW MANAGEMENT IN NORTH AMERICA AND EUROPE

Levitan and Barros (2003) noted that the management of farm plastics in New York State had significantly lagged behind other plastics waste streams, in large part because it was legal to burn/bury agricultural plastics on-site. Additionally, the study highlighted the fact that because APW is often contaminated, mixed, and degraded it would yield low values on recycling markets - and that this causes the economics of an APW recycling program to be negatively affected. Despite the difficulties, a number of initiatives existed at the time to manage APW responsibly and were documented by Levitan and Barros (2003); these were noted previously in Chapter 2. Recent examples of programs and initiatives that recycle APW in North America are a dedicated APW recycling plant in California that collects, washes, and recycles more than 45 000 tonnes of APW per year (Encore Recycling, 2016), agricultural container collection programs in

Canada and the USA (ACRC, 2016; CleanFARMS, 2015), and a company in Arkansas that collects as much as 68 000 tonnes of heavily soiled and contaminated plastics from farms and landfills for recycling into irrigation tubing (Delta Plastics, 2016).

In Europe, legislation has been in effect since 2012 regarding the management of APW. Despite active legislation and added capacity by 35 recycling companies to manage APW, the mechanical recycling rate for APW in Europe in 2013 was only 23% and the total APW recycling rate (including energy recovery) was 49.5% (Briassoulis, 2013a).

3.1.2 APW MANAGEMENT IN NOVA SCOTIA

LDPE is the predominant plastic used on farms in the Maritimes with silage film and bale wrap accounting for about 80%, followed by row covers and mulch film at 8% (CleanFARMS, 2012). CleanFARMS reported that the majority of plastics waste generated on-farm are dumped, burned, or sent to landfill, a finding supported by data collected via the Nova Scotia Federation of Agriculture's *Environmental Farm Plan* (P. Brenton, personal communication, December 22, 2014). Estimates suggest that Nova Scotia generates approximately 702 tonnes per year (CleanFARMS, 2012); findings from the research presented in Chapter 2 corroborate the CleanFARMS findings with primary data collected from farmers in NS, which calculated APW generation to be approximately 900 tonnes per year. Additionally, this research has supported the assertions by CleanFARMS that the majority of plastics waste generated on farms in NS is LDPE (in the form of bale and silage wrap), and is primarily sent to landfill.

3.1.3 MANAGEMENT OF LOW-VALUE PLASTICS WASTE IN NOVA SCOTIA

In Nova Scotia waste audits undertaken by the RRFB in NS in 2011 and 2012 identified that ~20% of all incoming material was plastic, representing 58,550 tonnes in 2011 and 60,600 tonnes in 2012. Figure 6 shows residential access to non-container recycling options for specific plastics in NS; many non-container plastics are not recycled

and therefore end up in landfill. The access rates for plastics recycling are based on the ability of municipalities and waste management groups to collect and market plastics to recyclers. Access to container recycling options in NS is nearly 100%. However, in Figure 6, there are a number of different plastics for which no market has been identified and no collection plan implemented, resulting in plastics from residential and industrial, commercial, and institutional (ICI) sources going to landfill.

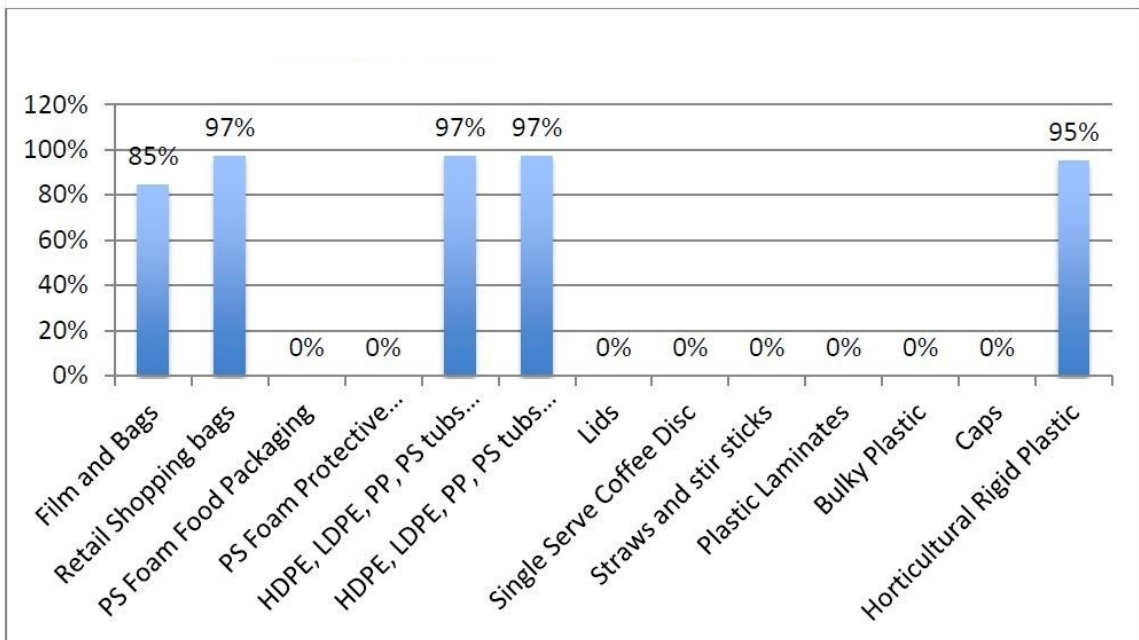


Figure 6: Residential access to non-container plastics recycling in NS (CM Consulting, 2014)

3.1.4 EXISTING APW RECYCLING INITIATIVES (GLOBALLY)

Countries such as Ireland, Iceland, and Spain have legislation in place that deals directly with the issue of APW management, while plastic film producers in the United Kingdom, France, Norway, and Sweden have developed efficient voluntary schemes that engage the stakeholders in various ways (Briassoulis, Hiskakis, & Babou, 2013; epro, 2012). The following section will discuss some of these initiatives.

3.1.4.1 ACTIVE PROGRAMS

Five organizations currently operating APW recycling programs were identified and chosen to be investigated for this research:

- Iceland Recycling Fund – Iceland
- IFFPG – Ireland
- Gront Punkt AS – Norway
- ERDE (RIGK GmbH) – Germany
- Island Waste Management Corporation – Prince Edward Island

The programs in Norway, Ireland, and Iceland were discovered to be successful, established, and functioning APW recycling programs.

As was noted in Chapter 2, The Gront Punkt AS program in Norway is voluntary, free (for farmers that deliver clean plastics), accepts all plastics, has a nearly 100% recovery rate, reaches “most” of the farming community, and has been active since 1996. An important aspect of this program is that a department exists that focuses entirely on recruiting producers and importers to the system – who then pay a weight based fee on plastics they sell in Norway. Oppositely, legislation that specifically targets APW or similar types of waste is the impetus for the programs in Ireland and Iceland. The programs require the organizations selling the plastics into the market, as well as the farmers, to pay to support the APW recycling system. Details of these programs are further discussed in the results section of this chapter.

Though a few APW recycling programs exist, the number is small considering the ubiquity of farming the world round. Recycling farm plastics is possible, as it seems that the technical and operational challenges that exist have been overcome in a number of ways and in a number of diverse settings.

3.1.4.2 CASE EXAMPLE: LABELAGRIWASTE PROGRAM

The LabelAgriWaste program is a European research project that is developing a framework for the economically sustainable collection and valorization of farm plastics (Briassoulis et al., 2010).

The **LabelAgriWaste** program requires:

- Detailed tracking and labeling of plastics from the point of sale to final disposal
- Adherence to specific guidelines for the use, collection, treatment, and transportation of the plastics
- A financial scheme including payments and refunds controlled by a national agency
- Legislation framework implementation with monitoring and penalties for non-compliance

(Briassoulis et al., 2010)

The program has detailed information regarding farm plastics management, but is limited in its transferability to other settings/jurisdictions, as it only provides information about one version of a potential management program. In particular it was developed in the context of Mediterranean agricultural production systems, and with much larger quantities of plastics than are found in NS, which allows the program to operate at significant economies of scale.

Briassoulis et al. (2010) detail beginning steps in establishing an APW recycling scheme as: a) establish an infrastructure; b) reach a voluntary agreement on overall cost for the programs; implement a labeling (or tracking) scheme according to related legislation; d. disseminate the scheme and train all parties involved; e. enforce penalties when needed. In the same work benefits are proposed for a number of stakeholders in an APW recycling scheme including the industrial sector, the plastics producers, the

farmers, the waste management enterprises, and to the recyclers and energy recovery enterprises. The LabelAgriWaste scheme is not the only APW recycling project in Europe, the Award Project and the AgroChePack are examples of region specific programs that exist due to the collaboration of academic, government, and industry representatives (AgroChePack, 2013; Award Project, 2015).

3.1.5 COMMON STAKEHOLDERS AND PARTICIPANTS IN APW RECYCLING PROGRAMS

An APW recycling program requires the participation of certain groups, Briassoulis et al. (2010) have detailed these in Figure 7. The important groups are:

1. National agency with a mandate for improving diversion rates
2. Plastics industry/suppliers/importers
3. Farmers
4. Local authorities
5. Plastics recyclers (mechanical)
6. Residual plastics users (other methods of diversion)

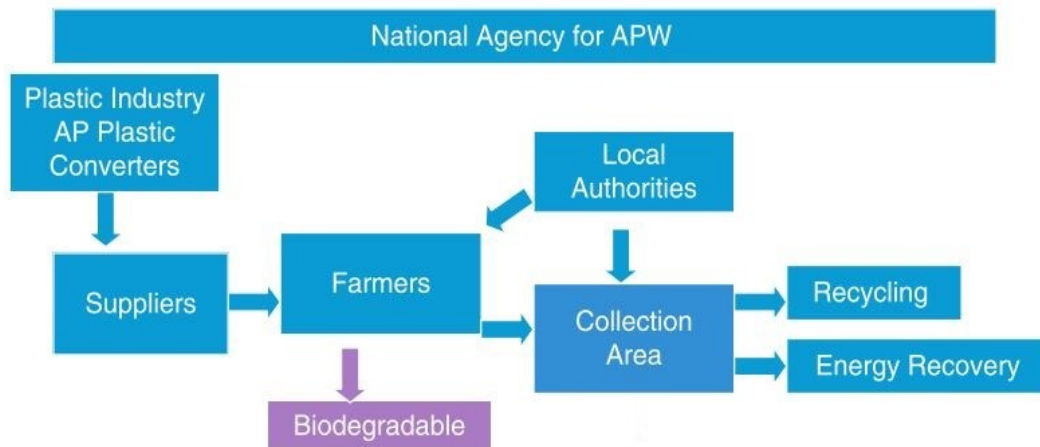


Figure 7: Organization of stakeholders and participants in an APW recycling program (Briassoulis et al., 2010)

3.1.5.1 GOVERNMENTAL AGENCIES

Government agencies (national or provincial) do not need to be acting under legislation that targets APW specifically, but progressive and proactive waste management goals would likely spur action on this specific waste stream. The national agency is crucial in that it will act as the organizational center of the program and direct each of the other players, whether the program is voluntary or mandated. The rest of the organizations can have a range of organizational and/or financial responsibility depending on the layout of the program. Information collected from APW recyclers in other jurisdictions will be discussed in relation to the various roles that government can play, through legislation or influence, in the results section of this chapter.

3.1.5.2 PLASTICS PRODUCERS/SUPPLIERS/IMPORTERS

These groups can support the program financially and provide a vehicle for education and branding for the recycling program. Provincial waste management regimes in Canada, notably in British Columbia, Quebec, and Manitoba, have developed EPR initiatives (EPR Canada, 2016), solidifying the position in their respective waste management practises that the “polluter” pays. In this context the plastics producers/suppliers/importers would be targeted as the responsible party for the disposal of the plastics which they have sold into the local market. The primary benefits to the industrial stakeholder participating in an EPR program are: a) improved public image resulting in continued and/or improved social license for the entity to continue operating; b) avoidance of strict regulation or exorbitant fines and fees imposed by governments (Lifset et al., 2013).

3.1.5.3 LOCAL AUTHORITIES/WASTE MANAGERS

Local authorities could participate in the branding and educational aspects of the program, but more importantly will be able to participate in the management of collection activities - which could be coordinated with local waste management groups

for the purpose of cutting costs and ensuring the success of an initiative. The local authorities will have the most information regarding the geography and current practices of waste collection in their given jurisdictions. The local authorities could have a detrimental impact on the development of a program if synergies could not be realized between the overseeing governmental or volunteer agency that is co-ordinating the APW recycling program or if waste management practices in place do not allow for separation/collection/recycling of APW being generated on farms. The local authorities may have practices and/or technologies in place that do not easily integrate the collection and processing of APW. For example, bale and silage wrap is usually a very long sheet of bundled plastic that has reportedly been problematic for separation technologies at a MRF in NS (J. Traver, personal communication, April 1, 2015).

3.1.5.4 FARMERS

Farmers will be on the receiving end of educational initiatives, potentially price increases (fees that fund the program directly) and potentially penalties (for mismanagement of plastics) and therefore the program needs to be designed so that the farmers are burdened as little as possible and are helped to understand the benefits of APW recycling regarding environmental and social health. This could prove challenging, it has been noted in the previous chapter that an appreciable fraction of farmers, especially older, male farmers in NS are not dissatisfied with the practices of burning and dumping plastics on-farm as a disposal method. Additionally, many farms are likely to operate on relatively narrow profit-margins and are not therefore able to participate in programs that will add excessive financial burdens.

3.1.5.5 PLASTICS RECYCLERS AND OTHER RESIDUAL PLASTICS USERS

Finally, recyclers need to be included in preparation of the program and on an ongoing basis in that the material needs to be managed to suit their needs. Recyclers may need to incorporate new technologies or make process adjustments to recycle the APW effectively as the incoming plastics could be contaminated and/or not of the

appropriate shape, size, or length to be introduced into the recycling equipment. Storing plastics for extended periods of time and in conditions that degrade the material may reduce their viability for recycling, something that needs to be addressed for the purpose of the recycler. The plastics recyclers need to be able to produce and market a product of consistent volume and quality. Therefore the plastics recyclers must be consulted on an ongoing basis to ensure that the collected plastics can be sold. Other residual plastics users are those that would use plastics waste in waste-to-energy (incineration with energy recovery) technologies or variations thereof. The needs of other residual plastics users would be different than those of mechanical plastics recyclers and would need to be considered if they were intended to be an end user of farm plastics waste.

3.2 MATERIALS AND METHODS

This thrust of the research used a mixed methods approach in order to determine how the practices and attitudes of plastics waste managers and policy makers in NS might impact development of an APW diversion and recycling program. As noted in Chapter 1 applicable survey questions and research methodologies were reviewed and approved by Dalhousie University's Research Ethics Board.

3.2.1 ANALYTICAL APPROACH

An email survey was sent to waste management professionals in Nova Scotia. The population of these waste managers was determined in consultation with the RRFB and individual municipalities. Of the 12 surveys distributed to regional waste management co-ordinators in NS 8 were returned. Surveys were returned from all of the MRFs in the province, as well as a number of landfills and transfer stations.

A second survey was sent to two employees of NSE seeking information regarding the management of APW and post-consumer low-value plastics waste from a

legislative perspective in NS. The survey was answered in conjunction by two employees of NSE.

A third email survey was sent to representatives of organizations that currently recycle APW in other jurisdictions. The survey was sent to 5 organizations and 5 surveys were returned.

See Appendices B, C, and D for sample questionnaires.

3.2.2 STATISTICAL ANALYSIS

Similar to the farmer survey data, data from these two additional surveys were recorded, tabulated, and tracked using Microsoft Excel software. Quantitative results, such as the amount of plastics recycled at MRFs in NS, were summed within the software and verified using multiple summation approaches. The management and analysis of the survey data was completed using Microsoft Excel. The open-ended write-in answers were analyzed using thematic coding, and were organized, categorized and summed using Microsoft Excel software. The thematic codes were developed by reviewing the responses holistically and using keyword searches to evaluate the prevalence of identified themes.

3.3 RESULTS

3.3.1 MUNICIPAL LEVEL WASTE MANAGEMENT IN NS

Managers of the MRFs in NS decide which plastics are collected for recycling based on a consideration of what materials are banned from landfill, and the availability and reliability of markets for selling collected plastics. According to these waste managers, in theory, all types of APW and post-consumer low-value plastics waste would be accepted at all of the MRFs - as long as they are clean and dry. However, the MRFs avoid collecting material that they will not be able to sell on to a recycling market,

as this material then becomes a financial burden to them in terms of storage space, transportation costs, and tipping fees for disposal in landfill. Plastics that they are unable to sell on to a recycling market are those that are mixed with other wastes, degraded, contaminated, or sent directly to landfill. The MRFs have not initiated collection of these plastics, as a profitable recycling scenario for them has not been established and they are not yet being rejected by landfills. Even if post-consumer low-value plastics waste in NS could be separated from other wastes with minimum contamination and stored until sufficient amounts are collected for shipping to a buyer, they would not be recycled without being shipped overseas as most NS waste managers are not aware of North American purchasers for this type of material. These plastics would therefore have to be sold and shipped to distant recycling markets – which can make producing a monetary profit on the process more difficult.

Respondents identified the ICI sector (which includes farms) as the largest generators of recycled plastics waste, however, farms were noted for producing a large amount of plastics waste that is sent to landfill. ICI organizations must arrange for the collection and transport of recyclable materials to the nearest MRF. Agricultural plastics are generally being accepted as garbage at landfills, and are not part of the recycling streams of any of the MRFs contacted. However, waste collectors and MRFs have limited influence when it comes to farm waste management, as being commercial entities farms are solely responsible for disposing of their waste (Province of Nova Scotia, 2009).

Regardless of the reason, the excessive amounts of plastic waste being sent to landfill is a problem for both waste management professionals and the government in NS. The data elucidate the extent of this problem. According to waste surveys conducted by the RRFB and results of the email survey with waste managers in the province, the province currently landfills approximately 60 000 tonnes of plastics waste a year (RRFB, 2012), while recycling about 9 thousand tonnes a year (Table 2). Nova

Scotia therefore has a plastics recycling rate that is estimated at between 10 and 15%, and a per capita plastics recycling rate of 9.7 kg/person/year, though it has not been discovered that any jurisdictions are currently reporting per capita plastics recycling rates.

Table 2: Amount of plastics recycled by major MRFs in Nova Scotia in 2014

Plastics Recycled in 2014 - Nova Scotia							
Plastic type	Scotia Recycling - Kentville/Yarmouth	Miller Waste - Halifax	Kemptown	Green Island Recycling - CBRM	Cumberland County	Other	Total (t)
Film plastics	1087	1376	505	375	154		5897
Mixed low-value plastics		1000				1400	
Rigid plastics (all other)	1145	700	725	375	113	9.3	3067.3
Total (t)	2232	3076	1230	750	267	1409.3	8964.3

3.3.2 THE LEGISLATIVE ENVIRONMENT FOR PLASTICS WASTE MANAGEMENT IN NS

The following section presents information gleaned from a survey completed by employees of NSE.

A landfill ban on most types of plastic exists in NS, including #1, 2, 4, and 6. Kitchen catchers are exempted from that ban, including reused shopping bags.

Table 3: Plastic type and use according to identification code

ID Code	Type of plastic	Uses
1	Polyethylene terephthalate (PET)	Soft drink bottles, food storage containers, cups
2	High density polyethylene (HDPW)	Milk bottles, toiletry bottles
3	Polyvinyl chloride (PVC)	Piping, plumbing, juice bottles
4	Low density polyethylene (LDPE)	Film, food bags, wrap, bottles
5	Polypropylene (PP)	Microwaveable containers, disposable cups and plates
6	Polystyrene (PS)	Egg cartons, styrofoam, disposable containers
7	Other/composite (O)	Milk cartons, electronic casing

(Greenpath Recovery Recycling Services, 2016)

Considering the amount of plastics being sent to landfill, it is clear that the ban is not being thoroughly enforced. EPR programs exist in NS for some materials and types of waste. However, EPR legislation targeting the banned plastics waste currently being sent to landfill was put on hold in September 2015 by then Nova Scotia Minister of

Environment, Andrew Younger (Bundale, 2015). The question of scale permeates the discussion of options for local uses for this waste, as the provincial representatives opined that plastics waste is being produced in too small of quantities and is too geographically disparate to warrant consideration of developing and constructing new local recycling technologies. Respondents seem to suggest that a local solution does not currently exist, and that post-consumer low-value plastics disposal methods outside of landfill or mechanical recycling have been considered, however, there is no evidence that NS is addressing the issue directly. The RRFB has made progress by performing waste audits and targeting difficult to recycle waste streams, but, as previously noted, the plastics recycling rate in NS is only estimated at 10 to 15%.

Though there is no legislation that deals specifically with APW, most of the farm plastics considered in this research are banned from landfill by virtue of their plastic type. It is the responsibility of end-users and waste managers, with support from the RRFB and under the scrutiny of NSE, to ensure that banned materials do not end up in landfill. According to the respondents' views at the time of the completion of the survey, improved diversion rates would have been expected with the enactment of EPR legislation, but implementing a stewardship program will take time, and thus far NS has made no move to re-visit the EPR legislation which was put on hold in 2015. Despite the earlier note that local options do not currently exist, it was suggested that establishing the methods for achieving a maximum amount of plastics separation in the short term could provide industrial inputs, such as fuel for cement kilns in NS, a common end-use for low-value plastics waste in Europe (Briassoulis et al., 2010; Plastics Europe, 2015). There was a clear aversion amongst respondents to pursuing low-value plastics recycling options that would require new construction in the province.

3.3.3 Potential stakeholders of an APW recycling program in NS

In addition to a jurisdictional agency with a mandate to address APW recycling, which in NS is the RRFB, any APW recycling program in NS will require input and co-

operation from a number of additional stakeholder groups (Figure 6) which were outlined previously (section 3.1.5) and discussed further in the following sections.

3.3.3.1 Plastics industry/suppliers/importers

The involvement of the plastics industry/suppliers/importers depends on either a voluntary initiative or EPR legislation which requires their involvement. An attempt to introduce EPR legislation was put on hold in 2015 and has not as of yet been re-visited, therefore a voluntary initiative is necessary in NS.

An APW recycling program needs funding that does not depend on producing profit as a result of the overall process. Briassoulis et al. (2010) have detailed in Figure 8 below a funding scenario for the LabelAgriWaste program in Southern Europe. In the described scenario funds come from the plastics producers/suppliers/importers, the farmers, and from the sale of the collected plastics.

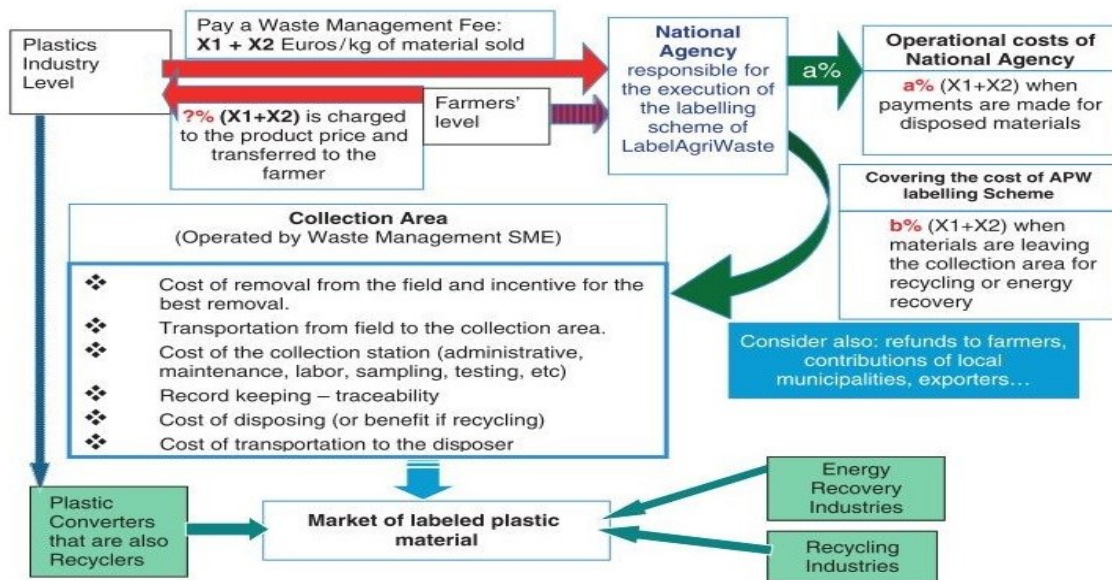


Figure 8: Proposed APW recycling program funding structure (Briassoulis et al. 2010)

3.3.3.2 FARMERS

Data presented in Chapter 2 suggest that the farming community in NS is by and large open to participating in an APW recycling program. The current prevalent methods

of disposal are recognized by many in the farming community as unsustainable and harmful to the environment. Farmers have expressed a willingness to take action on-farm to facilitate collection of the plastics and are willing to pay a small amount to support a program.

3.3.3.3 LOCAL AUTHORITIES: MUNICIPALITIES AND WASTE MANAGEMENT SERVICES

The municipalities of NS manage waste collection and disposal. A network of transfer stations, MRFs, and landfills comprise the entire system. Each municipality and/or the companies that are contracted to manage waste determine what material to collect, how to collect it, and how it is ultimately disposed of. Many waste managers in the province recognize the need for an APW recycling program and expressed interest to become involved in one. Each MRF manager contacted stated that farm plastics of all types can be received and processed at their facilities provided the plastics are relatively clean and dry. For example, the Municipality of Colchester County in NS ran a pilot program for the collection of silage and bale wrap in the spring of 2015. During the pilot they accepted farm plastics waste at no charge. Though only seven farms participated and some problems were encountered with the cleanliness and delivery of the plastics - nearly 25 tonnes of APW was collected (J. McFarlane, personal communication, October 9, 2015).

3.3.3.4 MECHANICAL RECYCLERS

The majority of APW is low value film and mixed plastics. Film plastics are marketed by waste management groups in NS to overseas recyclers where markets exist for these plastics, provided the plastics are clean and not significantly degraded. However, the prices paid for these plastics are comparatively low and highly variable.

3.3.3.5 OTHER END USERS

Options exist outside of mechanical recycling for post-consumer low-value plastics waste. Most notably, a private C&D and recycling company in NS has

collaborated with a private cement manufacturing company in NS to supply plastics waste to be used as fuel within the cement kiln. The cement manufacturer has agreed to pay for the plastics according to energy content (MJ/kg); the capacity for diverting post-consumer low-value plastics waste for this purpose is substantial (K. Jagoe personal communication, October 9, 2015). Other groups have proposed establishing plastics recycling technologies such as pyrolysis (plastics-to-fuel) (Bundale, 2013). Creating a local market for these plastics could make collecting and processing them a more tenable enterprise.

3.3.4 PROGRAM DETAILS OF ACTIVE APW RECYCLING PROGRAMS IN OTHER JURISDICTIONS

Questionnaires were completed by email with five organizations currently involved in APW collection/diversion programs in other jurisdictions. The purpose of the survey was to identify and articulate the operational aspects of functioning APW recycling programs.

- Iceland Recycling Fund – Iceland
- IFFPG – Ireland
- Gront Punkt AS – Norway
- ERDE (RIGK GmbH) – Germany
- Island Waste Management Corporation – Prince Edward Island

In all cases, the APW collected is intended for diversion to mechanical recycling operations. Table 4 provides an overview of the pertinent points related to the first three programs; the last two programs (Germany and Prince Edward Island) have such low participation rates it was decided data related to these would not be included, either in Table 4 or further discussion.

Table 4: Farm plastics recycling organizations in jurisdictions outside of Nova Scotia

	Iceland - Iceland Recycling Fund	Ireland - IFFPG	Norway - Gront Punkt AS
Voluntary?	NO	NO	YES
Producer/importer pays?	YES (mandatory)	YES (mandatory)	YES (voluntary)
Farmer pays?	YES (at point of disposal)	YES (discount given if proof of purchase of levied plastic provided)	NO (unless the plastic is dirty)
Farmer transports plastic?	NO	NO	YES
Specific plastic targeted/accepted	Wrap (film)	Silage wrap (film)	All plastics
% Recovery	100%	75% (23000 tonnes in 2013)	Approx. 100% (11000 tonnes in 2013)
% Participation	85-90%	35000 farms/yr (30.5%) *farmers dispose of plastics every 2 or 3 years	"most"
Year of inception	2005	2000	1996

*Red indicates aspects of the program which would not, according to observations from Chapter 2 of this work, be beneficial to include in a program in NS

The programs in Norway, Ireland, and Iceland all present potential strategies/options that could be integrated into a successful APW recycling program in NS. A detailed overview of the Gront Punkt AS program can be found in Table 5 below. An important aspect of this program is that a department exists that focuses entirely on recruiting producers and importers to the system – who then pay a weight based fee on plastics they sell in Norway. Farmers in NS have expressed an aversion to transporting plastics off-farm themselves, therefore a necessary feature of a program developed in NS would be that collection services are provided, combined with education on how to manage/sort/store the plastics, potentially with the provision of storage containers. A voluntary program which includes educational components and enablers (such as providing storage options and on-site waste pick up) would agree with the findings of

this research and with academic literature concerning waste management (Plummer et al., 2007; Sidique et al., 2010; Sidique et al., 2010a).

Table 5: Detailed participant roles and responsibilities in the Gront Punkt APW recycling program of Norway

<i>Norway - Gront Punkt AS - agricultural plastics recycling program</i>	
Roles and responsibilities of stakeholder groups	
Organizing body (Gront Punkt AS)	invoices producers/dealers and importers by # of kilograms of sold plastic
	funds collection and transport companies that QA and bale the plastic
	provides resources for recruiting suppliers and manufacturers into the system
	without the GPN system farm plastics would not be collected or recycled
	the GPN system avoids higher fees and taxes on the sale of such plastics
Farmers	deliver used plastics to a collector for free, or arranges (and pays) for pick up
	ensure the plastic is as clean as possible to avoid paying for disposal
	the plastic must be free of soil, product residue, sand, and other plastics
	a pamphlet provides specific instructions for the farmers to follow
Plastics producers/dealers and importers	the fees paid by these groups finance the system
Local government	provides collection and sorting facilities (that are also used for other waste streams)
	charges fees as needed to support facilities on a case by case basis
National government	does not provide any funding to support the system
	ensures compliance with European Union waste management regulations
	announced high fees on the sale of products that generate improperly managed waste (1996)
	the plastics producers/dealers and importers responded by creating the program
Collection agencies	sell the collected plastics to recyclers (from a list of approved recyclers)
	report the weight of recycled plastics into a database
	the program pays the collectors a fee per ton of plastics recycled (which varies by type)

It has been seen that the funding mechanisms of other APW recycling programs are relatively similar to the proposed LabelAgriWaste plan (Figure 8 above). The funding mechanisms for programs in Iceland, Ireland, and Norway are detailed below.

IRF in Iceland: To finance the national program referred to as the Iceland Recycling Fund, a recycling fee is collected on each product before it goes on the market, after its manufacture or importation. The fee is meant to pay the recovery cost on any waste remaining when the service life of the product or material is over. As applicable in each case, the fee covers the cost of handling waste at a collection point, transporting the waste from a collection point to a central accumulation point or recovery point, and recovering or disposing of the waste and paying the fee for disposal. The fee is paid by domestic manufacturers and importers of goods subject to the fee.

The obligation of paying extends to every producer and importer, including individuals, associations, funds and institutions, municipalities and their institutions, the State Treasury, state agencies, foreign contractors and any other entities importing or producing goods subject to the fee. If the fee did not exist there would be no recycling/management system for waste streams such as APW. In Iceland, the plastic producers are all importers and they pay the recycling fee at customs. There is a recycling fee included in the price of the hay bale wrap at the point of purchase, therefore the system for APW is also partially funded by the farmer. After use the farmer has to sort different materials and clean hay and dirt from the plastic. For most of the farmers the collectors pick up the plastic at the farm, though a minority of the farmers take the plastic to collection stations. APW is therefore captured as part of a comprehensive EPR system in Iceland.

IFFPG in Ireland: The APW recycling program is not for profit and funded through a levy charged on silage plastic that gets sold into the market and a weight based collection fee that is charged to farmers. Regulations require producers (importers and manufacturers) and suppliers (merchants and contractors) to either: a) directly become involved in the recovery of silage plastics from their customers (i.e. offer a deposit and refund scheme); or b) participate in a government approved silage plastics recycling scheme (i.e. become members of IFFPG, or purchase silage plastics from IFFPG members). Members currently pay 90 Euros per tonne of product placed on the Irish market. There are currently no producers offering a deposit and refund scheme. Currently, companies are either participating in the scheme (or buying product from scheme members), which represents more than 90% of the market. The APW recycling program in Ireland functions essentially as an EPR program, where the entities which sell the material into the market are primarily responsible for financing disposal of the material.

Gront Punkt in Norway: GPN invoices suppliers and manufacturers of plastic packaging according to the number of kilograms of plastic they sell, which funds collection companies that assure the plastic quality and bale the plastic. A department of GPN recruits producers and importers to the GPN system. The farmer delivers used plastics to a collector for free, or pays a collector to pick up the plastics on-farm. The plastics must be free of dirt, rocks and other debris or a fee will be charged at the point of disposal. The fee that the plastics producers pay GPN finances the system completely. The national government does not provide any financial support for this program. In 1996 the national government requested the plastic producers and importers take responsibility for all plastics waste to avoid large fees being attached the import and sale of plastics. The importers and producers then formed GPN, which is essentially a voluntary EPR program.

3.4 Discussion

Agricultural plastics waste is often distributed over large geographic areas, found in relatively small quantities and accumulates at varying times in the year. The result is that the costs associated with collection, transportation, cleaning and processing APW for mechanical recycling are higher than the costs of making plastics from virgin material, and the variation in collection times makes establishing a viable market for selling the material difficult (Briassoulis, 2013). These assertions are reflected in the responses and opinions of the waste management community of NS. Legislation and/or deposits/user fees ensure that many EOL products and materials are recycled in NS. However, when profit is not a likely outcome of recycling a material and legislation does not exist (or is not enforced) that requires it to be recycled, it is likely the material will end up in landfill.

In other jurisdictions, namely Ireland, Iceland, and Norway, successful APW recycling programs exist which do not depend on producing financial profit or on waste management groups at the collection and dispersion level to initiate or manage them.

The common theme is that APW recycling programs are mandated or encouraged by government organizations in the hopes of reducing the amount of waste being sent to landfill, and that the financial burden is born by the plastics suppliers/producers/importers and by the farmers themselves. Findings presented in Chapter 2 support this structure, as farmers in NS chose the plastics suppliers/producers/importers and themselves as the parties that should be most responsible for the organizational and financial support of an APW recycling program.

However, plastics are sensitive to heat, sunlight, and exposure and APW is therefore apt to be too physically degraded to be reprocessed (Briassoulis, 2013; Briassoulis et al., 2015). One of the most common use of plastics is for food packaging, but, as is the case with APW, mechanically recycled plastics that may have been exposed to substances that are unsafe for human ingestion cannot be used for these purposes, which decreases demand and selling price for the material (Briassoulis, 2013; Briassoulis, et al., 2015). Succinct co-operation between the farmers, the waste collectors and transporters, and the recyclers is needed to ensure that the materials are not being excessively damaged and that the maximum amount of APW is delivered to and purchased by recyclers.

It is important to consider the viability and stability of a potential APW recycling program in NS. Some suggest that farmers are likely to be positively predisposed to voluntary initiatives, as it speaks to their ethos of independent and responsible businesspeople/land managers (Kennedy et al., 2009). Evidence from at least one successful APW recycling organization supports the notion that such programs can function on a voluntary basis. Within NS, the farming community has expressed a willingness to participate on-farm to facilitate and fund (at least in small part) an APW recycling program. This also shows some alignment with the perspectives of European farmers (particularly as it relates to funding mechanisms) and the operational aspects of successful APW recycling programs in Europe. Such programs require effort and limited

financial support from farmers, but follow the academically supported waste management best-practices of providing education and practical logistical support (storage bins, drop off points, etc.) for waste collection (Martin et al., 2006; Sidique et al., 2010a). Additionally, the APW recycling programs reviewed in this research focus on collecting LDPE silage/bale wrap and similar plastics, which are the majority of APW produced in the province as well.

Alternatively, the province of British Columbia serves as an example for the development of an EPR program in Nova Scotia that could target APW. In 2004 the province of British Columbia enacted the Environmental Management Act and the Recycling Regulation. The Regulation requires industry groups to submit a stewardship plan for ministry approval and if the producers do not submit an acceptable plan the producer may not sell the designated product in the province (EPR Canada, 2016). Packaging and printed paper were added to the Regulation in 2011 and provide a good example of how an EPR program can target materials that are ubiquitous and diverse enough to make the creation of a stewardship organization challenging (Multi-Material BC, 2013). The policy environment in NS is arguably ripe for the enactment of progressive waste management legislation, such as EPR programs; NS is considered a waste management leader in Canada (Province of Nova Scotia, 2013), EPR legislation has been planned and proposed by Nova Scotia Environment, and EPR programs would help NS to continue to reduce the amount of waste being sent to landfill – having missed the landfill diversion rate 300kg per person per year set in 2007 (Ward, 2016).

3.5 CONCLUSIONS

Farmers generate plastics waste that can be categorized as low-value, mixed, degraded, and contaminated; plastics waste with any of these characteristics is often ignored by the plastics recycling community and disposed of in landfill. It has been seen that plastics are by and large landfilled in NS, and that the plastics recycling rate for the province is likely between 10% and 15%. This means that APW is actually one of a

number of plastics waste streams that are being sent to landfill despite legislation being in place that has made sending these plastics to landfill illegal. Recycling waste material is more likely to be undertaken by private organizations if the practice is profitable. In the case of post-consumer low-value plastics waste profitable recycling is difficult to achieve, especially when there are no local recyclers of any type.

A co-ordinated effort to collect more plastics of all types could integrate APW collection into any new initiative, but also include other low-value plastics as well. As collected amounts of all types of post-consumer low-value plastics waste increase environmentally responsible and/or potentially profitable markets could be established.

Addressing the case of APW directly, the most expedient and efficient method of diverting APW from landfill is to emulate the APW recycling programs detailed in this chapter. The conditions for implementation of a program similar to the successful programs described (most notably Gront Punkt in Norway) are, as discussed in the previous section, present in NS. The missing factor at the moment is initiative from the provincial government regarding this specific waste management problem. Research presented here has shown that APW is generated in appreciable amounts, that stakeholders are willing to engage on this issue, and that there are no insurmountable technical or practical barriers to solving this problem.

CHAPTER FOUR: CONCLUSION

Chapter four emphasizes the highlights and implications of the research findings as they relate specifically to policy recommendations and consideration of the feasibility of a resource efficient management program in NS that addresses EOL agricultural plastics.

The research sought to answer three questions:

1. What types and amounts of plastics are being generated on farms in NS, and how are they currently being managed?
2. What are the barriers facing farmers to engage with recycling of agricultural plastics?
3. What are the broader institutional barriers to recycling of agricultural plastics in NS and how can they be addressed?

4.1 POLICY CONTEXT OF FINDINGS

4.1.1 APW GENERATION AND MANAGEMENT IN NS

To generate a better understanding of the potential to address the agricultural plastics waste stream the farming community of NS was surveyed and assessed regarding: attitudes towards APW disposal methods; APW disposal practices; and plastics types and amounts being generated on farm. It was found that the majority of APW is being sent to landfill or disposed of on farm, that farmers are concerned about the fact that APW is not being disposed of in an environmentally superior manner, and that the majority of farmers are willing to invest money, time, and effort to increase APW capture for recycling. The farming community of NS generates as much as 900 tonnes of APW annually, much of which is disposed of in landfill or dumped and burned on-farm. These results suggest that increasing APW recycling rates relies on organizational initiatives from institutional bodies, and that farmers are willing and able

to participate in APW recycling programs that are not financially or logistically prohibitive.

4.1.2 LOW-VALUE PLASTICS WASTE MANAGEMENT IN NS

As has been noted, plastics waste recycling rates in Nova Scotia are low and the majority of plastics waste (80 to 90%) are being sent to landfill. While it is true that the majority of plastics containers and other easily collected and marketed plastics are being recycled, attempts to increase diversion rates and capture other plastics types for recycling have proven largely unsuccessful. However, stakeholders such as municipal level waste managers, provincial waste managers employed in the government, and waste generators such as farmers are motivated to address the problem of low plastics recycling rates.

4.1.3 APW MANAGEMENT AND RECYCLING IN NS AND IN OTHER JURISDICTIONS

Additionally, waste managers and waste management professionals in NS and other jurisdictions were interviewed to discover potential practical solutions to the problem of APW disposal and recycling in the province. The most common and successful method for managing an APW recycling program lays responsibility on a dedicated organization, usually under the direction of a governmental body, and is funded by the plastics producers/dealers/importers and the farmers. It has been noted that the RRFB in NS is uniquely situated to perform this role.

4.1.4 ESTABLISHMENT OF A STANDALONE APW RECYCLING PROGRAM IN NS

It has been noted that a plastics recycling program that is designed for and administered solely to farmers requires funding from outside sources, which in other jurisdictions has been generated primarily through EPR strategies involving plastics producers/suppliers/importers with some contribution from the farmers themselves. Funding is required to support an APW recycling program as market forces are not sufficient to drive a cost effective program if such programs are only supported by

product resale. Successful APW recycling programs in Norway, Ireland, and Iceland are managed and administered by government organizations, funded by plastics and farming industry stakeholders, and exhibit excellent APW capture rates. Farmer buy-in is high due to the fact that program participation is made convenient and the reasons for and actions required for participation are communicated effectively to the farming community. Having high farmer buy-in results in significant industry support as well - which is an important consideration for funding a voluntary program.

In order to begin the process of establishing an APW recycling program the RRFB should create a not-for-profit APW recycling unit modeled on the APW recycling programs described in Norway, Iceland, and Ireland. Legislation banning these plastics from landfill and provincial waste landfill diversion goals support the creation of such an entity. The farming community of NS is open to participating in and providing limited funding for such a program. Though dairy farms were seen to generate more plastics waste per farm than other farm types and male farmers over the age of 51 were identified as a group that warrants special attention for education and support regarding responsible disposal methods – the most logical approach is to target the entire population of farmers in NS for inclusion in an APW recycling program. The plastics producers/dealers/importers of the province, similar to those in Norway, would likely be willing to participate on a voluntary basis with the understanding that participation will help the industry avoid punitive measures or forced participation in an EPR program which would target the approximately 60 000 tonnes of plastics waste currently being disposed of in landfills in NS each year.

Practical recommendations are given here to facilitate the implementation of an APW recycling program in the province. For farmers, key considerations are linked to on-site handling practices:

- a. APW should be kept relatively clean and dry through practices such as shaking, hanging, and bundling directly after final on-farm use of the plastics
- b. Bins and/or large storage bags should be provided to farmers which have adequate storage space and protect the plastics from further contamination or deterioration
- c. Plastics that are generally physically similar to each other should be bundled and stored together. For example, film plastics such as silage wrap, bale wrap, and grain bags or tubing can be stored together while rigid plastics such as containers should be stored separately
- d. Regarding plastics collection two methods are most common: 1. Plastics are collected at specific times of year, co-ordinated by the organizing body of the recycling program; 2. Farmers contact collection agencies when collection is necessary and convenient for them

For waste management policy makers and organizations the considerations are linked to the financial implications:

- a. Levies should be placed on the sale of agricultural plastics in order to cover the majority of the estimated cost of the management and operation of an APW recycling program
- b. A levy of 3-4% of the cost of purchased plastics should be collected from the farmers at the point of purchase and an additional per tonne fee should be collected at the point of disposal for plastics that are excessively contaminated or degraded

4.1.5 ADDRESSING LOW-VALUE PLASTICS WASTE IN AN INTEGRATED MANNER IN NS

The plastics recycling rate in the province is estimated to be less than 15%; to increase plastics diversion from landfill the province needs to identify local disposal/recycling options for post-consumer low-value plastics waste, including APW.

Moreover, to increase ICI (which includes farmers) plastics waste recycling rates the province needs to monitor and enforce landfill bans on plastics - this may be the only way the province can be sure that private waste collectors contracted to dispose of ICI waste are not disposing of banned plastics waste in landfill.

An example that may also warrant further investigation to guide the effective implementation of a successful APW recycling program in NS is organic waste recovery. Organics are a low-value waste stream that requires considerable organization and effort to divert from landfill – low-value plastics waste requires a similar effort on part of waste management professionals to develop capture methods and end-use options. Proposed EPR legislation for NS, which was put on hold in 2015, would have encompassed a number of types of plastics waste and therefore established mechanisms for diverting plastics from landfill, as has happened with organic waste in NS in the last 20 years. The establishment of EPR regulations in NS should be re-visited – as market driven recycling options have not managed to achieve a decent plastics recycling rate in the province.

4.2 FUTURE RESEARCH

Future research should expand knowledge in two specific thrusts regarding APW recycling in NS. First, on-site audits should be done to further the understanding of the exact amounts, types, condition, and the feasibility of potential on-site handling and disposal practices of plastics waste being generated on-farm. Secondly, the specifics of the financing for an APW recycling program should be detailed with any economic, legal, and practical barriers being further investigated. However, any program development will benefit from the knowledge generated from this research and due consideration of the successful APW programs detailed in Chapter 3.

4.3 Limitations of the research

More attention should have been paid to the horticulture and plant based sector of the farming community and the plastics waste that they generate specifically. Horticulture farming produces different types of plastics waste and different challenges regarding management and collection, and horticulture operations account for an appreciable portion of farms in NS.

4.4 FINAL THOUGHTS

Plastics are ubiquitous in modern society, and irreplaceable as a material source for disposable products and durable products alike. Approximately 4% of world oil and gas production is converted to plastics and the production process for plastics consumes the energy equivalent to an additional 3-4% (Al-Salem et al., 2009). Improper disposal of recyclable plastics is a waste of material resources that will have knock on effects for future generations in the form of reduced resource availability and increased pollution.

Targeting specific waste streams may be necessary to increase recycling rates for plastics in NS and elsewhere. In the case of farm plastics waste, successful engagement with farmers requires provision of an APW recycling program that is not prohibitively expensive or difficult to access. Farmers are willing to participate in such a program and are frustrated with the lack of accessible and affordable options for plastics disposal.

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APPENDICES

APPENDIX A: SURVEY FOR NOVA SCOTIAN FARMERS

AGRICULTURAL PLASTICS WASTE MANAGEMENT IN NOVA SCOTIA:

Questionnaire

The first half of your postal code is requested.

This is not mandatory. If provided it will only be used to better understand the geographic distribution of the participants.

1. Are you male or female?

Male Female

2. What is your age range?

20-35 36-50 51-65 65+

3. Approximately how long have you been operating your farm?

0-5 years 6-10 years 11-15 years 16-20 years 21-25 years 26-30 years > 30 years

4. What percentage of your income comes from farming?

<10% 10-25% 25-50% >50%

5. Please list, in order of greatest to least, the 5 most important commodities produced on your farm in terms of financial value.

1 _____
 2 _____
 3 _____
 4 _____
 5 _____

6. Please list, in order of greatest to least, which commodities contribute most to your plastics waste.

1 _____
 2 _____
 3 _____
 4 _____
 5 _____

7. It is important to me that farm plastics waste is recycled or disposed of in some other sustainable manner.

Strongly Agree Somewhat Agree Neutral Somewhat Disagree Strongly Disagree

8. From an environmental perspective, disposal of farm plastics waste in a public landfill is an adequate method of disposal.

Strongly Agree Somewhat Agree Neutral Somewhat Disagree Strongly Disagree

9. What types of plastics waste are generated on your farm? Please check the amount of plastics waste generated on your farm for a given year.

	0 KG	1-5 KG	6-15 KG	16-25 KG	26-35 KG	36-45 KG	>45 KG (provide estimate)
Plastic baling twine							
Plastic grain bags or tubes							
Silage plastic							
Bale plastic							
Plastic containers							
Mixed agricultural plastics							



AGRICULTURAL PLASTICS WASTE MANAGEMENT IN NOVA SCOTIA:

Questionnaire

10. How do you typically dispose of each type of plastic? Multiple options are possible if you reuse some plastics before disposing of them.

	recycle	reuse	transport to landfill	roadside collection for landfill	stockpile	burn on farm	other	Are you satisfied with this method of disposal?	
Plastic baling twine								yes	no
Plastic grain bags or tubes								yes	no
Silage plastic								yes	no
Bale plastic								yes	no
Plastic containers								yes	no
Mixed agricultural plastics								yes	no

11. Do you need more information on how to recycle these plastics?

	Comments?	
Plastic baling twine	yes	no
Plastic grain bags or tubes	yes	no
Silage plastic	yes	no
Bale plastic	yes	no
Plastic containers	yes	no
Mixed agricultural plastics	yes	no

12. What barriers, if any, prevent you from collecting and consolidating plastics into one location on your farm for easier collection by a recycler?

13. What action would you be willing to take to divert the plastics waste from your farm into a recycling program?

	Separate, bundle & deliver to depot	Separate, bundle & store for pickup	Consolidate & store for pickup (without separating)	Return to supplier	Other (please indicate)
Plastic baling twine					
Plastic grain bags or tubes					
Silage plastic					
Bale plastic					
Plastic containers					
Mixed agricultural plastics					

14. If, for example, a roll of bale wrap costs \$75, how much would you be willing to contribute to support an agricultural plastics recycling program?

\$0.00 \$0.75 \$1.50 \$2.25 \$3.00 \$3.75 \$7.50

15. Who should have the organizational and financial responsibilities associated with agricultural plastics waste management? Choose those you feel should be included and indicate order of responsibility if the level is not equal (1 - most responsible, 2 - 2nd most responsible, etc.)

- The plastics producer/dealer/importer
 The farmer
 The municipal government
 The provincial/federal government

APPENDIX B: SURVEY FOR WASTE MANAGEMENT GROUPS IN NOVA SCOTIA

Isaac Muise - Dalhousie – SRES – 2015
Isaac.muise@dal.ca – (t) 902-999-5744 – (f) 902-494-3728

The following questions are designed to help me understand better the operational specifics of the management of different types of plastics waste at the municipal level in Nova Scotia, with a particular focus on low-value mixed plastics. If you have any further insights or comments please feel free to write them in the space at the end of this document. If you find that any questions are not applicable to you please write NA and continue to the next question. There are many questions here, if you would prefer to run through them quickly over the phone please call me any time at 902-999-5744. Otherwise please feel free to respond to the questions directly in this email, in the Microsoft Word document attached, or fax a hard copy to the number above. Thank you in advance for your time and help.

1. What type of waste management facility will you be providing information on?
(MRF, landfill, transfer station, other)
-
2. Where is the facility located? (Municipality)
-
3. Do you accept waste from any other municipality?
-
4. How does your facility (or municipality) determine which plastics will be accepted?
-
5. How much plastics is handled at this facility annually (in tonnes)? What % of the plastics end up in landfill?
-
6. Which industries, companies, commercial groups, or institutions produce the most plastics waste?
-
7. Do you currently stockpile any plastics?
If yes, why? -
What types and how much? -
For how long? -
Comments -
8. Are you aware of any recyclers in the Maritimes (or North America) that accept mixed, low-grade/low-value plastics?

-
9. Is there a different approach on how you collect and manage waste from residential, institutional, and commercial generators?

-
10. Do you accept agricultural plastics at your facility? If so, what types, and how much?

-
Under what circumstances could you not accept the following plastics?

Polypropylene (#5) -

Low-density polyethylene (#4) -

High-density polyethylene (#2) -

Plastic films (mixed) -

11. What factors influence your ability to collect plastics waste from farms?

-
Please feel free to comment on any coming changes policies, regulations, or requirements that will influence the collection and marketing of different types of plastics:



General comments:



APPENDIX C: SURVEY FOR EMPLOYEES OF NOVA SCOTIA ENVIRONMENT

The following questions are designed to help me understand better the legislative situation as it pertains to the management of end-of-life plastics in Nova Scotia. With particular interest in agricultural end-of-life plastics. If you have any further insights or comments please feel free to write them in the space at the end of this document. Thank you in advance for your time and help.

1. What plastics are currently banned from entering landfills?
2. How are new plastics types added to the list of banned materials?
3. What landfill bans concerning plastics are expected to come into effect in the next five years?
4. To what extent are material bans monitored and enforced?
5. What mechanisms are in place that deal specifically with agricultural plastics waste?
6. Would extended producer responsibility legislation increase the capture rate of agricultural plastics waste?
7. Would all plastics typically found on farms be considered packaging materials under an extended producer responsibility program? If not, could you foresee an extended producer responsibility category for such things as plastic sheet materials used for silage, wrapping and shipping products, etc.?
8. What barriers exist regarding the establishment of plastics waste recycling systems in NS that will not require exporting the material?
9. What changes to legislation or regulations are expected regarding plastics waste management systems that are not mechanical recycling or landfilling?

Comments:



APPENDIX D: SURVEY FOR APW RECYCLING ORGANIZATIONS IN OTHER JURISDICTIONS

Regarding the responsible management of agricultural plastics waste in your jurisdiction.

1. What roles and responsibilities fall on this organizing body? How does the organization remain financially viable? If this organization did not exist is it likely that another existing organization would take its place?
2. What roles and responsibilities fall on the farmer? What financial burdens or rewards are applied to the farmer in connection with this program? What level of farmer participation do you have in this program?
3. What roles and responsibilities fall on the plastics producers supplying your jurisdiction? What financial connections do they have to the program? Would the program be able to carry on successfully without the participation of the plastics producers?
4. What roles and responsibilities fall on the plastics recyclers themselves? What limits do the recyclers impose regarding amount, type, and condition of plastics provided? What problems have been encountered while selling material to the plastics recyclers?
5. What roles and responsibilities fall on the local government? Does the local government provide financial viability gap support for the program? Does the local government participate in the collection of this plastic? Does the local government monitor and enforce laws associated with this waste?
6. What roles and responsibilities fall on the national government? Does the national government provide financial viability gap support for the program? Does the national government provide financial incentives to any of the stakeholder groups? Has the national government passed relevant legislation?
7. What roles and responsibilities fall on the agencies that collect the plastics? What arrangements exist between the collection agency and any other stakeholders? What financial or organization support are provided to the agency by any of the stakeholders?

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