Agricultural Plastic Film Recycling:

Feasibility and Options in the Central Leatherstocking-Upper Catskill Region of New York State

January 2005

Lois C. Levitan
Program Leader
Environmental Risk Analysis Program
Department of Communication
Cornell University

David G. Cox
Agriculture Development Specialist
Cornell Cooperative Extension of Otsego County

Martha B. Clarvoe
Special Projects Manager
Otsego County Conservation Association

Address correspondence to:
Dr. Lois Levitan
311 Kennedy Hall
Department of Communication
College of Agriculture and Life Sciences
Cornell University
Ithaca, New York 14853

Phone: 607-255-4765
Email: LCL3@cornell.edu

Agricultural Plastics Recycling website:
<http://environmentalrisk.cornell.edu/AgPlastics/>

file: AgPlas-05-01-07

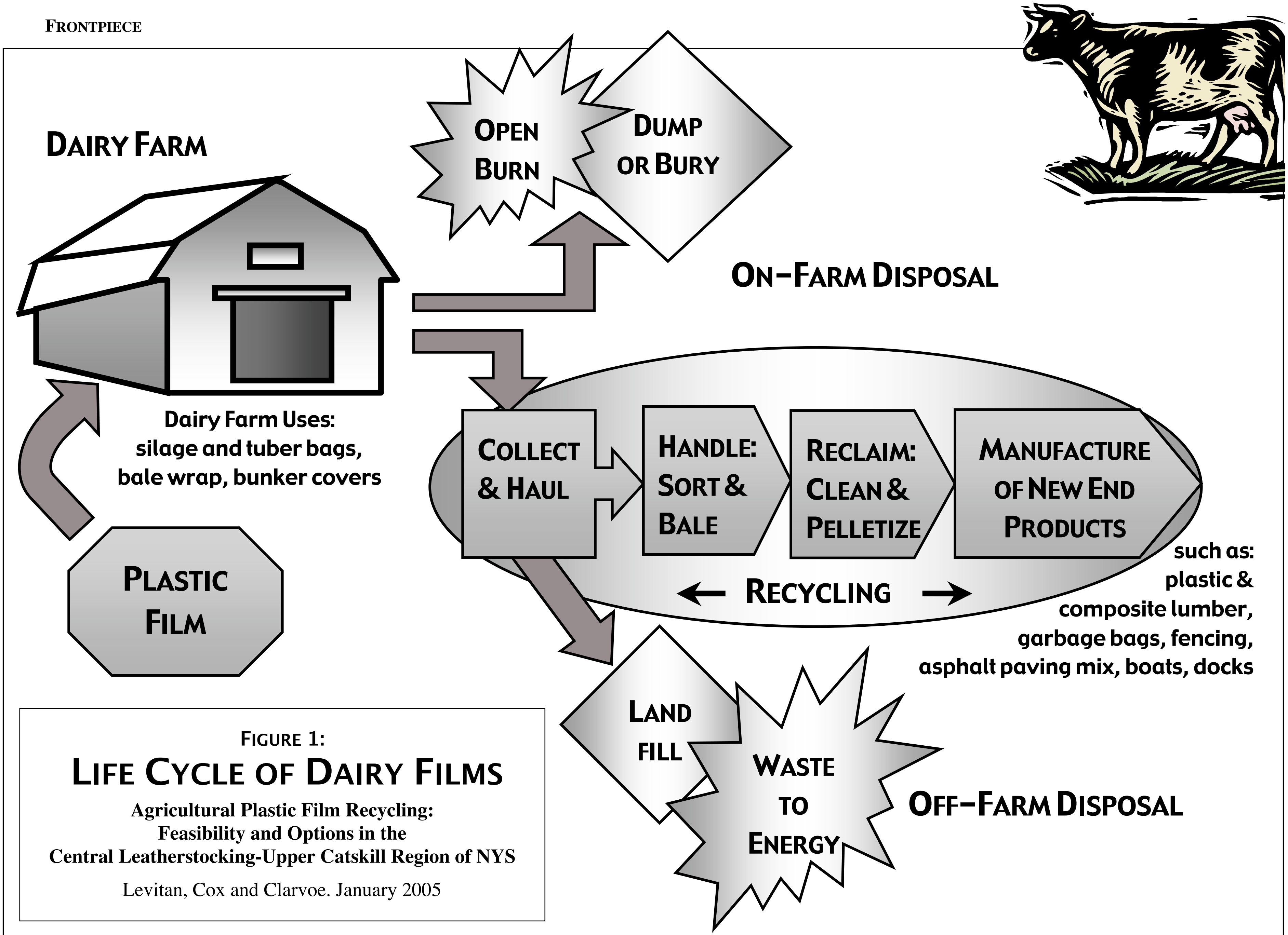


FIGURE 1:

LIFE CYCLE OF DAIRY FILMS

Agricultural Plastic Film Recycling:
Feasibility and Options in the
Central Leatherstocking-Upper Catskill Region of NYS

Levitan, Cox and Clarvoe. January 2005

Agricultural Plastic Film Recycling:

Feasibility and Options in the Central Leatherstocking-Upper Catskill Region of New York State

Lois Levitan, David Cox, and Martha Clarvoe

January 2005

TABLE OF CONTENTS

TABLE OF FIGURES, MAPS AND TABLES

Acknowledgements

We gratefully acknowledge support for research and preparation of this report received from the New York State Department of Economic Development, Environmental Services Unit; Cornell University, College of Agriculture and Life Sciences; and USDA Smith-Lever funds awarded by Cornell Cooperative Extension.

The authors are indebted to the many individuals and organizations that provided information used in developing this report, and for the energy and enthusiasm we are confident they will apply to bringing agricultural plastic films recycling programs to fruition. They include farmers; people associated with community development, waste management, farm, and environmental agencies and organizations; businesses that manufacture and supply plastic films, as well as those that re-process, collect and/or haul recyclables. Many of these individuals, businesses and organizations are referenced, listed as contacts, or mentioned in notes to the text. We would like to specifically acknowledge several others, with thanks:

- Participants in the Agricultural Plastics Film Recycling Feasibility Study Focus Group, who provided invaluable assistance and insights from diverse perspectives during our meeting on August 13, 2004 and, individually, at other points during this research. The full group invited to the focus session is listed in Appendix I (page 65). Special thanks are extended to Terry Bliss, Solid Waste Coordinator for Otsego County, whose input and interest are invaluable, and to Mary Ashwood, chair of the Otsego County Burn Barrel Education Group, who has tirelessly kept this issue in the public attention for more than a decade.
- Eric Strong, web programmer extraordinaire, who developed the Cornell Environmental Risk Analysis Program's Agricultural Plastics website <http://environmentalrisk.cornell.edu/AgPlastics/> and provided invaluable technical and research assistance throughout.
- Anna Bianchi, Administrative Manager of the Cornell Department of Communication; Mary Beth Vargha, Otsego County GIS Coordinator, who developed the maps that are integral to this report; and Madelyn Sanchez, office manager of the Cornell Cooperative Extension Association of Otsego County for patiently facilitating our work.
- Members of the New York Legislature who have sponsored public and policy forums bringing together farm, agency, and research communities interested in developing viable options for agricultural plastics disposal. They include: State Senator James L. Seward (Member, Agriculture and Economic Development Committees); Assemblymen David Koon (Chair, Legislative Commission on Toxic Substances and Hazardous Wastes; Vice-Chair, Commission on Rural Resources; Member, Assembly Committee on Economic Development); Thomas P. DiNapoli (Chair, Assembly Committee on Environmental Conservation); William Colton (Chair, Legislative Commission on Solid Waste Management and Member, Assembly Committee on Environmental Conservation); William Magee (Chair, Assembly Committee on Agriculture); and Darrel J. Aubertine (Member, Assembly Committees on Agriculture, Economic Development and Rural Resources)[1]. We are also indebted to those who organized and participated in these meetings, roundtables and hearings.
- Cornell University's ad hoc "open burning group" of faculty and extension educators who met throughout 2002 and provided context for our initial work, leading to development of the report *Recycling Agricultural Plastics in New York State* (March 11, 2003. Levitan and Barros).

[1] Information about committee memberships is from personal communications and from the NYS Assembly website <http://assembly.state.ny.us/mem/>, accessed September 2004. We have listed only those committee assignments we believe are pertinent to agricultural plastics recycling.

Preface

This report builds on prior research reported in *Recycling Agricultural Plastics in New York State* (Levitan and Barros 2003). While that report was a panoramic survey of the full array of farm plastics and related recycling programs, the current report focuses primarily on the plastic films used in dairy agriculture (#4 LDPE and LLDPE, low density polyethylene resins).

Some attention is paid in the current study to *(i)* polypropylene baling twine used to wrap forage (#5 PP, also called poly-twine) because this product is also used in the dairy agriculture sector and is not currently recycled, and to *(ii)* nursery/greenhouse films because they are made from the same plastic resins as the dairy films and could therefore be recycled as part of the same programs and processes. In this context we also look at the use and disposal of other (*i.e.,* non-agricultural) plastic films in the study area.

Geographically we focus on the Central Leatherstocking-Upper Catskill region of New York State (NYS), particularly the southern portion of the region within a 30-mile radius of Oneonta, New York (Otsego County, NY) (see Map 1, page 11). The rationale for these product-type and geographic foci is that the Central Leatherstocking-Upper Catskill region is a dairying area where agricultural plastics recycling has sparked the interest of local citizenry, the farm and recycling communities, government agency personnel, and policy-makers as a means to reduce the environmental and health risks of open burning and possibly as a means for generating value-added economic activity.

Consistent with these interests, our objective is to facilitate development of an infrastructure in New York State for off-farm disposal of agricultural plastic wastes in order to avoid the environmental health effects and other liabilities of burning, burying, or dumping on-farm.

We (the authors) have been participant observers in this research, interested both in assessing the technical and economic feasibility of recycling at the same time that we have used the research process as a means to develop networks and build interest in the tangible outcome of a recycling program. We do not believe that this activity prejudices our assessment. Rather we believe that technical and economic feasibility are "necessary but not sufficient conditions" for getting something done. Without community interest and individual/organizational leadership, the recycling of agricultural plastics will not happen!

Research Methods

We used primary and secondary research methods. Primary research involved open-ended interviews conducted face-to-face and by telephone with people from agricultural, recycling and re-processing communities in the region and nationally. Public- and private-sector leaders in recycling of agricultural plastics (containers and films) were interviewed in depth.

Members of the local agricultural community provided data and insight into specific purposes, sources and quantities of agricultural plastics used in the area. They also provided regionally-pertinent contact information that enabled us to develop a "snowball sample" of interviewees. The farm community also provided insight into constraints that dairy farmers would face in recycling and on incentives that could potentially increase their interest and overcome hurdles to participation. By working with both the agricultural and recycling/solid waste communities, we were able to develop a realistic model and set of expectations for a viable recycling program.

Secondary research involved surveying pertinent literature, much of it the "gray" (rather than the "scientific") literature of company websites, product circulars, unpublished memoranda and reports, etc. For the most part, publicly accessible literature is referenced in the bibliography while information drawn from personal communications and other inaccessible documents is cited in footnotes.

Introduction

Objectives and Background

The purpose of this study is to assess conditions under which recycling of used agricultural plastic films could be technically and economically feasible in New York State. The research focuses on dairy films generated within a 30-mile radius of Oneonta, New York (Otsego County), in the Central Leatherstocking-Upper Catskill region. When pertinent, we also look at a broader geographic context as well as consider *(i)* recyclable films generated from non-dairying sources and *(ii)* other types of plastic used in the dairy industry. The study:

I. Describes and quantifies use of plastic film (#4 LDPE and LLDPE, low density polyethylene resins) and polypropylene baling twine (#5 PP, also called poly-twine) in the dairy industry in the designated area and more broadly in New York State.

II. Describes and estimates use of nursery/greenhouse films as well as other (*i.e.,* non-agricultural) plastic films in the study area because these films are made from the same plastic resins as the dairy films and could therefore be recycled as part of the same programs and processes.

III. Identifies and evaluates options for materials preparation, aggregation and collection for recycling and re-processing.

IV. Identifies and evaluates existing and potential markets for used agricultural plastic films.

V. Identifies local networks, potential partners, and collaborators for each stage in the process.

The issue of recycling agricultural plastics has been garnering greater attention in recent years because these materials have become ubiquitous in all sectors of agriculture. Plastics are substituted for the longer lasting materials previously used—*e.g.,* concrete, glass, ceramic, metal, etc.—because they are often less costly, safer to use, and improve production efficiency.[2] However, after more than two decades of increasing use, the problem of disposal is ever more difficult to ignore or to put out of sight.[3]

---

[2] **WHY USE AGRICULTURAL PLASTICS?**
EXAMPLE: ADVANTAGES OF SILAGE BAG STORAGE SYSTEMS

Several compelling arguments support use of silage bags rather than other systems for storing dairy forage. Comparisons of three methods of high moisture storage (silage bag, bunker silo, tower silo) and dry forage storage (*i.e.,* hay bales) give high marks to the silage bags in terms of costs, safety, forage quality, post-harvest loss, and life-cycle environmental/health risks (Josefsson et al. 2000, 2001; the Crop Storage Institute, undated website; and Smith 2003).

Quite importantly, silage bags are not associated with the significant **occupational health risks** associated with tower silos, *e.g.,* risk of falling into silage and asphyxiation from exposure to toxic silage gas. A drawback to the silage bags and plastic-covered bunker silos is their larger footprint (*i.e.,* they require more **land area** than vertical silos). However, unlike these permanent structures, silage bags are portable and can be put on land that is not needed for other purposes at a given time.

In addition, Josefsson et al. (2000) has shown that silage bags require a far smaller **capital investment** than tower or bunker silos, an advantage that increases with size of farm: Purchase of sufficient plastic silage bags for a small farm (55-cows) requires 46 percent of the initial capital investment required for a tower silo of equivalent storage capacity, and 58 percent the investment for a concrete bunker silo. Silage bags for larger farms (219 cows) require 27 percent the initial capital investment required for a tower silo and 40 percent of bunker silo investment.

Several studies indicate that most agricultural plastics are burned or buried on-farm, creating fire hazards, clogging water channels, and releasing high levels of polluting emissions.[4] Agricultural plastics have been difficult to recycle because they are dispersed across the rural landscape, bulky, and often contaminated with debris (*e.g.,* dirt, pebbles, vegetation, chemical residues, moisture), limiting their suitability and value for re-processing. By describing options and assessing feasibility, this project builds on a growing momentum to overcome these hurdles and develop a sustainable infrastructure in New York State for agricultural plastic film recycling.

Recycling Infrastructure and Terminology

Figure 1 (frontpiece) illustrates the primary stages in the plastic recycling process, as they are outlined by the American Plastics Council (APC) and the Environmental and Plastics Industry Council of Canada (EPIC), and described below (American Plastics Council 1994; EPIC-Infrastructure).

(i) **Hauling**. Collection of recyclables; transport to a handler.

(ii) **Handling**. An intermediate scrap process involving sorting, baling, shredding.

(iii) **Reclamation**. Conversion of used plastic products into pellets or flakes ready for re-use. This stage may involve washing prior to pelletizing. Plastic feedstock is sold in the form of pellets or flakes, whether from virgin or recycled resins.

(iv) **Manufacture of New End Products**. Manufacture of a finished product from post-consumer (or post-industrial) plastic.

We frequently heard the term "recycling" used in referring to the handling stage alone as well as when referring to the overall process, and the term "re-processing" used when referring to the reclamation stage. These terms are therefore used interchangeably in this report. Some county/regional recycling

---

Footnote 2 continued:
Annual costs are also lower when interest and principal on the capital investment are considered as well as operational costs. At all herd sizes, annual costs for bunker and vertical silos are approximately the same and about 20 percent more than annual costs of storage in silage bags. Approximate annual costs per cow are calculated as follows (based on Josefsson et al. 2000):

FOOTNOTE TABLE I: COMPARATIVE ANNUAL COSTS FOR FORAGE STORAGE METHODS

METHODS	55-COW FARM	219-COW FARM
Silage bag	$267 per cow	$200 per cow
Concrete bunker silo/Tower silo	$314 per cow	$245 per cow
Annual Savings	**~ $2500 per farm**	**Nearly $10,000 per farm**

3 While **biodegradable plastics** are beyond the purview of this study, we would like to note that there are promising developments in the arena of **biodegradable plastics for use in agriculture**. A new product that contains neither polyethylene nor starch is now on the market (see <http://www.cortecvci.com> and <http://www.ecofilm.com> for information about Cortec Corporation's Eco Film).

The overall cost to farmers for use of biodegradable film will be less than for use of conventional plastic mulch film if the product cost is less than twice that of conventional film. The reason is that labor costs for laying and removing the mulch film is significant. Since biodegradable films do not have to be removed from the field, labor costs are approximately halved (personal communication with Anu Rangarajan, Associate Professor of Horticulture, Cornell University, at a focus group session of the Cornell Open Burning Group, June 24, 2002).

4 See Levitan and Barros 2003, page 1, for an overview of environmental/health risks associated with open burning of agricultural plastics and other wastes.

agencies oversee or perform both hauling and handling operations while others organize only the hauling stage. These operations may be accomplished either by contracting with private haulers or by performing the work in-house. APC and EPIC consider all stages *(i.e., i* to *iv* above) as potential markets for recyclable goods. We follow their protocol and do the same in considering options and optimal arrangements for moving agricultural plastics off-farm and through this four-stage recycling process.

Organization of the Paper

After describing the agricultural sector in the study area and the uses of plastic films in dairying, the remainder of the paper is structured along the lines of the four steps in the recycling process. We follow the life-cycle of the plastics from their manufacturer to their use on the farm, and through disposal, focusing on options and steps that lead to re-processing into new goods (see frontpiece Figure 1: *Life Cycle of Dairy Films*).

Geographic Parameters of the Study

We focus on recycling potential in the Otsego County, New York area. Geographic parameters (the geographic hub and the size of the study area) were set after consideration of several factors described in this section.

We established Oneonta as the **geographic hub** of the study because of its:

- **central location:** Oneonta is located on Interstate Route 88, a major transportation route. It is the largest municipality in Otsego County as well as the largest municipality within at least 30 miles in any direction.
- **organizational and individual networks:** There is much to recommend developing an agricultural plastics recycling program that works with, if not through, existing recycling channels. In Otsego County, recycling is coordinated by the Otsego County Solid Waste Department, which works closely with the regional solid waste authority (the Montgomery, Otsego, Schoharie Solid Waste Authority or MOSA). The Otsego County Solid Waste Department is based in Oneonta and its coordinator is strongly interested in developing an agricultural plastics recycling program.

In deciding how far from the Oneonta hub to extend, we balanced competing considerations: A recycling program covering a larger collection area may be more viable because of access to higher volumes of material.[5] On the other hand, participation is likely to be greater within a smaller program area because of cost and administrative factors. In establishing the geographic bounds of the study, we considered transportation distance, agricultural infrastructure, and political boundaries.

[5] A truckload (about 20 ton) is the typical threshold for handling by material re-processors, and thus has been used as the unit-of-analysis for much of this study. Otsego County alone would not likely have sufficient flow-through to establish a viable recycling program.

- **Distance:** Drawing from the experience of others with regard to how long and how far a farmer is likely to travel for purposes of recycling[6], we set a distance of 30 miles and a driving time of approximately 45 minutes as the bounds of the study area. This distance is indicated on the four maps included in this report by a set of darkly shaded concentric circles drawn around Oneonta at 10-mile increments. We use a lighter shade to indicate the area within a 30- to 50-mile radius of Oneonta. The area circumscribed by the 50-mile radius circle encompasses the nine-county Central Leatherstocking-Upper Catskill region of New York, while the 30-mile circle encompasses much of the southern portion of this region. The larger area covers the dairying region to the north of Oneonta, in southern Madison and Herkimer Counties and eastern Montgomery County.
- **Dairy/Nursery Industries:** For efficient and effective promotion, administration and implementation of a recycling program, we wanted the study area to encompass active and relatively-cohesive regional nodes of the dairy and nursery agricultural sectors. We anticipate that promotional and educational efforts targeting these farm groups will work through Cornell Cooperative Extension's (CCE) regional agricultural specialists (both dairy and nursery/greenhouse), the private sector supply network, and the recycling markets. The CCE Central New York Dairy, Livestock and Field Crops (CNYDLFC) specialists' region includes Chenango, Herkimer, Montgomery/Fulton, Otsego, and Schoharie counties. While CNYDLFC does not serve Delaware County directly, most of Delaware County's dairy community is situated within the 30-mile study area radius. In addition, a large nursery (and user of greenhouse plastic films) is located just over the Otsego County line, in Delaware County.
- **Political Boundaries:** Despite our primary interests in being central to the dairying industry and to transportation, we also use political boundaries to define the study area because *(i)* much data are collected by county and *(ii)* relevant budgetary matters may be constrained by political boundaries. *I.e.,* if collection and hauling of agricultural plastics are subsidized as part of a county recycling program, as is often the case with other components of a recycling program, the service would likely extend only to county borders. For these reasons, and also because the 30-mile radius covers significant portions of Otsego, Chenango and Delaware Counties, we have designated these three counties as the primary study region (see Map 1, page 11, and Table 1, page 14). It is important to note, however, that MOSA and the Otsego County recycling program are not constrained to accept only those materials generated from within their political borders.

In sum, the primary study area is within a 30-mile radius of Oneonta, New York. To a lesser extent, we also consider the larger area within a 50-mile radius around Oneonta. Strong arguments could be made for encompassing the area to the north in a recycling program because of its intensive dairy agriculture and proximity to the New York State Thruway/Interstate 90 corridor.

---

6 A survey of Vermont dairy farmers found that nearly half of the respondents were willing to travel at least 10 miles to haul their used plastic films for recycling; 27 percent would travel 10-25 miles; and 5 percent, were willing to travel more than 25 miles. Three-quarters of respondents said they would haul plastic film to a recycling center if they were not charged a fee and 21 percent would haul if charged a moderate fee. Nearly one-quarter said they would pay to have plastics picked up on-farm (Negra and Rogers 1998). We assume that commercial haulers will travel a longer distance if remunerated, and thus set the study area bounds at a 30-mile radius from Oneonta.

In New Jersey, where farms as well as other industries are prohibited from open burning, recycling coordinators have found that farmers will travel no more than 1 hour. Without this legal constraint on open burning, Pennsylvania farmers have not been traveling more than 20 minutes for recycling (based on personal communications with Karen Kritz, New Jersey Department of Agriculture, and Dennis DeMatte, Recycling Coordinator for the Cumberland County Improvement Authority, New Jersey, both in September 2003; and Don Gilbert, Pennsylvania Plastic Pesticide Container Recycling Program, October 2003).

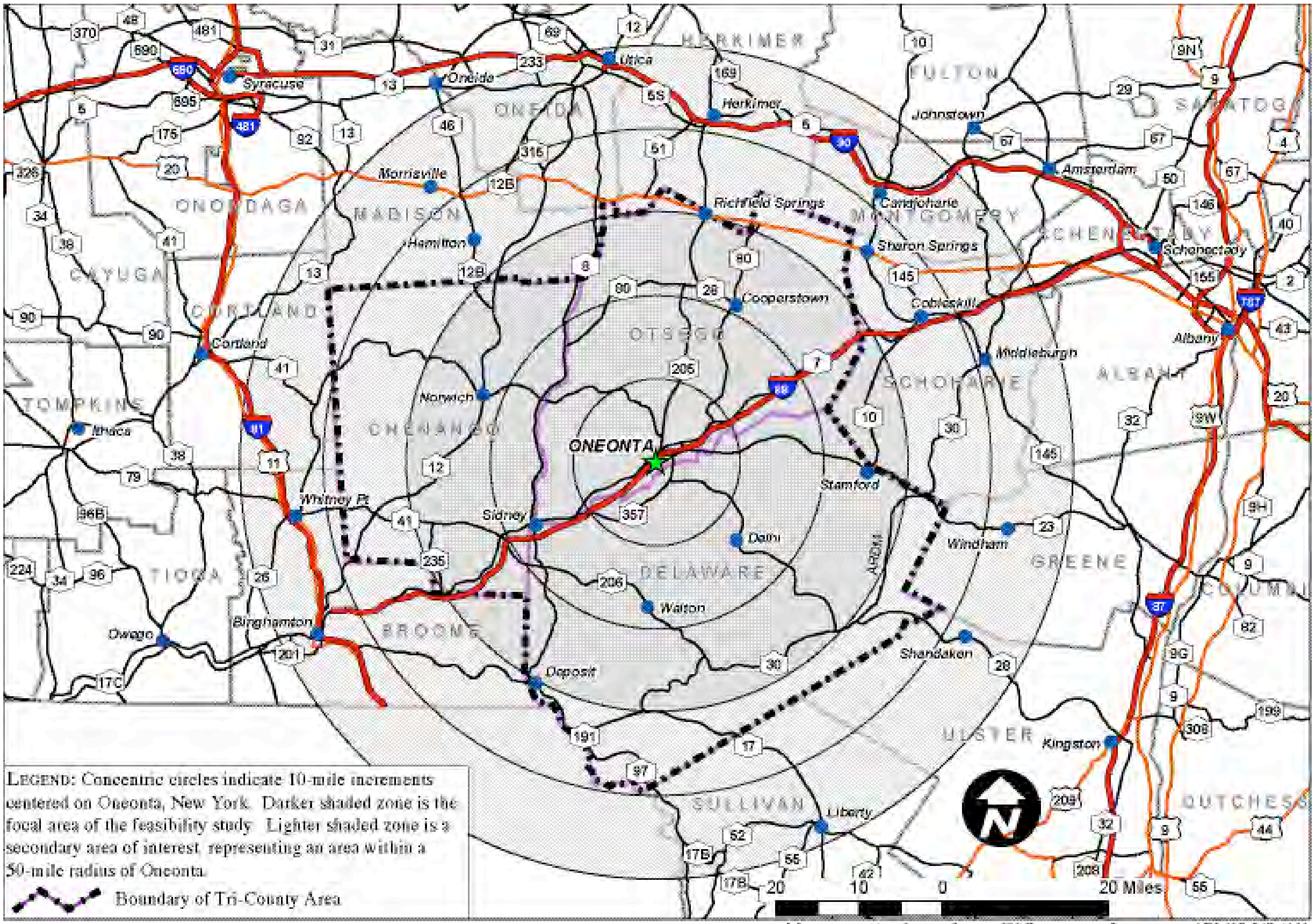
Solid Waste Handling and Recycling in Otsego County and the Surrounding Area

There are five transfer stations in the three-county area served by the Montgomery, Otsego, Schoharie Solid Waste Authority (a.k.a. MOSA). Two are in Otsego County: the Northern Otsego Transfer Station in Cooperstown and the Southern Otsego Transfer Station in Oneonta. The other three are the Amsterdam and Western Transfer Stations in Montgomery County and the Schoharie Transfer Station near Cobleskill in Schoharie County. All five are shown on Map 3, page 42. Solid waste from the three counties is now trucked to a landfill in Western New York, about 4 hours distant. All three counties are mid-contract with MOSA, with an obligation to deliver all county wastes to a MOSA transfer station. However, recyclables are credited against the contractual quota, such that the quota would be reduced by the tonnage of plastic film recycled from County sources.

Recyclables are handled differently in each of the three MOSA counties. Otsego County has about a dozen drop-off sites where residents can leave several types of recyclables at no charge. In January 2004 Otsego County began a three-year contractual arrangement with Naef Recycling of East Syracuse, New York, for pick-up and processing of paper, cardboard and glass. It is estimated that Naef will recycle 10 tons per day from Otsego County. This compares with the 50 tons per day they recycle from Oswego County (source: The NYSAR3 Network. Spring 2004).

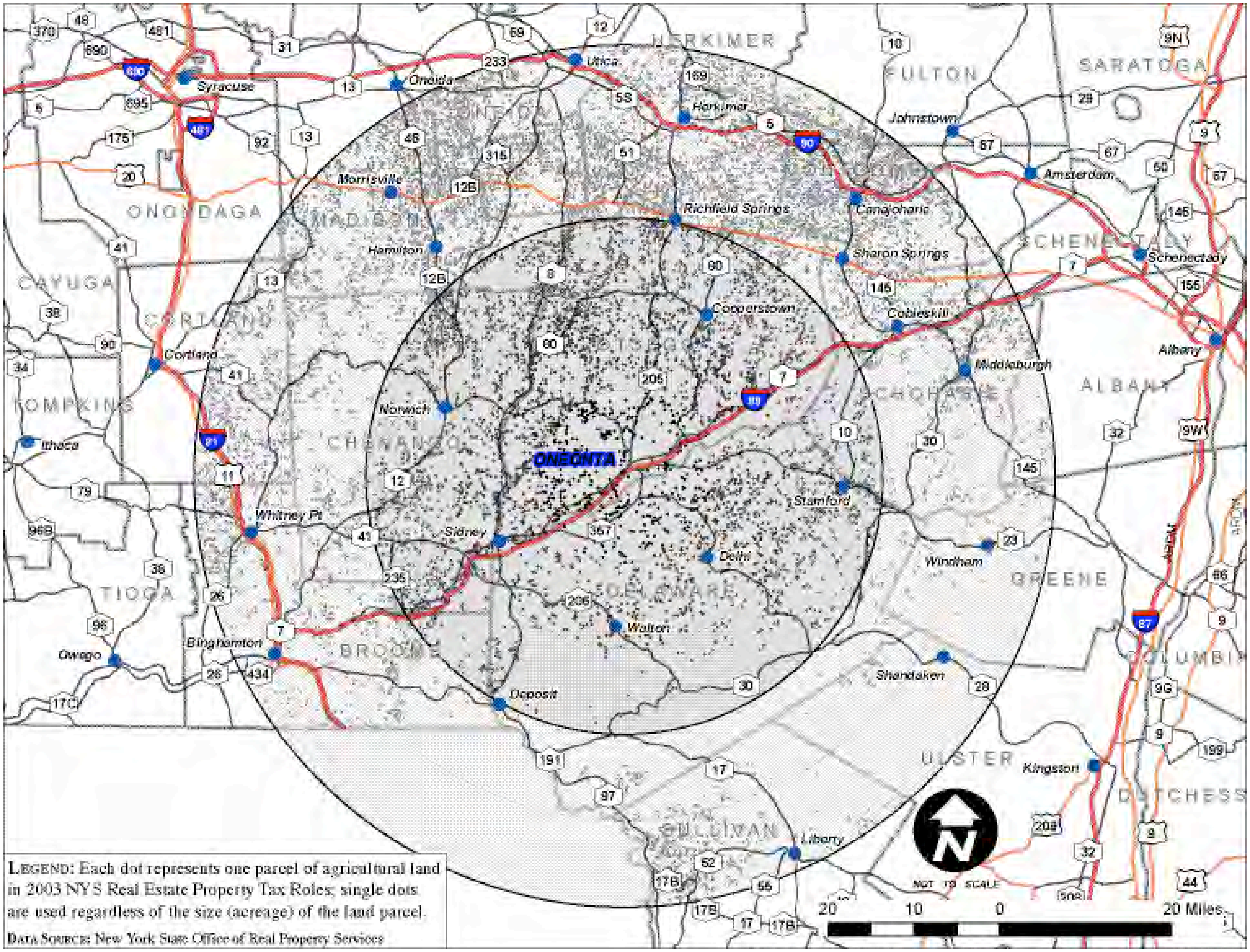
The recycling program is costly for Otsego County, which pays for pick-up and transport to the Naef facility as well as for the collection boxes. Otsego County residents can also dispose of scrap metal at no charge, working with local scrap haulers who pick it up and sell to the metal recycling market. Otsego County does not currently sponsor a plastics recycling program.

Map 1: Feasibility Study Area: Central Leatherstocking-Upper Catskill Region, New York State



Map prepared by: Otsego County GIS Department, Cooperstown, NY 607-547-4292

MAP 2: AGRICULTURE PARCELS IN THE STUDY AREA



Map prepared by: Otsego County GIS Department, Cooperstown, NY 607-547-4292

Farms & Farming
in the Central Leatherstocking-Upper Catskill Region

The three-counties surrounding the City of Oneonta, New York—Chenango, Delaware and Otsego—are in the southern portion of a region commonly known as the Central Leatherstocking-Upper Catskills.[7]

The City itself—sitting nearly equidistant between Albany and Binghamton on Interstate 88—has a population of 14,000 and is home to Hartwick College and to the State University of New York (SUNY) at Oneonta. It is the largest municipality within more than a 30-mile radius.

Most of the land area of these counties is non-urbanized and remains in agriculture. Each county contributes nearly equally to the $153,000,000 market value of agricultural products sold annually in the three-county area (US Census of Agriculture 2002) (see Map 1, page 11, and Map 2, page 12).

The three-county focal area contains 8.3 percent of the New York State population[8] and generates 5-8 percent of New York State agriculture, based on the indicators shown in Table 1 (page 14):

- about 7.5 percent of farms
- fewer than 5 percent of dairy farms
- nearly 8 percent of farmland
- 7.2 percent of cows
- more than 8 percent of hay
- nearly 7 percent of milk produced in New York State.

As shown on Map 2, there is a greater concentration of agricultural parcels and dairy farming in the northern portion of the study area and beyond, in the fertile Mohawk Valley.

[7] The entire Central Leatherstocking-Upper Catskills region includes all or portions of Chenango, Delaware, Fulton, Herkimer, Madison, Montgomery, Oneida, Otsego, and Schoharie Counties, most of which have geographic ties to the Mohawk Valley and lie within 50 miles of Oneonta. The region is surrounded geographically by the Adirondacks and North Country to the north, the Hudson Valley to the east, the Fingers Lakes to the west, and the Catskill Mountains and Southern Tier to the south/southeast. Although tourism has become an increasingly important industry, agriculture remains vitally important in the region, generating a market value of nearly half a billion dollars from products sold in the nine counties (US Census of Agriculture 2002).

[8] Population in the three-county study area (160,081) is 8.34% of the total New York State population (19,190,115). Population estimates for 2003 are based on extrapolations from the 2000 US Census, *US Census Bureau: State & County QuickFacts,* <http://quickfacts.census.gov/qfd/maps/new_york_map.html>, accessed December 2004.

TABLE 1: FARM, FARMLAND AND SELECTED AGRICULTURAL PRODUCTION INDICATORS for the 3-County Southern Portion of the Central Leatherstocking-Upper Catskill Region[9]

COUNTY	POPULATION	FARMS	FARMLAND (ACRES)	DAIRY FARMS	DAIRY COWS[10]	MILK (MILLION LB)	HAY[11] (TONS)
Chenango	51,659	955	189,800	267	18,000	320	95,800
Delaware	47,226	780	190,500	220	13,600	201	87,500
Otsego	62,196	1020	205,900	274	17,300	285	114,500
Regional	**161,081**	**2,755**	**586,200**	**761**	**48,900**	**806**	**297,800**
NYS	**19,190,115**	**37,000**	**7,650,000**	**15,971**	**671,000**	**11,952**	**3,680,000**

[9] **NOTES TO TABLE 1:** Data are for 2003, with exception of Column 5, which gives the number of dairy farms in 2002. Except as noted, data are from various tables in the *New York County Estimates 2004*, New York Agriculture Statistics Service, <http://www.nass.usda.gov/ny/Bulletin/Coest/2004/2004coest.htm> (NASS 2004). The number of **dairy farms** (Column 5) is from the *2002 Census of Agriculture—County Data*, Table 11: Cattle and Calves—Inventory and Sales: 2002-1997, New York data, pp 292-311 <http://www.nass.usda.gov/census/census02/volume1/ny/st36_2_011_011.pdf>.

Population data for 2003 (Column 2) are extrapolated from the 2000 US Census, taken from the *US Census Bureau: State & County QuickFacts,* <http://quickfacts.census.gov/qfd/maps/new_york_map.html>. Regional data are calculated by the authors.

[10] The **number of dairy cows** (Column 6) is based on NASS calculations of the "Average Annual Milk Cows." This number is derived by dividing known milk production for the county by the Dairy Herd Improvement (DHI) statistic for productivity per cow. This statistic differs county-to-county.

For example: In Chenango County, 320,000,000 lb milk were produced in both 2002 and 2003, but the DHI figure increased from 17,300 lb to 17,800 lb milk per cow, so that the calculated number of cows decreased. In Otsego County, the quantity of milk produced decreased from 300,000,000 lb to 285,000,000 lb, but the DHI also decreased from 17,400 lb to 16,500 lb, so that calculated number of cows increased. In Delaware County, milk production decreased from 229,000,000 lb to 201,000,000 lb and DHI decreased from 16,200 lb to 14,800 lb.

The US *2002 Census of Agriculture* gives slightly different statistics for the number of milk cows than the numbers given in Column 6: Chenango County—18,334; Delaware County—14,778; Otsego County—16,600.

[11] By NASS definition, "**Hay**" refers to dry alfalfa and other hays. It does not include silage or green chop. We are using the quantity of hay as an indicator of the amount of polypropylene (PP) bailing twine discarded regionally and in the State. If we can assume that 1.5 lb twine is used per ton of baled hay, then the nearly 300,000 tons of hay produced in the region may generate 450,000 lb twine (= 225 tons twine). Statewide, 2,760 tons of PP twine may be used and likely discarded. The estimate of twine used per ton of hay is from personal communication with Alan Jongsma, co-proprietor of Agri-Plas, Inc., an agricultural plastics recycling business in Keizer, OR, October 2003.

Dairy Films: Uses, Sources, Quantities

The plastic films used to protect, cover and wrap feed on dairy farms are composed primarily of low-density polyethylene resins (#4, LDPE or LLDPE). Nutrient bags and bags containing other farm inputs are typically also of the same materials (Table 2, page 16). The softness and flexibility of these films is due to the random linking of the ethylene monomeric units, with long and short branching from the main chains preventing the chains from packing tightly.[12] LDPE plastics differ in this way from high density polyethylenes (#2, HDPE), which have few side branches and can thus pack tightly to create rigid plastics, such as those used as containers for pesticides and veterinary products.

Uses of Plastic Films on the Farm

Silage bags and **bale wrap** are the primary plastic film products used on dairy farms in the study area (see Appendix III, page 69).[13] These are the increasingly familiar giant white "sausage" and "marshmallow" shapes seen across the agricultural landscape that are used for storing and fermenting wet forage under anaerobic conditions. **Tuber bags**, which look similar to silage bags, can be used in lieu of bale wrap to create conditions for anaerobic fermentation of baled hay. Rather than wrapping individual bales in bale wrap, tuber bags enclose a line of bales placed end-to-end.

Bale wrap is a thin (1 mil) stretch film that is recommended to be wrapped around the bale five times to a 5-mil thickness (Smith 2003).[14] Over the years, farmers have been advised to wrap with increasing numbers of layers in order to reduce post-harvest crop loss.[15] Silage and tuber bags are typically 7.5- to 9-mil in thickness.[16] About half the silage bags sold in New York are sold under the label Ag-Bag™, which has become nearly synonymous with the generic product. AG-All™ and Tube All™ are other product names for silage and tuber bags. Value-Seal Ag Stretch Wrap™, Agri-Guard™, Stretch All™, and Bale-All™ are some of the trade names under which bale wrap is sold.

Bunker silos have also gained in popularity around the State, particularly among larger dairy producers, as a means for storing wet silage. The bunkers are concrete or block-walled structures that are filled with silage and covered by plastic sheeting.[17] The plastic **bunker silo covers** are typically held in place by an array of closely packed used tires or other means of weighting down the contents and cover to exclude air. Product names include HERMETIX™ COVER ALL™ and RHINO SILO™, both sold in 5-mil thickness.[18] The bunkers are said to be faster to fill and arguably cheaper to fill than silage bags,[19] but they are less common in the study area than the bags.

Bale net covers are typically clear plastic netting used in place of twine around bales of dry forage to hold the contents in place and help shed water. Bale nets are advertised as having an advantage over

---

[12] Source: the Canadian Plastics Industry Association's *Plastic films* website, <http://www.plastics.ca/film/>. For additional technical information about LDPE plastics, see excerpts from *A Guide to Polyolefin Film Extrusion*, Equistar Chemicals, LP, accessible from Blue Ridge Films website <http://www.blueridgefilms.com/page2.htm>.

[13] This information is based on our survey of suppliers and distributors of dairy films who operate in the study area. This section of the report also draws on information posted on websites of manufacturers and distributors.

[14] One mil = 1/1000 inch thickness.

[15] Personal communication with focus/advisory group, August 13, 2004.

[16] Personal communication with Calvin Mazurenko, Business Manager/Agricultural Films, AT Plastics, Oct 2004.

[17] Bunker silos may appear to the uninitiated to be the basement or foundation for a large house or barn.

[18] Source: Klerk's *Plastic Products Manufacturing* website <http://www.klerksusa.com/>, click on Ag-All™.

[19] For a comparison of costs and other factors among tower silos, bunker silos and silage bags, see the *Introduction* to this report, footnote 2, pages 6-7.

twine because they do not create grooves that trap moisture. FABPRO Bale-Lok Plus™ Net Wrap is one product name in this category. Bale net wraps are a minor product in the study area.

The color of the plastic film—white, black, black and white, green, etc.—is one of the factors used in selecting a specific product because color characteristics affect heat and longevity of the stored forage.

TABLE 2: PLASTIC RESINS—TYPES AND RECYCLING CODES

CHEMICAL NAME	ABBR	CODE[20]
Polyethylene Terephthalate	PET or PETE	1
High Density Polyethylene	HDPE	2
Polyvinyl Chloride or Vinyl	PVC	3
Low Density Polyethylene	LDPE	4
Linear Low Density PE	LLDPE	4
Polypropylene	PP	5
Polystyrene	PS	6
Other resins or mixed resins	Other	7

Source: The American Plastics Council. *Resin Identification Codes*. <http://www.americanplasticscouncil.org/s_apc/docs/1200/1101.pdf>

Manufacture of Dairy Films

Plastic films are produced and sold in a competitive global market. Manufacturers are located all over the world, including many in Third World countries. Since everyone uses similar materials, a competitive advantage goes to those who can manufacture at least cost (Resource Recycling March 2004).

Manufacturers of agricultural plastic products sold in the study area are listed in Appendix II (page 67). Regional dealers verified that those listed are the "major players" in the Northeast.[21]

Suppliers and Distribution

Dealers concur that agricultural plastic manufacturing and distribution are very competitive on all levels, including their own. Agricultural plastic film users have many options in choosing where to purchase supplies. Materials manufactured at plants throughout the world may be distributed by regional suppliers

[20] These recycling codes were introduced by the Society of the Plastics Industry, Inc. (SPI) in 1988 at the urging of recyclers (Source: *American Plastics Council* website).

[21] Among our objectives in compiling this list is our interest in involving agricultural plastic product manufacturers in product recycling and life-cycle stewardship. Recycling could be facilitated by harmonizing the product specifications of agricultural plastics with the requirements of re-processors. *E.g.,* the Trex Company, manufacturers of composite lumber products, is unable to use most dairy films as manufacturing feedstock because of their color and ash content. Other re-processors described constraints in recycling agricultural plastics because of non-recyclable components such as the rubber-based glue strips used to join large sections of nursery film. Others are constrained by difficulty in feeding large sheets of agricultural plastics through the machinery used for reclamation.

to local retail dealers, delivered to farms or more centralized pick-up locations, or held by contract balers who travel to farms with the requisite equipment to wrap bales and/or fill silage bags.

For example, distributors for the Dairylea Cooperative receive shipments directly from the factory and bring it to central locations where farmers come to pick up their year supply. In New York State about 250,000 lb are distributed, primarily in the North Country region of the state (only about 1000 lb are delivered in the study area).[22] Most distribution is in late spring-summer.

Quantity of Dairy Films Used in the Study Area

The use of plastic of farms has ramified throughout all sectors of agriculture. A decade ago, HDPE and mixed-resin nursery containers were the primary uses of plastic in agriculture (Amidon 1994), but all sources concur that use of LDPE dairy films is on an upward trajectory relative to other means for storing forage, and is now possibly the dominant use of plastics in agriculture.

This market dominance is likely due in large part to the economic and safety factors described in the *Introduction* (footnote 2, pages 6-7). Information about lower cost, greater safety and reduced post-harvest crop loss with plastic film wraps of various types is being incorporated into educational programs and recommendations for farmers (*e.g.,* see Smith 2003). The trend towards plastic-wrap storage may also be due in part to the reality that many of the vertical silos punctuating the landscape are coming to the end of their 30-year product life cycle (Resource Recycling March 2004).

Our survey of dealers and distributors revealed that approximately half a dozen manufacturers of agricultural plastic films are represented in the three-county study region by about ten large and three smaller distributors.[23] They sell an estimated 206,000 lb of plastic film to the subset of the 760 dairy farms in the three counties that use plastic silage bags, bale wrap or bunker silo covers (see Appendix III, page 69, and Table 1, page 14). The vast majority of forage-wrap films are used on cow dairies. *I.e.,* other types of livestock farms generate only a few percent of forage-wrap films. Horses, for example, are fed a high quality hay that is typically stored in square bales, not wrapped in plastic.[24]

206,000 lb of dairy film is sold in the study area by some 10 large and 3 smaller distributors, who represent half a dozen manufacturers

This quantification of dairy films used in the study area is not precise, but we believe it is sufficiently accurate for purposes of this feasibility study. We also think it is the most reliable of the three methods of approximation we used, all of which gave results of similar magnitude (see Table 3, page 18).

In the remainder of this section we detail the several estimation approaches we used, our assumptions and calculations, as well as limitations to these and other methods. Appendix VIII, page 79, is a compilation of conversion factors and quantitative relationships that we used in making these estimates and which may also be pertinent to other calculations of plastic film use and costs. These relationships are based on observations, anecdotal evidence and measures recommended by advisors and respondents to this study, and from descriptive statistics made available by product manufacturers and re-processors.

---

[22] Personal communication with Jan Martusewicz, Leray Sealed Storage, distributor to Dairylea Cooperative, June 5, 2003. For information about Dairylea Cooperative see <http://www.dairylea.com/>.

[23] We are using a threshold value of 5,000 lb film per year to designate larger distributors for the area.

[24] Personal communication with Bill Gibson, Farm Services Administration (FSA), August 13, 2004.

TABLE 3: ESTIMATES OF THE QUANTITY OF DAIRY FILMS USED IN THE STUDY AREA AND IN NYS[25]

METHOD	REGION	NEW YORK STATE[26]
Dealer survey (personal communications)	206,000 lb	NA
Usage per cow (derived from NASS statistics and our assumption that 50 percent of cows are fed using a plastic wrap system)	187,000 lb	2.5 million lb (= 1,250 ton)
Milk volume (calculated from quantity of milk produced from nutrients contained in a bag, Klerk's *Plastic Products Manufacturing* website <http://www.klerksusa.com/>)	375,000 lb	5.8 million lb (= 2,900 ton)

Dealer Estimates of Dairy Film Sales

Because of their global scale of operation, we were unable to get locally relevant information from agricultural plastic manufacturers. Thus personal communication with regional dealers became the most practical and reliable means for developing an estimate of agricultural plastics film sold (and likely used and disposed) within the 30-mile radius of Oneonta. The dealers we spoke with verified our approximations and list of manufacturers.

While most dealers report increasing sales of dairy films, they also acknowledge that the regional decline in dairy farming has forced them to service customers at much greater distances, often as far as a 100-mile radius. Therefore they typically made a rough approximation of the volume of their sales within the study area (30-mile radius of Oneonta) and even at the volume of sales within the primary three-county area. Consistent with this trend, suppliers from outside the region are more likely than we had anticipated to be servicing customers within the 30-mile study area; thus our inventory of suppliers may not be complete. However, we are reasonably confident in the estimate of usage derived from our survey of dealers. However, we cannot extrapolate from this estimate of dairy film use in the region to usage in New York State.

Usage Per Cow as an Indicator of Dairy Film Use

By synthesizing anecdotal information from farmers, dealers and analysts, Levitan and Barros (2003, footnote 21) estimated that 7.5 lb of plastic film is used to wrap the forage consumed by one milk cow. To extrapolate from this per-cow usage to estimate the quantity of dairy films used in the region, we

25 Assumptions used in these calculations are based on conversion factors and quantitative relationships compiled in *Appendix VIII: Conversion Factors & Quantitative Relationships re: Plastic Film Use,* page 79.

26 **Comparison with Quantities Used in Other States and Provinces.** We estimate 1,250-2,900 ton of dairy films are used annually in New York State. In comparison, it is estimated that more than 10,000 tons are left in the fields in Oregon each year (personal communication with Dari Jongsma, co-owner Agri-Plas, Inc., an agricultural plastics recycling business in Keizer, OR, October 2003).

The Prince Edward Island (PEI) Department of Fisheries, Aquaculture and Environment, Canada, estimated that 500-600 tons of dairy films were used in PEI in 1995 and anticipated that the quantity would increase with establishment of a new beef processing facility on the Island. A new drop-off recycling facility serving the western half of PEI received about 8 tons for recycling in 2002, primarily in the months May and June (O'Neill 2002). This represents a capture rate of 1.6%.

multiplied by the number of cows (Table 1, page 14) and adjusted for the fraction of cows fed on a plastic-wrap forage system, rather than on dry forage or another system.

If we assume that half of the cows in the study area are fed on a plastic-wrap system,[27] an estimated 187,000 lb of plastic dairy film is used in the region and 2.5 million lb are used in New York State (Table 3, page 18). This estimate of dairy film usage in the region is remarkably close to results derived from our survey of dairy film dealers.[28]

A more precise estimation might also consider differences in quantity of plastic used per cow on farms of different size. For example, larger farms tend to use bunker silo systems, which require less plastic per cow than bale wrap or silage bags. Among farms using bunker systems, larger farms tend to have a more compact and higher pile, with a lower ratio of top surface area to volume. To put these differences into context, our advisory group noted that the farmer who uses 7.5 lb of film per cow operates a small-scale farm without indoor storage, and is considered a heavy user of plastic."[29]

Estimating regional dairy film use by extrapolating from usage of film per cow may be a good means of providing a window into the future, as the percentage of farms using plastic-wrap systems changes. *E.g,* if 75 percent of cows were fed on a plastic-wrap system, a proportion approaching the rate of usage in Vermont, the quantity used in the region would be 50 percent greater, or about 280,000 lb per year within the tri-county study area.

Milk Production as an Indicator of Dairy Film Use

The third method we used to estimate annual usage of dairy films is based on an advertising claim by Klerk's Plastic Products Manufacturing, a large international producer of dairy and greenhouse films.[30] Klerk's claims that a 10 ft x 300 sq ft silage bag contains nutrients that will produce 390,000 pounds of

---

[27] We do not have a precise or documented estimate for the number of farms in the region that use plastic, nor for the number of cows fed on a plastic-wrap forage system. We assume 50% on the basis of the expert judgments of members of our advisory/focus group who estimate that 50 percent of regional farms use some form of plastic film wrap or cover. This is a significantly lower percentage than indicated by a Vermont survey showing 80 percent of Vermont dairy farmers using some type of plastic-wrap system (42 percent bunkers, 20 percent silage bags, 19 percent silage wrap) in the mid-1990s (DSM 1996; Negra and Rogers 1998). However, we have confidence in the expert judgments of our group because calculations of dairy film use based on the 50% estimate are remarkably close to results from our survey of dairy film dealers in the region. See the following footnote for calculation details.

[28] Calculation details: 50,000 cows in 3-county region x 0.5 fed on plastic-wrap system x 7.5 lb per cow fed on plastic-wrap system = 187,500 lb dairy film used in the region. Statewide, with 671,000 cows: 671,000 x 0.5 x 7.5 = 2.5 million lb dairy film used in New York State.

If we hold the quantity of dairy films used in the region constant, at the level estimated from our dealer survey (206,000 lb) and keep the per cow allotment at 7.5 lb, we find only a small difference in the calculated percentage of farms using plastic-wrap forage systems as compared with the percentage estimated by our expert panel: 55 percent as compared with their estimate of 50 percent.

[29] Personal communication, focus/advisory group, August 13, 2004; Levitan and Barros 2003, footnote 21. Dairy experts in the advisory group note that silage on larger farms is often piled to 14 ft, while on smaller farms, to 8 ft..

[30] Klerk's *Plastic Products Manufacturing* website <http://www.klerksusa.com/>

milk. Using a string of conversion factors, we calculate that 375,000 lb of dairy film would be used in the region and 5.8 million lb in New York State.[31]

Significance of Estimates vis-à-vis Viability of a Recycling Program

Based on these estimates of dairy film use—and assuming a 100 percent capture rate of recyclable-quality film collected annually—used dairy films from the study area could fill at least five (5) full truckloads of baled plastic for the re-processing market each year. One 40,000 lb truckload per year—typically the minimum quantity of interest to re-processors—would require a capture rate of 19 percent of recyclable quality material collected from dairy farms.[32]

This approximation of the quantity of dairy films used in the region provides important baseline information, leading to significant conclusions:

- Sufficient quantities of dairy films are used in the study area such that an agricultural plastic film recycling program could be viable.
- There is not sufficient usage to expect that a local re-processing/manufacturing facility would be viable.
- Viability of a recycling program would be enhanced by actively pursuing collection of films from other sources: *e.g.,* greenhouse/nurseries, marinas where boats are wrapped in plastic stretch wrap for the winter, industrial facilities, as well as wholesale and retail outlets where deliveries are palletized and wrapped in plastic.
- The quality of disposed films is a critical factor for the viability of a recycling program.

Identifying and Filling Data Gaps

While we believe that our estimate of dairy film use is sufficiently accurate, the survey and calculation methods utilized do not provide insight into other factors that would be useful, if not critical, to setting up a effective agricultural plastic film recycling program. These factors include:

- Size and location of farms using plastic-wrap systems
- Demographic data on farmers using/not using plastic-wrap systems
- Current disposal practices
- Interest in recycling
- Receptivity to information about Best Management Practices (BMPs) for handling plastic films to increase their value and suitability for recycling

---

[31] We approximated the number of silage bags of this dimension used in the area by dividing the total regional milk production (806 million lb) by milk produced per bag (390,000 lb). We adjusted the result (2,066 bags) by the estimated fraction of cows on plastic-wrap systems (50 percent), then multiplied the result (1,033 bags) by 300 ft to estimate linear feet of silage wrap used in the region (1,033 bags x 300 ft = 309,900 linear feet of silage wrap). Extrapolating from a "rule of thumb" that 8-9 ft diameter silage bags weigh about one pound per linear ft, we estimated that a 10 ft diameter bag weighs 1.25 lb per linear ft, and calculated that 375,000 lb of dairy film are used in the region and 5.8 million lb are used in New York State (see Appendix VIII, page 79).

[32] Full truckloads are typically defined as 38,000-42,000 lb (or approximately 20 ton), comprised of bales averaging 1,000 lb.

Various methods could be used to fill these gaps. The following is an overview and critique of several of these approaches:

- **Direct mail surveys** to farmers in the region are not thought to be reliable due to typically low rates of return and likely reticence to respond on the part of farmers who now bury or burn their used plastics on-farm.
- **Telephone survey** of farmers in region. With proper timing and under auspices of informed interviewers representing a trusted organization/agency, this approach might reveal additional information and be more precise than what has been gathered. It may be possible and potentially useful to tag pertinent questions to a study currently being conducted by Suzanne Stack of the New York Center for Agriculture, Medicine and Health (NYCAMH) (see Appendix I, page 65, for contact information).
- **Farm visits**: expensive, unless in conjunction with other work. It may be possible to tag questions to a study currently underway in the Unadilla River Corridor by the Natural Resource Conservation Service (NRCS). Or utilize the regular contact that the Farm Services Administration (FSA) has with about 90 percent of farmers in the region (see Appendix I, page 65, for contact information).
- Administer **surveys/open-ended interviews at gatherings** of farmers, farm community advisors, etc. While the sample of respondents at such meetings would not be likely be representative of the population of users, it may provide a good sampling of farmers more likely to be leaders/participants in an agricultural plastic recycling program. (See Levitan and Barros 2003, page 21, for a proposed survey instrument).
- **Visual inspection:** A GIS coordinated "fly-over" of the study area in mid to late November could provide an efficient means for confirming dealer estimates of usage.

Greenhouse & Non-Agricultural Films: Uses and Disposal

Uses of Greenhouse and Non-Agricultural Films

It has become common practice to wrap boats with plastic film in the winter, to deliver cars and motorcycles wrapped in plastic sheeting, and to use plastic stretch wrap to secure palletized goods for delivery and often until sold. Pallet and boat wrap are both typically 7 mil thickness (with multiple wrappings, building up to 11 mil).[33] About half pound of plastic is used to wrap each industrial pallet.[34]

Among greenhouses, plastic-covered hoophouses have become more common than the traditional glasshouses.[35] Greenhouse films are typically used for several years before replacement. Sheets are commonly 48 ft x 100 ft, weighing 30 lb per 1000 sq ft at 4-6 mil thickness. Greenhouse management typically involves two full sheets of film layered over a hoophouse.[36]

We surveyed[37] a selection of regional greenhouse nurseries and non-agricultural users of plastic film—including grocery stores, household and office suppliers, motorcycle shops and boatyards—to determine:

- if any plastic film recycling programs are already in motion locally;
- whether a dairy film recycling program could potentially "piggy-back" on existing arrangements for hauling and handling;
- how these materials are currently disposed, if not recycled;
- what equipment is currently used to handle the films; and
- whether non-agricultural users might be interested in collaborating/participating in a program to recycle dairy films.

Our rationale for pursuing this line of inquiry was, first, that these greenhouse and non-agricultural plastics are typically a cleaner, more valuable product of greater interest to re-processors than dairying film, and secondly, that a higher volume of used plastic film would likely improve the viability of arrangements and negotiations with any re-processing market.

For example, virtually all of the re-processors interviewed for this study indicated that the threshold minimum volume for their accounts is one truckload per year, or 3000 lb per month. Since re-processors typically pay for shipping, they are typically interested only in near-full truckloads of materials (≥ 25,000

---

[33] Date re: thickness of shrink wrap are from Shrinkit, Inc. website <http://shrinkit-inc.com/>. These thicknesses can be compared with 1 mil for bale wrap, which is also wrapped in multiple layers, and 5 mil for bunker silo covers. One mil = 1/1000 inch thickness.

[34] Personal communication with Andrea Dahl, the Trex Company sales representative, December 2003.

[35] Glasshouses cost $30 per sq ft to purchase and are taxable, whereas plastic high tunnels are considered impermanent and therefore not assessed for property taxes. Initial cost is approximately $3 per sq ft (personal communication with attendee at Penn State workshop organized by James Garthe, May 2003).

[36] Data are from personal communication with a sales representative from the Latham, New York, branch of Griffin Nursery & Greenhouse Supplies, September 2004. Griffin describes itself as "the top greenhouse and nursery supplier in the Northeast and Mid-Atlantic" <http://www.griffins.com/>. Corporate Headquarters are in Tewksbury MA, with eleven branch locations in the Northeast, including three in NY: Auburn, Latham and Brookhaven.

[37] Appendices IV and V, pages 73-76, give a tabular summary of survey results. The questions and topics covered in the open-ended interview guide are given in Appendix VI, page 77.

lb, ideally 40,000 lb).[38] Furthermore, several re-processors intimated that they might provide an on-site baler if guaranteed a consistent and significant supply over time.

Recycling of Greenhouse and Non-Agricultural Films

While nationally a number of grocery stores and chain stores are recycling these disposable packaging materials, we did not find this to be the case locally.[39] Of the facilities surveyed in the Oneonta area, only Hannaford Supermarkets currently recycles plastic film.

We estimate that at least one full truckload of film could be collected per year from several of the facilities surveyed in the Oneonta area that expressed potential interest in participating in a plastic film recycling program. For example, Frazier's greenhouse/nursery, the largest such business in the study area, removes approximately 3200 lb of greenhouse film per year.[40] BJ's Wholesale Club, Inc., disposes of about 25,000 lb stretch wrap per year by compacting and having it hauled to a landfill. None of the facilities surveyed own a baler or bale their films locally.

To put these local quantities into context: In its first five years of operation (1997-2001), the New Jersey nursery plastic recycling program accepted drop-off of 1.8 million lb of used film from 100-125 growers. This is approximately one-third of the one million lb of nursery film generated in New Jersey annually. Growers each brought in an average of 2800-3600 lb annually, a quantity similar to that replaced by Frazier's greenhouse/nursery each year.[41]

Although the processing of the nursery and non-agricultural films will present other impediments—including *(i)* the need for removal of non-recyclable components such as wood frames, nails, staples, glue strips, strapping used in boat wraps, etc., and *(ii)* the need to conform to the supply timeline of each company—collaboration with non-agricultural users and non-dairy sectors of agriculture could significantly boost volume and could potentially provide other valuable services, including sharing of baling equipment, provision of collection facilities, etc.

---

[38] Estimated at $800 per load, average (personal communication with Trex Company representatives, Dec 2003).

[39] See Appendix IV: *Non-Agricultural Users of Plastic Films in the Oneonta Area*, page 73.

Ivy Acres, a Suffolk County, New York (Long Island) nursery, recycles 95 percent of its plastic film by returning it to the supplier (personal communication with Bill Sanok, retired Agricultural Program Leader, Cornell Cooperative Extension of Suffolk County, June 24, 2002).

[40] The calculation of the weight of plastic film replaced annually by Frazier's nursery assumes: *(i)* 30 lb per 1,000 sq ft (per personal communication with sales representative from Griffin Greenhouse and Nursery Supplies, Sept 2004), *(ii)* removal of 30-40 sheets per year, and *(iii)* sheet dimensions of 30 ft x 100 ft x 6 mil (per personal communication with Bobbie at Frazier's, September 2004). Results: 3,000 sq ft per sheet x 35 sheets x 30 lb per 1000 sq ft = 3150 lb replaced annually. According to a sales representative from Griffin Greenhouse and Nursery Supplies, sheets are more typically 48 ft x 100 ft.

[41] Calculated from data provided by Karen Kritz, New Jersey Department of Agriculture, Agribusiness Development Representative, cited in Levitan and Barros (2003). Pounds per enterprise were estimated by first calculating the quantity collected on average in each of the five years (*i.e.,* 1.8 million ÷ 5 = 360,000 lb) and dividing lb per year by number of growers or enterprises participating (*i.e.,* 360,000 ÷ 100 to 125 growers = 3,600 to 2,800 lb).

Polypropylene Baling Twine

Baling twine was traditionally made from sisal fiber, a natural biodegradable product. However, since 1980 the market has shifted almost entirely to use of polypropylene baling twine (#5 PP, poly-twine), which costs about two-thirds the price of sisal.[42] It is not clear to us whether poly-twine's capture of the market is entirely a function of lower purchase price or also a function of quality characteristics, supply, branding, and/or bundling of this product with other agricultural plastic supplies from the same dealer/distributor.[43]

There are considerable hidden costs to poly-twine: It is not biodegradable. If left in the field, it can be ingested by livestock and tangled in machinery. Entanglement is also a problem if landfilled. To avoid these problems, poly-twine is typically disposed by open burning, with consequent environmental/health impacts.

We chose to include the use and disposal of polypropylene baling twine in this study because this product is used in dairy agriculture, is not currently recycled, and current means of disposal are hazardous. Furthermore, various sources familiar with agricultural plastics recycling have advised that a recycler's willingness to collect a broader array of used materials has a direct positive relationship with higher levels of farmer participation in a film or container recycling program.[44]

Poly-Twine Quantities

Nearly 1.5 lb baling twine is used per ton of hay.[45] With nearly 300,000 tons of hay produced in the three county study area (Table 1, page 14), as much as 450,000 lb or 225 tons of twine may be thrown away each year. Using this metric, there is enough baling twine used and disposed within the study area each year to fill more than 10 truckloads of polypropylene for recycling, if 100 percent were collected.

This calculation must be considered only a first-cut estimate. In absence of more realistic data, a number of simplifying and untested assumptions have been made, including: (a) 100 percent of hay is baled, (b) all twine is PP, (c) baled hay is the only source of twine, and (d) baled hay is not imported or exported from the region. While the first two of these factors suggest that the 225 tons is likely a considerable overestimate, the last two factors may mitigate this inflation. For example, in addition to use of twine to bale hay, it is also used to bale the straw used for animal bedding and mulch, to wrap burlap around trees and shrubs sold for landscaping, etc.

---

42 Our discussion of poly-twine draws extensively from a feasibility study of baling twine recycling in Alberta, Canada (Baling Twine Study 2000) and from personal communications with Alan and Dari Jongsma, co-owners of Agri-Plas, Inc., an agricultural plastics recycling company in Keizer, Oregon, October 2003.

We did not formally investigate the poly-twine market share for this study. Comments about cost and market share draw from observations in the study area and from anecdotal evidence reported in the Alberta, CA study. Viz., an Alberta, CA distributor reported selling a 9:1 ratio of poly-twine to sisal.

Sisal is about 50 percent more expensive than poly-twine in Canada: A 7,200 ft role of poly-twine purchased from United Farmers of Alberta (UFA) in March 2000 cost $22.95 Canadian, while the same length of sisal cost $35.95 (Baling Twine Study 2000).

43 For example, the Polymer Group, Inc, the largest North American manufacturer of agricultural baler twine (Tygert Tuff™) also produces Commercial Tying Twine and Knitted Net Wrap for hay baling (an LLDPE). Tygert Tuff™ is distributed in the Northeast US by a large distributor of silage bags.

44 Personal communication with Alan Jongsma and others, October 2003.

45 Personal communication with Alan Jongsma, October 2003

Recycling of Poly-Twine

There are numerous impediments to recycling of poly-twine:

- Few recycling markets have developed for polypropylene (#5, PP), perhaps because this polymer constitutes less than two percent of recycled plastics.
- Handling and collection of old bales may expose field staff to dangerous aerosols, *e.g.,* molds and rodent droppings.
- The PP polymer loses tensile strength with exposure to ultraviolet (UV) light and becomes brittle at low temperatures, so loses considerable recycling value if left out over winter.[46]
- Cost of collection and re-processing are close to the market value of re-processed resin, even if brokers receive the twine free of charge from farm users.[47]

Developing Markets

The 2000 Alberta CA study identified several emerging markets for recycled poly-twine (Baling Twine Study 2000). These include use as an:

- **ingredient in rubber composite shingles.** Based on a technology used in Germany, the WERX manufacturing firm in Spruce Grove, Alberta, CA, was initiating a pilot of this process, anticipating that Provincial demand would exceed supply.
- **reinforcing agent for concrete and asphalt**. The use of recycled PP as a re-enforcing agent is thought to be viable in Alberta because several US manufacturers have been using virgin PP for these purposes and marketing the product in Alberta.
- **binding agent for cold mix asphalt** applications.
- **energy source**. The energy value of polypropylene is high, about double the average gross heat value of coal and far greater than most other waste products.[48]

  In 2000 a Canadian waste-to-energy operator was developing a facility north of Edmonton, Alberta, using PP to heat greenhouses. It was expected that demand for feedstock for this facility would more than consume the post-consumer twine generated within Alberta. However, the tipping fee was expected to exceed that charged by major urban landfills.

---

[46] A 2002 product circular from Polymer Group, Inc., manufacturers of Tygert Tuff™ Baler Twine, asserts that this product has been UV and heat stabilized, and will not deteriorate within 18 months of outdoor storage. Tygert Tuff™ may, therefore, have higher value for recycling than the poly-twines described in earlier literature. Tygert Tuff™ Baler Twine is sold in tensile strengths from 90-400 lb for use on square bales, round bales and as wire replacement.

[47] Approximate costs per pound for collection and reclaiming polypropylene, in Canadian currency (not all steps are required for all processes and uses): • Collection and transportation—$0.03 per lb, assuming full truck loads and use of open top truck with moveable floor. • Education and outreach—$0.02. • Administration—$0.01. • Baling—$0.02.5. • Grinding—$0.04. • Cleaning—$0.04. • Cutting / de-furling—$0.03. • Disposal/tipping fees—$0.008 to $ 0.1.6. Total costs = $0.21 per lb (Baling Twine Study 2000). These costs compare with $0.17-0.19 US per lb in revenues from sale of polypropylene flakes to end markets 2004 (Table 8, page 47, from Block 2004).

[48] See Table 4, page 31, for the energy value of polypropylene (19,850 Btu per lb) in comparison with other waste products. Energy values for coal vary considerably, from less than 5,000 Btu per lb to about 12,000 Btu per lb Source: US Department of Energy, Energy Information Administration, *International Coal Information* <http://www.eia.doe.gov/emeu/international/coal.html#Heat>.

Dairy Film Disposal: Options & Issues

Objectives of a Disposal Program

Once the useful life of dairy films is over—which is typically after a single use or one annual cycle—a significant proportion of the films have been disposed on-farm by burning, burying in a trench, or simply storing out of the way (Figure 1, frontpiece). In order to protect the environment and health, as well as for aesthetic purposes, a first tier objective of a dairy film collection program may simply be to move used plastics off-farm for disposal.

Another objective of a dairy film collection effort might be to reduce the life-cycle environmental costs of disposable materials and contribute to resource sustainability. Meeting this objective would place a higher value on disposal by recycling or converting waste-to-energy (WTE) rather than landfilling, since landfilling does not take advantage of the physico-chemical properties of the plastic nor its high energy value (Table 4, page 31).

The working objective of a recycling program might be to optimize the collection and transport of multiple truckload units of recyclable-quality film, minimizing transportation and environmental costs, and maximizing revenue and revenue multipliers to the agricultural and rural communities of Upstate New York. While direct economic benefits from a recycling program—in forms such as greater net farm income or increased employment opportunity—are likely to be negligible, the perception of the balance between the benefits and burden of recycling will be greatly influenced by legal and financial incentives and constraints for other means of disposal.

Legal and Other Incentives and Constraints Affecting Film Disposal

In New York State there are no legal constraints to on-farm disposal, although there has been a push in the New York State Assembly for more than a decade to pass legislation prohibiting open burning. Despite quite widespread concern about the hazards of open burning, the legislation has repeatedly stalled in the Senate, with the primary stated objection being reluctance to burden farmers with additional costs and regulations. The regulations in effect since 1972 exempt agriculture from a general prohibition of open burning in cities, villages and towns with populations over 20,000 (NYS Open Fires 1972).

In absence of New York State legislation, several counties (*e.g.,* Oneida, Herkimer and Suffolk) have ordinances prohibiting open burning, including agricultural burning. Anecdotal evidence suggests that in places where burning is prohibited, some agricultural films are landfilled, whereas in places where burning is not prohibited, less plastic film passes through solid waste transfer stations.

As noted in a later section (page 37), the distance that farmers are willing to travel in order to participate in drop-off film collection programs appears to be directly related to legal constraints on open burning. Willingness to participate in recycling programs is also greatly influenced by the cost of landfill tipping fees (see the range of landfill tipping fees listed in Table 5, page 33).

An assessment in Prince Edward Island (PEI), Canada—where on-farm burning is prohibited by Air Quality Regulations under the PEI Environmental Protection Act, and burial/dumping on-farm is restricted by regulations requiring permits to operate dumping sites—concluded that legislative prohibitions are necessary but not sufficient motivations for farmers to participate in film recycling. The study notes that because economic benefits from recycling do not accrue directly to farmers, the majority of farmers have not been motivated to "properly handle their silage wrap to provide for recycling." In addition, despite legal constraints, enforcement has not been strong and "farm disposal practices have not been scrutinized or penalized" (O'Neill 2002).

Technical Impediments to Recycling of Dairy Film Plastics

Ideally, plastics bound for recycling are clean, dry, compacted and generated at one large industrial or commercial facility. However, for the most part, agricultural plastics are dispersed on farms and fields, and often dirtier than plastics used for non-agricultural purposes. While clean, clear LDPE films are the most desirable for recycling markets (Table 8, page 46), most agricultural films are pigmented. In addition, after their use in agriculture, films are likely to be contaminated with debris, vegetation, mud, etc. Therefore it is perhaps inevitable that most agricultural films will be low grade relative to other LDPE films on the recycling market, and indeed will not be accepted by many markets.

Material brokers, re-processors and/or manufacturers raised the following issues as constraints to their purchase and/or use of agricultural films for re-processing. The first set of issues are beyond the control of the farmer and could perhaps be addressed by having dairy film manufacturers and potential re-processors brought around the same table to develop product specifications that will improve potential for recycling. This point is elaborated below in the section *Product Life-Cycle Stewardship*. The second set of issues involve farm practices, and will be further addressed in the section below on *Best Management Practices*.

- **color** of dairy films and bags (typically white, black, or black and white) will likely preclude their use in products that have a precise color standard. The suitability of an agricultural plastic product for a specific end-use must be determined by sending samples of the materials to potential brokers and manufacturers.

  Trex® products, for example, are typically used in high visibility locations where color aesthetics matter. Trex engineers have found that the Trex® color recipes do not work with the high ash content of deeply pigmented plastics. They have found that the whites and blacks typically used in agricultural plastics mix to an unsuitable muddy grey. Trex® products, and indeed most LDPE lumbers, are not suitable or approved for structural uses where the lumber would not be seen and where color would not matter.

- **non-recyclable rubber-based and other glues** are used to adhere segments of plastic sheets and drip tape. Other non-recyclables, such as the strapping sometimes used around pallets, create a similar problem. If the products are nevertheless accepted by re-processing markets, the non-recyclable parts must be laboriously removed, adding to the expense of recycling. These constraints could potentially be reduced if manufacturers of agricultural plastic products would modify product characteristics to make them more compatible for recycling. For example, the use of heat-sealed joints in lieu of glued joints should be explored.

- large **size** of agricultural plastic sheets (*e.g.,* hoophouse and bunker silo covers, silage and tuber bags, bale wraps) renders them difficult to bale and, later, to shred. This problem could be overcome by cutting sheets to a smaller size (*e.g.,* ≤ 8 x 8 ft) prior to baling.

- **organic matter (OM) contamination** (*e.g.,* vegetation from the field, remnants of silage, manure). Organic matter is problematic for several reasons. For most buyers any contamination beyond the 3-5 percent permitted by terms of the bale specifications render the feedstock "off-spec" (see Figure 3, pages 55-56). There are several specific concerns for those markets willing to consider re-processing of agricultural films:

  <u>Contamination with *E. coli* and other pathogens</u>. One re-processor noted that when silage bags are exposed to manure they may become contaminated with disease pathogens. The pathogens can be released into the factory atmosphere and to waste water during washline processing. Development and adoption of Best Management Practices (BMPs) could reduce this contamination, either by instituting means for reducing exposure to manure and/or by establishing a practice of pre-cleaning.

Another potential end-market—producing an asphalt paving mix—may be constrained from use of agricultural films because the organic matter may prevent binding of the aggregate mix used to produce the asphalt. Testing of plastic samples in the product mix will determine if this is in fact a limiting constraint. Again, BMPs would be a means of reducing the problem.

- **moisture** is a contaminant in the granulating process. In addition, if films are collected and baled when moist, more dirt and organic contamination adheres to the film. To minimize moisture problems, *(i)* recycling collection programs should be structured to facilitate removal from the field and storage under dry conditions, and *(ii)* farmers should be encouraged to follow BMPs that keep the plastic dry and under cover after removal from the field.
- **mineral contamination**, *e.g.,* rocks, are harsh to the processing equipment.
- **exposure to ultraviolet (UV) light and to the elements** causes the plastic to degrade, rendering it useless for re-processing. Increasingly, agricultural film products are advertised as "UV resistant." While this may reduce one problem, the additives that create UV resistance may be introducing another contaminant. Laboratory evaluation of film samples will determine if these additives are problematic for a particular re-use.

  Storing used films under cover may reduce the long-term exposure problem. It should be anticipated that especially in the early years of an agricultural film recycling program, old stores of film may be brought in and will likely be unsuitable for recycling because of partial degradation. Skilled personnel will be needed to sort these films from recyclable materials.
- **pesticide contamination** has been mentioned as a potential constraint to recycling of mulch and greenhouse films. However, this issue was not raised by any of the potential re-processing markets we spoke with. Research conducted in the mid-1990s at the Pennsylvania State University analyzed pesticide residues on agricultural films at the end of the season when they would typically be removed. In cases where pesticide residues were found, the residues were at very low levels that did not exceed food tolerances.[49]

Product Life-Cycle Stewardship

The concept of product life-cycle stewardship is sometimes taken to mean that producers of agricultural films should re-use film plastics in new products of the same sort. However, this direct re-use may not always be practical, and there are at least two other ways that agricultural film manufacturers could support life-cycle stewardship of their products:

- **Product specifications:** product development that optimizes for physico-chemical characteristics most conducive to recycling. *E.g., (i)* avoid mixing of different resins in a way that is difficult to separate; *(ii)* avoid use of non-recyclable materials and glues because these become difficult-to-handle contaminants in re-processing; *(iii)* mark products with inks and labels that can be recycled; etc. These and similar issues could be addressed in forums involving the research and development teams of both manufacturers and re-processors. Some agricultural film manufacturing companies may be poised to take a lead in this process because they have both manufacturing and re-processing arms (*e.g.,* Klerk's Plastic Recycling (KPR) in Belgium <http://www.klerks.com/klerks/nl/kprfsnl.html>).

[49] "Food tolerances" refer to the quantity of a pesticide residue per unit quantity of food that is permitted by the US Environmental Protection Agency on the basis of an analysis of health and environmental risk. Data about pesticide residues on agricultural films were conveyed in personal communications with James Garthe, the Pennsylvania State University, at a focus group meeting conducted by the Cornell Open Burning Group, June 24, 2002.

- **Financial support for recycling:** The Agricultural Container Recycling Council (ACRC) provides a model for life-cycle stewardship of rigid plastic pesticide containers (#2 HDPE resins). The ACRC is an organization comprised of pesticide manufacturers. For the past 12 years they have supported the collection, re-processing and sale of regrind for manufacturing new products through a nationwide network of contractors (Levitan and Barros 2003; ACRC website <http://www.acrecycle.org>). Such support is critical when dealing with a process that lacks market efficiency, such as the recycling of difficult-to-handle materials. Half of the agricultural film suppliers on Prince Edward Island who were interviewed by O'Neill (2002) were optimistic that manufacturers and distributors would contribute financially towards the recovery and reuse of their products.

Best Management Practices (BMPs): a Means for Overcoming Impediments

Best Management Practices (BMPs) for handling of agricultural film plastics are needed and should be widely disseminated to improve the suitability of agricultural films for recycling. While the value of used films is *de facto* limited by their physical characteristics and prior use in agriculture, sustaining the interest of re-processing markets will be a function of how the films are handled and stored on the farm and during the collection process.

Guidance regarding BMPs should be made available to farmers well in advance of scheduled collection; *e.g.,* no later than early autumn for information about handling and storage of materials that will be collected the following spring.[50] The development and/or adaptation of locally pertinent BMPs should be budgeted into a film collection program, with attention to the validity of recommendations, minimizing the effort they will require, and maximizing their dissemination and adoption.

Negra and Rogers (1998) describe several pilot agricultural film collection programs in Vermont in which the reject rate was very high in the absence of BMPs. In one case 73 percent of the nearly 4000 lb collected was rejected due to dirt, mice or moisture. *I.e.,* most of the collected film was unsuitable for recycling and had to be disposed by other means. In its initial years of recycling pesticide containers, the ACRC program had a 15 percent reject rate due to pesticide residues. With persistent, simple messaging and communication about BMPs, the reject rate has now declined to less than 1 percent.[51]

BMP Guides for Recycling Agricultural Plastics

We were not able to identify any educational materials suitable for "off-the-shelf" use to communicate BMPs for recycling agricultural films. However, the following materials may provide some useful guidance:

The Environment and Plastics Industry Council of Canada (EPIC) guide for handling household films for recycling—*Best Practices Guide for the Collection and Handling of Polyethylene Plastic Bags and Film in Municipal Curbside Recycling Program*—and the American Plastic Council's *Stretch Wrap Recycling: A How-To Guide* for recycling commercial and industrial films—have little information pertinent for agriculture plastics recycling (EPIC 1998-BMP; American Plastics Council 1994).

Among guides that are appropriate for agriculture, the Crop Storage Institute advises on BMPs to improve the value of forage stored within silage bags (*e.g.,* by preventing and repair of holes, removing rodent-attracting weeds and garbage), but do not address BMPs for recycling (<http://www.cropstorage.com/>).

---

[50] Collecting silage bags from the field in the winter is at best difficult and unpleasant, so they are typically left there until springtime, by which time they are likely to be very muddy or partly degraded.

[51] Personal communication with Rob Denny at National Pesticide Stewardship Alliance (NPSA) panel, Oct 2003.

The Cornell Integrated Pest Management Program brochure about BMPs for nursery producers contains guidelines for pesticide and fertilizer storage, nutrient management, pest control, weed control, maintenance, and construction. It is well structured to add a short section about BMPs for handling the nursery films to increase their suitability for recycling.

The PEI Department of Agriculture, Aquaculture and Forestry contracted for development of a CD that would provide a visual guide for handling of agricultural films for recycling, but it has not been published.[52]

What are BMPs for Agricultural Films?

Critical points to cover in a BMP guide are the need to store plastics away from UV light, moisture and additional dirt, and to collect films when they are dry—since moist films act as a magnet for contaminants. Care should be taken to prevent exposure to manure, which one re-processor saw as the major constraint to their re-processing of silage bags. The practicality and impact of suggestions to reduce contamination—such as cutting silage bags horizontally to separate the bottom portion from the less-contaminated sides and top—should be explored and incorporated into BMPs if effective.[53]

Waste-to-Energy

Waste-to-energy (WTE) is a means of disposal that involves the controlled burning of high Btu waste products to provide energy in the forms of steam or electricity. It is an established technology: More than half of the solid waste generated on Long Island, New York, is now disposed by WTE processing (American Ref-fuel undated), and more than 70 percent of waste in Denmark and Switzerland is incinerated for energy recovery.[54] Plastic resins have a very high energy content, approximately double the average gross heat value for coal and nearly twice that of rubber, three times that of wood, and five times the average of municipal solid waste (MSW) (Table 4, page 31, and footnote 48, page 25).

Although WTE processing is a means of extracting additional use and value from waste materials, it is not considered to be recycling. We did not investigate the economic, legal or environmental issues of WTE in any depth for this study. However, because of the marginal quality of much used agricultural plastic, we recommend that WTE be critically evaluated as an off-farm disposal option. To facilitate such assessments, we have provided links to additional sources of information about WTE. We also outline several particular concerns and issues regarding WTE that arose in course of this study.

Since tipping fees for WTE are typically comparable or higher than landfilling fees (Table 5, page 33), WTE cannot be thought of as an income-generating or cost-saving measure for the agricultural community. However, WTE contributes to the domestic energy supply and offers an off-farm disposal option for non-recyclables (*e.g.,* for very contaminated LDPE films and mixed resin agricultural plastics).

A study funded by the National Watermelon Board found an 85:1 energy balance from a system of collecting used mulch films, processing them into nuggets, and burning the plastic at high temperature with coal.[55]

---

[52] Personal communication with Don Jardine, PEI Department of Agriculture, Aquaculture and Forestry, Oct 2004.

[53] Other suggestions from the farm community are discussed, but not evaluated for practicality or efficacy, in Levitan and Barros (2003, page 6).

[54] Personal communication with Brian Sanders, UK, unpublished *Plastic Meeting Notes,* August 25, 2003.

[55] Personal communication with James Garthe, Pennsylvania State University, at a focus group meeting of the Cornell Open Burning Group, June 24, 2002. Garthe noted that if the system were differently analyzed—to include transportation costs, for example—the energy balance might decrease to 40:1.

TABLE 4: ENERGY VALUE OF PLASTICS AS COMPARED WITH OTHER WASTE MATERIALS[56]

MATERIAL	BTU PER POUND
Polyethylene	***19,900***
Polypropylene	***19,850***
Polystyrene	***17,800***
Rubber	10,900
Newspaper	8,000
Leather	7,200
Corrugated paper boxes	7,000
Textiles	6,900
Wood	6,700
Average for MSW	***4,500***
Yard Waste	3,000
Food Waste	2,600

Issues re: a WTE Component to an Agricultural Film Recycling Program

- **Landfill option.** In some areas, farmers are not permitted to landfill large films because *(i)* the films become entangled in landfill equipment or *(ii)* disposal is precluded due to perception or reality of pesticide residue. Thus WTE may be the only off-farm disposal option.
- **Landfill quotas.** Since marginal-quality agricultural films would likely have been disposed on-farm, and thus would not have contributed to county landfill quotas, the issue may arise of how to account for their disposal if materials are diverted to a waste-to-energy facility. *I.e.,* Would diversion of waste agricultural plastics from landfill to waste-to-energy facilities provide a respite from the landfill quota contracts, similar to the allowance for recycled materials?
- **Tipping fees.** Particularly in its first years of operation when old materials stored on the farm may be collected, an agricultural film recycling program is likely to receive films that are too contaminated or degraded for recycling.[57] The collection program is likely to proceed more smoothly and with better farmer participation in the future if *(i)* these materials are accepted, rather than turned away, and *(ii)* costs to the farmer (*i.e.,* the tipping fee) are kept artificially low by some means of subsidy. Program planners should anticipate this scenario and determine who should be responsible for these fees when incurred as part of a plastic film recycling program.

[56] Source: Clarke 1993, page 149, citing *Council for Solid Waste Solutions* 1990.

[57] This consideration was raised by our advisory group and in personal communication with Austin Boyd, Agri-Plas Systems 2000, and Andy Adams, Island Plastics, re: unpublished company report by O'Neill 2002. The collection of non-recyclable-quality materials also hampered the pilot programs in Vermont reported by Negra and Rogers (1998).

WTE Resources:

- **Integrated Waste Services Association** (IWSA) Washington DC, <http://www.wte.org/>, promotes integrated solutions to municipal solid waste management. IWSA strives to encourage the use of waste-to-energy technology as a key component of community solid waste programs.
- **Columbia University Earth Engineering Center, Waste-to-Energy Research & Technology Council (WTERT),** <http://www.seas.columbia.edu/earth/wtert>, is a technical group that brings together engineers and scientists from industry, federal, state and local government, and universities around the world to advance both the economic and environmental performance of waste-to-energy technologies.
- **James Garthe, Department of Agricultural and Biological Engineering, The Pennsylvania State University**, <jwg10@psu.edu>. See in particular Garthe 2003, *Used Agricultural Plastics as Fuel*. This and other of Garthe's publications can be accessed from <http://environmentalrisk.cornell.edu/AgPlastics/References/>

Agricultural Film Recycling: Steps in the Process

As illustrated in Figure 1 (frontpiece), there are four basic steps in the movement of agricultural films from farm to factory: *(i)* collection and hauling, *(ii)* sorting and baling, *(iii)* reclamation by cleaning and pelletizing, and finally *(iv)* manufacture of new products. However, there are variations to the route.

Collection and hauling can involve:

- farmer drop-off of materials on specific collection days or during certain periods of the year,
- contract hauling from farms to a central collection site, arranged and paid by the farmers,
- pick-up organized (and possibly paid for) by the recycling program, or
- backhauling of films by the supplier, when bringing new films for the next season or at some other time. Backhauling is also referred to as "buy-back" or as a "milk run."

Hauling to a central collection area can occur before or after the handling steps (sorting and baling).

Baling can be done with a portable baler brought to the farm, by a semi-portable baler rented for occasional use at a local collection point, or by a stationary baler at a central recycling facility.

Cleaning could occur at any stage. Transportation and baling of clean materials is more cost efficient because the additional weight and bulk of non-recyclable contaminants are eliminated, but on-farm cleaning may be difficult and not completely effective. More rigorous cleaning may still be needed at the re-processing facility in order for the dairy films to be suitable for re-processing. Similarly, **sorting** of recyclable quality films from waste may be most efficient on-farm, but that would require a large time investment by people skilled in making such distinctions.

The route taken in any particular case will be a function of the equipment and facilities locally available and economically pragmatic for the scale of a recycling program. Table 5 (below) is a compilation of quantitative measures pertinent to each of the four steps in the recycling process, drawn from a number of recycling programs and other sources of information.

TABLE 5: QUANTITATIVE MEASURES OF COSTS AND TIME FOR RECYCLING AND OTHER DISPOSAL

PROCESS	COST	SOURCE
TIPPING FEES—LANDFILL & WTE		
Landfill tipping fee, MOSA transfer stations, 2003-2004, for solid waste from 3-county area	$86 per ton (=$ 0.043 per lb), subsidized by Otsego County @ $16 per ton. *I.e.,* most haulers pay $70 (=$0.035 per lb)	Terry Bliss, Otsego Co Recycling Coordinator, personal communication
Landfill tipping fee, MOSA transfer stations, 2003-2004, for solid waste from out-of-county haulers.[58]	$54 per ton (=$ 0.027 per lb)	*ibid.*
Landfill tipping fee, NYS average	$50 per ton (= $0.025 per lb)	Kaufman et al. 2004
Landfill tipping fee, United States range of state averages	Low—California: $13.63 per ton (= $0.007 per lb). High—MA: $72.60 per ton (= $0.036 per lb)	*ibid.*

cont. next page

[58] The tipping fee for haulers of solid waste from outside the MOSA three-county area = $54/ton, an amount deemed sufficient to cover MOSA base costs. This is $16 less per ton than paid for solid waste from the three counties contractually obligated to meet their quota with MOSA.

TABLE 5 CONTINUED

PROCESS	COST	SOURCE
TIPPING FEES—LANDFILL & WTE		
Landfill tipping fee, New Jersey average	$60 per ton (= $0.030 per lb) (previously the NJ average was $100 per ton = $0.05 per lb)	Dennis DeMatte, NJ pers comm, Sept 2003
Landfill tipping fee, Cumberland Co, New Jersey (lowest in state)	$43-55 per ton (= $0.022-0.028 per lb)	*ibid.*
Landfill tipping fee, Canada, average 2003	$95 Canadian per ton (= $0.048 Can per lb)	O'Neill 2002
WTE tipping fee, New York average	$65 per ton (= $0.033 per lb)	Kaufman et al. 2004

TIPPING FEES—RECYCLABLES		
NOTE: *Tipping fees for recyclables are often used to cover program costs, including baling, hauling, etc.*		
Recyclables, tipping fee, Otsego Co	no charge	*op. cit.,* Terry Bliss
Recyclables, tipping fee, Canada 2003	$35 Canadian per ton (= $0.018 Can per lb)	O'Neill 2002
Recyclables, tipping fee (for baling) Cumberland Co, NJ	$20 per ton (= $0.01 per lb)	*op. cit.,* D. DeMatte,
Recyclable plastic, tipping fee (primarily covering cost of baling), Prince Edward Island, CA, 2002	$30 Canadian per ton (= $0.015 Canadian per lb)	O'Neill 2002

COLLECTION & HANDLING		
Remove: greenhouse film	$300-400 per ton (= $0.15-0.20 per lb)	Amidon 2002
Remove, haul, bale: nursery film, typical costs for manual process	$300-640 per ton (= $0.15-0.32 per lb)	*ibid.*
Remove, haul, bundle: nursery film, typical labor effort for manual process	25-30 people cut film into sections, bundle, transport by trailer to dumpster (capacity 1000-2000 lb due to trapped air), compact with bucket loader. Cost of dumpster: $400-$500.	Robert Baker Companies, West Suffield, CT cited in Amidon 2002
Remove, bale: greenhouse film using an early model of the Tiger Baler	5 people removed plastic from six 300 ft hoophouses per hour (= 10 minutes per hoophouse)	*ibid.*
Remove, bale: greenhouse film using a current model of the Tiger Baler, average size hoophouse	2 people can bale film from average hoophouse in 2-5 minutes	Tiger Baler website <www.tigerbaler.com>

cont. next page

TABLE 5 CONTINUED

PROCESS	COST	SOURCE
COLLECTION & HANDLING		
Remove, bale: greenhouse film using Tiger Baler	< $60 per ton (< $0.03 per lb)	*op. cit.,* Amidon 2002
Remove, bale: vegetable mulch film, using Tiger Baler	3 people can bale 25+ acres per day, on properly prepared field	*op. cit.,* Tiger Baler
Baling of miscellaneous agricultural plastics, cost of operation	$30 per ton (= $0.015 per lb)	Personal comm., Dari Jongsma, Agri-Plas, Inc., October 2003
Baling of nursery films, minimum actual cost to cover labor and equipment	$40 per ton (~ 2 bales) (=$0.02 per lb)	*op. cit.,* D. DeMatte
Baling: time to bale non-agricultural stretch film	1.25 hr per 900 lb bale	Re-Sourcing Associates 1999
Baling: cost for baling with manual removal of nursery film (cost of manual removal: $0.08-0.20 per lb)	$100-160 per ton (=$0.05-0.08 per lb)	*op. cit.,* Amidon
Hauling: charged by Agri-Plas Inc for pick-up of plastic recyclables from farm to recycling/reprocessing plant	$1.00 per mile	*op. cit.,* D. Jongsma
Hauling: nursery film	$40-80 per ton (= $0.02-0.04 per lb)	*op. cit.,* Amidon
Hauling + tipping fee: greenhouse film	$900-1100 per ton (= $0.45-.55 per lb)	*op. cit.,* Amidon
Hauling: average cost of trucking from central collection point to re-processor	$800 per truck (= $40 per ton or $0.02 per lb when hauling 40,000 lb in a truckload; cost per pound higher for truckloads of lesser weight, *e.g.,* $0.025 per pound when hauling a 32,000 lb truckload.)	Personal communication, Andrea Dahl, Trex sales representative, Dec 2003

RECLAMATION		
Grinding or pelletizing	$200 per ton (= $0.10 per lb)	personal comm., Neil Ringers, B.Schoenberg Company, Sept. 2004
Pelletizing greenhouse plastic, in Jordan, 1998	$215 per metric ton (= $0.098 per lb) Note: metric ton = 2,204.6 lb	IDRC 1998

Agricultural Film Recycling: Collection & Hauling

Collection can be by means of**:**

- drop-off of loose film—by the farmer or by a hauler—at a central collection site, or
- pick-up arranged by the recycling program or as part of a backhaul agreement with the supplier/distributor. The supplier/distributor may pick-up used films at the same time that new films are delivered for the next season.

Capture Rates

Drop-off programs are less expensive to administer, but typically experience a far lower capture rate than "curbside" pick-up. For example, Clarke (1993) reports a 10 percent capture rate for drop-off programs as compared with a 70-90 percent return when recyclables are picked up (Table 6, page 37). Based on the quantity of dairy films used in the study area, we determined that a 20 percent capture rate is needed to generate one truckload of film per year—the minimum quantity for a viable program (Table 3, page 18). Costs of recycling are higher on a per unit weight basis when the capture rate is low, especially if it is lower than anticipated (see DSM 1996 and Negra and Rogers 1998 for reports of very low capture rate and very high unit expense for collection and baling in Vermont dairy film collection pilot programs).

The New Jersey nursery film collection program estimates that in its first five years about one-third of the State's one million lb per year of nursery film was captured for recycling. The two or three New Jersey collection sites are open February 1 to September 1, during the time most film is removed and replaced.

The Agricultural Container Recycling Council (ACRC) estimates that about 30 percent of plastic pesticide containers used in the US have been recycled through their programs in recent years, an increase from 1.4 percent in 1990, to 13.2 percent in 1993, and 20 percent in 1998. Some of these programs sponsor "one-time collection days," others permit drop-off at permanent or semi-permanent sites, whereas others involve collection from farms (Amidon 1994; ACRC 1999). Programs with permanent collection sites typically experience higher capture rates than those with drop-off collection days (Gilbert 2001). The Pennsylvania Departments of Agriculture and Environmental Protection invest in the State's plastic pesticide container collection program in order to increase the capture rate. Without this subsidy, the program would not surviv—revenues from the sale of regrind would not be sufficient to cover the labor and equipment costs.[59]

While capture rate for drop-off programs is likely to increase with more options in the drop-off schedule, fewer drop-off dates permit greater efficiency of labor for sorting recyclable quality materials from poor quality, collecting associated fees, and assembling a crew for efficient baling.

Conversely, if drop-off is scheduled for a specific collection day, poor weather can badly compromise film quality unless there is sufficient space in a covered structure to protect the films from the elements. Postponing the collection to another day adds an element of confusion and indecision that has been found to affect farmer participation (Negra and Rogers 1998). Farmer participation has also been found to decrease on good weather days when farmers typically have other things to do. Care should be taken to schedule collection days at a time convenient for the local farm community.

While pick-up programs are likely to have a higher capture rate, they may not be feasible due to higher operational costs. In such situations it may be advisable to begin a film recycling program by working with a small number of industry leaders who are willing to bring their plastics to a collection site as well as to follow BMPs and to sort recyclables from waste-quality materials.

---

[59] Personal communication with Don Gilbert, Coordinator, Pennsylvania pesticide container recycling , Oct 2003.

TABLE 6: COLLECTION RATES FOR DROP-OFF, BACKHAUL AND PICK-UP

TYPE	COLLECTION RATE (%)
Drop-Off	10
Buy-Back (Backhaul)	15-20
Curbside	70-90

Source: Clarke 1993, adapted from Center for Plastics Recycling Research, Rutgers State University of New Jersey, Piscataway, NJ.

Willingness to Travel for Drop-Off and/or to Pay for Hauling

In a survey of Vermont dairy farmers, 23 percent of respondents said they would pay to have plastics picked up on-farm. While 73 percent said they would haul recyclables to a recycling center if they were not charged a tipping fee, their willingness to transport recyclables declined steeply to 21 percent if charged a moderate fee. Proximity of the drop-off site is important: nearly half of the respondents would travel only up to 10 miles, while only 5 percent expressed willingness to travel more than 25 miles (Negra and Rogers 1998).

The New Jersey nursery film recycling program found that growers would travel no more than one hour, while farmers in Pennsylvania appeared willing to travel only half as long. The difference may be attributable to the regulatory environment: Open burning of films is illegal in New Jersey and permitted in Pennsylvania.[60] However, far more labor time is invested in the preparation of the materials than in transport, so the difference between 30 and 60 minutes may be irrelevant to the farmer.

Our survey of nurseries and non-agricultural users of LDPE film in the study area found that most users of LDPE film now pay to have it hauled to the landfill. Most expressed interest in recycling if the films were picked up. These users typically do not have vehicles suitable for hauling, unlike dairy farmers who are likely to have a hay wagon that could be used for temporary storage and other vehicles that could be used for hauling. Although we did not inquire whether the non-dairy user group would be willing to pay for pick-up, we assume they would because they now pay for hauling to a transfer station for landfilling.

Backhauling

There is at least one backhauling arrangement that could be expanded to involve local users of clean LDPE films: Poly-America—a major manufacturer of silage bags (supplying the Ag-Bag™ label), garbage bags, and stretch film—advertises that it will buy back (or backhaul) clear, un-printed LDPE films for recycling.[61] Poly-America currently supplies Morgan Recreational, a Long Island-based distributor of stretch film, which in turn supplies a marine storage business in the Oneonta area. While the local firm does not currently sell back its used films, it could do so through Morgan Recreational's backhaul arrangement with Poly-America to pick-up used films for recycling when new deliveries are made. Used films are collected in large plastic bags that can be purchased for $5. The bags are of sufficient size to hold film wrappings from several mid-size boats. In addition to backhauling boat wrap

60 Personal communication with Dennis DeMatte, Cumberland Co NJ Improvement Authority, Sept 2003.

61 See <http://www.poly-america.com/>, "Materials We Buy."

films, Poly-America will buy recyclable-quality white and clear nursery films. For example, Poly-America has purchased nursery films collected through the New Jersey film recycling program.[62.]

Potential Collection Sites

An ideal collection site would have the following characteristics:

- **staffing** during collection periods by person(s) who would sort materials by quality, resin type and color; collect tipping fees if necessary, and maintain BMPs during storage and handling.
- **multi-functional** to allow staff to occupy themselves with other projects, particularly if the drop-off period spans any length of time.
- **covered structure** on-site.
- **sufficient space** to accommodate delivery vehicles, loose film, a baler (if baling is to be done on this site), and a dry van-type truck trailer

Large farms (or composting facilities, scrap dealers, etc.) could be suitable collection sites for agricultural film. These facilities could either contract directly with a waste management group to supply a dumpster, or work through their local recycling agency. For example, Prides Corner Farms, a wholesale nursery in Lebanon, Connecticut, uses dumpsters provided by their local refuse firm, Willimantic Waste. Willimantic Waste bales the plastics for pick-up by the Canusa-Hershman Recycling Company (CHRC),[63] a plastic recycling firm based in Branford, CT. Prides Corner Farms nets $0.02 per pound.[64]

Several potential collection sites in the study area are indicated on Map 3 (page 42), most of which are the location of regional dairy film suppliers who indicated a tentative interest in having a collection bin on their site available for drop-off.[65] The map also shows the locations of the MOSA transfer stations in and near the study area. These include the Northern Otsego Transfer Station in Cooperstown and the Southern Otsego Transfer Station in Oneonta, one of which could conceivably be the central collection site for the area.

The physical space needed for processing plastic film can be a major constraint for recycling agencies and companies, and the primary reason that some do not deal with this material. As a means of saving space, the *Plastic Film Recovery Guide* recommends storing loose film in a dry van (or enclosed truck trailer) at the collection site (Re-Sourcing Associates 1999). While this would be sufficient for keeping the clean, homogeneous films generated from industrial and commercial sites out of the elements, it would be

---

[62] Personal communication with Bill Neal, Poly-America contact for New England area (972-337-7260), Sept 2004.

[63] Sources: Prides Corner Farms website <http://www.pridescorner.com/> and Canusa Hershman Recycling Company (CHRC) website <http://www.chrecycling.com/>). Hershman merged with Canusa in 2002, prior to which the Hershman company was handling 1000 tons per month of recycled plastics. According to information on the company website, they now deal with virtually all commodities and grades of scrap and post-industrial polyethylene film, accepting material in form of parts, purges, bales and rolls. Their grinding and extrusion equipment has capacity to process millions of lb per month.

[64] Source: Farm Waste Management. Connecticut Grown website <http://www.state.ct.us/doag/business/agtech/agtechfw.htm>, accessed December 2002.

[65] O'Neill (2002) surveyed ten suppliers on Prince Edward Island, Canada, and found that while most (8 of 10) thought that a permanent bin on the premises of suppliers would be an effective means for collecting dairy films, the same number were not willing to have such a collection bin on their own premises. Four of the ten respondents deliver dairy film supplies to large accounts, but only one of the four expressed willingness to pick-up the films after they were used on the farm. Most respondents were not favorable towards imposing a levy at point-of-sale to defray downstream costs of disposal (7 of 10 were negative; 2 were positive; 1 had no comment), but felt that manufacturers should support the recycling of their films.

difficult to use such a space for handling of agricultural films, which also require room for sorting recyclable quality films from waste, as well as sorting by color and resin type.

Space Requirements for Storage of Films Prior to Baling

The quantity of loose plastics that comprises a truckload would take up about 10,000 sq ft prior to baling.[66] Clearly most collection sites would not have adequate space to store film for a full truckload without baling. Once baled, a 3 x 4 x 6 ft bale has a footprint of 24 sq ft (as compared with 245 sq ft unbaled). Stacked two high, the 40 bales for a full truckload would require 480 sq ft.

A covered structure at the collection site should have sufficient space to hold loose materials for several bales at any one time, as well as room for a baler and the finished bales, space to process deliveries and to sort the delivered material. An unused warehouse or barn could be rented for these purposes, or a simple pole barn could be constructed if funds were available. A 1200 sq ft structure adequate for these purposes would cost about $15,000 (Table 7).

TABLE 7: COST OF POLE BARN FOR A COVERED COLLECTION SITE

OPEN POLE BARN, ESTIMATED COST	$12/SQ FT	$15/SQ FT
30 ft x 40 ft = 1200 sq ft	$14,400	$18,000
30 ft x 60 ft = 1800 sq ft	$21,600	$27,000
30 ft x 80 ft = 2400 sq ft	$28,800	$36,000

Estimates assume $12-$15 per sq ft for a covered pole barn without sides.

[66] Calculated based on the size and capacity of a 42-inch cube Gaylord container, the type of container often used for storage of loose plastic. A "Gaylord" can typically hold 50 lb of loose stretch wrap (American Plastics Council 1994). At 50 lb per container, 20 containers would be needed to store plastic for a 1000-lb bale. The footprint of one Gaylord container is 12.25 sq ft. Thus the footprint of the 20 containers needed to make up one bale is 245 sq ft. At 245 sq ft per bale x 40 bales per truckload, 9800 sq ft of loose plastic in Gaylords is needed to fill a truckload. We have rounded to 10,000 sq ft per truckload, prior to baling.

Agricultural Film Recycling: Balers & Other Equipment

Baler Options & Efficiency

Most re-processors expect to receive plastic film for recycling in rectangular, stackable bales that can be maneuvered with a forklift (see Figure 3 for examples of bale specifications, pages 55-56).[67]

Baling for an agricultural film recycling program could be done with *(i)* a portable baler, used in the farm field prior to hauling to a central collection area; *(ii)* a semi-portable machine brought to collection areas as needed; or *(iii)* a stationary baler located at a recycling facility.

Whichever system is used, the success of a film recycling program may hinge on the efficiency of the baling process. Useful efficiency targets are **1.25 hours labor time per 900 lb bale**, which is the time estimate for baling non-agricultural films (Re-Sourcing Associates 1999), and a **cost of $40 per ton** (or $20 per bale, $0.02 per lb), which was the New Jersey nursery film recycling program's cost in 2003 (Table 5, page 33). Advisors recommend that balers have an automatic feed conveyor mechanism.

In contrast, the inefficient horizontal baler used in a Vermont dairy film pilot project required six hours of labor (involving two people) to manually load film for one 1000-lb bale (Negra and Rogers 1998). At $18 per hour actual labor costs, baling cost nearly $0.11 per lb in the mid-1990s. To put this cost in perspective, it is seven times more than would be generated by charging a $30 per ton tipping fee.

Balers in the Study Area

We sought to identify balers in the study area suitable for baling of plastic films and available to contract for that purpose. None of MOSA facilities have balers. Otsego AutoCrushers, a private scrap collection and processing facility in Oneonta, has a baler but is not interested in contracting to handle the plastic films nor in renting their baler for use with agricultural plastics.[68] None of the 18 non-agricultural users of plastic films surveyed for this report have a baler on premises (see Appendices IV and V, pages 73-76). The only equipment reported in this survey was one trash compacter at BJ's Wholesale Club, Inc.

The Oneida-Herkimer Solid Waste Authority (<http://www.ohswa.org/>), located in Utica about 50 miles due north of Oneonta (Map 1, page 11), has two large horizontal stroke balers manufactured in the Netherlands by Bollegraaf Recycling Machinery (<http://www.bollegraaf.com/>). The Director of Recycling at the Oneida-Herkimer SWA expressed doubt that these balers, which do not have cutting mechanisms, would be suitable for use with plastic films.[69] Plastic films are not currently collected for recycling in Oneida-Herkimer Counties.

The Fulton County recycling facility, located in Johnstown, about 55 miles northeast of Oneonta, has an automated Cranston Horizontal Baler but does not accept materials for baling from out-of-county. The Fulton County recycling coordinator is not aware of other balers in the three-county study area. Fulton County does not recycle film plastic because of the space needed for loose film before baling.[70]

Naef Recycling, located about 65 miles northwest of Oneonta in East Syracuse, currently contracts to handle Otsego County recyclables. The company has a horizontal Loggerman Baler that is used to bale all

---

[67] See also discussion of baling and balers elsewhere in this report; Levitan and Barros 2003; and Re-Sourcing Associates 1999.

[68] Personal communication with Terry Bliss, Otsego Co recycling coordinator, September 2004.

[69] Personal communication with David Lupinski, Oneida-Herkimer Solid Waste Authority, September 2004.

[70] Personal communication with Jeff Brouchard, Fulton County Solid Waste Authority, September 2004.

types of materials (bale size = 48 x 62 x 30 inches, average bale weight = 1500 to 2100 lb). The baler automatically shears off at the length specified to create the right size bale. The company is willing to explore potential for involvement in an agricultural plastics recycling program.[71] However, use of this baler would involve trucking loose film to East Syracuse.

Some re-processors have implied they will provide a baler and storage trailer for recycling programs that are guaranteed or anticipated to meet a certain threshold of film collection. We suggest this be used as a point of negotiation in arranging terms with re-processing markets, as well as a motivation to collaborate with non-agricultural users of film to increase flow-through to the threshold level.

See the later section *Sources of Information about Re-Processors, End-Markets & Equipment* for information about purchasing used balers.

The Tiger Baler: a Portable Baler Designed for Use in Agriculture

The Tiger Baler was developed specifically for use with agricultural films.[72] Its advantages for agriculture are that it:

- *(i)* is portable and can be pulled in fields by a 70-hp tractor, and on roads by a pick-up truck;
- *(ii)* integrates the processes of removing the film from the field and baling, thus reducing costs of handling and hauling;
- *(iii)* minimizes additional contamination of the films during collection and storage by lifting the hoophouse films, for example, off their frame and feeding them directly into the baler.

The Tiger Baler was first developed for removing and baling mulch films. It was later adapted for removal and baling of hoophouse covers. Both of these uses typically involve film removal once or twice a year. In contrast, dairy films are used and removed incrementally throughout much of the year and thus require on-site storage before collection and baling. Thus the dramatic cost savings of 50-90 percent documented from use of the Tiger Baler in comparison with manual removal of hoophouse films may not be similarly realized in applications with dairy films (see Table 5, page 33).

The portability of the Tiger Baler is appealing for film collection programs. A portable baler could obviate the need for a large, covered storage structure to accommodate loose films. It could be used either in a farm pick-up program, or on a circuit covering a number of central collection sites, within and beyond the bounds of the study area. By baling on-site or close-to-site, the efficiency of sorting recyclable quality from waste quality films would likely be improved (though other costs could be greater).

A collection and baling system involving a Tiger Baler would require acquisition of a baler (purchase price $25,000-$35,000) as well as a truck for hauling the baler, labor to operate the baler and sort materials, and a dry storage trailer for the finished bales.[73] With the potential for seeing immediate reward in finished bales and the removal of loose plastic from the farm, a higher capture rate and greater interest in the program might be expected, as compared with alternative systems.

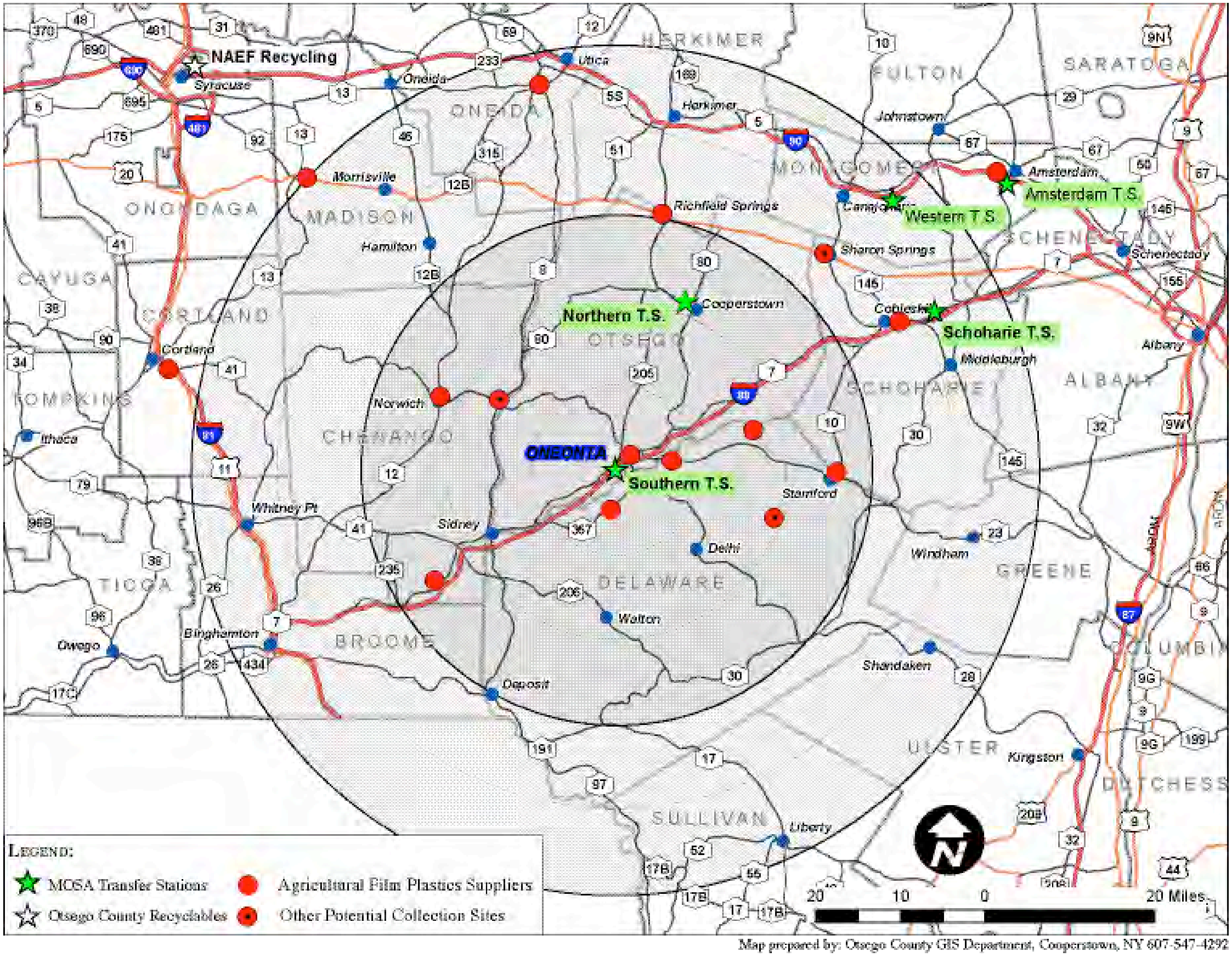
---

[71] Personal communication with Mark Naef, president of Naef Recycling (315-952-1511), October 2004.

[72] Information about the Tiger Baler is from *(i)* personal communication with its developer, Dennis Sutton (941-761-8293, Dennis@TigerBaler.com) of Bradenton, FL; *(ii)* the Tiger Baler website <http://www.tigerbaler.com>; *(iii)* Arthur Amidon, a recycling consultant who studied the use and efficiency of the Tiger Baler in baling hoophouse plastic; and from The Newsletter of the Connecticut Greenhouse Growers Association (CGGA 2001).

[73] A Tiger Baler costs about 2.5 times more than a generic downstroke baler (see Levitan and Barros 2003 and Re-Sourcing Associates 1999). Its square bales are about 650 lb. The baler has two feed options: a hopper with a funnel or a conveyor belt with puller.

MAP 3: LOCATION OF MOSA TRANSFER STATIONS, DAIRY FILM DEALERS AND OTHER POTENTIAL FILM COLLECTION SITES



Re-Processing & Manufacture of New Products

Re-processors, brokers and manufacturers are all potential markets for recycled films. They are considered together here because in some cases manufacturers of new products also reclaim the recycled film, pelletizing or grinding and cleaning it as needed for the production process.[74] In other cases, recycling companies or agencies perform these steps, then broker the sale of pellets or regrind to end-markets.[75] In still other cases, brokers are intermediaries between the handling and reclaiming steps; *i.e.,* they purchase bales of recycled films from recyclers and "shop it around" to find markets for re-processing and/or manufacture.

To illustrate using the example of B.Schoenberg, the second largest recycling company in the country with revenues of about $100 million per year:[76] The company purchases and transports baled truckloads of film (≥ 30,000 lb) to its warehouse in the New York City metropolitan area. There it is processed into pellets for re-sale. Alternatively, bales are sent for re-processing to B.Schoenberg's wholly owned Polywood plastic lumber manufacturing facility in Edison, New Jersey, or to another of its five manufacturing facilities around the country (Map 4, page 47). Because Polywood manufactures railroad ties, it is able to utilize lower quality materials than are required for decking lumber and other similar consumer products. When B.Schoenberg receives higher quality recyclables, they are likely to sell the feedstock to manufacturers such as the Trex Company, which pays a price differential for quality.

A full truckload containing 40,000 lb of cargo is the target "unit of exchange" referenced by most re-processing markets. To maximize transportation efficiency—*i.e.,* in order to be able to fit at least 40,000 lb of plastic on a dry trailer—the minimum target bale density is 12-15 lb per cubic foot, with typically no more than 20 lb per square ft pressure. Bale weight is typically 900-1200 lb, which extrapolates to 38-42 bales per full truckload. The *Plastic Film Recovery Guide* addresses technical details to consider in preparing materials for re-processing (Re-Sourcing Associates 1999).

Recycled Feedstock for Re-Manufacture: Cost and Quality

Depending upon their facilities and needs, polyethylene (PE) product manufacturers purchase plastic feedstock in the form of *(i)* virgin polyethylene plastic in the form of pellets, flakes or granules, *(ii)* recycled PE films that have been re-processed into these forms, or *(iii)* bales of used plastic. The price difference is considerable (see Table 8, page 46).

Various sources give the price of virgin PE at $0.40-0.61 per lb, while the cost of recycled PE in the form of pellets or flakes is currently $0.13-0.24 per lb; *i.e.,* about 3:1 (Block 2004). While specific prices are negotiated with the materials sourcing representative of a company after examination of samples, the following price ranges provided through personal communications with several re-processors are informative for planning purposes. All of the re-processors interviewed pay pick-up and trucking costs—estimated at $800 per truckload on average[77]—to bring baled films from central collection points to their warehouse or manufacturing plant.

---

[74] For example, see Figure 2, page 54, and the accompanying narrative describing the Trex Company's process of reclaiming recycled materials for the manufacture of composite lumber.

[75] For example, in recycling HDPE plastic pesticide containers, the Ag Container Recycling Council (ACRC) sub-contractors typically bring portable grinders to collection sites. These sites may be municipal solid waste transfer stations, recycling drop-off sites, agribusiness suppliers, or farms. For information about ACRC and plastic pesticide container recycling: <http://www.acrecycle.org>; 877-952-2272; info@acrecycle.org.

[76] Source: *Plastics News* cited in personal correspondence with Neil Ringers, B.Schoenberg sales representative, (770-804-8686), September 2004.

[77] Personal communication, Andrea Dahl, Trex Company material sourcing representative, December 2003.

- Trex Company, Inc.—the largest manufacturer of wood-plastic composite lumber (WPL), with about 50 percent of the market—buys off-spec virgin LDPE flakes for $0.30-0.40 per lb, bales of used stretch film for $0.05-0.10 per lb, or bales of used grocery bags at the lower price of $0.03-0.06 per lb because the bags may contain trash that has to be manually removed. Since installing a "washline" that can clean contaminated films, Trex is also sourcing materials requiring this extra cleaning process. The firm has been paying up to $0.03 per lb for films that require cleaning. Depending upon the extent of contamination, some "washline" films are acquired at no cost beyond that of trucking to the plant.[78]
- B.Schoenberg & Co., Inc.—ranked by *Plastic News* as the second largest plastics recycling company in the country and owners of Polywood, Inc., manufactures of recycled plastic lumber (RPL)—pays $0.05-0.14 per lb for baled LDPE. After investing approximately $ 0.10 per lb for re-processing into pellets, they re-sell to manufacturers for prices in the "high $0.20s" per pound.
- Poly-America—part of a group of privately held companies that is a major manufacturer of agricultural plastic films, garbage bags, etc.—pays $0.04-0.05 per lb for materials that require washline cleaning (and they use the washline for relatively clean agricultural films, such as those removed from nurseries).
- General Materials Recovery—a broker that has previously recycled films from the Oneonta, New York, area—will pay $0.02 per pound for clean nursery film, but will not pay for material contaminated with a non-recyclable adhesive strip. General Materials Recovery (GMR) does not have facilities for handling contaminated materials, and thus would be an unlikely market for dairy films.

The cost of reclaimed LDPE is low in comparison with other recycled plastic resins and is less now than it was in 1994 (Table 8, page 46). Activity in the plastic recycling market has increased primarily for PET (#1), HDPE (#2), and PS (#6) resins, but sources of and demand for LDPE (#4) have been unreliable. However, given the large price differential between virgin and recycled PE, a number of companies are actively pursuing recycled LDPE feedstock.

Washlines

With the incentive of the cost differential and international competition in sourcing higher quality recycled film,[79] more large re-processors and end users have been investing in "washlines." This is equipment that enables re-processors to clean plastic feedstock and thus utilize lower grade recyclable films such as those that have been used in agriculture.

The washlines make it feasible for dairy farmers and recycling programs to consider recycling agricultural films. For example, a California recycling program has been selling used fumigation sheets to the Trex Company at $20 per ton ($0.01 per lb). However, the equipment is costly. Climenhage (2003) notes that a "wash recycling plant needed to process curbside film to a state suitable for use in wood-plastic composites could cost $10-15 million [Canadian]." The Trex Company washline is said to have cost more than a million dollars.

[78] Information about the Trex Company is from personal communications with plant managers, research and development engineers, and the materials sourcing representative, primarily in December 2003.

[79] Various personal communication sources have told us that most recycled films have been sold to the export market (particularly to China, but also to Indonesia), which until recently paid a higher price for lower quality materials than has been offered by the domestic re-processing market.

Experts in pesticide container recycling calculate that washlines are economically justifiable if they process at least three million lb per year.[80] The Trex Company has found that their washline, with capacity to process 60 million lb per year, requires labor of 1.5-2.0 additional people, This additional labor demand is not quite enough to generate an additional job per shift. Tri-Rinse Environmental Contractors, a company that processes all types of containers for recycling, has also found that the washing step requires an additional 1.5-2.0 FTE. However, it has created just one additional staff position because additional labor needs are met by "borrowing" from other parts of the operation as needed.[81]

The Agri-Plas, Inc. agricultural plastics recycling company in Keizer, Oregon, has been developing an aspirator system for cleaning dirty films. This may provide an alternative to washline technology that is useable in the field and at smaller re-processing facilities.[82]

Identifying Markets for Recycled Film

There has been so much instability, growth, and change in the plastics recycling market over the past decades that authors of earlier reports about agricultural plastics recycling, and plastics recycling more generally, have lamented that the information they wrote about re-processing markets was out-of-date before it was published. The internet now enables access to current information in a way that the printed word could not. However, the fact of being listed (or not listed) on the web does not guarantee accuracy of the information, nor reliability of the firm.

When the time comes to identify markets for a specific agricultural film recycling program, it is strongly recommended that use be made of the resources of plastics recycling organizations,[83] the several online directories described below, and the web pages of the various companies we mention as potential markets. Indeed the details in this report about specific LDPE re-processors and manufacturers should be viewed only as examples of various options. When a recycling program is at the point of seeking tangible markets, samples of collected materials must be submitted, and prices and procedures must be negotiated anew. There is no substitute for personal communications, both to understand what a company has to offer and on what terms, and for recommendations regarding reliability.

As a means of focusing the search on markets that are likely to be interested in lower quality agricultural films, the recycling program should seek out re-processors, brokers and/or manufactures that deal with end-use products such as asphalt mix, garbage bags, agricultural and construction films, and lumber products, *i.e.,* products that are not intended for household or decorative uses.

In seeking such markets, the coordinator of the New Jersey agricultural plastics recycling program[84] advises new film recycling programs to:

- seek out and develop new potential markets on an ongoing basis
- diversify, rather than relying on arrangements with only one company

---

80 Personal communications with panelists at the annual meeting of the National Pesticide Stewardship Alliance (NPSA), October 2003. Their observation is with regard to processing of HDPE plastics, which have about twice the value of LDPEs in the recycling market (see Table 8, page 46).

81 Personal communication at the National Pesticide Stewardship Alliance annual meeting, October 2003, Session B: Container Collection Methodologies.

82 Personal communication with Dari Jongsma, October 2003.

83 For example, websites of the Canadian Plastics Industry Association, *Plastic films* section <http://www.plastics.ca/film/>; the Environment and Plastics Industry Council <http://www.cpia.ca/epic/>; the Plastic Lumber Trade Association <http://www.plasticlumber.org/>; and the American Plastics Council <http://www.americanplasticscouncil.org/>.

84 Personal communication, Dennis DeMatte, Coordinator, Cumberland County Improvement Authority, Sept 2003.

- identify reliable brokers and re-processors
- deal with companies that have good credit history
- not deal with any broker or end-user who has not paid for the previous load.

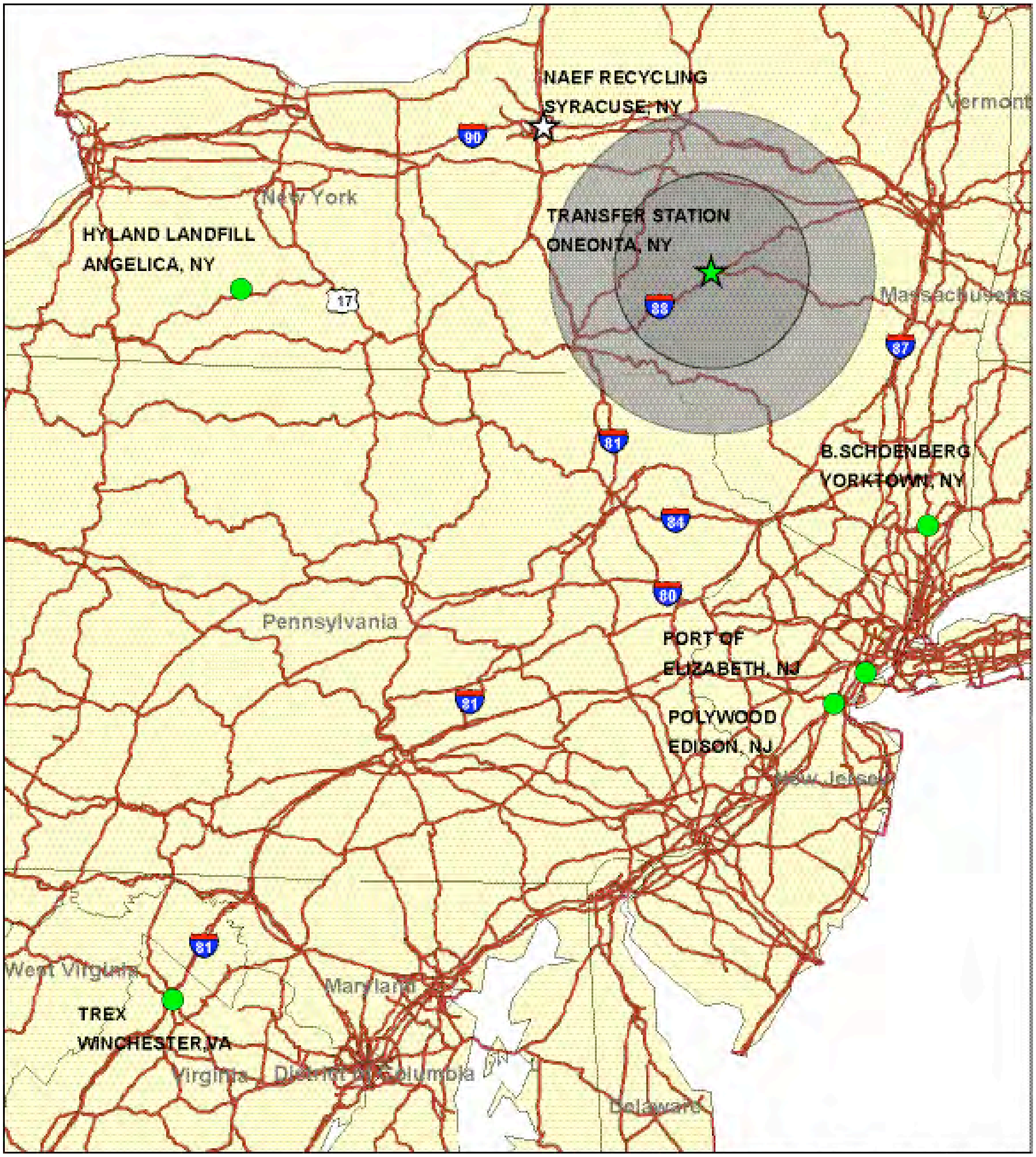
TABLE 8: PRICES FOR RECYCLED PLASTIC RESINS, 1994 & 2004 (CENTS PER LB)

		1994		2004	
RESIN	**PRODUCT DESCRIPTION**	**PELLETS**[85]	**REGRIND OR FLAKE**	**PELLETS**[86]	**REGRIND OR FLAKE**
PET or	Bottles, clear, post-consumer	48-57	35-42	55-57	40-45
PETE	Bottles, green, post-consumer	36-43	25-30	44-48	38-40
HDPE	Bottles, natural, post-consum.	31-37	27-33	40-43	25-28
	Bottles, mixed color, post-con	24-29	19-25	32-33	23-27
	Bottles, mixed color indust.	21-26	16-21		
	Film, post-consumer	22-27	—		
PVC	Clear, industrial	—	14-22		
	Flexible, post-industrial			32-40	—
	Rigid, post-industrial			56-60	—
LDPE	Clear, post-consumer film	33-36	—		
	Colored, post-consumer film	23-28	8-12		
	Printed/mixed, post-consumer			13	—
	Printed, post-industrial			20	—
	Not printed, post-industrial			24	—
LLDPE	Stretch film, post-consumer	25-30	—	28	—
PP	Industrial	33-38	23-28	21-27	17-18
	Post-consumer			17-19	—
PS	Industrial	35-40	25-30		
	High heat crystal, post-cons	43-46	30-36		
	High impact black, post-cons			43-46	39-41
	High impact, natural, post-con			50-55	—
	General purpose, black			38-40	30
	General purpose, natural			43-45	38-40

[85] Recycled resin prices for 1994 were derived from interviews by *Plastic News* reporter Tom Ford with buyers and suppliers. Prices are in US cents per lb for prime resin, unfilled, natural color, FOB supplier, unless otherwise noted. (Resin pricing chart, *Plastic News,* November 7, 1994).

[86] Recycled resin prices for September 2004 are from Block (2004). PET bottles and HDPE prices are noted to be applicable only for clean materials.

MAP 4: LOCATION OF SELECTED LANDFILLS, SHIPPING PORTS AND PLASTIC FILM RE-PROCESSING PLANTS IN THE NORTHEAST UNITED STATES



Map prepared by: Otsego County GIS Department, Cooperstown, NY 607-547-4292

LEGEND: Dark and lighter shaded concentric circles represent 30 and 50 mile radii respectively around Oneonta, New York.

● Landfill, Shipping Port, or Plastic Film Reprocessing Plant

★ Oneonta NY MOSA Transfer Station

Sources of Information about Re-Processors, End-Markets & Equipment

Re-Processors and End-Markets

The *Recycled Plastic Markets Database* contains information about more than 1650 recycling companies in the North America post-industrial and post-consumer plastics industry. The database has been maintained since 1990 as a joint effort of the American Plastics Council (APC) and the Environment and Plastics Industry Council of Canada (EPIC).[87] While it is not possible to search specifically for buyers of agricultural plastics—which imply a level of dirty-ness that is unacceptable to many buyers—searches can be narrowed by geography, resin type, films versus other product types, and various post-industrial uses.

The current 2003 edition of the *Scrap Plastics Market Directory* lists more than 330 North American firms that purchase plastic scrap (Resource Recycling 2003).[88] In 1995 *Resource Recycling* published a directory of about 60 US and Canadian manufacturers of plastic lumber (Resource Recycling 1995). This directory is updated online by subscription to the *Plastics Recycling Update*, which costs $58 per year, or less in combination with the *Scrap Plastics Market Directory*.

A search for "plastic recycling" on the online *Manufacturers News Inc.: MNI guide to US manufacturers, suppliers and business services* brings up 170 companies that are markets for recycled plastic (<http://www.mniguide.com/>).

Global Recycling Network (GRN) is an electronic information exchange specializing in the trade of recyclables reclaimed in Municipal Solid Waste (MSW) streams, as well as the marketing of eco-friendly products. The Plastics Recycling section of the GRN website gives current market prices for full truckload and less-than-truckload quantities of plastic resins, and provides an on-line database of markets and suppliers (see <http://www.grn.com/a/1004.html>).[89]

The Center for Plastics Recycling Research, under auspices of the California Integrated Waste Management Board maintains a *Plastics Recyclers/Re-processors Directory* database: <http://www.ciwmb.ca.gov/Plastic/>. However, we found that this database has limited information on companies outside of California.[90]

A number of references in the bibliography to this report contain detailed analysis of segments of end-user markets, including the market for railroad ties (Railroad Ties 2003), marine lumber (Marine Lumber 2003), and plastic lumber generally (see for example, CIWMB 2004-Lumber; Climenhage 2003; EPIC 2003-PlasticLumber; Robbins 1999, 2000).

---

[87] See *Recycled Plastic Markets Database* <http://www.plasticsresource.com/>. When accessed in spring 2004, it was surprising to note that B.Schoenberg was not listed; the Trex Company was listed only under its Fernley, NV location; and several companies advertising in the Plastics Recycling Showcase in the April 2004 issue of *Resource Recycle* were not listed.

[88] The *Scrap Plastics Markets Directory* lists more than 330 firms that purchase scrap plastics of different types. It also lists manufacturers of plastics recycling equipment. The *Directory* can be purchased online (<http://www.resource-recycling.com/plastics.html>) for $49, or at a lower combination price when ordered with the *Plastics Recycling Update* newsletter.

[89] The GRN database for LDPE listed 81 markets and 46 suppliers when accessed October 19, 2004.

[90] As an indication of its scope, the database includes just four companies outside of California that accept LLDPE and LDPE. Entries for companies we are familiar with are incomplete and contain inaccuracies.

Balers & Other Equipment

The *Recycler's Exchange* maintained by *Recyclers World* is an online database of new and used equipment <http://www.recycle.net/>. *Resource Recycling* journal and website also provide information about equipment including plastics granulators, pelletizers, shredders, magnets, baling supplies and balers, and collection bins (<http://www.resource-recycling.com/recyclingshowcase.html>).

Products Made from Recycled Agricultural Films

The most promising end-uses for recycled dairy films are those that will not be compromised by the colors and contaminants of the used plastics. Such products include garbage and construction bags; agricultural bags, wraps and covers; lumber for uses that are neither decorative nor structural; construction materials like roof shingles and asphalt paving mix; mulch and playground chips, etc. Some of the technologies that will permit these uses are still under development. Market development for LDPE plastics in general lags behind that of other resins, and agricultural plastics are but a small proportion of the LDPE feedstock on the market.

The following vignettes describe a few of the existing and potential markets for re-processed agricultural films:

Asphalt Paving Mix

A New York State manufacturer of hot mix asphalt for paving believes it would be cost effective to use re-processed LDPE granules, if these materials could be sourced close to the firm's manufacturing plants. The company's target price of $0.10 per lb for LDPE feedstock (≤ 0.25 inch, ≥ 75 percent pure LDPE), is just a few cents less than September 2004 prices for the lowest grade of printed, mixed color post-consumer film (see Block 2004 and Table 8, page 46). Low grade film should suffice for this market because a number of the contaminants that are constraints for other markets are not likely to be problematic in manufacturing the asphalt mix. The "contaminants" would simply serve as filler. However, remnants of organic matter adhering to the plastic granules may be a constraint because they could impede the coating of the aggregate. Volume requirements for this use in New York State could be met by local supply.[91]

Agricultural Films

Several of the major agricultural film manufacturers have been exploring the re-use of recycled agricultural films in new products destined for agriculture.[92]

Recycled Plastic Lumber and Wood-Plastic Composite Lumber

In the late 1990s, the recycled plastic lumber (RPL) industry—with about 70 firms in 29 states and four Canadian provinces—was growing at an estimated 40 percent annually and receiving a great deal of publicity from several large projects (Batelle Columbus cited in Powell 1996). Among these were a $2.6 million pedestrian pier in New York City built from more than 600 tons of scrap plastic lumber and pilings supplied by three producers: Plastic Pilings (Rialto, CA); Seaward International (Clearbrook, VA) and Trimax (Ronkonkoma, NY).

---

[91] Details are omitted to product business confidentiality; contact the lead author of this report for more information.

[92] Karen Kritz and Dennis DeMatte of the New Jersey nursery film recycling program reported in personal communications that AT Plastics was using re-processed agricultural film in manufacture; Bill Neal of Poly-America described in personal communications, September 2004, similar nascent efforts on the part of that company, although they have not yet mastered the recycling of mulch films.

However, LDPE films are used as feedstock for only a minority of RPL products. Most processes use HDPE, which is a more structurally rigid polyethylene, or polypropylene (see Levitan and Barros 2003, footnote 19; Climenhage 2003). Products such as railroad ties and marina docks, which have lower feedstock quality standards, rely almost entirely on HDPE rather than LDPE because of this structural difference. Because plastic lumber is in general much more flexible than wood, composite lumbers have been developed incorporating materials such as wood, fiberglass rods, or dispersed fiberglass with the plastic to increase stiffness.

For example, Seaward International, manufacturer of the piers used in the New York City pedestrian pier, uses six to 16 fiberglass re-enforcing rods per 10-16 inch diameter piece of lumber. In addition to reducing flex, the composites reduce weight of plastic lumber and can add to the aesthetics. However, composites made with wood also absorb water, increase potential to burn, and are harder to process due to wood's low bulk density.[93]

In some cases the composites were developed for the purpose of utilizing more than one type of scrap as feedstock. For example, Suffolk Environmental Solutions in Suffolk, Virginia, received a $450,000 federal grant to build a $2 million plant to manufacture pallets from a mix of plastic scrap and peanut shells. The plant was located next to Birdsong Peanuts, and was expected to employ 15 people in making 250,000 pallets per year.

Most RPL firms manufacture lumber as an offshoot of another company function. For example, ARW Polywood (Lima, Ohio) was an offshoot of a trucking company; Bedford Industries (Worthington, Minnesota) was generating HDPE scrap from manufacture of twist ties; Collins & Aikman used by-products from their manufacture of floor coverings; and Custom-Pac Extrusions, (Chagrin Falls, Ohio) used by-products from manufacture of electrical insulation. Plastic lumber was a new extension of the marine products line of Seaward International (Clearbrook, Virginia), and United Resource Recovery was involved in many aspects of solid waste handling (Powell 1996).

The 70 firms identified by Powell (1996) were processing 40-60 million lb of scrap plastic annually in the mid-1990s. Production efficiency ranged from less than 1000 lb per 8-hour shift to more than 30,000 lb per shift. Annual consumption of scrap plastic among the 30 companies interviewed for Powell's report ranged from 250,000 lb per year to 6.2 million lb per year (mean = 2.4 million lb per year).

In comparison, in 2003, output from the Trex Company plant in Winchester, Virginia, was 350-400 million lb per year, half of which was plastic (*i.e.,* 200 million lb of plastic scrap was reprocessed by this plant alone). Trex's plant in Fernley, Nevada processes 125 million lb per year. The company buys about one million lb of plastic per day (both recycled and off-spec virgin plastics) that arrive in more than 20 truckloads. The company is in process of developing a new plant that will have double the capacity of the Winchester plant.[94] By these and other indications, market future is bright for RPL and thus for its feedstock. By 2003, plastic lumber decking materials captured 11 percent of the North American market for decks and was valued at $395 million (based on 2001 data).

Plastic-wood composite products comprise about 80 percent of the plastic lumber market, and the composite lumber sector is growing more rapidly than the pure polymer sector of this market. Most pure polymer products are made from extruded HDPE, not LDPE resins. After rapid growth in the 1990s, and a period of consolidation and slow down 2000-2001, RPL and WPL manufacturing is again on the upswing, boosted by several factors:

[93] Source: Brent English, USDA Forest Products Research Lab.

[94] The Trex Company has controlled about 50% of the wood-plastic composite market, with about 40 other companies competing for the other 50% market share. The Trex Company supports a staff of nearly 500 at its plants in Winchester, Virginia, and Fernley, Nevada, and in corporate management, sales, materials sourcing, and research and development (personal communications December 2003).

- recent agreement between the US Environmental Protection Agency (EPA) and the American lumber industry to phase out toxic chromated copper arsenate (CCA) compounds from pressure treated wood
- development of standards for coded uses of plastic and composite lumbers, as a joint effort of the Plastic Lumber Trade Association and ASTM. These standards are expected to boost consumer confidence in plastic and composite lumber products (Robbins 1999, 2000)
- growing reputation of the products and appreciation of the product characteristics (Climenhage 2003; EPIC 2003-PlasticLumber).

Market expansion is prompting additional private sector research, which is expected to open more doors for use of "imperfect" feedstock, such as that from recycled agricultural films. For example, after four years of research and development, the Demer Corporation in Covington, Louisiana, received a patent for a thermoplastic railroad tie. The company was seeking financing to begin production of railroad ties that would be made from 60 percent recycled-gypsum filler and 40 percent post-consumer high- and low density polyethylene and polypropylene (#2 HDPE, #4 LDPE, and #5 PP) (Plastics News 1999).

The competition for re-processed plastic has firms searching beyond obvious and nearby sources. Used films from Canada are shipped to several of the large WPL manufacturers in the United States, including the Trex Company in both Virginia and Nevada; US Plastic Lumber in Boca Raton, Florida; and Advanced Environmental Recycling Technologies, Inc., in Springdale, Arkansas (Railroad Ties 2003).

Boats and Barges[95]

St. Stephen Boatworks, Inc. in New Brunswick, Canada,[96] recently developed a patent-pending method of building box-shaped work barges with extensive use of recycled plastic lumber (RPL). The method was developed in conjunction with the National Research Council of Canada (NRCC) and tested by the Department of Wood Sciences and Technology at the University of New Brunswick.[97] These barges are among the first structural uses of RPL. The structural applications that are feasible in water would not work on-land because most LDPE-based RPL is too flexible to withstand structural loads.

The prototype barge was recently launched at the Maritime Museum of the Atlantic, Halifax, Nova Scotia, Canada. It has been donated to the museum where it can be viewed by the public, as well as by prospective buyers. Another of the St. Stephen Boatworks RPL barges will be used by an aquaculture farm in Connecticut. The box-shape is framed by plastic two-by-fours. Interior struts and trusses on 2 ft centers are packed with expanded polystyrene foam that fills virtually all voids within the hull. The polystyrene is completely enclosed to prevent deterioration and loss of flotation capacity. Deck planking is 2 x 6-3/4 inch tongue-and-groove RPL.

The boat builder estimates the cost of the RPL barges at about 20 percent less than a fiberglass/wood version. Since the RPL does not require painting, maintenance costs are expected to be far lower and to have less negative environmental impact.

Although total boat costs are comparable, the RPL lumber itself is three times the price of wood and twice as heavy. In comparison with wood, RPL is 10 times as flexible. In laboratory tests, RPL joints have withstood twice the strain of wood—6,200 lb force before breaking as compared to 3,100 lb of force to break the wood sample—because the plastic absorbs the load and distributes it widely. The RPL was

---

[95] Sources: *Plastics in Canada* newsletter, <http://www.bizlink.com/enewsletters/plastics/2004/plastics_jan7.html>, Jan 7, 2004; Aquaculture Barges, September 24, 2003, by Stu Sheppard in *Fish Farming*.

[96] St. Stephen Boatworks, Inc., David Prior, President and CEO, 506-465-0918. 9129 Rt. 3, Old Ridge, New Brunswick, CA E3L 4X2, 888-465-0918; (ssbw@ststephenboatworks.ca); <http://www.ststephenboatworks.ca/>.

[97] University of New Brunswick contact: <woodsci@unb.ca> - mention IPI 9902-1.

purchased from the now-defunct Island Plastics Company (IP) in Prince Edward Island, Canada. IP used LDPE agricultural films almost exclusively as feedstock; however it is not clear from information published about this barge whether it was made from LDPE or the less flexible HDPE resin.
The same method used to build the barge is also used to manufacture floating docks, which weigh 40 percent less than their steel counterparts, cost about the same, and require less maintenance.

Process of Manufacturing Composite Lumber: *e.g.,* the Trex Company

The process of manufacturing Trex® composite lumber is described below and illustrated in a simplified flow chart (see Figure 2, page 54). Trex® products are a 50-50 mix, by weight, of wood and plastic scrap, each of which are separately processed before mixing.

Processing of Scrap Wood

The process of preparing **wood** for the mix is far simpler than the process of preparing plastic. The wood feedstock is post-industrial hardwood scrap from pallet recyclers and furniture manufacturers. It arrives in the form of wood chips or sawdust. Only hardwoods are used because they have fewer volatiles than softwoods, and only untreated scrap that is not contaminated with glues, finishes or fillers. The wood is heated during processing to further reduce release of volatiles as air pollutants in the plant. To meet color standards for Trex® products, only limited quantities of cherry and mahogany woods are used because of their dark color.

Truckloads of wood chips arrive on walking floor trailers that move the load using hydraulic pressure and unload it automatically. The scrap is passed through a strong **magnet** to remove nails and other metal contaminants, and then goes directly to a **wood hammermill** that pulverizes the chips into dust or "flour," the form in which it is stored.

Processing of Recycled Plastic

Recycled plastic arrives at the Trex plant in rectangular, stackable bales. Each bale is about 1000 lb, 3 x 4 x 6 ft in dimension, and a homogenous color and resin type. The bales are manually **unloaded at the receiving dock** and sorted by color and resin type as well as by quality. Bale specifications typically permit 3-5 percent contamination by weight (*e.g.,* moisture, paper, wire, other plastics) (see Figure 3, pages 55-56, for detailed bale specifications). If a bale is judged to have a higher-than-permitted percentage contamination it may be sent through the washline for cleaning. A description of the washline process follows the description of steps in processing clean films.

Since the entire plant (*i.e.,* all extrusion lines) runs the same color of finished product at any one time, plant workers at the receiving dock select incoming bales by color, based on recipes for mixes that will produce an end product of the desired color. By blending films of different colors, the mix approaches the color of the finished product. A dye concentrate is added to bring the blend to a color identical to one of the five Trex® product lines, but plant engineers try to limit its use since the dye is both expensive and non-recyclable.

Full bales are put through a **shredder** at low speed in order to break up the contents into pieces of manageable size. A this stage, plant workers check manually and **remove large contaminants** such as strapping and soda bottles**.**

The relatively homogenous, shredded films are then **granulated** and passed through a **magnet** to remove metal contaminants.

The granules are then fed into the **rock box**, which sorts materials by density for further decontamination. This process removes smaller contaminants that were missed by the manual sorting process, but which can be captured after granulating (*e.g.,* bottle caps, glass fragments, etc.). After again going through a magnet to pull out metal contaminants, the **fluff is stored** in 200,000 lb capacity blend silos.

Washline Process

The **washline** process[98] cleans and densifies films contaminated up to 25 percent by weight, recycling the wash water it uses. Moisture—which is typically considered a contaminant of baled plastics—is not considered a contaminant for plastics going through the washline process.

After shredding the bales, the plastic is cleaned and processed into pieces the size of a small fingernail. It uses a series of **float sink tanks** to clean and sort the shredded films, then a **screw press** to wring out the water. During this processing, the PE rises to the top. After a **snowball grinder** breaks up clumps, the pieces are dried to less than 10 percent moisture using electric-heated forced air in a closed loop that filters plastic dust and returns it to the feedstock pile. Finally a **melt extruder** dries and granulates the plastic into small chips or fluff.

Processing of Mixed Plastic and Wood

The wood dust and plastic fluff are mixed 50-50 by weight and heated. The mix has the consistency of play dough. It is processed through an extruder to form the lumber pieces. The lumber is then moved by conveyor into a water bath for controlled cooling. The heat for the extrusion process is supplied by heat generated during the screw drying process, with additional heat generated by electric power.

[98] Information from personal communication with Preston Blake, Trex Company washline supervisor, Dec 2003.

FIGURE 2: TREX® PRODUCTION FLOW CHART FOR RECYCLED PLASTIC-WOOD COMPOSITE LUMBER

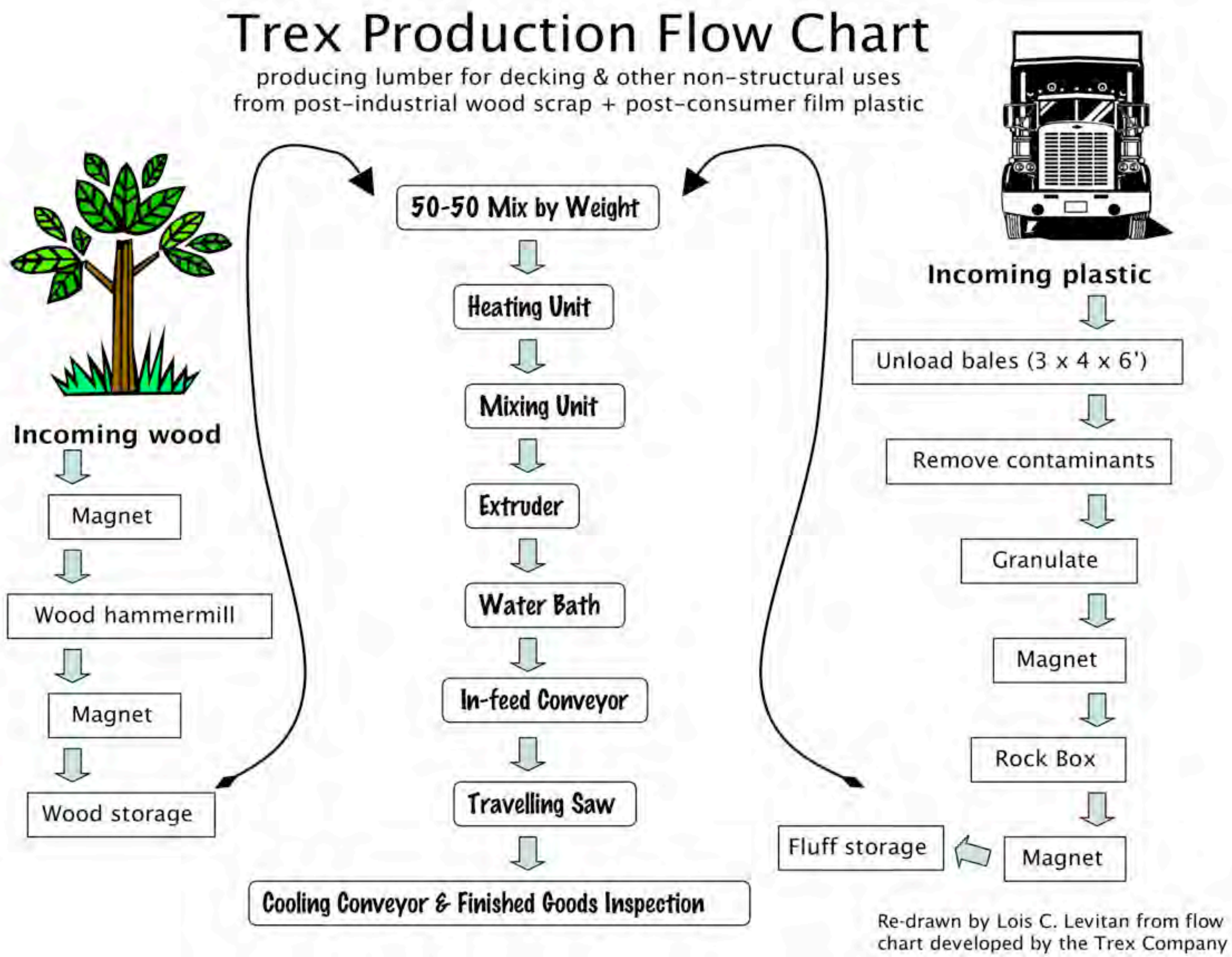


FIGURE 3: BALE SPECIFICATIONS, EXAMPLES FROM THE AERT AND TREX COMPANIES

P.O. Box 1237, 200 Porter Avenue, Springdale, AR 72764
Phone: 479-756-7406 Fax: 479-756-7413

LLDPE STRETCH FILM BALE SPECIFICATIONS

- **Stretch Film:** Bales must contain at least 96% stretch film
- **HDPE Bags:** Less than 2% HDPE bags or color; no more than 2% colored film
- **LDPE Bags:** Clear LDPE bags, stretch film, and bubble wrap can be mixed

Bale Specifications

- **Dimension:** Not to exceed 3' x 4' x 6'
- **Bale Weight:** Not to exceed 1300 lbs.
- **Density:** Bale density should equal or exceed 20 lbs. Per ft.^{3}
- **Strapping:** Galvanized wire or polypropylene
- **Integrity:** Must maintain contents through shipping and handling
- **Markings:** Each bale must be clearly marked with supplier name, D.C. #, A.E.R.T.'S PO #, and bale weight

General Specifications

- **P.E.T.E. – PP:** No loose P.E.T.E. or Polypropylene Strapping
- **PVS and PVDC:** No PVC (vinyl) or PVDC (saran) films (meat wrap is PVC or cryovac)
- **Loose Paper:** No loose paper, corrugated or paperboard inside bales
- **Hazardous Materials:** No hazardous materials, medical wastes, or containers used to package these products
- **Moisture and Trash:** No moisture, trash, oil or grease
- **PS/PU:** No polystyrene or polyurethane foam
- **Wood:** No wood or broken pallet pieces
- **Paper Labels:** Must not contain greater than 2% paper labels

April 1, 2003

Trex

>>SEARCH

Find Trex Near You: Contractor Zipcode: >> SEARCH

Trade Professionals
- Partner Login
- Architectural Binder
- Technical Info
- Product & Installation Guide
- TrexPro™ Program
- Material Suppliers
  - Plastic
  - Wood
  - Contact Us
- FAQs
- Request Information

Material Suppliers

STRETCH FILM SPECIFICATIONS

Item: PS-0001
Source: Distribution or industrial sites.

CONTENT SPECIFICATIONS:

Bales to contain at least 98% stretch/shrink film and:

- Less than 3% colored/printed HDPE, LDPE bags.
- No PVC or PVDC (Saran) films (meat wrap is PVC).
- No moisture – dry bales only.
- No trash, loose paper or corrugated materials inside bales (attached paper labels ok as long as they are not excessive).
- No corrugated materials or poly slip sheets as headers/end caps on bales.
- No strapping twine or tape (within the bale).
- No wood, broken pallet pieces or pallets.
- No polystyrene, polyurethane foamed, Polypropylene or PET.
- No oil or grease.
- No hazardous materials, medical wastes, nor containers used to package these products.
- No metal.
- Either plastic or metal banding is acceptable. If wire, must be 13 g. or smaller. Bale integrity must be maintained during transit and unloading.

BALE SIZE/MARKINGS

Bale Dimension:	24" x 36" x 42" minimum to 36" x 48" x 72" maximum
Bale Weight:	750 lbs. Minimum to 1,200 lbs. Maximum
Other:	Bale integrity must be maintained through shipping, unloading and storage. Trucks to be floor loaded without pallets.
Markings:	
TL Shipments:	Supplier's name, Trex Company item # and PO # listed on bill of lading.
GENERAL:	Good faith effort to eliminate all forms of contamination. No trash, loose paper or corrugated materials inside of bales.

Home | Products | Deck Ideas | Warranty & Care | Trade Professionals | Investors | Contact Us | Site Map

Ireland | United Kingdom

Economic Feasibility of Dairy Film Recycling

This section provides a framework for realistically assessing the economic feasibility of recycling and local re-processing of agricultural films.

Economic Feasibility of Programs for Collection & Handling of Dairy Films

Revenues

It should be assumed that dairy films will require cleaning prior to reclamation (*i.e.,* prior to pelletizing or granulating). The prices paid for these "dirty" LDPE films are far lower than what is paid for clean LDPE films (as shown in Table 8, page 46). Expectations for revenues from agricultural plastics recycling, and the budget for a recycling program, must reflect this reality. Price quotes we received from several potential re-processing markets for agricultural plastics are tabulated in Table 9 (below). The price per lb, which is the unit typically quoted, is extrapolated to expected revenue for *(i)* a 1000-lb bale, *(ii)* one ton and *(iii)* a full 40,000 lb truckload.[99]

TABLE 9: POTENTIAL REVENUES FROM SALE OF AGRICULTURAL FILMS TO RE-PROCESSORS

PRICE PER LB	REVENUE PER 1000 LB BALE	REVENUE PER TON	REVENUE PER FULL TRUCKLOAD
0	0	0	0
1 cent	$10	$20	$400
2 cents	$20	$40	$800
3 cents	$30	$60	$1200
4 cents	$40	$80	$1600
5 cents	$50	$100	$2000

Revenue-Expense Worksheet

The *Dairy Film Recycling Economic Worksheet* (Table 10, page 58) provides a framework for tallying potential revenues and expenses for a dairy film recycling program. In the example given, net profit is set to zero. The example was structured in this way in order to clearly show the limits to expected revenues. It can be inferred that if the assumptions underlying the values used in the Worksheet are met, a plastic film recycling program could be economically viable without additional social subsidy. These assumptions are detailed in the line-by-line notes following Table 10.

Comparison of our Worksheet with the *Plastic Film Recovery Guide's* Economic Worksheet (hereafter referred to as the *Guide*): In the *Guide*, net economic benefits of recycling are calculated as the sum of net revenues and avoided disposal costs, arriving at a $0.062 per lb variable net benefit from plastic film recovery (Re-Sourcing Associates 1999, Worksheet page C-1).

However, most of the assumptions in the *Guide* do not pertain to the type of community or regional agricultural plastic recycling program that we are assessing. Rather, the *Guide* describes a recycling

[99] A 40,000 lb truckload of dairy film represents a capture rate of approximately 20 percent in the study area.

program that might be found in a warehouse, factory or large store where clean films are generated from a single site that previously trucked its waste to a landfill. In this context it is appropriate to add avoided disposal costs to revenues, whereas for our calculations the avoided disposal costs are not pertinent because few farmers in the study area currently use the landfill and pay the landfill tipping fee.

The *Guide* estimates $0.083 per pound in avoided disposal costs, which is 80 percent of their calculated gross economic benefit of recycling the film. Had we adopted this framework for calculating net benefit, our balance sheet would show the approximately $40 per ton difference between landfill tipping fees and recycling tipping fees as an "avoided cost" revenue. Without the imputed revenue from "avoided costs," LDPE film recycling is more costly.

Another avoided cost that is not reflected either in the *Guide* or in this Worksheet is the social cost of environmental and health impacts associated with on-farm disposal (*i.e.,* the detrimental effects of open burning). Translating these costs into dollar values is not straightforward, but they are important to consider in monetary terms by some means of estimation.

TABLE 10: DAIRY FILM RECYCLING ECONOMIC WORKSHEET

	REVENUES AND EXPENSES	REVENUE & EXPENSES PER LB	REVENUE & EXPENSES PER TON	REVENUE & EXPENSES PER TRUCKLOAD
1	Revenue from sale of film to re-processor (range: $0.0-0.05 per lb) (Table 9, page 57)	$0.030	$60	$1200
2	Tipping fee for recyclables (range: no fee-100% cost of program) Assume $30 per ton (=$0.015 per lb)	$0.015	$30	$ 600
3	**Total Potential Gross Revenue**	**$0.045**	**$90**	**$1800**
4	**Expenses for Collection and Handling**			
5	Baling	($0.020)	($40)	($ 800)
6	Other	($0.025)	($50)	($1000)
7	**Total Expenses for Material Recovery**	**($0.045)**	**($90)**	**($1800)**
8	**Net**	**0**	**0**	**0**

Notes to Table 10

Line 1—Revenue from sale of film to re-processor: This value is the approximate midpoint in the range given in personal communications with several re-processors ($0.0-0.05 per lb) (Table 9, page 57). Prices given in Table 9 for "dirty" films are significantly lower than those given in Table 8 (page 46) for clean, higher grade LDPE films. The implication is that program revenues from sale of agricultural plastics will be far lower than from sale of clean stretch film for recycling.

Line 2—Tipping fee for recyclables: Primarily to cover the cost of baling, agricultural film collection programs have tended to impose a tipping fee for recyclable films in the range of $20-$35 per ton. The value of $30 per ton used in this Worksheet is $10 more than the tipping fee charged by the New Jersey nursery film recycling program, and $40 less than the MOSA tipping fee for solid waste going to a landfill. *I.e.,* by recycling, farmers in the study area who now haul their plastics to a transfer station for landfilling would save $40 per ton. [100]

For farmers who currently dispose of plastics by burning or dumping on-farm, the tipping fee will be an additional expense. The impact of the tipping fee as a determinant for choosing between throwaway and recycling is a matter of some debate. Some recycling coordinators have suggested that farmers are significantly more willing to pay $20 per ton than $30, citing the example of a failed program in Ohio that charged the higher fee.

In order to encourage recycling, many community recycling programs do not charge a tipping fee for drop-off of recyclables. For these reasons and despite the real costs of baling, the Prince Edward Island, Canada, recycling program made a political decision to eliminate tipping fees for agricultural films collected in their drop-off program.[101]

Line 3—Total Potential Gross Revenue: Gross revenues include income to the recycling program both *(i)* from sale of materials to a re-processor, and *(ii)* the tipping fee received from the farmer or a hired hauler bringing materials to the drop-off site.

Line 4—Expenses for Collection and Handling: We include expenses of handling and baling film at a central collection area.

We have not included the expense of removing film from fields and hauling it to the farm gate for pick-up because we assume this cost is approximately equal to the cost of removing the films and hauling them to the "Back 40" for on-farm disposal. Therefore these on-farm costs are not included either as program expenses or as avoided costs.

The expense of hauling from the farm gate to the central collection area is also not included here because it is not pertinent to drop-off programs. Actual expenses of pick-up programs would vary considerably with different contractual arrangements with haulers, distances and quantities served. Sources have suggested $1 per mile as a rule-of-thumb for costs of trucking from the farm to the central collection area (see the *Collection & Handling* section of Table 5, page 33). In considering whether to develop a drop-off or pick-up collection program, refer to the prior discussion about "capture rates" in the section *Agricultural Film Recycling: Collection & Hauling*, and see Table 6, page 37, for a comparison of the efficacy of drop-off, backhaul, and pick-up programs.

The cost of shipping baled films to a re-processor is typically covered by the re-processing market and is therefore not included as a recycling program expense.

Line 5—Baling: Actual program costs for baling of nursery films in New Jersey has been estimated at $40 per ton (= $0.02 per lb). [102] This includes costs of labor, bale twine or wire, and equipment rental (see

---

[100] At 300-500 lb per large silage bag, one could estimate about five silage bags per ton in calculating cost and savings to farms of different sizes.

[101] When a waste management authority recently took over the collection of agricultural films and instituted a tipping fee, the PEI Federation of Agriculture formally requested that farmers not be charged for recyclables (O'Neill 2002).

[102] The estimate of $40 per ton in actual costs is from personal communication with Dennis DeMatte, Coordinator of the New Jersey nursery film recycling program. With only two collection sites in the State, this program operates at a relatively high volume of approximately 300,000 lb per year, and has the benefit of experience going back to the mid-1990s. Furthermore, used nursery films are cleaner than used dairy films and therefore are likely to be easier to sort and bale than dairy films. Thus real costs for other programs may be higher. DeMatte also notes that the $20 per ton tipping fee is charged on wet, loosely packed films laden with debris, while revenues from the sale to re-processors is based on the weight of dry, tightly packed and cleaner bales.

the *Collection and Handling* section of Table 5, page 33). Actual costs will depend on *(i)* collection period; *(ii)* type of baler; *(iii)* quantity processed; *(iv)* quality of film; and *(v)* program efficiency. As noted in footnote 102, actual baling costs for less efficient programs may be higher than $40 per ton.

Line 6—Other Expenses: A value of $0.025 per lb in "Other" expenses was selected in order to show a zero net balance to the Worksheet calculations under the current set of assumptions for revenues and expenses.[103] This could be considered a target value that would enable the plastic recycling program to operate without additional subsidy.

With $0.025 per lb allocated for all "other" expenses, $1000 per truckload of bales would be the total amount available to cover expenses that might include the cost of *(i)* storage containers; *(ii)* a covered collection site; *(iii)* a storage trailer or structure for bales; *(iv)* administrative leadership and support; *(v)* education and training in BMPs; and *(vi)* skilled labor to sort waste from recyclable quality. "Other' expenses could also include landfill or WTE tipping fees for films that are not suitable for recycling.[104]

Given that we are considering one truckload as the initial target for annual flow-through for a nascent film recycling program, the implication is that this $1000 may be asked to serve many purposes. It is reasonable to assume, therefore, that other sources of funding will likely be needed to cover some expenses of the recycling program.

Economic Feasibility of Local Re-Processing

The study area is bisected by Interstate 88, and close to the US Route 20 corridor and the New York State Thruway, both of which serve as access to New England and the New York City metropolitan area and ports (Map 4, page 47). Thus it is in a strategic and prime location for materials collection and re-processing before shipping in more densified and efficient form to more distant manufacturers.

If the savings in material transportation costs were sufficient to justify capital investment in re-processing equipment and operating costs, a re-processing plant (or mobile granulating unit[105]) could provide an economic development opportunity for the region. However, such an operation could not be supported by the quantity of agricultural films used in the study region (about 200,000 lb per year), nor likely by the quantity of recyclable films generated by all industrial and commercial users of LDPE film in this area.

Manufacture of new products and materials from re-processed film is a competitive, capital-intensive undertaking. Despite considerable growth and optimism in this industry,[106] industry analysts have noted that during the period of expansion in the mid-1990s, the publicly traded companies were not making money (Powell 1996).[107]

---

[103] With the exception of Line 6, "Other" expenses, all values used for revenues and expenses are drawn from actual experiences of agricultural plastic recycling programs (see Table 5, page 33, for context and sources).

[104] The expense of landfill or WTE tipping fees for materials not suitable for recycling could be allocated to farmers rather than paid by the recycling program. However, in order to build momentum and good will for the program, it may be wise to minimize economic impact on participating farmers and seek temporary subsidy from other sources.

[105] The plastic pesticide container recycling programs organized by the Agricultural Container Recycling Council (ACRC) have typically utilized mobile granulator units that process the containers at local/regional collection sites, and transport the densified product to central warehousing facilities.

A granulator truck is the most expensive piece of equipment owned by the Pennsylvania pesticide container recycling program (valued at $90,000 in a program with total equipment assets of $227,000) (Personal communications with Don Gilbert, coordinator of the PA pesticide container recycling program, Oct 2003).

[106] *E.g.,* the Trex Company plans to open a third plant in 2005 that will nearly double its productive capacity.

[107] For example, in 1996 Advanced Environmental Recycling Technologies (AERT) employed 125 people and had sales of nearly $5 million per year, but had not been profitable since its founding in 1989 (Powell 1996).

Conclusions and Recommendations

Quantity Thresholds

An estimated 200,000 lb of LDPE film is used per year on dairy farms within the tri-county study area. As shown on Map 1 (page 11), this area is within an approximate 30-mile radius of Oneonta, New York. The quantity of dairy films used in the area is likely to increase if farmers continue on the trajectory of adopting plastic-wrap systems for preparation and storage of animal feed.

If the estimated 50-55 percent of farms in the area now using a plastic-wrap system increases to 75 percent (approximately the proportion of users in neighboring Vermont), then dairy film usage in the area will increase to 280,000 lb per year.

Current usage represents five full truckloads of baled dairy plastics generated from the area per year. At least one additional truckload could be generated from films used in local nurseries as well as non-agricultural industrial facilities and retail outlets.

LDPE film re-processors are typically interested in dealing in full truckload units—approximately 40,000 lb—in order to maximize transportation efficiency. One truckload per year, containing at least 25,000 lb, is likely to be the minimum flow through of interest to re-processors.

A 20 percent capture rate of dairy films used in the area would be sufficient to fill a full truckload. A capture rate of 12 percent would generate the 25,000 lb threshold likely to interest a re-processor in negotiating for pick-up.

We conclude that there is sufficient use of plastic film in the study area for a viable agricultural film recycling program.

However, there is not sufficient usage in the area to expect that a local re-processing or manufacturing facility would be viable, if it were dependent primarily on locally generated materials.

Technical Viability

The recycling of agricultural films is technically viable, despite various impediments arising both from product characteristics (*e.g.,* color, size and mix of non-recyclable components into products or as a component of product packaging) and from product use and handling (*e.g.,* contamination with mud, moisture, organic matter, etc.). These constraints can be reduced through development and adoption of Best Management Practices (BMPs) for handling of recyclables, by identifying markets for which the impediments are irrelevant, and perhaps by working with agricultural film manufacturers to "tweak" product characteristics so they are more compatible with recycling.

Economic Viability

The economic balance sheet for recycling of dairy plastics is very tight. Recycling program revenues from sale of a truckload of used dairy plastics—including both the tipping fees paid by farmers as well as income from sale of the film to re-processors—is estimated to be about $1800 (see the *Dairy Film Recycling Economic Worksheet*, Table 10, page 58).

Assuming $800 in expenses for baling the 40 bales in a truckload, $1000 per truckload of sales remains in the kitty to cover all other costs of the recycling program (*i.e.*, all administrative and handling expenses).

Thus a viable recycling program would likely require some level of public support, especially at the early stages, in order to:

- provide sufficient incentive for farmer participation
- develop and disseminate educational messaging about proper materials preparation, and to advertise the program
- invest in the equipment and facilities needed for efficient operation.

Social investment in the recycling program is justified by the social and environmental benefits accrued, including reduced air pollution and potential food-chain contamination, improved visual aesthetics, and resource conservation. Social investment could take the forms of *(i)* incorporating agricultural plastics recycling into existing, county-subsidized recycling programs; and/or *(ii)* facilitating access to capital equipment, such as a baler appropriate for use with agricultural plastics and/or dry storage facilities to maintain quality of the collected materials.

Initial public support could spawn viable private sector economic activity. Examples include a mobile agricultural film baling enterprise serving the broader Central New York region, or a multi-use collection site at which recyclable agricultural films could be processed.

Recommended Steps & Approach to Developing a Film Recycling Program

We recommend starting with a small, simple recycling program that has the target objective of filling one truckload of recyclable quality film within a one-year time frame.

To do so, we suggest:

- Work with **leaders in the farm community** who have sufficient interest and motivation to drop-off their films at a collection facility once or several times a year (or to hire private haulers to transport the films to the recycling facility). By working with this leadership community, the factors that motivate and constrain farmer participation in this locale will become better understood so that the film recycling program can evolve to address these issues and broaden participation. Alternatively, the community might seek funding to subsidize a pick-up route in order to increase participation and capture rate.
- Initiate an **educational program** that provides guidance on Best Management Practices (BMPs) for handling and storage of films on-farm and during the collection period. BMPs will increase the value of films for recycling. Educational outreach could also address the environmental/health risks of on-farm disposal of plastics and the benefits of film recycling.[108]
- Arrange for rental, purchase or loan of an **efficient baler**, suitable for use in baling agricultural plastic films.
- Arrange for access to a film **collection site with a covered structure** of sufficient size to permit unloading of plastic in wet weather, sorting of materials by quality and type, storage of loose film prior to baling, the baling process, and storage of bales in preparation for transport.
- Identify potential **re-processing markets** and send them samples of the agricultural films that are representative of the materials that will be collected for recycling.
- Negotiate terms with a single initial market from among those that have reviewed and accepted the submitted samples. Work towards meeting **product quality and quantity specifications** for that market.
- Be prepared to **handle films of unsuitable quality for recycling**. *I.e.,* have the skills for sorting recyclable quality from waste films, the space for sorting, a means for transporting and paying tipping fees on waste films, and a plan for improving quality of collected films. We anticipate that this will be a bigger problem in early years of the recycling program when old, degraded, contaminated films that have been stored on the farm may be submitted for recycling.
- Set the **collection time period** and **advertise** it widely. Select dates and duration that optimize for labor efficiency of staff who will be processing, handling and baling incoming films. Select a period of time when farmers are removing used films and/or have access to stored films, as well as fewer-than-usual competing activities.
- **Train staff** in sorting, handling and baling procedures.

[108] BMP recommendations should be evaluated in terms of their *(i)* utility in improving recycled film quality and *(ii)* rate of adoption by the agricultural and recycling communities.

Appendices

Appendix I: Agricultural Plastics Feasibility Study Focus Group

Advisors and Invitees to Meeting Held August 13, 2004 at the
Cornell Cooperative Extension Otsego County
123 Lake Street, Cooperstown, NY 13326

Mary Ashwood
Chair, OC Burn Barrel Committee
282 Gage School House Road
Cherry Valley, NY 13320
607-264-3124
<m.ashwood@juno.com>

Dave Balbian
Area Dairy Specialist
CCE Montgomery-Fulton
55 East main St.
Johnstown, NY 12095
518-762-3909/8155 (fax)
<drb23@cornell.edu>

Terry Bliss
Otsego County Solid Waste Coordinator
Solid Waste Department
197 Main Street
Cooperstown, NY 13326
607-547-4303/7549 (fax)
<blisst@otsegocounty.com>

Charles Buck
Dairy Farmer/Schoharie MOSA Board
498 North Rd., Jefferson, NY 12093
607-652-2926

Anthony Capraro
Soil Conservationist
Natural Resource Conservation Service
967 Co Hwy 33, Cooperstown, NY 13326
607-547-8337/8814 (fax)
<anthony.capraro@ny.usda.gov>

Gilbert L. Chichester
Executive Director, MOSA
MOSA Administrative Complex
PO Box 160, Route 7
Howes Cave, NY 12092
518-296-8884 ext. 52
<gil@mosainfo.org>

Martha Clarvoe
Otsego County Burn Barrel Committee
Otsego County Conservation Association
PO Box 931
Cooperstown, NY 13326
607-547-4020/4020 (fax)
<mclarvoe@stny.rr.com>

Don Coager
Don's Dairy Supply
290 Roses Brook Rd.
South Kortwright, NY 12342
607-538-9464/1514 (fax)

David Cox
Extension Educator/Ag Development Specialist
CCE Otsego County
123 Lake Street
Cooperstown, NY 13326
607-547-2536 (x226)/5108 (fax)
<dgc23@cornell.edu>

Kevin Ganoe
Area Field Crop Specialist
CCE Herkimer County
5657 State Hwy 5
Herkimer, NY 13350
315-866-7920/0870 (fax)
<khg2@cornell.edu>

Bill Gibson
County Executive Director
FSA – Otsego/Herkimer Counties
967 Co Hwy 33, Cooperstown, NY 13326
607-547-8131 (x2)
<william.gibson@ny.usda.gov>

Kevin Hodne
Executive Director, CADE
250 Main Street, Oneonta, NY 13820
607-431-6034/4028 (fax)
<khodne@cadefarms.org>

Appendix I (continued)

Sarah L. Johnston
Executive Director
NOFA-NY
PO Box 880, Cobleskill, NY 12043
518-922-7937/7646 (fax)
<sarahjohnston@nofany.org>

Lois Levitan, PhD.
Program Leader
Environmental Risk Analysis Program (ERAP)
Department of Communication
213 Rice Hall, Cornell University
Ithaca, New York 14853-5601
607-255-4765/0238 (fax)
<lcl3@cornell.edu>

David Lupinski
Director of Recycling
Oneida-Herkimer Solid Waste Authority
1600 Genesee Street, Utica, NY 13502
315-733-1224
<ohswa@ohswa.org>

Meredith J. MacNeil
Professor of Agriculture (ret.), SUNY Cobleskill
Schoharie MOSA Board
169 Lawyersville Road
Cobleskill, NY 12043-6301
518-234-7535
<mjmcn@midtel.net>

Jason Mulford
OCSWCD District Field Manager
967 Co Hwy 33, Cooperstown, NY 13326
607-547-8131 (x4)
<jason-mulford@ny.nacdnet.org>

Jim Mumford
Dairy Farmer
2257 Route 205, Mt Vision, NY 13810
607-432-2357

Jim Powers
Dairy Farmer/Otsego County Representative
719 Co Hwy 18, South New Berlin, NY 13843
607-764-8358
<impholet@norwich.net>

Steven Sinniger
President
Otsego County Farm Bureau
665 Co Hwy 5
Otsego, NY 13825
607-988-7071
<stevensin@catskill.net>

Suzanne Stack
Research Assistant
NYCAMH
One Atwell Road
Cooperstown, NY 13326
607-547-6023
<sstack@nycamh.com>

Maureen Weir
Industrial Hygienist
NYCAMH
One Atwell Road
Cooperstown, NY 13326
607-547-6023
<mweir@bassett-healthworks.com>

Ed Wesnofske
OCCA Board/Otsego MOSA Board
One Suncrest Terrace
Oneonta, NY
607-432-6770
<wesnofer@oneonta.edu>

Jeff Williams
Senior Associate Director of Public Policy
Legislative Director
New York Farm Bureau
159 Wolf Road
P.O. Box 5330
Albany, New York 12205
518- 431-5618
<nyjwilliams@fb.org>

Teresa Winchester
Executive Director
Otsego County Conservation Association
PO Box 931, Cooperstown, NY 13326
607-547-4488/4020 (fax)
<occa@wpe.com>

(Revised 12/04

Appendix II: Manufacturers of Agricultural Films Used in the Oneonta, NY, Area[109]

MANUFACTURER	PRODUCTS	NE DEALERS	COMMENTS
AEP Industries 125 Phillips Ave., S. Hackensack, NJ 07606 800-999-2374	Baler and Netting		Many types of films, including shrink wrap and construction films.
Ambraco (American Brazilian Company) Matt 800-225-8946	Bale Net Wraps Plastic & Sisal Twines Stretch Wrap (bales) Jumbo Jackets (hay bales)	Tractor Supply, Oneonta	
AT Plastics Alberta, Canada			
Klerk's Plastic Products Manufacturing, Inc. 546 L&C Distribution Park Richburg, SC 29729 803-789-4000 Toll Free Order Line *(Voice)* 888-255-3757; 803-789-4001 Jocelyn Griffiths, Sale Rep. (x 4007) <http://www.klerksusa.com/frames.htm>	• Premium & Standard Bunker Covers: 24 ft-52.5 ft wide x 100- 200 ft; 5 mil tri-layering in White/Black; Dark Green • Plastic Tubes: White • Bale Tubes: White/Black; Black • Stretch films: 1 mil; 20" x 5900 ft; 30" x 4900 ft; Black, Lt. Green, White • No Bale Wrap	• Adams Supplies, Dennis Foltz 717-393-9282 717-393-8098 (f) • Bradley Paddington Rte 34B, Scipio Center, NY 13147 315-364-8880 (o) 315-729-5924 (c)	JG knew of Dennis Foltz as sole distributor in Northeast; learned from Dennis Foltz that Bradley Paddington also distributes Klerk's; Paddington brought on Klerk's because of a difficult year getting supplies from anyone; sells very little of Klerk's; Klerk's has recycling program in Netherlands.
Plasti-Tech 478 Notre Dame, St-Remi, Quebec CA J0L2L0 450-454-3961 (o); 450-454-6638 (f) Toll Free: 1-800-667-6279 Toll Free Fax: 1-877-667-1584 800-667-6279 (Technical Info) 800-667-6279 (To Order) <www.plastitech.com/anglais/contact-an.html>	Complete line of agricultural and horticultural plastics; see website.	St-Remi, Quebec Waterford, Ontario Regina, Saskatchewan Vineland, New Jersey Immokolee, Florida Palmetto, Florida;	Ag film specialists: Eric Menard, Philippe Bergeron

[109] Information in Appendix II was collected primarily by personal communications with regional dealers/distributors, and from company websites.

Appendix II (continued)

MANUFACTURER	PRODUCTS	NE DEALERS	COMMENTS
Roto Press 877 First Ave. NW, Sioux Center, IA 51250 866-722-1488; 712-722-3356; 712-722-1487 f <sacinc@mtcnet.net>	Bagger Machinery (not bags)	Sioux Automation Center, Inc; NE rep = <RonS@siouxautoma tion.com>	
Sacomatic (Canada)			No website.
Suntex Plastics Corporation 125 East Merritt Island Cswy. Suite 209, PMB #314 Merritt Island, FL 32952 321-455-6671 321-459-1186 (f) Steven Paterson <stevenpatterson6@cs.com>			
Tyco Plastics 1401 West 94th St, Minneapolis, MN 55431 800-873-3941 (Laura Ott) - Bob Broten, Sales Representative 130 E. Center Ave., Lake Bluff, IL 60044 847-604-8847 <bob.broten@tycoplastics.com> - Jay Mulhearn; 800-551-5036 (x 150) (Monroe, LA)	Bale WRAP Greenhouse Films Poly Pipe	Brandow's IBA, Inc. Co Hwy 9, Fergusonville, NY 12155	DC/Bob Broten; confirmed current estimates for Bale Wrap as "reasonable" for study area; interested in recycling report.
Up North Plastic Jim Bertrand Director of Sales P.O. Box 159 Cottage Grove, Minnesota 55016 800-544-7659 <www.upnplastics.com/public_html/ products.html> Up-North is "sister company" to Poly-America, Texas. Bill Neal: 972-337-7260 (o).	Silage Bags Bunker Covers Shrink Wrap	Multiple dealers	MC/Jim Bertrand: Use of plastic doubling every year; big players are Up North Plastic, Klerk's, AT Plastic. Notes: Manufactures agricultural plastic film products for Ag-Bag International (2320 SE Ag-Bag Lane, OR, 97146, 800-334-7432) Ag Bag sales = 50% in NYS; sales dropping because price not competitive; not manufacturer, but must compete with others

Appendix III: Agricultural Plastic Film Suppliers in the Oneonta, New York, Area

First Column: "*" denotes larger suppliers. "√ " denotes possible interest in collaborating in recycling program. Total weights are approximate.

	Agricultural Film Dealers	Silage Bags	Bale Wrap	Bunker Covers	Net Covers	Tuber Bags	Total Weight	Comments	
*	**Adams Supplies** Lancaster County, PA Dennis Foltz 717-393-9282 (Rollin Cross Farm in Afton, NY is distribution point for area supplies)	- 135 units; 8 ft x 150 ft (180 lb) - 135 units; 9 ft x 200 ft (280 lb) b&w					62,100 lb	Rule of thumb: 1lb per ft.	
*	**Bradley Paddington** Rte 34B, Scipio Center, NY 13147 315-364-8880 (o) 315-729-5924 (c)	- 10 units; 10 ft x 300 ft- (500 lb) 135 units; - 20 units 9 ft x 200 ft (280 lb) b&w					9,200 lb	Incomplete estimates; large Ag Bag™ dealer; carries other manufacturers; would like to see program in place.	
*	**Brandow's IBA Inc.** Co Hwy 9 Schenevus 607-278-5712 607-278-5674 (Roger Brandow) Dave Brandow	5 tons; LDPE; b&w	20 tons; white	5 tons; b&w and black			60,000 lb	Largest dealer in area; supplies to farms and other farm dealers.	

Appendix III continued

	Agricultural Film Dealers	Silage Bags	Bale Wrap	Bunker Covers	Net Covers	Tuber Bags	Total Weight	Comments	
*/√	**Catskill Tractor** Center Street Franklin, NY 13755 607-829-2600 Roger	- 50 units; 9 ft x 200 ft (280 lb) LDPE b&w	- 28 rolls 30"x6000 ft (70lb) white				(15,960 lb) 50% to study area = 7,980 lb	Will consider location as potential drop-off site.	
	Clinton Tractor & Implement Co. Route 128 Meadows St. Clinton, NY 13323 315-853-6151 (o) 315-853-6065 (f) <www.clintontractor.net>						1,000 lb	Very little sold in study area. John	
*/√	**Don's Dairy** 349 Roses Brook Rd. South Kortright NY 13842 607-538-9464 607-538-1514 fax <coagerd@dmcom.net> Don Coager; Jeff	- 25 units; 8 ft x 150 ft- (180 lb) - 25 units; 9 ft x 200 ft (280 lb) LDPE b&w		48 boxes (70lb per box)			14,860 lb	Also deliver to Syracuse area, VT, CT, PA;	
*	**Eckland's Farm Supply** Route 10 Stamford, NY 12167 607-652-6321 William Eckland		- 240 rolls 30"x 6000 ft (70lb) - 80 rolls 20"x 6000 ft (60lb)				(21,600 lb) 50% to study area = 10,800 lb	Not confident about farmers willingness to participate in recycling; likely to burn regardless of reasonable incentives from program.	

Appendix III continued

	Agricultural Film Dealers	Silage Bags	Bale Wrap	Bunker Covers	Net Covers	Tuber Bags	Total Weight	Comments	
*	**Empire Tractor** (Lucas' Farm Equip) Jim Lucas-315-655-8146 - 5563 E. Main St. Rd. Batavia, NY 14020 - 1437 Route 318 Waterloo, NY 13165 - PO Box 302, 2893 Rte. 20 E Cazenovia, NY 13035	- 12 units; 8 ft x 150 ft (180 lb) - 12 units; 9 ft x 200 ft (280 lb) LDPE b&w	- 155 rolls 30"x 6000 ft white; (70 lb) (40 boxes to study area)		very little	100 boxes; 4 ft x 150 ft (60 lb); white; (50% to study area)	11,300 lb	Sold more this year than last year. Additional NY locations: PO Box 150, Rte. 371 Atlanta, NY 14808 3865 US Route 11 S Cortland, NY 13045	
	Leray Sealed Storage Watertown, NY Jan Martusewicz 315-629-4143						1,000 lb	Very little sold in study area.	
*/√	**Sharon Springs Garage** US Rt 20 Sharon Springs, NY 13459 518-284-2346 Bob Spohn **Sharon Springs Garage** 6799 St Hwy 23 Oneonta, NY 13820 607-432-8411		Sharon: - 84 rolls 30"x 6000 ft (70lb each) white - 84 rolls 20"x 6000 ft (60lb ea); Oneonta: - 42 rolls 30"x 6000 ft (70lb each) white			- 5 boxes 4 ft x 150 ft (60 lb each); white	(11,200 lb) 25% to study area = 2,800 lb	Will consider Sharon Springs location as potential drop-off site; believes farmers will continue to burn regardless of reasonable incentives from recycling program.	

Appendix III continued

	AGRICULTURAL FILM DEALERS	SILAGE BAGS	BALE WRAP	BUNKER COVERS	NET COVERS	TUBER BAGS	TOTAL WEIGHT	COMMENTS
*/√	**SNB Valley Supply** Rt 8 N, South New Berlin Bruce Beckert 607-859-2252		- 50 rolls 30"x 6000 ft (70lb ea) - 20 rolls 20"x 6000 ft (60lb ea) white		- 5 rolls; 51" x 6000 ft (35 lb each)		(4,900 lb) (Amount included under Brandow's IBA Inc.)	Bags not big item; will consider SNB as drop-off site; believes farmers would participate in program with reasonable convenience and cost.
*/√	**Springers, Inc.** 56 Main Street Richfield Springs, NY 315-8585 Doug France		- 150 rolls 30"x 6000 ft (70lb ea) - 50 rolls 20"x6000 ft (60lb each) white				(14,800 lb) 50% to study area = 7,400 lb	Add 1,300 lb for twine; willing to consider Richfield Springs as drop-off site; thinks farmers would cooperate if recycling program not too expensive or inconvenient.
	Tractor Supply, Inc. 6396 St Hwy 23 Oneonta, NY 13820 Joe [?] 431-9791 Steve Dodds 431-9150 Multiple locations in NYS & study area		- 24 boxes; 20"x 6000 ft (38lb per box); white		- 10 rolls; 51" x 10,000 ft (50 lb each)		1,500 lb	Next to the wrap, twine is biggest seller. Biodegradable twine is sisal from Israel. Also testing film line to make as biodegradable product.
	APPROXIMATE TOTAL						**206,400 LB =103.2 TON**	

Appendix IV: Non-Agricultural Users of Plastic Films in the Oneonta, New York, Area[110]

*/√[111]	COMPANY & CONTACT PERSON	FILM TYPE	CURRENT DISPOSAL	COMMENTS
√	**Arctic Cat (Snowmobiles)** Oneonta Motor Sports – ATV 6526 State Route 23, Oneonta Attention: Peter Neuer	White/black	Trash. Bert's Refuse. Fill dumpster every few months with oil and antifreeze containers, plastic.	
*/√	**BJ's Wholesale Club, Inc.** Route 23 & James Lettis Hwy, Oneonta Attention: John Eagle – operations manager. 431-1111	Clear. Use ~ 15,000 sq ft per week, 750,000 sq ft per year = approx. 25,000 lb if 7 mil	Vet's picks up from roll-off, which receives trash from inside trash compactor	Truckload of shrink-wrapped pallets is delivered daily. If goods are removed, pallet is re-wrapped. In addition to shrink-wrap on delivered goods, use 4-5 rolls of 18 ft x 2000 ft shrink wrap per week = 15,000 sq ft. Interested in recycling but need pick-up. Company has trash compactor, no baler.
*/√	**Dave Rees Marine. Boat Storage** 2385 Route 28, Oneonta <http://www.davereesmarine.com> Spoke with Todd Hovick (431-9978)	Shrink wrap in rolls (14x198 ft; 17x175 ft; 20 x 149 ft) ~ 20 rolls per year, ~57,000 sq ft per year = approx. 2000 lb	Trash. Fill 4 cubic yard dumpster per week May, June, July. Disposal cost $176 per week.	Store 150-200 boats per year. Remove all wrap in Spring. Disposal charge is at average level for household waste. Supplied by Morgan Recreational, Framingham LI, NY, a company that has a buy back program for the shrink wrap supplied to their customers.[112]

[110] Information was collected primarily by means of open-ended telephone interviews, September 2004, based on an interview guide developed for this purpose (see Appendix VI). Calculated quantities are based on raw data estimates provided by respondents.

[111] First column: "*" denotes larger users. "√" denotes potential interest in collaborating in recycling program.

[112] **Morgan Recreational "Shrink Wrap Buy Back" program:** Morgan Recreational supplies Dave Rees Marine and other dealers in the marine accessory market with plastic film for wrapping boats, etc. The film is purchased from Poly-America, their sister company Up North Plastics, and other suppliers. Poly-America and Morgan Recreational have a shrink wrap buy back program. The purchase of collection bags is the only cost to the dealerships. Shrink wrap from several mid-size boats can fit into one collection bag (cost = $5). Delivery and pick-up of collection bags on an as-needed basis is arranged by calling Morgan Recreational. Additional information: <http://www.morganrec.com/>. Contact information: Morgan Recreational, Denny Drive, Farmington NY 14425; attention Mike Hartman 1-800-836-5300 (personal communication with Daryl, Morgan Recreational, Dec 04; and with Bill Neal, Poly-America, Sept 04).

Appendix IV continued

*/√	COMPANY & CONTACT PERSON	FILM TYPE	CURRENT DISPOSAL	COMMENTS
√	**Delaware Sports Center** 30104 State Highway 10, Walton 13856 Attention: Earl Sines, owner (865-8888	Plastic tarp and clear	Trash. Packed in barrels (8 per month) that are taken to Delaware County landfill.	
	Hannaford [Supermarket] Route 28, Oneonta 432-0012		Recycle plastic bags, shrink wrap, plastic jugs	Call 518-766-7386 for more information about current recycling program
?	**Home Depot** 659 State highway 28, Oneonta Attention: Rick Schoettler, Store Manager. Spoke with Chris Miller 432-1089	Unable to say		Have cardboard baler. Respondent unable to say re: current disposal or interest in recycling. Pursue with store manager.
√	**J & J Yamaha,** Sherburne Attention: Tom Shuster, Manager 674-4323	Clear and white	Dumpster. Picked up by Holden's Refuse	Interested in recycling if can handle sporadic pick-ups. ATVs and snowmobile wrapping includes steel frame (goes to scrap dealer).
√	**Klinger's Kawasaki + SkiDoo** 20 West Street, Walton 13856 Attention: Butch Klinger 865-6326	No shrink wrap. Plastic bags and peanuts		Ship the peanuts back out. Interested in plastic bag recycling.
√	**Kmart** 171 Delaware Avenue, Sidney 13838 Attention: Store Manager 607-563-7004	Clear	Landfill. Small quantities shrink wrap	
	Office Max Route 23, Oneonta Attention: Ed, manager. 432-1091			Use very little shrink wrap, only when small packages break open. Rarely get pallets that are shrink-wrapped.
√	**Performance Recreation** Route 20, East Springfield Attention: Dan Beebe 264-3155)	White/black.	Trash ~ 100 wood crate/ plastic containers per year. Est. disposes of three 30-yard roll away containers per year	Sell ATVs, snowmobiles. Re-use packing peanuts. Machines come crated in wood covered with plastic tarp (sounds like Endurapak). Crate dimensions: 1x4.5x4.5.

Appendix IV continued

*/√	COMPANY & CONTACT PERSON	FILM TYPE	CURRENT DISPOSAL	COMMENTS
√	**Price Chopper**[113] 1000 Main Street, Oneonta Attention: Ed Zawisza, 432-8905	Shrink wrap. 2,210-2,860 lb per year	Trash hauler.	No longer recycle plastic grocery bags. Potentially interested in recycling if container and pick-up provided. Receive 75-100 pallets per week; wrap ~ 10 pallets per week in-house. Total 85-110 pallets per week, 52 weeks per year @ 0.5 lb wrap per pallet = lb per year.
√?	**Sam Smith's Boat Yard** Attention: Nancy Haven, 547-2543, supervisor	White shrink wrap	Hauler picks up.	Boats are shrink wrapped for winter. Plastic removed in the spring, sometimes re-used. Special order boats only.
√	**Valley Recreational** Route 28, Milford Attention: Robert Cooper, sales manager	White shrink wrap + other (see comments)	Picked up by Vet's Sanitation	Quantities vary. Boats shrink-wrapped. ATVs: metal crates wrapped in white plastic mesh. Snowmobiles; wooden crates wrapped in multi-colored plastic (8.5ft x 4. ft x 4.5 ft).
?	**Wal-Mart** Attention: Rick Case, Store Manager 431-9557	Clear	Picked up by Vet's Sanitation	Need information/proposal in writing to comment re: potential for participating in recycling
?	**Yamaha—Bennett Motors** 6453 State Highway 28, Fly Creek 547-9332	Small quantities bubble & shrink wrap		Contact owner Raymond Bennett to discuss further

113 The sales manager at Generated Materials Recovery (GMR), a broker that picks up truckloads of baled films and sells them primarily to overseas re-processors, told us that GMR used to pick up post-consumer stretch wrap and grocery bags returned to the Oneonta Wal-Mart and Price Chopper.

Appendix V: Greenhouse/Nursery Users of Plastic Films in the Oneonta, New York, Area[114]

*/√	COMPANY & CONTACT PERSON	FILM TYPE	CURRENT DISPOSAL	COMMENTS
	Carefree Gardens Beaver Meadow Rd. Cooperstown 547-9744	Greenhouse sheets	Landfill what is not reused	Periodically replace plastic of 4-6 greenhouses.
√	**Davis Tree Farm** Walter Davis Rd., Edmeston 965-8223 Kelly Bennett, owner	Greenhouse sheets @1 mil for 37 greenhouses	Farmers take for covering hay.	Replace annually because they make ventilation holes in the plastic. Interested in pick-up (do not have vehicle) and disposal all-at-once rather than having to wait for people to come by.
*/√	**JR Frazier's & Sons** 190 Southside Drive, Oneonta [Oneonta mailing address, in Delaware Co] Attention: Bobbie (432-5199)	~ 100,000 sq ft of clear 6 mil LDPE[115]	Remove and roll 30-40 sheets of 100 x 30 ft plastic. Rolls picked up by Burt's Refuse, Delaware Co.	Recover greenhouse arches in fall. Would need recycling pick-up twice a year. Purchased from Griffin Suppliers, Albany.
√?	**Let it Grow** Route 33 , Middlefield Center 264-3247	Very heavy sheets		Have used same very heavy sheets purchased 7 years ago. If has to throw away would be interested in recycling
	Mohican Flowers 207 Main St., Cooperstown 547-8822	Very heavy sheets		Purchase very heavy sheets of film and reuse it repeatedly
	Mt. Vision Garden Center County Highway 46, Mt. Vision 432-1260			Large nursery — no answer
	Otsdawa Gardens Wells Bridge, Otego Rd. Otego, NY 988-2291 Carolyn Vengen, owner	6 mil poly sheets		Replace in August-September. Usually donate film to people in community who need it for projects. After 4 years or so they take it off even thought it is warrantee is for 6 yrs. Usually people are waiting for it.

[114] Information was collected primarily by means of open-ended telephone interviews, September 2004, based on an interview guide developed for this purpose (see Appendix VI). Calculated quantities are based on raw data estimates provided by respondents.

[115] *I.e.*, Frazier's nursery/greenhouse uses more than **3,000 lb per year** of greenhouse film, assuming 30 lb per 1,000 sq ft, sheet dimensions of 30 ft x 100 ft x 6 mil, and removal of about 35 sheets per year.

Appendix VI:
Interview Guide: Non-Agricultural and Greenhouse Users of Film

Background: We are exploring feasibility of setting up a program to recycle agricultural plastic films. To increase the volume of recycled plastic film from the area, we are asking other (*i.e.,* non-agricultural) users of plastic film if they (a) might be interested in collaborating/participating or (b) already have a recycling program in motion.

1. Do you recycle used plastic films?

A. If YES, continue with question 2

B. If NO, ask: Do you use plastic films in this business?

i. If YES, ask how they now dispose of materials and if they might be interested in collaborating on a recycling program. Collect details re: types of plastics and uses (adapt and ask questions 3, 4). Collect contact information. End interview.

ii. If NO, end interview.

2. Are recycling arrangements made at this office/store or by a central office/distribution center?

A. If made at this location, continue with question 3

B. If arrangements are made elsewhere, after asking respondent remaining questions (*i.e.,* continue with question 3), ask for contact information for decision-maker, central collection location, etc.

3. Which types and uses of plastic (*e.g.,* the stretch wrap around the pallet-loads of delivered goods? grocery bags returned by customers? boat wrap? other?) **In what approximate quantities?**

- Try to differentiate between programs involving consumer returns of plastics from programs involving only in-house distribution and re-use (*i.e.,* differentiate between post-consumer and post-industrial collections)
- Try to differentiate between stretch wraps (LLDPE, which are also used in bale wrapping) and other films (LDPE)

4. How are materials collected:

- Where are the collection bins/trucks?
- What size are the containers or trucks? (*i.e.,* Do they load directly into transport vehicles?)
- Collected over time as accumulated or at specific times of the year?
- When/how/by whom moved from this location to a central collection point or transported to re-processor? *I.e.,* on contract with a hauler? a recycling company? Name/contact information

5. Baling

A. Are recyclables baled on site?

i. If not, where are they baled?

B. Whose baler? Who does the baling?

C. Specs on the baler?

D. Possibility of renting baler to use in baling agricultural plastics

Appendix VII: Haulers of Solid Waste: Otsego County

Rubbish and refuse collection in Otsego County is currently privatized for residents and businesses within the county.
Rates and pick-up schedules will vary according to company.

PRIVATE REFUSE COLLECTORS	ADDRESS	TYPE OF SERVICE	AREA	PHONE
A&P Disposal	Martin Brook Rd, Unadilla, 13849	Residential/Commercial	Unadilla Area	(607) 369-9415
(Daryl) Barton Disposal	120 Deminco Rd, Burlington Flats, 13315	Residential	NW Otsego Co.	(607) 965-6202
Budget Refuse	315 Axtell Rd, Maryland, 12116	Res/Comm/Roll-offs/Compact.	SE Otsego Co.	(607) 638-9360
Burt's Refuse	PO Box 702, Oneonta, 13820	Res/Comm/Roll-offs	Oneonta Area	(607) 278-6610
(Wendell) Close Trucking	20 Hudson Street, Oneonta 13820	Clean-up, misc.	Oneonta Area	(607) 432-2136
(Bruce) Eager Disposal	PO Box 635, East Worcester, 12064	Residential/Commercial	SE Otsego Co.	(607) 397-8412
(Doc) Evans Services	1304 US Route 20, West Winfield, 13491	Clean-up	County-wide	(315) 822-6816
(George) Leech Disposal	PO Box 255, Otego, 13825	Residential	Butternuts, Laurens, Otego	(607) 988-6305
Logan's Trucking	23 Myrtle Ave, Oneonta, 13820	Residential/Commercial	Oneonta Area	(607) 432-5736
(Ronald) Miller Disposal	PO Box 121, Otego, 13825	Residential/Commercial	Gilbertsville, Otego, Unadilla	(607) 988-7100
Robert's Refuse & Recycling	35 Ford Ave, Oneonta, 13820	Res/Comm/Roll-offs	County-wide	(607) 432-6424
(Russell) Smith Disposal	339 Co Hwy 26, Cooperstown, 13326	Res/Comm/Roll-offs	Cooperstown, NE	(607) 547-9618
Spohn's Disposal	PO Box 297, Mohawk, 13407	Res/Comm/Roll-offs/Compact.	County-wide	(800) 696-3076
Trash Time Waste Removal	PO Box 597, Mt. Vision, 13810	Residential	Central Otsego Co.	(607) 433-2086
Value Waste Services	PO Box 648, Richfield Springs, 13439	Residential	Exeter, Plainfield, Northern	(315) 822-3427
Vet's Disposal	49 Lower River St, Oneonta, 13820	Res/Comm/Roll-offs/Compact.	County-wide	(607) 432-5351
(Randy) Weaver Disposal	118 Korniat Rd, Ft. Plain, 13339	Residential	NE Otsego Co.	(518) 673-2868
(Mike) Wheelock Disposal	1095 U.S. Hwy 20, West Winfield, 13491	Res/Comm/Roll-offs	Northern Otsego Co.	(315) 822-3427

Montgomery-Otsego-Schoharie Solid Waste Management Authority (MOSA)
PO Box 160, Howes Cave, 12092 (518) 296-888

Source: Adapted from Listing Provided by Terry Bliss, September 24, 2004

Current as of 04/01/03

Appendix VIII:
Conversion Factors & Quantitative Relationships re: Plastic Film Use

RELATIONSHIP	STATISTIC	SOURCE
Plastic film use per large dairy farm (a distributor's estimate)	7,000-8,000 lb per big farm	Jan Martusewicz, Leray Sealed Storage, June 2003
Plastic film used per year on "average" Vermont dairy farm, 1995	1.2 million lb total.1859 farms = 650 lb per farm	Calculated from Negra and Rogers 1998
Weight of film used to wrap 1 round bale	1 lb	Jan Martusewicz, June 2003
Thickness of bale shrink wrap	1 mil, recommended wrapping 5 times	Smith 2003
Weight and thickness of greenhouse film	6 mil, 30 lb per sq ft	
Forage consumed per adult cow, with replacement, per year	7 lb	CCE dairy team specialists
Weight of stretch film used to wrap 1 industrial pallet	0.5 lb	The Trex Company, on-line factsheet
Cost of contract baling (*i.e.,* packing hay into silage bags)	$5-6 per ton	Bradley Paddington, Cayuga Co, September 2004
Thickness of silage bags	Typically 5 mil	Klerk's: <www.klerksusa.com/silage_bags.htm>
Number of 10 ft x 300 ft silage bags used, based on regional milk production. See footnote 31, page 20, for details.	[lb milk production] ÷ 390,000 lb = number of silage bags	*Ibid.,* click on Ag-All
Weight of silage bag per linear foot, 8-9 ft diameter	1 lb per linear foot	Personal communication with dairy film dealer
Average density of mixed waste	150 lb per cu yard	
Average density of loose plastic film	45 lb per cu yard	
Costs of forage per cow using silage bag	$267, 55-cow farm $200, 219-cow farm	See *Introduction*, footnote 2
Costs of forage per cow using concrete bunker silo or tower silo	$314, 55-cow farm $245, 219-cow farm	See *Introduction*, footnote 2
Baling twine used per ton hay	1.5 lb	Jongsma, Agri-Plas Inc.
Mulch film: area covered per bale	4 x 4 ft bale contains mulch film from 3 acres of vegetables mulched	Personal communication with Anu Rangarajan, June 24, 2002.
Mulch film: acreage of film per dumpster	25 acres mulch film per average size construction dumpster	*ibid.*

References

IN-TEXT CITATION	BIBLIOGRAPHIC INFORMATION
ACRC 1999	Agricultural Container Research Council. 1999. *Recycling Ag Containers: do your part*. 8-panel brochure. http://environmentalrisk.cornell.edu/AgPlastics/References/ACRC99.pdf
American Plastics Council 1994	American Plastics Council. 1994. *Stretch Wrap Recycling: A How-To Guide*. Washington DC. 22 pages.
American Plastics Council-undated	American Plastics Council. website <http://www.americanplasticscouncil.org/>.
American Ref-fuel	American Ref-fuel. undated. *LI Solid Waste: Management & Disposal*. <http://www.ref-fuel.com>
Amidon 1994	Amidon Recycling. 1994. *Use and Disposal of Plastics in Agriculture*. Prepared for the American Plastics Council. 95 pages. <http://environmentalrisk.cornell.edu/AgPlastics/ References/Amidon94.pdf>
Baling Twine Study 2000	Randall Conrad & Assoc Ltd. 2000. *The Market Feasibility of Recycling/Recovering Post Consumer Polypropylene Baler Twine in Alberta*. Prepared for the Poly-Twine Market Feasibility Steering Committee, Alberta, Canada. 47 pages. <http://www.cpia.ca/files/files/files_baler_twine_study.pdf>
Block 2004	Block, Debbie Galante. 2004. Recycled Resin Prices—September 2004. *Plastics Technology*. <http://www.plasticstechnology.com/articles/200409recprice.html>
Canadian Plastics Industry Association	Canadian Plastics Industry Association. undated (accessed June 2004). *Plastic films [website]*. <http://www.plastics.ca/film/>
CIWMB 2004 -Lumber	California Integrated Waste Management Board. (acces Sept 2004) *Recycled Plastic Lumber*. <http://www.ciwmb.ca.gov/Plastic/Recycled/Lumber/>
Clarke 1993	Clarke, Stephen P. 1993. Prospects and Problems with Plastics in Agriculture. *Silage Production: From Seed to Animal: Proceedings from the National Silage Production Conference, Syracuse, NY, February 23-25, 1993*. NRAES-67. Northeast Regional Agricultural Engineering Service, Cornell Cooperative Extension. 144-156.
Climenhage 2003	Climenhage, David. 2003. *Recycled Plastic Lumber: A Strategic Assessment of its Production, Use and Future Prospects*. Prepared for EPIC (Environment and Plastics Industry Council). 48 pages. <http://www.cpia.ca/files/files/files_PlasticLumber-Final-Report.pdf>

IN-TEXT CITATION	BIBLIOGRAPHIC INFORMATION
Crop Storage Institute	Crop Storage Institute. undated (accessed June 2004). <http://www.cropstorage.com/>
DMS 1996	DMS Environmental Services. 1996. *Vermont Agricultural Plastics Film Recycling Collection Pilot - Summer 1996*. Prepared for the American Plastics Council. unpaged.
Enviros RIS 2001	Enviros RIS. 2001. *Plastic Waste Management Strategy for Ontario*. Prepared for WDO (Ontario Waste Diversion Organization), EPIC, CSR (Corporations Supporting Recycling). 74 pages. <http://www.cpia.ca/epic/publications/reports.php>
EPIC 1998-BMP	EPIC (Environment and Plastics Industry Council). 1998. *Best Practices Guide for the Collection and Handling of Polyethylene Plastic Bags and Film in Municipal Curbside Recycling Programs*. 27 pages. <http://www.cpia.ca/files/files/files_Best_Practices_Guide.pdf>
EPIC 2003 -PlasticLumber	EPIC (Environment and Plastics Industry Council). 2003. *Recycled Plastic Lumber and Woodfibre Composites*. 8 pages. <http://www.cpia.ca/files/files/files_plastics_lumber_special_report.pdf>
EPIC-Infrastructure	EPIC (Environment and Plastics Industry Council). undated. *Plastics Recycling: Building an Infrastructure*. 8 pages.
EPIC-undated	Environment and Plastics Industry Council of Canada. Undated website. <http://www.cpia.ca/epic/>
FWM 2002	*Farm Waste Management: Connecticut Grown*. 2002. <http://www.state.ct.us/doag/business/agtech/agtechfw.htm>
Garthe 2003	Garthe, James W. March 2003. *Used Agricultural Plastics as Fuel*. 12 pages. <http://environmentalrisk.cornell.edu/AgPlastics/References/Garthe2003.htm>
Gilbert 2001	Gilbert, Don. 2001. *Establishing Permanent Collection Sites for Container Recycling at Business Locations—How to Convince a Pesticide Dealer to Collect Containers for You*. National Pesticide Stewardship Alliance Conference, November 27-30, 2001. Memphis, Tennessee. Paper C3C. <http://www.npsalliance.org/2002_conf.html>
IRDC 1998	*Recycled Plastic Sheets for Greenhouses* 1998. International Development Research Centre, Ottawa, CA, 3 pages. <http://www.crdi.ca/nayudamma/greenhouse_44e.html>
Josefsson et al. 2000	Josefsson, K Gunnar, Marcia Miquelon, and Larry J Chapman. 2000. *Use Silage Bags: Ideas for more efficient dairy farming*. Work Efficiency Tip Sheet. University of Wisconsin Madison Healthy Farmers Healthy Profits Project: Madison, WI 53706. 2 pages. <http://bse.wisc.edu/hfhp/>

IN-TEXT CITATION	BIBLIOGRAPHIC INFORMATION
Josefsson et al. 2001	Josefsson, K Gunnar, Larry J Chapman, Alvaro D Taveira, Brian J Holmes, and David Hard. 2001. A Hazard Analysis of Three Silage Storage Methods for Dairy Cattle. *Human and Ecological Risk Assessment* 7 (7): 1895-1907.
Kaufman et al. 2004	Kaufman, Scott M, Nora Goldstein, Karsten Millrath, and Nickolas J Themelis. 2004. The State of Garbage in America: 14th Annual Nationwide Survey of Solid Waste Management in the United States. *BioCycle* 45(1): 31-41.
Levitan and Barros 2003	Levitan, Lois and Ana Barros. March 2003. *Recycling Agricultural Plastics in New York State*. Cornell University, Environmental Risk Analysis Program. 30 pages. <http://environmentalrisk.cornell.edu/AgPlastics/>
Marine Lumber 2003	CIC Innovation Consultants Inc. 2003. *A Custom Market Research Study Reviewing the Potential for Plastic Lumber in Canadian Marine Applications*. Prepared for Environmental and Plastics Industry Council. 13 pages. <http://www.cpia.ca/files/files/files_Marine_Applications.pdf>
NASS 2003	New York Agricultural Statistics Service. 2003. *Agricultural Statistics 2002-2003*. 86 pages. <http://www.nass.usda.gov/ny>
Negra and Rogers 1998	Negra, Christine and Glenn Rogers. 1998. *Agricultural Plastic Recycling: Investigation of Opportunities and Obstacles in Vermont*. Prepared for USDA.
NYS Open Fires 1972	Open Fires. May 1 1972 (effective). *6 NYS Codes, Rules and Regulations §215*. <http://www.dec.state.ny.us/website/regs/part215.html>
O'Neill 2002	O'Neill, Patrick. October 31, 2002. *Study of Collection of Used Silage Wrap*. Prepared for Island Plastics, Inc., Stratford PEI, Canada. 15 pages. <http://environmentalrisk.cornell.edu/AgPlastics/References/ONeill2002.pdf>
PLTA-undated	Plastic Lumber Trade Association. undated website. <http://www.plasticlumber.org/>
Powell 1996	Powell, Jerry. 1996. The Recycled Plastic Lumber Industry: Moving Toward Adulthood. *Resource Recycling* 15 (2): 20, 22-24, 26-29.
Railroad Ties 2003	CIC Innovation Consultants Inc. 2003. *A Custom Market Research Study Reviewing the Potential for Plastic Railroad Ties in Canada*. Prepared for EPIC (Environmental and Plastics Industry Council). 31 pages. <http://www.cpia.ca/files/files/files_Plastic_Railway_Ties.pdf>
Resource Recycling 1995	Resource Recycling Inc. 1995. Directory of U.S. and Canadian Plastic Lumber Producers. Plastics Recycling Update Newsletter. Portland, OR 97210. unpaged. <http://www.resource-recycling.com/pru.html>

IN-TEXT CITATION	BIBLIOGRAPHIC INFORMATION
Resource Recycling 2003	Resource Recycling Inc. 2003. *Scrap Plastics Markets Directory*. <http://www.resource-recycling.com/plastics.html>
Resource Recycling undated	Resource Recycling Inc. undated. Plastics Recycling Update. <http://www.resource-recycling.com/pru.html>
Re-Sourcing Associates 1999	Re-Sourcing Associates Inc. September 1999. *Plastic Film Recovery Guide*. Prepared for the American Plastics Council. Re-Sourcing Associates Inc. Seattle, Washington. 61 pages.
Robbins 1999	Robbins, Alan E. 1999. *Development of ASTM Standards for Plastic Lumber, a Comprehensive Overview of Standards to Date and Work in Progress*. Annual Recycling Conference, November 1999, Dearborn, Michigan. Plastic Lumber Trade Association.
Robbins 2000	Robbins, Alan E. 2000. *2000 State of the Recycled Plastic Lumber Industry*. Prepared for the Plastic Lumber Trade Association. 7 pages. <http://www.plasticlumber.org/ stateof.htm>
Smith 2003	Smith, R David. 2003. Using Balage: An opportunity for small farms. *Farming* 39-44.