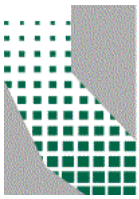

California Integrated Waste Management Board

May 2008

Contractor's Report

To The Board

Postconsumer Agricultural Plastic Report

Produced Under Contract by: Sean Hurley, California Polytechnic State University

California Environmental Protection Agency

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Table of Contents

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Executive Summary

Plasticulture in California

The use of plastic in agriculture dates as far back as 1948 and, since then, has spread throughout the agricultural industry. Plastic and its use has become important to the industry and named plasticulture by scientists who have examined its usage. Some of the many uses of plastic in agriculture include: 1) plastic film mulches, 2) drip irrigation tape, 3) row covers, 4) low tunnels, 5) high tunnels, 6) silage bags, 7) hay bale wraps, and 8) plastic trays and pots used in transplant and bedding plant production.

California is one of the most diverse agricultural states in the nation with more than 400 commodities grown within the state. This state produced $32 billion in direct farm sales in 2005, which makes it the largest agricultural-producing state in the country and one of the largest in the world. With so much diversity in agricultural production, it is not surprising that a segment of California producers engage in the practice of plasticulture to enhance their crop production. Many of the top 20 agricultural commodities in the state have a proportion of their producers engaged in plasticulture.

While it is understood that plasticulture is practiced in California, it is unclear how much plastic is used by each agricultural industry in the state, as well as how it is used. There is also a lack of knowledge on the disposal and recycling practices used by the producers. This report presents a detailed examination of plastic usage in California agriculture and develops a recycling strategy for agricultural plastic in the state.

There were four primary tasks assigned to this project:

- Conduct an extensive review of the literature on recycling agricultural plastics.
- Conduct a focus group with agricultural producers regarding their use and recycling of agricultural plastic.
- Develop and conduct a survey to examine California producers' usage and recycling of agricultural plastic.
- Use the results from the survey and focus group to develop a strategy for recycling agricultural plastic.

The Survey

Information analyzed in this report was from a survey developed from focus groups of producers and administered to California agricultural producers. This survey was categorized into five different sections. The first section of the survey collected information regarding the producers operation, i.e., general demographic information. Sections Two through Four gathered specific information by type of plastic regarding producers' usage and disposal of agricultural plastic. The final section explored general information regarding producers' disposal and recycling of agricultural plastic.

The producers in the survey were represented by the following industry groups: berries other than strawberries, strawberries, peppers, melons, tomatoes, nursery, greenhouse and horticulture, dairy, hay, grapes, and orchards which included stone fruit and tree nuts. Information was also

collected regarding plastic usage by producer who produce other types of vegetables other than the ones listed. These groups are believed to use the bulk of the agricultural plastic in California.

Surveys were sent out to 3,000 producers in the state. Out of all the surveys sent out, 2,206 producers sent back the survey by mail, completed the survey by phone, or verbally declined over the phone to participate in the survey. There were 895 producers who responded to at least a portion of the survey with 389 respondents indicating that they use agricultural plastic. Hence, 43 percent of the producers that filled out a portion of the survey indicated they used some form of agricultural plastic. Examining this usage rate by industry showed that the orchard industry had the lowest participation rate at 22 percent and the strawberry industry had the highest usage rate of 94 percent. The other usage rates for the other industries in the study are in Table ES 1.

Table ES 1: Percentage of Survey Respondents Using Agricultural Plastic by Industry

Industry	Number of Survey Respondents	Number Indicating Plastic Usage	Percentage Using Agricultural Plastic
Berries other than strawberries	36	16	44.44%
Strawberries	64	60	93.75%
Grapes	140	33	23.57%
Melon	38	24	63.16%
Orchard	281	63	22.42%
Pepper	52	38	73.08%
Tomatoes	102	37	36.27%
Vegetables	128	67	52.34%
Dairy	65	39	60.00%
Hay	168	67	39.88%
Greenhouse	94	71	75.53%
Nursery	154	107	69.48%

Major Findings

One finding in this study is that there currently is a group of producers who indicated that they are recycling some of their agricultural plastic. This group represents 35.94 percent of the plastic users in the survey. This suggests that there is a group of producers who have found value in recycling their agricultural plastic and are currently undertaking the practice. Table ES 2 shows the participation rate of recycling by industry. Examining this table shows that the melon industry had the lowest recycling rate at 13 percent, while the nursery industry had the highest recycling rate at 46 percent. These results suggest that there is a current demand for recycling services.

Table ES 2: Percentage of Survey Respondents Who Recycle Agricultural Plastic by Industry

Industry	Number of Producers Who Reported Recycling	Number of Producers Who Do Not Recycle	Percentage of Producers Recycling Agricultural Plastic
Berries other than strawberries	4	12	25.00%
Strawberries	18	40	31.03%
Grapes	14	18	43.75%
Melon	3	20	13.04%
Orchard	24	39	38.10%
Pepper	10	28	26.32%
Tomatoes	9	27	25.00%
Vegetables	20	46	30.30%
Dairy	11	28	28.21%
Hay	15	51	22.73%
Greenhouse	29	41	41.43%
Nursery	49	57	46.23%

Producers indicated in the survey that the greatest incentive they could receive for recycling is offering on-farm pick-up for agricultural plastic. Figure ES 1 shows the number of producers who indicated a particular incentive would encourage them to recycle. The survey revealed that a large group of producers would recycle if a pick-up service existed. This incentive had the highest number of respondents over all other options given. The plastic pick-up service option was examined for each industry and the results showed it as the preferred choice. There was a group of producers in the survey who indicated they would pay for a pick-up service for their agricultural plastic. The amount that producers were willing to pay depended upon the industry, and whether or not they had to sort their agricultural plastic.

Figure ES 1: Options that Would Encourage Producers to Recycle Agricultural Plastic

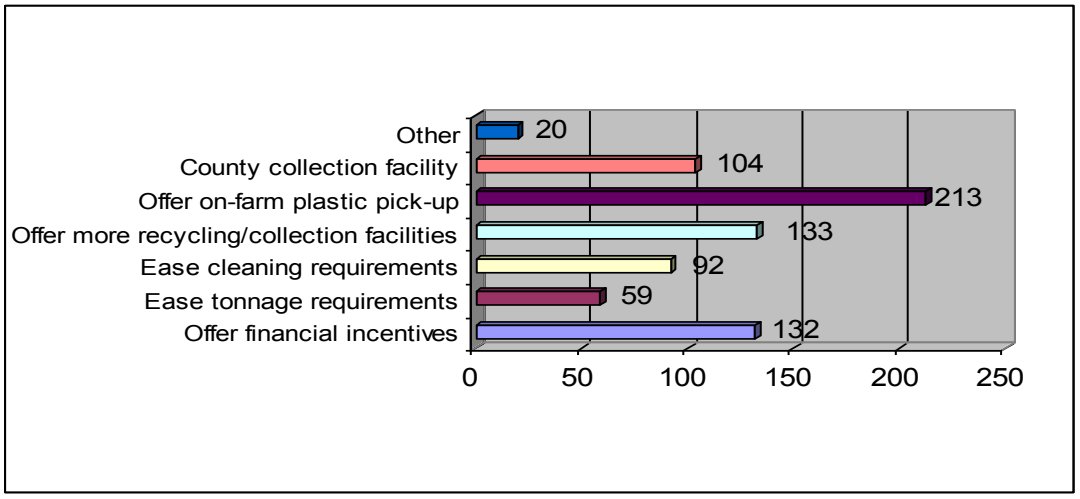
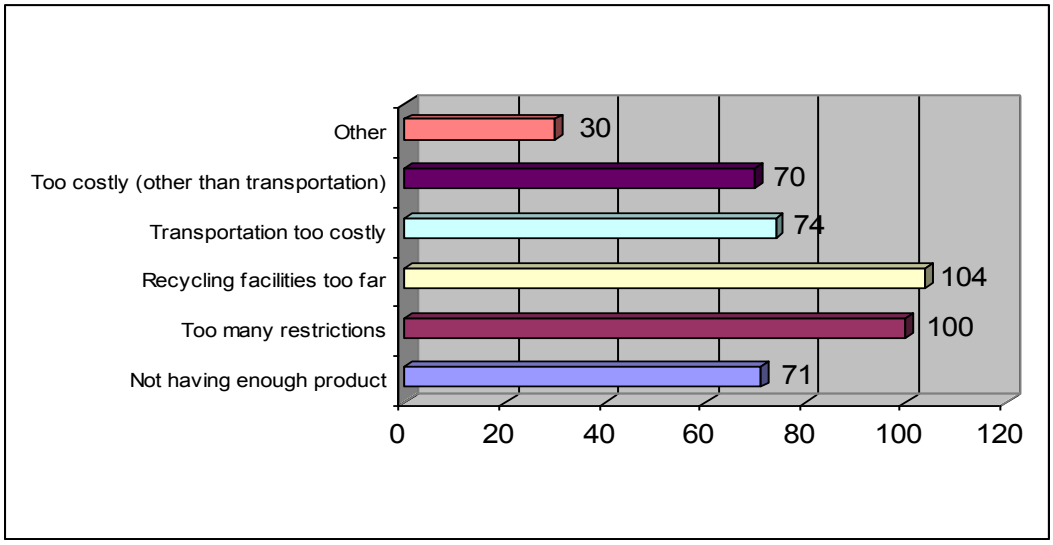


Figure ES 2 displays the producers' expected and experienced difficulties with recycling agricultural plastic. The producers in this study indicated that the greatest difficulty they perceive or have encountered with recycling their agricultural plastic is that the recycling facilities are too far from their operations. This suggests that one way to increase the recycling rate is to have recycling facilities closer to the point of operation. Another top identified difficulty was that there are too many restrictions on recycling agricultural plastic. These restrictions could include the type, color, amount, cleanliness, etc. It is expected that if some of these restrictions were lifted, the recycling participation rate would increase.

Figure ES 2: Expected and Experienced Difficulties with Recycling Agricultural Plastic



When examining many of the results in this study, it was found that the average results were substantially higher than the median results. This indicates that there are a few producers at the upper end of the distribution of each answer that strongly pull the average away from the median. This suggests that agricultural plastic usage is concentrated on larger farms utilizing relatively large amounts of plastic. This also indicates that a successful recycling strategy would target their efforts on getting these large producers on-board with recycling if they wanted to capture the easiest source of plastic first.

Using the survey information, three estimates were developed for how much agricultural plastic is disposed of on a yearly basis. The first estimate relied on the assumption that the average usage per farm in the survey was equivalent to the average usage of the farms in California. Using this formula the estimate of the annual agricultural plastic disposal for the state is 198,289.8 tons. This assumption was not practical because it weighs each farm equally in production and size which is not the case in the state due to its diversity in the types of crops.

Using a more realistic assumption that approximately 25 percent of the producers in the state produce over 96 percent of the agricultural product, agricultural plastic disposal for the state was estimated at 48,768.8 tons per year. A third and more refined estimate was made that took into account that plastic disposal was dependent upon the different industries that used agricultural plastic. The total and industry estimates of agricultural plastic disposal are presented in Table ES 3. This industry information provided a new estimate of plastic disposal at 55,506.7 tons per year. This is considered the most accurate estimate given the information collected in the survey. This estimate would increase to 107,794.3 tons per year if there was 100 percent participation in

plastic usage by producers in each industry. This is a better estimate of the total upper limit on the amount of agricultural plastic disposal given current production methods.

Table ES 3: Estimated Tonnage of Agricultural Plastic Disposed of on a Yearly Basis by Industry

Industry	Tons of Agricultural Plastic Disposed of Annually	
	Estimate Based on Average Producer	Estimate Based on Median Producer
Other Vegetables	12,194.29	4,101.06
Greenhouse and Nursery	11,799.81	927.21
Strawberries with Fumigation Plastic	10,484.31	9,555.00
Dairy	7,902.53	1,185.21
Orchard	4,544.79	51.55
Tomatoes	4,196.70	2,653.45
Hay	2,187.14	765.44
Peppers	1,536.94	1,433.32
Grapes	340.04	273.29
Melons	193.29	5.65
Berries other than Strawberries	126.84	63.88
Total	55,506.70	21,015.05

Future Research

Since the other vegetable industry, as defined in this study, had the highest amount of disposal further studies should be conducted to examine the usage and disposal of agricultural plastic by each commodity in this industry. The plausible reason the other vegetable industry had such a large disposal rate was possibly due to the large amount of acreage the industry occupies.

A closer look at what conditions need to exist to induce producers to utilize an on-farm pick-up service for their agricultural plastic requires additional research. The results from the survey suggest that this is the preferred incentive that would induce producers to recycle their agricultural plastic. The issue with this result is that the producers indicated interest in this service without knowing the details. The cost and convenience of the service will most likely dictate the true number of producers who would choose a pick-up service for their agricultural plastic.

One aspect that this study did not explore was how satisfied producers who currently recycle were with their current ability to recycle. Problems may arise for an agency to try to encourage recycling of agricultural plastic if the current producers are not happy with their ability to recycle. Understanding why this current group of producers is recycling their agricultural plastic would allow for a more complete development of a recycling strategy for the state.

The producers indicated the greatest difficulty with recycling agricultural plastic is that the current recycling facilities are too far from their operation. This suggests that further analysis is needed to understand how far producers would travel to recycle their agricultural plastic. This study examined how far producers would travel if recycling was free. Other studies should focus on how far producers would travel if they paid to recycle their agricultural plastic or if they were compensated for bringing their plastic to the recycling facilities.

While this study identified that producers perceive that there are too many restrictions with recycling, it did not examine which restrictions caused producers difficulties. A study identifying the specific restrictions that are causing producers difficulties and determining whether to reduce these restrictions should be examined to better understand how to encourage producers to recycle.

Introduction

The use of plastic in agriculture dates as far back as 1948 when Emery Myers Emmert used polyethylene as a cover for greenhouses instead of glass (Jensen, 2000; Splittstoesser and Brown, 1991). Since this time, the use of plastics in agriculture has spread throughout the agricultural industry and has been renamed "plasticulture." Splittstoesser and Brown (1991, p. 241) define plasticulture as the "science and technology of the use of plastics in agriculture," while Orzolek (2003) has more generally defined plasticulture as the use of plastic in agriculture. Some of the many uses of plastic in agriculture include the following: 1) plastic film mulches, 2) drip irrigation tape, 3) row covers, 4) low tunnels, 5) high tunnels, 6) silage bags, 7) hay bale wraps, and 8) plastic trays and pots used in transplant and bedding plant production (Orzolek, 2003). Agricultural plastics are used in this report to signify all types of plastics used by producers.

Plastic has many advantages and disadvantages in agriculture. Plastics are used as a low-cost method to extend the season of some crops (Roos and Jones, no date). It is also used to conserve water, control weeds, and maintain high quality fruit when used as mulch (Kasperbauer, 2000). One disadvantage of using agricultural plastic, especially as a season extender, relates to the disposal issues that come with the use of plastic (Roos and Jones, no date). Most agricultural plastic used on farms is non-biodegradable and is either taken to a landfill or sent to a recycler. Some agricultural plastics are recyclable under a certain set of conditions set by a recycler, while others are not for various reasons that are explained below. Even though biodegradable plastic exists, much of the plastic used in agriculture is currently non-biodegradable because of the infancy of the technology.

California is one of the most diverse agricultural economies in the nation with more than 400 commodities produced in the state (California Department of Food and Agriculture, 2007). This state produced $32 billion in direct farm sales in 2005 which makes it the largest agricultural producing state in the country and one of the largest in the world. With so much diversity in agricultural production, it is not surprising that a segment of California producers engage in the practice of plasticulture to enhance their crop production. Table 1 shows the top 20 agricultural commodities along with the total cash farm receipts for each industry. Many of these commodities have a portion of their producers engaged in plasticulture.

Table 1: Top 20 Agricultural Commodities in 2005

Commodity	(billions)	Commodity	(billions)	Commodity	(billions)
Milk and Cream	$5.220	Chickens	$0.715	Walnuts	$0.540
Grapes	$3.170	Cotton	$0.634	Broccoli	$0.514
Nursery	$2.430	Oranges	$0.604	Carrots	$0.455
Almonds	$2.340	Pistachios	$0.577	Rice	$0.408
Cattle and Calves	$1.740	Strawberries	$1.110	Peaches	$0.280
Lettuce	$1.690	Floriculture	$0.984	Lemons	$0.278
Hay	$1.150	Tomatoes	$0.942		

Source: California Department of Food and Agriculture, 2006

While it is commonly known that plasticulture is practiced in California, it is unclear how much plastic is used by each agricultural industry in the state, as well as, how agricultural producers are using it. There is also a lack of knowledge on the disposal practices used by these producers. This

report presents a detailed examination of plastic usage in California agriculture and provides suggestions for a recycling strategy for agricultural plastic in the state.

There were four primary tasks that were required for this project. The first task was an extensive review of the literature on recycling agricultural plastics. The second task was to conduct a focus group with agricultural producers regarding their use and recycling of agricultural plastic. The third task was to develop and conduct a survey to examine California producers' usage and recycling of agricultural plastic. The final task was to use the results from the survey and focus group to develop a strategy for recycling agricultural plastic.

The rest of this report is categorized into seven other sections. The first section presents the review of literature regarding agricultural plastic with an emphasis on recycling. The next section discusses the method used for running the focus group and conducting the survey on agricultural plastic usage and recycling. A discussion of the information found in the focus groups makes up the third section. The fourth section highlights the major results of the survey. The fifth section presents an estimate of how much agricultural plastic is disposed of on a yearly basis in California. The sixth section provides recommendations on a recycling strategy for the state given the results from the focus group and the survey. The final section is devoted to summary, conclusions, and future research ideas.

LITERATURE REVIEW

Estimation of Plastic Usage

The use of plastic in agriculture has increased over the last couple of decades. Hemphill (1993) cites an estimate given by Ennis (1987) that the United States uses over 110 million pounds of agricultural mulch used for vegetables, strawberries, other row crops, and orchards. Amidon (1994) estimated that the United States used 521 million pounds of plastic in agriculture. The majority of this plastic was used in the nursery industry in the form of containers. As recently as 2003, Levitan and Barros (2003) estimated that there were 1.678 billion pounds of plastic used in the agricultural sector in 2002. This estimate was made by assuming that 3 percent of all plastic sold in the United States was purchased directly or indirectly by the agricultural sector. This represents a threefold increase over a ten-year span.

Amidon's (1994) study went further than estimating the total amount of plastic used in agriculture. He also estimated the amount of plastic used for three categories -- film, nursery containers, and pesticide containers. Nursery containers made up over 66 percent of total plastic consumption in agriculture. Within this category, injection-molded high density polyethylene (HDPE) pots had the highest share. Agricultural film accounted for approximately 29 percent of agricultural plastic with the largest allocation going to low density polyethylene (LDPE) mulch film. High density polyethylene pesticide containers accounted for less than 5 percent of the agricultural plastic used.

Disposal and Recycling of Agricultural Plastic

Da Costa et al. (1996a) conducted a survey of recycling coordinators and individuals responsible for managing agricultural plastics in each county of New York State. The objectives of their study were: 1) identify the options available to producers for managing agricultural plastic, 2) identify existing barriers to best management practices of agricultural plastic film, and 3) to correlate counties with similar characteristics and develop plans that would meet each group of counties needs. They found at the time that there were no collection programs for low density polyethylene agricultural plastics in the state and inferred that most agricultural plastic was entering the waste

stream. The authors were able to identify many barriers to managing agricultural plastics including: contamination of the plastics, lack of convenient options for recycling, high transportation costs, and lack of an adequate set of handling procedures. Da Costa et al. (1996b) find from their secondary research that the main barriers to recycling agricultural plastics come from collection issues, transportation of the material, contamination of the plastic, and lack of end markets.

With an increasing quantity of agricultural plastic used on the farm, disposal of this type of plastic is becoming a greater consideration that needs addressing. Clarke (1995) identifies five choices farmers have for handling the agricultural plastic acquired during normal operations. They can 1) reuse it for other purposes, 2) recycle it, 3) dispose of it by burying it, 4) send it to a landfill, or 5) use it as a fuel (e.g., burn it).* Each method has its own unique requirements and potential restrictions. For example, Clarke and Fletcher (2002) report that many landfills either have high tonnage charges or will not accept agricultural plastics outright.

Garthe and Kowal (1994) provide a look at the process and its related terminology for recycling agricultural plastics. They categorize the process of recycling into four stages. The first stage of the process is the collection stage. Collections of the recyclable materials are accomplished by curbside pick-up, buyback locations, or drop-off locations. The authors state that an obstacle to collection is the high cost of transportation due to the bulky nature of the product. The second stage of the recycling process is the handling and storage stage. Within this stage, the agricultural plastic is evaluated for suitability for recycling and then sorted. The main reason cited for rejecting the plastic for recycling is due to contamination. The third stage in the recycling process is the reclamation stage. In this stage the recyclable plastic is conditioned for re-use. The final stage in the recycling process is the production and sale of a usable product made from the recycled plastic. This product is a clean form of the original product, which is either re-used as an agricultural plastic, or is a completely different product.

Garthe and McCoy (no date) provide a classification of the different types of plastics used for different agricultural practices. They categorized the plastic based on its composition. Low density polyethylene (LDPE) is used to make mulch film, greenhouse film, silage bags and wraps, and trickle irrigation tubing. Linear low density polyethylene (LLDPE) is used for row covers and silage bag and wraps. Polypropylene is used to make row covers, nursery pots, and nursery trays and flats. Pesticide containers and nursery pots are made from high density polypropylene (HDPE). Nursery pots, trays, and flats are made of polystyrene.

Plastics have a high energy value in comparison to many other municipal solid waste items. According to Garthe and Kowal (1993), polyethylene has an energy value of 19,900 BTU, polypropylene has an energy value of approximately 18,500 to 19,500 BTU, and polystyrene has an energy value of 17,800 BTU. These energy values are close to that of fuel oil with an energy value of 20,900 BTU. One concern with turning agricultural plastic waste into a fuel source is the contamination of the material by pesticides. Another concern with incinerating agricultural plastics as a fuel source is that agricultural plastics, which are compressed to make transportation more cost effective, can burn too hot and damage the incinerator.

Clarke and Fletcher (2002) report on a pilot project for recycling agricultural plastic carried out in Ontario since 1992. They found that agricultural producers are willing to participate in a

* Garthe and Kowal (no date) report that 60 percent of farmers who participated in a survey conducted by the Penn State Cooperative Extension burned their used agricultural plastic.

recycling program as long as a "practical" collection system exists. The producers in this pilot study were willing to develop simple methods for collecting and storing their used agricultural plastics to maintain cleanliness of the plastic. They report that producers were willing to drive up to an hour away to dispose of their used agricultural plastic to a recycling center. One major concern that producers had with transporting agricultural plastic any great distance was the liability that comes with transportation.

Hussain and Hamid (2003) explain some of the difficulties of recycling agricultural plastics. They believe that the main obstacle for recycling agricultural plastic comes from the high cost of collecting, transporting, and cleaning plastic. They further explain that agricultural plastics are contaminated by as much as 50 percent of their initial weight. These contaminants may include pesticides, vegetation, dirt, etc. All of these contaminants have a detrimental effect on the ability to recycle agricultural plastics.

Garthe and McCoy (no date) would agree with Hussain and Hamid (2003) that contamination of agricultural plastics is a main issue to recycling. Garthe and McCoy (no date) also believe that buyers of recyclable plastics are concerned with an inconsistent product that arrives in small quantities. The main obstacle that is faced with agricultural plastics is that there is often not a viable way to compress the bulky plastic to a more transportable form. It is suggested by the authors that this is alleviated with a cooperative-owned baler, hiring custom operators, or creating rebate programs to influence both buyers and sellers. One of the more time-consuming and tedious components to recycling is the preparation of the material. The material needs cleaning and drying.

A best practices guide for managing agricultural plastic film was put out by The Environmental and Plastic Council (EPIC, no date). The EPIC guide provides three reasons why producers should recycle their agricultural plastic. First, they explain that there is legislation against on-farm plastic disposal through burying or burning. They further explain that if a producer decides to burn the agricultural plastic, the fumes are toxic to the producer and the local environment. The second reason given by this guide is the reluctance of local landfills to take bulky material. The final reason given is that recycling agricultural plastics converts the material into a new useful product.

DSM Environmental Services, Inc. (1999) developed a document explaining best management practices for handling agricultural film waste. This document was derived from an examination of two pilot projects on recycling and composting agricultural plastics in Vermont. This report emphasizes the need for the producer to properly handle the used agricultural plastic and to keep it as clean and dry as possible for either disposal or recycling purposes. Guidance is provided in this report on handling round bale wraps, bunker covers, and silage bags. At the time of the study, markets for recycled agricultural plastic were limited and firms were not willing to pay for the materials.

Economic and Feasibility Studies for Recycling Agricultural Plastic

It is estimated that 3,500 tons of polypropylene baler twine was sold in Alberta, Canada, to agricultural producers in 1999 (Randall Conrad and Assoc. Ltd., 2000). Given this large quantity of non-biodegradable agricultural plastic, Alberta was interested in whether it was possible to recycle this twine for other uses. A study conducted by Randall Conrad and Assoc. Ltd. (2000) was commissioned to study the market feasibility of recycling this twine. They identified two emerging markets for the baler twine. These included using the recycled twine as an ingredient for a rubber composite shingle or using the twine as a reinforcement agent for concrete and

asphalt. They also examined using the baler twine as a fuel source. The overall conclusion from the study was that it was currently infeasible to recycle polypropylene baler twine. The authors of the study recommended that the government agency responsible for overseeing the recycling strategy for the province should continue to monitor the shingle and asphalt industries as they progress in utilizing recycled agricultural plastics in their products.

Kwak, Yoo, and Kim (2004) conducted a study to estimate the societal benefits for recycling waste agricultural film in South Korea. They discuss the need for a recycling program in South Korea due to the diminishing land available for landfills. In 2001, they utilized a professional polling firm to send out over 650 surveys to residents in Seoul, South Korea between the ages of 20 to 65. The response rate was over 95 percent. Using contingent valuation methods, specifically dichotomous choice questions, they were able to estimate that the mean willingness-to-pay per Korean household for this recycling program was $3.60 per year. They equated this value to a societal benefit of approximately $11 million per year.

Jaeger (2006) conducted a feasibility analysis of a business using recycled agricultural plastic along with juniper plants to create a fuel cube to sell as a fuel source. He states that the source of the plastic could come from the strawberry and nursery industry where approximately 16 to 18 million pounds of plastic per year are generated from these industries.[†]

Jaeger (2006) finds that there are a set of conditions that will allow this fuel cube to compete against wood as a fuel source. There are two important assumptions that Jaeger makes when estimating the feasibility of the fuel cube operation. First, he assumes that the agricultural plastic necessary to operate the plant is sourced within an 80 mile roundtrip. The second major assumption is that acquisition of the agricultural plastic is free and the transportation costs are $12 per ton. Given that these two assumptions hold, Jaeger estimates that a million BTU's worth of plastic cube fuel source would cost $2.60. This compares unfavorably to wood which has an estimated cost of $2.05 per million BTU. The company may be able to defray the building costs with a subsidy, and then the cost of production for the plastic fuel cubes could decrease to $1.80 per million BTU's. These two results are heavily dependent upon obtaining the agricultural plastic for free. Jaeger cites anecdotal evidence that suggests producers could obtain $0.06 per pound for "dirty" agricultural plastic and up to $0.28 per pound for relatively clean used agricultural plastic.

Levitan, Cox, and Clarvoe (2005) released a report on the feasibility of recycling agricultural plastics in the Central Leatherstocking-Upper Catskill region in the state of New York. The authors investigated this issue by conducting many "open-ended" interviews with agricultural producers, recyclers, and re-processors. The emphasis of their study was on the recycling operation. They estimate that approximately 200,000 pounds of low density polyethylene is used by dairy farms within their study region on a yearly basis. They also estimate that there is another 40,000 pounds of plastic films generated in the area by nurseries and non-agricultural industries. Given this quantity of plastic produced in the area, they find that recycling agricultural plastic in the area is technically feasible. The authors found that from an economic perspective "the economic balance sheet for recycling of dairy plastics is very tight (p. 61)." They estimated $1,800 in revenue generated per truckload of recyclable agricultural plastic.[‡] After an $800 baling

[†] Jaeger (2006) does not explain the geographical location that this plastic is being sourced from or where he obtained this estimate.

[‡] Levitan, Cox, and Clarvoe (2005) estimate that a truckload of plastic is approximately 40,000 pounds.

cost, the recycler is estimated to have $1,000 per truckload to pay for administrative and handling expenses. The authors conclude that a "viable recycling program" would require public support during the infancy of the program. They also justified public support through the public benefits that come with the recycling program.

Technology and Agricultural Plastic

Parish, Bracy, and McCoy (2000) have tested an in-field incinerator of plastic mulch in 1999. This incinerator takes plastic mulch directly off the field, incinerates it, and then drops the residual on to the field. They found that the technology burned much of the mulch, but left some globules. Based on this finding, they concluded that the in-field incinerator equipment did not perform adequately. Furthermore, they found that the labor needed to operate the machinery was excessive.

Garthe (2002) took a different approach. Instead of incinerating the plastic in the field, he proposed developing plastic fuel nuggets to power a boiler. In his research, he tested fuel nuggets developed from agricultural plastics from California, Pennsylvania, and Florida. He found that the fuel nuggets could be used in conjunction with coal boilers. Another advantage is that fuel nuggets can be safely stored and shipped. The nuggets were developed with the idea of using only agricultural plastics, but Garthe (2002) believes it is feasible to use plastics from other industries. One of his major findings was that the composition of the fuel nuggets varies due to the differences in agricultural plastics from across the country and the foreign matter that is included in the plastic.

Since recyclers do not want bulky, loose, and dirty plastic, proper handling of agricultural plastic is necessary for recycling. Goldy (no date) tested several methods of modifying agricultural round balers to handle agricultural plastic. He found that since plastic is heavier than hay, the belts on the baler would often break and that a baler using chains is more efficient. In addition, he found that the plastic would often get caught on the tines and removing the outside set of tines helped. However, some growers removed the complete pickup head which then makes it necessary to physically feed the baler with material. This is both labor-intensive and dangerous. Again, it is noted that the product is clean and free of any foreign matter.

University of California Extension Cost Studies

An examination was conducted of the University of California (UC) Extension cost studies to obtain clues as to which agricultural industries used agricultural plastic and film. The Extension agency keeps data on 174 enterprise budgets that encompass 92 different commodities. Table 2 presents the results of the analysis of these studies. Of the 92 different commodities, 29 have the potential for using agricultural plastic in some form or another. The orchard industry used plastic in the form of drip irrigation and micro sprinklers, while the berry industry and specialty vegetable industry used drip irrigation and mulch. Depending on the commodity, the enterprise budget developed has the amount of plastic used and disposed. This is usually the case for plastic that is used on a yearly basis. There is no guidance given to how much plastic is used for the industries that utilize plastic for more than one year.

Table 2: Commodities Identified in UC Extension Enterprise Budgets that Utilize Agricultural Plastic

Commodity	Use of Agricultural Plastic	Commodity	Use of Agricultural Plastic
Alfalfa	Baling Twine	Grapes	Drip Irrigation
Almonds	Micro Sprinklers	Lemongrass	Greenhouse Plastic
Apricots	Micro Sprinklers	Lemons	Drip Irrigation
Chinese Long Beans	Greenhouse Plastic	Olives	Drip Irrigation and Micro Sprinklers
Green Beans	Drip Tape	Onions	Drip Irrigation
Blueberries	Drip Irrigation	Oranges	Drip Irrigation
Boysenberries	Drip Irrigation	Pears	Drip Irrigation
Cantaloupe	Plastic for Beds	Peppers	Drip Tape and Plastic Mulch
Cherries	Micro Sprinklers	Raspberries	Drip Irrigation
Mandarins	Micro Sprinkler	Squash	Drip Tape and Plastic Mulch
Minneolas	Drip Irrigation	Strawberries	Drip Tape and Plastic Mulch
Pummelos	Drip Irrigation	Sweet Potatoes	Plastic for Tunnel Houses
Cucurbits	Greenhouse Plastic	Tomatoes	Clear and Black Plastic
Eggplants	Plastic Mulch and Drip Irrigation	Watermelons	Drip Tape and Plastic Mulch
Figs	Drip Irrigation		

Source: *http://coststudies.ucdavis.edu/*

Data Collection

Developing a strategy for the recycling of agricultural plastic and film requires a vast amount of information on production practices employed by California agricultural producers. While the cost studies from UC Davis provide a look at which producers are using agricultural plastics, most of the cost studies are built around a representative farm and do not necessarily differentiate production practices used by producers. These cost studies do not examine the producer's desire or willingness to recycle plastic.

A two-prong approach was used to collect information in order to provide guidance for a recycling strategy. The first was the creation of two focus groups. These focus groups consisted of interested producers to discuss their disposal and recycling practices for agricultural plastics. The second was a producer survey on the use and disposal of agricultural plastic. The next section of this report covers the creation of the focus groups.

Focus Groups

One method used to gather information on producers' use and disposal of agricultural plastic was the implementation of multiple focus groups. There were two primary purposes of these focus groups. The first purpose was exploratory in nature. One of the main points of the focus group was to develop a dialogue with producers on their disposal practices of agricultural plastic. The participants in the focus group were given a rough draft of the survey in order to establish dialogue. This was helpful in creating the terminology in the survey that producers use when

dealing with agricultural plastic. These groups were also helpful in developing a strategy for querying producers.

The second purpose of the focus group was to receive feedback on the preliminary design of the producer survey. Initially, the survey was built utilizing a survey that was conducted by Cornell University's Environmental Risk Analysis Program. This survey covered issues regarding the disposal and recycling of bunker silo covers, bale wraps, silage bags, mulch film, and pesticide containers. While this survey was a valuable template, it was not designed to investigate usage on crops which was one of the mandates of this project. Hence, the survey for this project provided substantial modifications to the base survey. Given these modifications, it was necessary to get feedback from industry representatives regarding how best to present the questions asked.

There are tradeoffs between collecting information from focus groups and surveys. The value of the dialogue that comes from a focus group over using a survey is that it allows for follow-up to answers that are requested by inquiry. The disadvantage is that only a few opinions are represented with a small group of producers, unlike a rigid survey that can query the information and opinions of many different producers.

When this project was initially developed, it was thought that one focus group with a diversified representation of agricultural producers could be brought together. During the process of developing the focus group, two major issues arose. The first issue was a general lack of interest from producers regarding the topic of disposal of agricultural plastic. The most interested parties were strawberry and other berry producers. Hindsight shows that most producers do not view the topic of recycling agricultural plastic as a pressing issue. Except for the berry and nursery producers who are disposing of agricultural plastic on a yearly basis, most producers who are using plastic dispose of it much less frequently. The second issue that made it difficult to conduct a single focus group was the geographical dispersion of the producers. The most efficient way to handle this issue and get the producers to meet in a single location was to split the focus groups up by industry.

Two focus groups were conducted for this project. The first was conducted with berry producers in Watsonville, and was represented by strawberry, blackberry, and raspberry producers. The main reason to conduct a focus group with berry producers is because they are in an industry that is disposing of agricultural plastic on a yearly basis. The second focus group was with representatives from the dairy industry which was conducted in Merced. While it was unclear prior to this study that dairy producers were large users of plastic, they do represent one of the few livestock industries that is potentially using agricultural plastic, especially for their lagoons.

There was an attempt made to create a third focus group with greenhouse and nursery producers, however, this did not come to fruition. This group was selected because the literature indicated that these industries were heavy users of agricultural plastic. It is unclear why there was a lack of interest from this industry, but it is conjectured that much of the plastic that is used by this industry is disposed of by the end consumers of their product. Hence, when a nursery sells tomatoes in plastic containers to a customer, that container is taken by the consumer and disposed by the consumer. This suggests that while greenhouse and nursery producers are big users of plastic, they may not directly dispose of that plastic.

Summary of Findings from Berry Producer Focus Group

The first focus group completed was with the berry industry (raspberries, strawberries, blackberries, etc.). This group was very informative and provided some valuable lessons

regarding the questions that should be asked of producers. Insight into the berry industries' view of recycling agricultural plastic was also gained, which was not anticipated before the discussion.

The consensus of the group is that the berry industry would conditionally desire to recycle agricultural products. One producer stated that his operation is willing to spend a little more than the dump disposal fees to recycle the agricultural plastic because the owner believed in recycling. Although, he also indicated that there are limits due to competitive pressures within the industry. It is unclear whether this participant represents the norm or whether he was an outlier.

The berry producers foresee two major issues with recycling agricultural plastics. The first issue is that the plastic supply for recyclers is not uniform throughout the year. They explained that there is approximately a three- to four-week window when all the agricultural plastic (except for fumigation plastic) used by the strawberry industry in a particular region will come off the field. Because many producers lease the land, they have stringent requirements when they must have the fields prepared for the next crop (e.g., all the plastic must be off the ground). This suggests that the recycler must handle all the agricultural plastic in a short period of time for the strawberry industry.

One producer indicated that his experience with recycling was that many producers in the area tried to recycle when it was available, but these producers had to wait in long lines. Furthermore, some producers were turned away because the recycler could not handle all the plastic brought in to the collection facility. This provided a disincentive to many producers who wanted to recycle but could not afford the time loss trying to recycle their plastics.

The second issue mentioned by producers was the requirements for the handling of the agricultural plastic. Experience has shown one producer that the recycler he dealt with was only willing to take certain types and colors of plastic. This required the producer to have to sort out the different agricultural plastics into the recyclable type and the non-recyclable type. Factoring in the cost of labor for sorting quickly drives up the cost of recycling, which makes it a less desired option.

The berry producers in this focus group suggested that they are interested in a recycling plan if they could take all of their agricultural plastic and film to a drop-off site where they can leave it there for the recycler to pick-up. The producer then would not need to make two trips to dispose of their plastic. This suggests that it might be acceptable for a recycler to pick-up the recyclable plastic and film from the producers operation. The drawback that the producer would have to separate out the recyclable plastic from the non-recyclable plastic still exists. The producers believed that this is a time-consuming task.

A per-acre estimate was developed by one of the berry producers on their usage and disposal cost of agricultural plastic. He estimated that plastic disposal costs his operation approximately $16 per acre on his strawberry field. Bolda et al. (2004) with the UC Cooperative Extension found that a representative producer spends $18 per acre on landfill fees. The cost of disposal, not including transportation costs, represents less than 1 percent of the operation costs which runs approximately $27,000 per acre. The cost of labor to sort the agricultural plastic would dissuade the producer from recycling, even if the recycler was willing to accept the plastic free of charge. Given the current wages in the industry, the producer is willing to allocate no more than two hours per acre for sorting plastic.

The berry industry primarily uses plastic as part of the crop fumigation process. One of the producers in the survey pointed out in the focus group that many producers in his area used a vendor to fumigate the crops. This finding is important because it means that in our survey we

will need to ask the producers if they do their own fumigation. If they do not, then the survey would underestimate the plastic usage for the berry industry. One of the producers explained how to calculate the amount of plastic used for fumigation for those producers who do not do their own fumigation.

The berry focus group discussed that some companies are implementing a recycling program that gives credit to purchase more of the product if that product is recycled. The recycling program used by this participant was the Toro® Recycling program for drip tape. Information on this program can be found at: http://www.toroag.com/HTML/WinWin_Brochure.pdf. Currently, the producers from the focus group are not completely happy with the system because of the restrictions.

One of the main reasons for running the focus group was to pre-test a survey that was developed for agricultural producers using plastic. One of the most important and useful critiques from this group was that the survey was asking questions which were too specific. One question, which was meant to elicit each type of plastic (e.g., black plastic, green plastic, clear plastic, etc.) used for each crop, was deemed by the producers as too specific. The producers at the focus group mentioned that the level of detail would dissuade producers from participating in the survey. This finding presents a dilemma for developing the survey. Having discovered that the recycling companies are selective on the types of plastic they are willing to recycle, it is useful to know the types of plastic used. Unfortunately, it does not appear that the growers are interested in giving that level of detail. Hence, the survey will only have the potential for estimating the amount of agricultural plastic as a whole. It appears that the best way to ask for the amount of plastic is by usage, e.g., mulch, drip tape, etc.

Another item that was brought up in the focus group was that some producers in the berry industry are moving over to tunnel houses for some of their berry operations. This discovery indicates that our survey would obtain how much plastic is currently used, but the information may become outdated quickly depending on the rate of technology adoption and how many producers are moving to this new production method. This suggests that a question should be asked regarding the producer's future plans on usage of plastic, which would provide information on whether the producer is considering expanding plastic usage.

A third issue that was explored by the focus group was that some of the questions were confusing to them or they did not know the answer. One question asked how many plastic containers the producer uses, including pesticide containers. The only plastic containers the berry industry uses in production are from pesticide containers. The producers mentioned that they do not keep track of how many containers they used and would be guessing.

One of the recommendations provided by the berry focus group was to send different surveys for the different groups that were targeted to minimize confusion. This was a valid critique but it would require greater resources than were allotted for this project. The main reason this is impractical is because many producers have diversified operations. To address this issue, the survey was segmented into sections related to each producer group.

Summary of Findings from Dairy Producer Focus Group

The next focus group that was conducted was the dairy industry. The literature review showed that the dairy industry on the East Coast was a big user of plastic related to the baling of their feed. After a brief examination of the California dairy industry, it was learned that California dairymen do not generate much plastic related to feed. Follow-up research to the literature review has identified two uses of agricultural plastic by the California dairyman that was not identified in

the literature. These producers used agricultural plastic for two reasons—to cover their lagoons and to cover their manure piles. While this plastic is not easily recyclable, there is value on understanding how much is used in California.

Pulling the dairy group together was difficult. One of the main reasons was due to a lack of interest. There were two reasons why this group apparently was not interested in participating in a study on disposal of agricultural plastic. Both reasons were confirmed when the focus group was conducted with a couple of dairy producers. First, the dairy industry does not see itself as a large agricultural plastic user. Unlike the berry industry, the plastic used in the dairy industry is for long-term purposes and has a long life. The dairy producers then do not have to deal with disposal on a yearly basis like the berry industry. While the plastic that producers cover their manure piles with was disposed of more frequently than the lagoon plastic, it is not a considerable amount.

The second reason is because disposing of plastic is quite low on their list of priorities. Many of the producers contacted wondered why they were considered for this issue. Disposal of plastic is considered a non-issue for this group of producers. It is conjectured that in the future when these dairies dispose of the plastic covering their lagoons, they will become concerned. It is likely that much of the plastic used in the dairy industry will not be recyclable, but no evidence was found to support this thought.

Like the berry industry focus group, the preliminary survey was shown to the dairy producers to obtain their feedback. After reviewing the survey, the producers said the recycling of agricultural plastics was not at the top of their list of concerns and they were unfamiliar with the topic. It is unclear whether this result is indicative of the industry or the people that were participating in the focus group. They explained that the main reason for the lack of concern with recycling is that the plastic is used as a long-term product and is not removed on a regular basis. Of greater concern were U.S. Environmental Protection Agency regulations that are immediately affecting their operations.

The dairymen also indicated the survey did not pertain entirely to their industry and that made it difficult to answer all the questions. This is an important finding because if the producers perceive the questions as difficult to answer, they are less likely to fill out the survey. The questions pertaining to recycling were not answerable by the focus group participants because they were unfamiliar with it. Also, since they have not experienced a large amount of plastic disposal on a regular basis, they were not familiar with costs involved. Since they are more concerned with other regulations and have plastics that are used for long periods of time, they did not express much concern for recycling agricultural plastics. The lesson learned from this is that the survey needs to incorporate a “Not Applicable” option for those producers who are not familiar with recycling issues.

The dairy focus group has brought up some very important issues. Since plastic usage is still very much in its infancy as a technology utilized by producers in some industries, many industries may be unfamiliar with the disposal issues that accompany plastic usage. This is true in the dairy industry. This suggests the survey needs to be developed in such a way that the producers are willing to share enough information to calculate their plastic usage, as well as designing the questions so that the producers are not dissuaded from answering the survey. The dairy focus group pointed out that the initial survey needed more work.

Design and Implementation of the Producer Survey

The second prong of the study focused on a producer survey to elicit information from producers on their usage, disposal, and recycling practices for agricultural plastic. There were three

underlying goals for this survey. The first goal was to collect information on the amount and type of plastic used for a select group of industries that were believed to use agricultural plastics. This information is instrumental in estimating how much agricultural plastic is used in California. The second goal was to gather information that would provide a picture of how agricultural producers are currently disposing their agricultural plastic. The third goal was to explore producers' knowledge and desire to recycle agricultural plastic. The information gathered for this goal was used to develop a strategy for recycling agricultural plastic in the state.

The California branch of the National Agricultural Statistics Services (NASS) of the United States Department of Agriculture was used to assist with the design and the implementation of the survey. This branch operates out of the California Department of Food and Agriculture (CDFA). There are five reasons why CDFA was selected to conduct this survey. Initially, when the project was proposed, NASS was listed as the agency to conduct the survey. Discussions with NASS indicated it would have difficulty meeting the deadline for the project and recommended using their California branch. The second reason was access to a database of all producers in the state and their knowledge of sampling techniques. The third major reason is that it allowed the project researchers to provide strict anonymity, as required by the university to protect the participants in the study. CDFA's Statistics Service also has the ability and expertise to draw the stratified sample that was needed for this project, and California producers are familiar with receiving information from this agency, a factor which should help the response rate.

The final survey instrument is located in Appendix A. Preliminary drafts of this survey were based on a survey conducted by Cornell University's Environmental Risk Analysis Program administered in July and August 2002. The Cornell survey is located in Levitan and Barros (2003). This survey was changed substantially to meet the requirements of the project by using information from the focus groups and the advice of CDFA's statistical branch.

The survey was sent out to 3,000 producers in California. From the literature review, many producers were identified as users of agricultural plastic. The industries included vegetables, strawberries, other row crops, and orchards (Ennis, 1987). Another industry that was identified as a user of agricultural plastic was the hay industry, which uses baling twine (Clarke and Fletcher, 2002). The survey was sent out to the following industry groups: berries other than strawberries (80), strawberries (150), peppers (150), melons (150), tomatoes (300), nursery (300), greenhouse and horticulture (300), dairy (220), hay (250), grapes (250), and orchard which included stone fruit and tree nuts (300). The numbers in parentheses represent the sample size drawn for each commodity of interest and were chosen by the agency that performed the sampling. Since strawberries are unique in production practices to other berry producers, a unique sample was drawn for strawberry producers. Hence, for this report, the berry industry is separate from the strawberry industry.

Producers in each of the nine sampled commodities were drawn randomly. Since producers can grow multiple crops, the number represented in parenthesis denotes the producers' primary crop. It should be noted that a producer selected in the sampling process to represent strawberries also may produce other berries and could provide information for both sampling categories.

The survey was sent out in the mail early March 2007. Producers were asked in the survey to return it by March 30, 2007. If a producer did not return the survey by this deadline, a follow-up phone call was made in an attempt to gather the information over the phone. Once all the surveys were collected from producers who wanted to participate in the study, CDFA's statistical branch entered all the data into a SAS data file and returned it to the project's researcher.

The survey was categorized into five sections. Section one asked for general demographic information regarding producers' operations. Sections two, three, and four were used to collect information on producers' usage and disposal of agricultural plastic by different industries/commodities. Each asked producers to provide the amount of each plastic disposed per year in terms of pounds as well as the frequency that they disposed each type of plastic. These three sections also gave producers the opportunity to list any plastic usage that was not covered in the section. Finally, section five asked more in-depth questions regarding producers' disposal and willingness to recycle their agricultural plastics.

Section one included information regarding the county they produced the target crops in, and quantity (e.g., number of cows for dairies, square feet for greenhouses, acres for most crops, etc.) which is used for the basis of estimation. The producers were also asked whether they used agricultural plastic or were planning on using agricultural plastic in the next five years. If the producers indicated that they did not use and were not planning to use agricultural plastic, they were informed to stop with the survey and send it back. If the producers indicated that they used agricultural plastic, they were asked to go to sections two, three, or four of the survey.

Section two was designed to elicit usage and disposal practices for producers in the dairy and hay industry. Producers were asked to report their usage of: 1) lagoon covers, 2) manure/compost covers, 3) haystack covers, 4) silage bags, and 5) plastic twine. Depending on what purpose the agricultural plastic was utilized, producers were asked to report their usage in terms of either square feet or linear feet. They were also asked to provide the thickness of the plastic they used.

Section three was designed for nursery and greenhouse producers. These producers were asked questions regarding their usage of many different sizes of containers that range from one gallon up to 15 gallons. They were also asked to elaborate on the amount of six pack containers and trays that are handled. Producers were asked to provide their usage of greenhouse plastic and hoop/tunnel house coverings in terms of square feet and thickness of the plastic.

Section four covered the most producers. This section targeted berry, vegetable, orchard, and grape industries. This section asked producers to provide their usage of mulch film, drip tape, micro-sprinklers, and hoop/tunnel house covering. Depending on the usage of the plastic, producers were asked to provide either square footage or linear feet as the unit of measurement for the plastic. In addition, they were also asked to provide the thickness of the plastic. The final question in this section asked producers whether they fumigated their crops and, if so, whether they did it on their own or contracted out the service.

When interpreting the results from sections two through four, it should be understood that a major limitation of this survey was that it relied on producers' record keeping. While some producers might keep good records, others may not. Another issue that arises is that even if the producers keep diligent records in general, there is no guarantee that these producers keep detailed usage and disposal information on their plastic usage. Hence, the responses from these three sections could represent the producer's estimate or guess. Given this possibility, it is expected that there will be a wide range of producers' responses.

Section five of the survey was meant to be answered by any producer who reported that they used agricultural plastic. This section was divided into two major areas. The first set of questions inquired about the producers' usage and disposal practices of agricultural plastic. Producers were also asked about their annual expense on agricultural plastic, how the plastic was disposed, when the plastic was disposed, and the annual cost to dispose the plastic.

The second set of questions in this section was related strictly to recycling of the agricultural plastic. The first question in this area asked producers to identify how far they are willing to travel to recycle their agricultural plastic for free. The next question asked how much they are willing to pay per ton if a service would pick up unsorted or sorted agricultural plastic from their facility. Two questions asked whether the producers knew of any recycling facilities in their county and whether they know any recycling facility that would take their plastic. One question asked about actual or expected difficulties of recycling agricultural plastic. The final question asked what would encourage the producer to recycle their agricultural plastic. Producers had the option of selecting multiple responses for each question for each of these last two questions.

Survey Results

General results

There were 3,000 surveys sent to producers regarding their usage, disposal, and recycling practices regarding agricultural plastic. A follow-up phone call was generated to gather the survey information if the producers did not return the survey by mail. Out of all the surveys sent, 2,206 producers returned the survey by mail, completed the survey by phone, or declined over the phone to participate in the survey. Eight hundred and ninety-five producers responded to at least a portion of the survey, with 389 respondents indicating that they used agricultural plastic. Hence, 43 percent of the producers that filled out a portion of the survey indicated they used some form of agricultural plastic.

Table B1 in Appendix B lists by county the participants who were contacted for this study. It presents how many producers were contacted, how many indicated they used agricultural plastic, and how many producers did not use agricultural plastic. Out of California's 58 counties, five counties were represented from either the mailed survey or phone follow-up. These counties were: Alpine, Amador, Inyo, Mariposa, and San Francisco. Each of these counties represents a very small amount of agriculture production in the state. Forty-six counties in the survey had at least one producer indicating that they used agricultural plastic. Close examination of this table shows that the counties which had the highest amount of producers using agricultural plastic were: Monterey, San Diego, Santa Barbara, Fresno, and San Joaquin. The first three counties contain large numbers of berry and nursery producers and were expected to have the largest amount of producers indicating they used plastic. Santa Barbara is the only county which is not in the top ten agricultural production regions.

When drawing the target sample, an attempt was made to exclude producers with less than $100,000 in average gross income. The project researcher determined that the big agricultural plastic users and the bulk of plastic usage are associated with larger farms. This is due to the fact that the majority of California agricultural production comes from large farms. Figure 1 shows the distribution of average yearly gross income earned by producers in the survey, while Figure 2 presents the distribution of average gross income for the producers who indicated they used agricultural plastic. The target group for the study was producers who earned an average gross income over $100,000, though there still was a small group of producers in the survey that reported earning less than $100,000. Considering that approximately 75 percent of the agricultural producers in the state report less than $100,000 in yearly gross income, the sampling process removed most of the producers that were not targeted for the survey.

Figure 1: Average Gross Income of All the Producers in the Survey

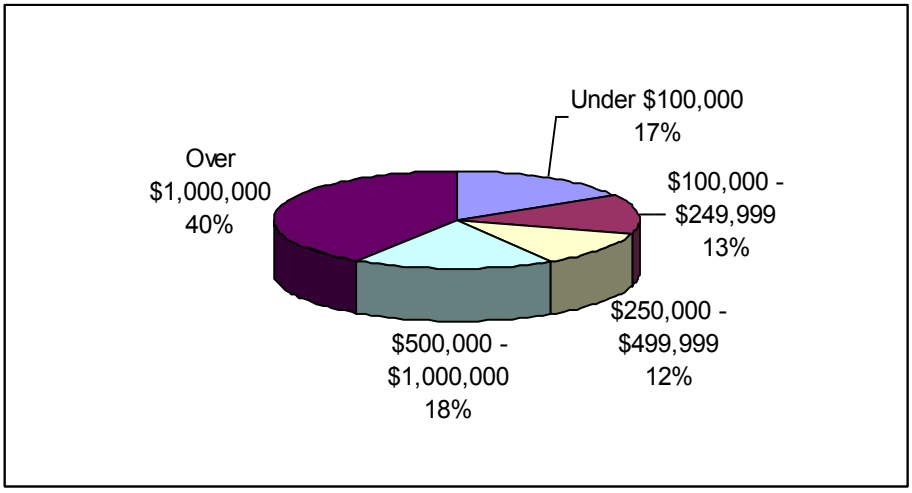
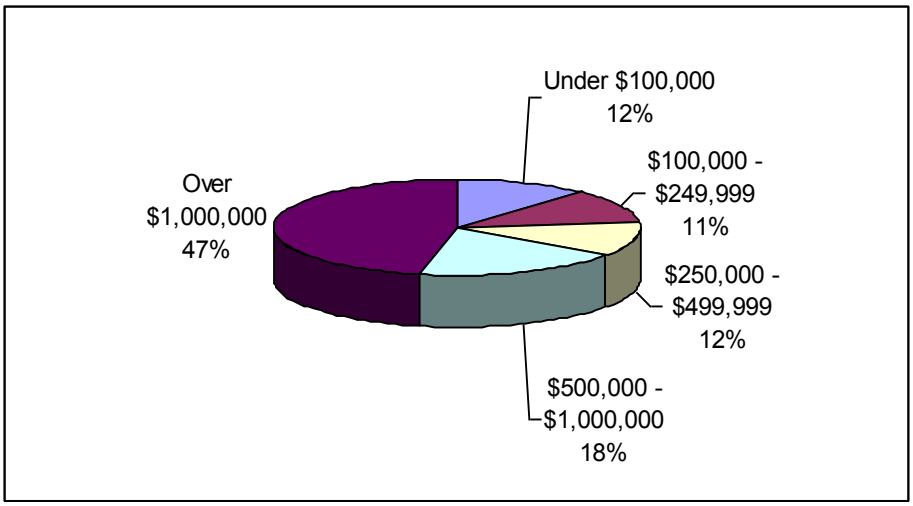


Figure 2: Average Gross Income of the Producers Who Used Agricultural Plastic



Comparing the distribution of producers based on gross income distribution with 2002 USDA Agricultural Census data shows that the respondents in the survey are biased towards large producers with over $500,000 in average gross income. It is reasoned that this bias is occurring because crops that use agricultural plastic, e.g., strawberries, nursery, etc., generally are high value crops, which suggests a predisposition in gross income towards the upper-end of the distribution. Examining the producers who reported utilizing agricultural plastic with the total producers in the survey who answered the questions demonstrates that plastic users were slightly skewed towards the high side in relationship to gross income. This supports the notion that larger producers are more likely to use agricultural plastic than the small producers.

Producers who used agricultural plastic indicated they spent $14.3 million per year to purchase agricultural plastic. This group specified that they disposed of approximately 5.57 million pounds of plastic per year. This calculation includes one producer who indicated that he disposed of 3 million pounds of plastic per year. This number is clearly an outlier. When factoring out this result, the group which made up 215 of the producers indicated they disposed of 2.57 million pounds of plastic per year.

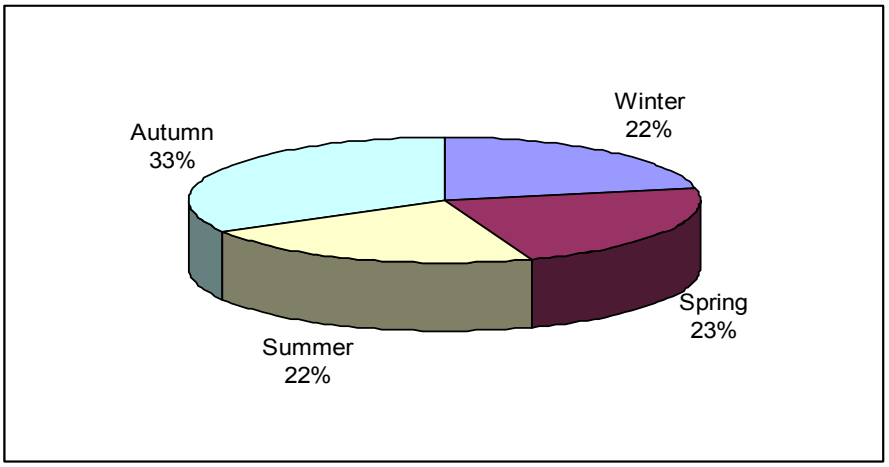
Table 3 provides the distribution of this disposal by income level. The highest average and highest total disposal was reported by producers who made over $1 million. Ninety producers in this income bracket reported that they disposed of 2.31 million pounds of agricultural plastic which equates to 25,614 pounds per producer. This highest income bracket represents nearly 90 percent of the total disposal reported. The second highest average and total was reported by a producer who earned between $500,000 and $1 million in gross income. The lowest total and average was reported by the lowest income bracket. This group represented only 0.36 percent of the total disposal reported. The largest farms by income on average disposed 80 times the amount of plastic than the lower income bracket farms.

Table 3: Pounds of Agricultural Plastic Disposed of Annually By Income Level for Producers in the Survey

Income	Total	Average	Total Reporting
Under $100,000	9,280	320	29
$100,000 - $249,999	95,884	3,306	29
$250,000 - $499,999	50,630	1,808	28
$500,000 - $1,000,000	109,962	2,820	39
Over $1,000,000	2,305,224	25,614	90
Total	2,570,980		215

Figure 3 shows the primary season producers disposed their agricultural plastic. Autumn had the highest percentage with one-third of the producers indicating this was the primary season for disposing agricultural plastic. The other three seasons garnered approximately the same percentage of producers. These results indicate a slight bias for producers to dispose their agricultural plastic in the autumn months; otherwise, the bulk of plastic is disposed throughout the year. Caution should be taken when interpreting this result, because agricultural plastic is disposed throughout the year. However, the volume of plastic is not equally distributed throughout the seasons. Some industries do heavily utilize and dispose of the agricultural plastic in one particular season.

Figure 3: Primary Season Producers Disposed of Their Agricultural Plastic



The producers who did not use agricultural plastic were asked whether they had any plans to utilize agricultural plastic in the next five years. Nine producers indicated that they were definitely planning to start using agricultural plastic, while 68 producers indicated there were no plans in the next five years. An overwhelming majority of the producers, 418, did not know whether they would start using agricultural plastic over the next five years. This group of potential "fence sitters" is waiting to see how well the management of plastic is incorporated into the industry before they adopt the practice. These unsure producers could represent a large group of agricultural plastic users especially if they determine that the benefits outweigh the cost. There is a possibility that plastic usage in the next five years could increase.

The primary methods for producers to get rid of their agricultural plastic are to either take their agricultural plastic to a landfill or to a recycling collection facility. The average distance producers haul their agricultural plastic for recycling or disposal is 10.6 miles. The range of distance traveled is from zero to 200 miles. The producers were asked various questions regarding recycling of agricultural plastic. One question asked how far producers are willing to travel if recycling their plastic was free. The average response to this question was 25.5 miles. This result in comparison to the average distance the producers travel to dispose of their plastic, 10.6 miles, shows that producers on average are willing to drive an extra 15 miles to recycle their plastic for free. The median producer reported traveling eight miles to dispose of his agricultural plastic and indicated a willingness to travel 17 miles to recycle this plastic for free.

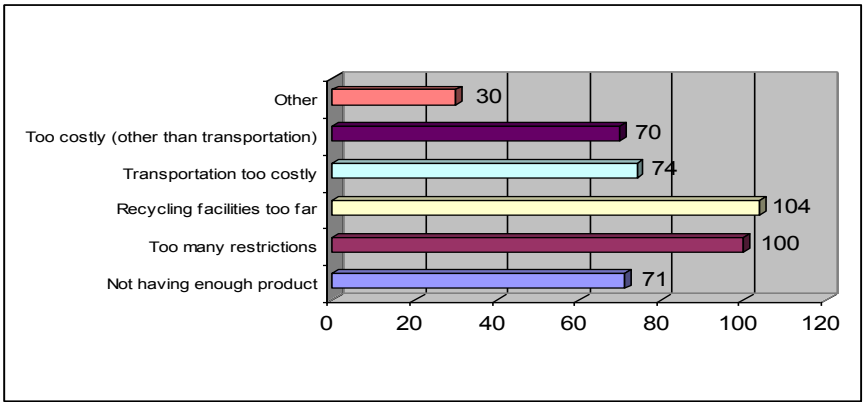
If there was a recycling pick-up service for agricultural plastic, the average producer would be willing to pay $189 per ton if not required to sort it and $191 per ton if required to sort it. Eight producers indicated they would spend over $1,000 per ton, while 106 producers indicated they would pay nothing for recycling pick-up. If you factor out the high and low ends of the responses, then the average tonnage charge this subset of producers would pay is $91 for plastic pick-up for unsorted plastic. Examining this same set of producers for sorted plastic pick-up shows that these producers would pay an average of $109 per ton for the service.

Thirty-five percent of the plastic users in the survey indicated that they currently recycle some of their agricultural plastic. Twenty-two percent of producers indicated that they knew of recycling programs in their county, while 27 percent knew of recycling facilities that would take their agricultural plastic. Since 27 percent of the producers knew of recycling facilities while 35

percent indicated that they recycle some of their agricultural plastic, it seems that some producers reuse some of their plastic for other uses rather than taking it to a recycling facility.

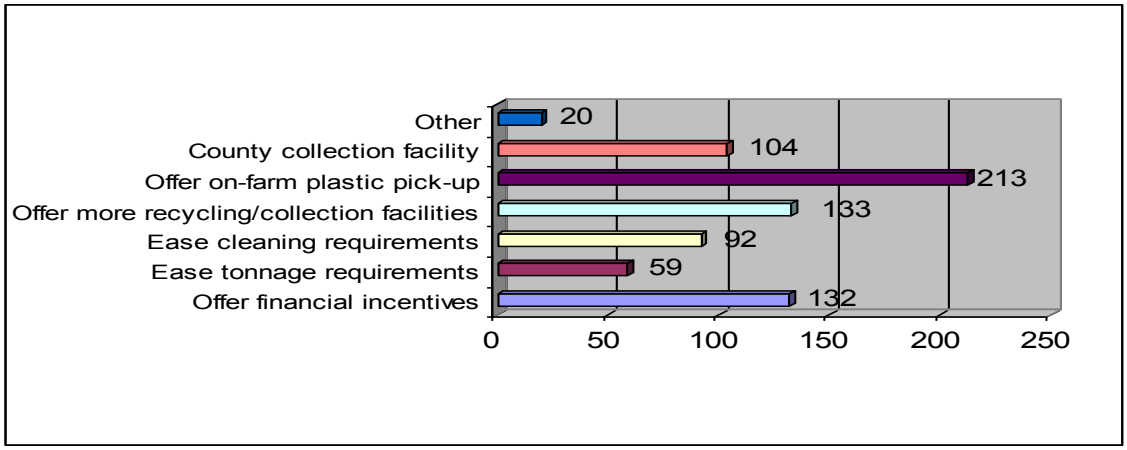
Producers were asked to indicate all the difficulties they have experienced or anticipated with recycling their agricultural plastic. Figure 4 provides the results to this question. The biggest difficulty reported by producers is that recycling facilities are too far away from their operations. This was closely followed by too many restrictions placed on what they can recycle. The response "transportation was too costly" was listed as the third biggest difficulty with 74 producers identifying it. Close to this result were responses of not having enough product and recycling is too costly in general.

Figure 4: Identified Difficulties with Recycling Agricultural Plastic



A question on the survey asked what would encourage the producers to recycle their agricultural plastic. Producers had the ability to choose multiple options on this question. Figure 5 shows that the greatest incentive that encourages producers to recycle is offering on-farm pick-up. This option garnered 213 producers, which is approximately 60 percent higher than the second closest option. The next choice to a pick-up service was providing additional collection facilities. This option had approximately the same amount of producers as the option that offered financial incentives. It appears that reducing tonnage requirements is less of an incentive than any other that was presented in the survey.

Figure 5: Options that Would Encourage Producers to Recycle Agricultural Plastic



Results for the Berry Industry Other Than Strawberries

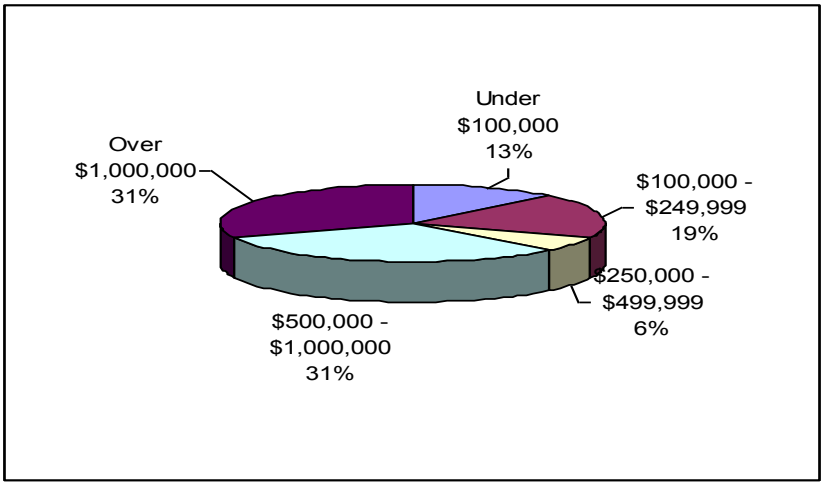
There were 80 surveys sent out to berry producers other than strawberry producers. This group included raspberry, blueberry, blackberry, etc. Out of this group, 22 producers returned information regarding their usage of plastic. Another 14 producers chosen for other crops indicated that they also produce berries other than strawberries. These other producers included two from the strawberry industry and the nursery industry, one from the pepper, greenhouse and melon industries, three from the tomato industry, and four from the orchard industry. This suggests that the sample represented a total of 36 berry producers. Sixteen of these producers indicated that they used agricultural plastic while the rest identified themselves as non-plastic users. This equates to a 44 percent participation rate for berry producers other than strawberries using agricultural plastic. This group represented 1,631 acres of berries other than strawberries. Seven producers had less than ten acres, while three producers had over 100 acres of berries.

As seen in Table 4, the berry producers represent nine different counties in California. Monterey and Santa Cruz counties had three producers each, while the remaining counties were each represented by one berry producer. Figure 6 presents the distribution of income of these producers. The majority of producers had a gross income over $500,000 per year. Thirteen of these producers indicated that they spent a combined $147,732 on agricultural plastic in the year, which equates to $940 per acre. The median amount spent on agricultural plastic was $300 per acre.

Table 4: County and Number of Representatives Who Used Agricultural Plastic for the Berry Industry Other than Strawberries

County	#	County	#	County	#	County	#
Fresno	1	Merced	1	San Joaquin	1	Shasta	1
Los Angeles	1	Monterey	3	Santa Clara	1	Tulare	1
Madera	1	San Bernardino	1	Santa Cruz	3	Ventura	1

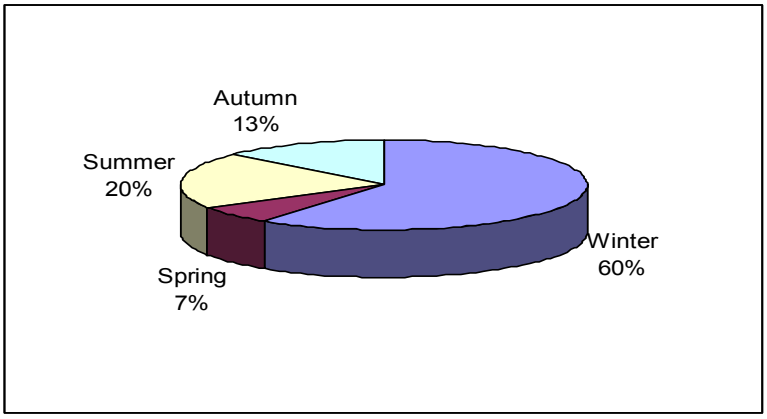
Figure 6: Average Gross Income Distribution of Berry Producers Other than Strawberries Using Agricultural Plastic



Although 16 berry producers indicated that they used agricultural plastic, few producers shared their usage of agricultural plastic in the survey. The only agricultural plastic that received more than one response was the use of drip tape. Four producers reported a range of usage of drip tape that spanned 119 linear feet per acre to 30,000 linear feet per acre. They consistently indicated that the drip tape they used for production was six mils thick. One producer reported that he disposed of his drip tape every two years, while two other producers indicated they disposed of their plastic every 12 months. The three other plastics used by the berry producers were mulch film, micro sprinklers, and hoop/tunnel house coverings. Due to the sketchiness of the data reported for these plastics, they are not presented in detail. Fifteen producers reported the primary season they disposed of their agricultural plastic.

The berry producers in this study provided much more information on their disposal habits of agricultural plastic. As seen in Figure 7, 60 percent of these producers indicated that the winter season was the primary time they disposed of the plastic. Twenty percent of producers indicated that they disposed of their agricultural plastic in the summer months, while another 13 percent indicated autumn as the primary month for disposal. The rest of the producers indicated spring was the primary month for disposing their agricultural plastic. The primary method of discarding agricultural plastic for berry producers is to take it to a landfill. Eleven producers indicated that they used this option. Another four producers noted that they take their agricultural plastic to a recycling collection facility.

Figure 7: Primary Season Other Berry Producers Disposed of Their Agricultural Plastic

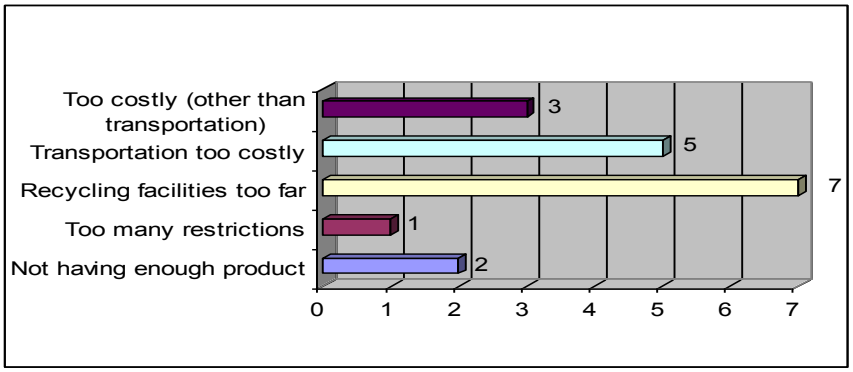


While berry producers were not forthcoming on the agricultural plastic they disposed of on a commodity basis, they did answer the question on the disposal of their agricultural plastic. The median reported disposal of agricultural plastic was 290 pounds per year, whereas the average was 4,996 pounds per year. Examining this on a per-acre basis shows the median at 68 pounds per year and the average at 116 pounds per year. Berry producers traveled an average of nine miles to dispose their agricultural plastic. The furthest any producer traveled was 30 miles. The average amount a year in tipping fees was $397 per year, while the hauling cost average was $660 per ton.

Four berry producers out of the 16 indicated that they currently recycle their agricultural plastic. Three berry producers knew of recycling facilities in their county that would take agricultural plastic, but only two producers knew of recyclers that would take the plastic that they used. When berry producers are given the choice of recycling, they indicated that they were willing to travel up to an average 41 miles to recycle their plastic for free. Berry producers are willing to pay $38 per ton whether or not they had to sort the plastic. Since the amounts are identical, it is assumed that berry producers are indifferent to sorting their plastic for a company that is willing to pick up the plastic. This result may stem from the fact that these producers did not use different types of plastic on their operations; therefore they did not value sorting their plastic over not sorting it.

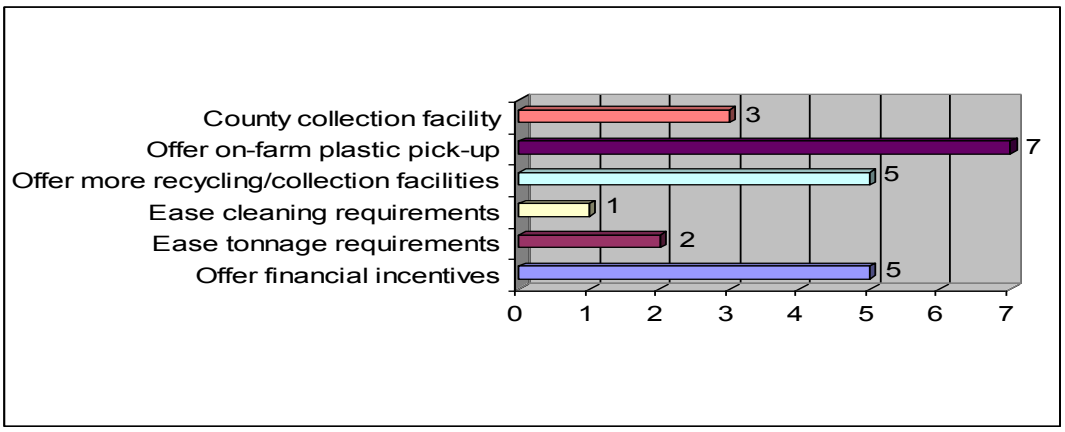
Figure 8 provides information regarding the perceived or actual difficulties with recycling agricultural plastic for the berry producers. It shows seven berry producers believed that recycling facilities were too far away from their operations and that five producers reported that transportation was too costly to recycle. Three producers mentioned that it was too costly beyond the transportation cost, while two producers thought that not having enough product may pose a problem. Only one producer stated that there were too many restrictions which made it difficult to recycle.

Figure 8: Identified Difficulties by Other Berry Producers for Recycling Agricultural Plastic



Information on the incentives that encourages berry producers to recycle their agricultural plastic is presented in Figure 9. This figure shows that berry producers prefer on-farm pick-up above any other incentive for recycling. Seven producers indicated that a pick-up service would encourage them to recycle. Five producers responded that they would recycle if financial incentives were offered, while five other producers indicated that offering more recycling/collection facilities would induce them to recycle. The least important incentive was easing the cleaning requirements with only one producer selecting this choice. Easing the tonnage requirement only garnered two people, while having a collection facility received three responses. Producers were allowed to select more than one response for this question.

Figure 9: Incentives for Encouraging Recycling of Agricultural Plastics for Other Berry Producers



Results for the Strawberry Industry

Since strawberry users were identified to be heavy users of agricultural plastic and have unique production practices using agricultural plastic, this group was separated from other berry producers. There were 150 surveys mailed to producers in the strawberry industry. Out of this group, 43 producers submitted information for the survey. Another 21 producers from other commodities selected for the survey indicated that they also produce strawberries. This group was comprised of three each of berry and nursery producers, eight pepper producers, a single melon producer and a single greenhouse producer, and five tomato producers. This brings the total of strawberry producers to 64, which represent 7,522 acres of strawberries. Out of this group of producers, 60 strawberry producers identified themselves as plastic users. This suggests that approximately 94 percent of producers in the strawberry industry are using some form of

agricultural plastic. These producers reported spending $2.25 million on purchasing agricultural plastic. This equates to a median amount of $583 per acre and an average price of $706 spent per acre on agricultural plastic. Three other producers indicated that they did not use plastic, while one did not respond whether or not they used plastic. Two out of the three non-plastic users accounted for only one acre of strawberry land, while the third non-plastic user accounted for 215 acres. Figure 10 shows the income distribution of strawberry producers using agricultural plastic. Sixty-two percent of these plastic users reported an average gross income stream from production over $1,000,000.

Figure 10: Average Gross Income Distribution of Strawberry Producers Using Agricultural Plastic

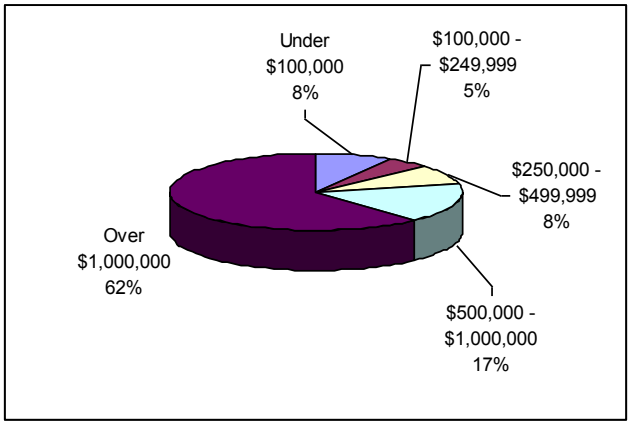


Table 5 below shows the number of producers who used agricultural plastic categorized by counties. Santa Barbara and Monterey had the highest number of producers using plastic on their strawberry fields. Each of these counties had 12 producers return the survey. Ventura and Santa Cruz counties had the next highest amounts of producers who indicated they used plastic at ten and nine respectively. These four counties represent approximately 72 percent of the strawberry producers from the sample that uses agricultural plastic. This group accounts for 5,579 acres out of 7,552 reported by the entire sample of strawberry producers. The recycling industry, which is interested in recycling agricultural plastic from strawberry producers, should focus on these four counties due to the high number of strawberry producers.

Table 5: County and Number of Representatives Who Used Agricultural Plastic for the Strawberry Industry

County	#	County	#	County	#	County	#
Fresno	1	Orange	4	Santa Barbara	12	Ventura	10
Los Angeles	2	San Benito	1	Santa Clara	4	Yolo	1
Madera	1	San Bernardino	1	Santa Cruz	9		
Monterey	12	San Diego	1	Santa Luis Obispo	1		

The strawberry producers in this study consistently identified two types of plastic that they used in their production. Twenty-six producers in the study provided information on their usage of plastic mulch estimated in square feet, while 27 producers supplied information on their usage of

drip tape approximated in linear feet. Two producers indicated that they were using micro-sprinklers. One producer reported using some other type of plastic for their strawberry production but they did not identify what type or its use. Given the low usage of micro-sprinklers and other types of plastic, discussion is limited to mulch plastic and drip tape.

There was a wide range reported by the strawberry producers on how much agricultural plastic mulch is used on an acre basis. The lowest per-acre usage of this plastic was four square feet per acre; whereas, the highest usage reported was 90,000 square feet per acre. The second lowest producer indicated that they used 1,000 square feet of plastic per acre. The thickness of the plastic used by producers ranged from one to six mils. Fifty percent of producers indicated that they used two mils thick plastic, while another 43 percent responded that they used one mil thick plastic. While studying the thickness levels of agricultural mulch plastic used for strawberries, it was found that there are thickness levels that are between one and two mils. It is believed that some producers in the survey rounded the thickness either up or down.

The average plastic mulch usage for the sample was calculated at 35,145 square feet per acre, while the median was 42,667 square feet per acre. Careful examination of the data shows that the amount of plastic used per acre is positively correlated to the amount of acres that is used by strawberry growers. Given this information, a weighted average using acres was taken to give large producers a greater impact on the average. Examining this weighted average shows that producers who responded to this survey used approximately 43,500 square feet of agricultural plastic per acre. This result is much closer to the median than the average implying that smaller producers are using less plastic per acre than larger producers. An acre of land is 43,560 square feet, suggesting that the typical producer is not covering every inch of ground with plastic. This may be due to buffer strips that are required to meet certain regulations for producing. Focusing on the top four counties reveals that Ventura County uses the most plastic mulch with an average of 48,134 square feet per acre. All three other counties used much less plastic per acre. This suggests from a quantity standpoint, the recycling industry interested in plastic mulch from strawberry fields should first focus its attention on Ventura County.

The strawberry producers were asked to indicate how often they discarded their plastic mulch. Sixty-eight percent of the producers indicated that they disposed of their plastic mulch yearly. Another 12 percent responded that they disposed of this product every six months, while 10 percent reported that they disposed of their plastic mulch on a monthly basis. Other responses for this question included every two months, nine months, 11 months, 14 months, and 24 months.

These producers were asked to indicate how much plastic mulch they discarded in a year. The responses to this question ranged from 7.69 pounds per acre up to 704 pounds per acre. The average poundage eliminated annually was 312 pounds while the median was 325 pounds. Taking a weighted average based on acreage gives a disposal weight of 311 pounds per acre. The UC Davis Cost Studies for strawberries typically used a weight of 350 pounds per acre. The information found in this producer survey is lower than what these cost studies report. Hence, it is suggested that an estimation of plastic mulch disposal for the state based on the cost study is viewed with caution. Results from the survey show a large fluctuation on how much plastic is used and it appears that these results are specific to the county.

Other than plastic mulch, the other type of plastic that is highly used by berry producers is plastic drip tape. The responses for the amount of drip tape used per acre ranged from 5.22 linear feet per acre up to 75,144 linear feet. It is unclear why the low end is so low. It is possible that the producer indicating this usage was testing the possibility of utilizing drip tape. Or, the producer made a calculation error when making the estimate on usage. There were two other producers

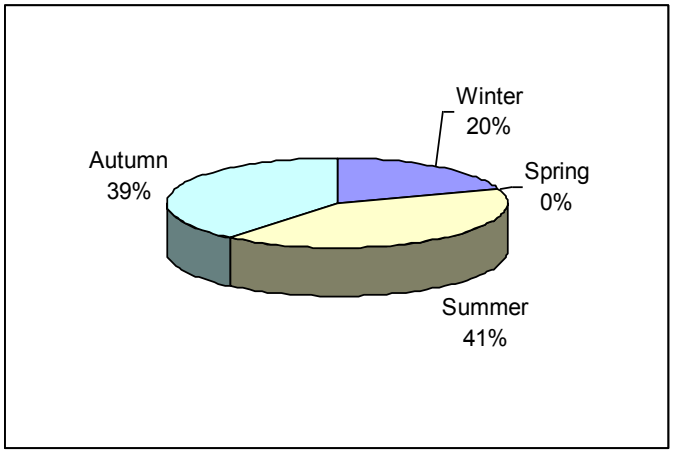
who reported drip tape usage less than 3,000 linear feet per acre. One reported 18 linear feet per acre, while the other producer indicated a usage of 240 linear feet per acre. The producer who indicated 18 linear feet was also the producer from above that estimated their plastic mulch usage at four square feet per acre.

The median strawberry producer reported using 16,000 linear feet of drip tape per acre. An average usage of drip tape was reported at 17,937 square feet. Taking a weighted average using acres, the estimated usage of drip tape per acre is 22,871 linear feet. The thickness of the drip tape used ranged from one mil thick up to eight mils thick. The primary thickness of the drip tape used ranged from four mils to six mils thick. Forty-seven percent of the producers indicated that they used four mils thick plastic, 26 percent used five mils thick drip tape, and 12 percent used six mils thick. Six percent of the producers indicated that they used eight mils thick drip tape, while another 6 percent used one mil thick drip tape. The rest of the producers reported that they used drip tape that was seven mils thick. When asked how much drip tape the producers discarded each year, the median reported weight was 104 pounds per acre. The average reported weight per acre was 189 pounds, while the weighted average based on acreage was calculated at125 pounds per acre.

Producers were queried on how often they discarded their drip tape. Sixty-nine percent of producers indicated that they disposed their drip tape on an annual basis, while 12 percent discarded their drip tape on a monthly basis. Five percent of the strawberry producers reported that they disposed their drip tape every two months, while another 5 percent indicated disposal occurred every 24 months. Other responses for this question were every nine, 11, 14, and 36 months.

Figure 11 provides a look at the primary months that strawberry producers eliminated their largest volume of agricultural plastic. At 41 percent, the summer season garnered the highest percentage of producers indicating that they disposed the largest volume of plastic during this season. At the other end of the spectrum, none of the producers indicated that they disposed of their agricultural plastic in the spring. Thirty-nine percent of strawberry producers primarily discarded the agricultural plastic in the autumn months, while only 20 percent reported that this occurs in the winter months.

Figure 11: Primary Season Strawberry Producers Disposed of Their Agricultural Plastic



A regional perspective is valuable when examining the seasons that strawberry producers primarily disposed of their agricultural plastic. Examining the top four producing strawberry counties from the survey--Santa Barbara, Monterey, Ventura, and Santa Cruz--show that the disposal of agricultural plastic differs by region. Almost all of the producers in Ventura County discarded their agricultural plastic in the summer months. A slight majority of producers in Santa Cruz County disposed of their agricultural plastic in the autumn months following a high proportion disposing agricultural plastic in the winter season. There is an equal split of producers in Santa Barbara County that discard their agricultural plastic in the summer and autumn months. Fifty percent of producers in Monterey County indicated that they threw out their agricultural plastic in the autumn months, while most other producers in this county used the winter months to discard the plastic.

There were 55 producers who responded to a question regarding their fumigation practice. Eight of these producers, which represent approximately 14 percent of the sample, indicated that they fumigate their own fields. Examining acreage and location showed no patterns for producers who fumigated their own field. A slight majority of 28 producers indicated that they contracted to have their fields fumigated. Another 19 producers indicated that they did not fumigate their fields.

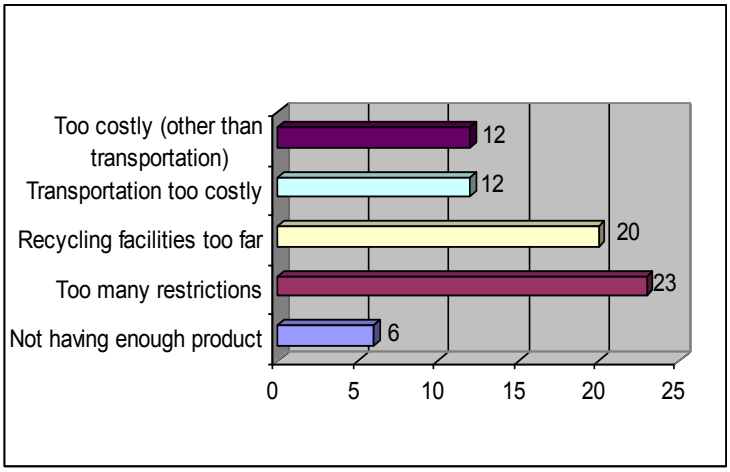
The primary method to get rid of the agricultural plastic for strawberry producers was taking it to a landfill. Thirty-nine producers indicated that they take their agricultural plastic to a landfill, while 17 producers indicated that they take their plastic to a recycling facility. Four of the producers who recycle are primarily in Monterey, six strawberry producers recycle in Santa Barbara, one in Santa Clara, and three each are in Santa Cruz and Ventura. The average distance traveled to a landfill is 11 miles, while the median travel distance is ten miles. Producers reported that they paid an average of $2,028 per year in tipping fees and another $1,250 per ton in hauling costs which includes travel and labor costs.

Producers in the survey were given a couple of different disposal options in the survey. Producers are willing to travel an average of 28 miles or a median of 20 miles if there are no disposal costs. This suggests that strawberry producers on average would travel an extra 17 miles if they could dispose of their agricultural plastic for free. Producers are willing to pay $69 per ton if a recycling program was willing to pick-up their agricultural plastic but required them to sort it. Strawberry producers will pay an average of $127 per ton if they do not need to sort the plastic. Producers, therefore, are willing to pay an average of $58 per ton to avoid sorting the agricultural plastic.

Approximately 31 percent of strawberry producers indicated that there was a recycling program for agricultural plastic in their county, while another 31 percent indicated there was no such facility. The rest of the producers did not know whether or not a recycling facility existed. There was no particular county in the top four strawberry counties that had a majority of the producers indicating that a recycling program existed in their county. Only 20 percent of the producers indicated that they knew of a recycling facility that would take their plastic. This means that although 30.5 percent of the producers know that there is a recycling program for agricultural plastic, some of these programs may not accept agricultural plastic from strawberry fields. Interestingly, 31 percent of producers indicated that they recycle agricultural plastic.

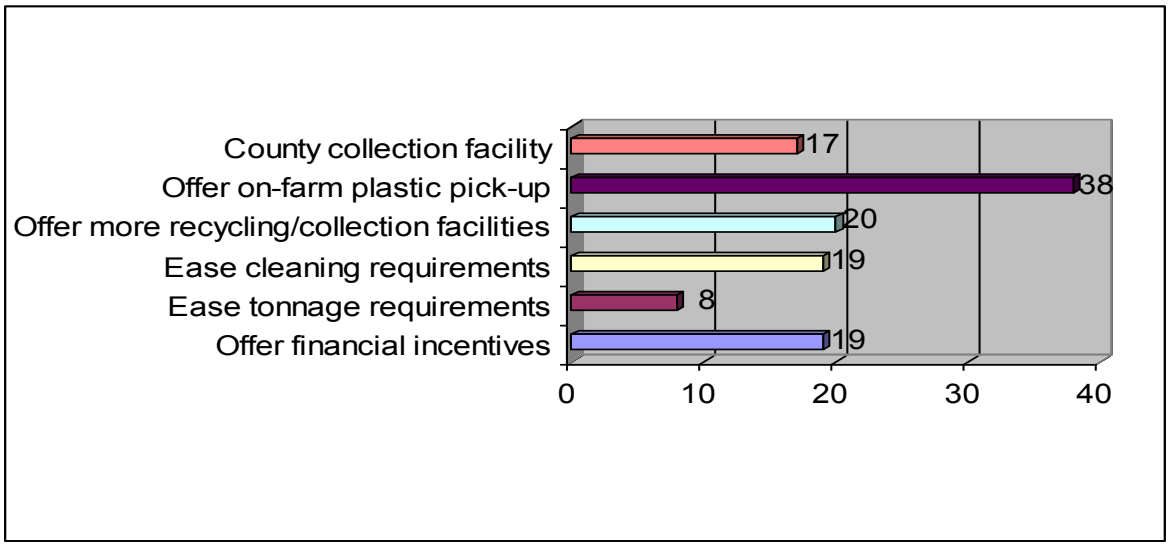
Producers were asked to identify what difficulties they expect or have experienced with recycling agricultural plastic. These producers were able to mark as many possibilities that applied to them. Figure 12 shows the results of this question. The top two difficulties seen by strawberry producers are that there are too many restrictions on recycling and the recycling facilities are too far away from their operation. Twenty-three strawberry producers indicated that a difficulty with recycling was that there were too many restrictions. This was followed closely by 20 producers that reported that the recycling facilities were too far from their operation. Only a small amount of producers thought that not having enough product was a restriction.

Figure 12: Identified Difficulties by Strawberry Producers for Recycling Agricultural Plastic



While the previous figure showed the difficulties foreseen with recycling agricultural plastic, Figure 13 shows what incentives would induce strawberry producers to participate in recycling their agricultural plastic. The biggest incentive these producers identified was to offer on-farm plastic pick-up. This option has twice as many producers as the next closest options of county collection facilities and offering more recycling facilities. This suggests that strawberry producers are looking for the convenience of on-farm pick-up. The key to this solution is the cost of the on-farm pick-up. Prices producers were willing to pay for a pick-up service for sorted and unsorted plastic were given above. The option that received the fewest producers was easing of the tonnage requirements. This was an issue that was mentioned by a producer in the strawberry focus group, but it does not seem to be a big issue for producers in the survey. This may be due to the lack of experience with recycling the agricultural plastic.

Figure 13: Incentives for Encouraging Recycling of Agricultural Plastics for Strawberry Producers



Results for the Grape Industry

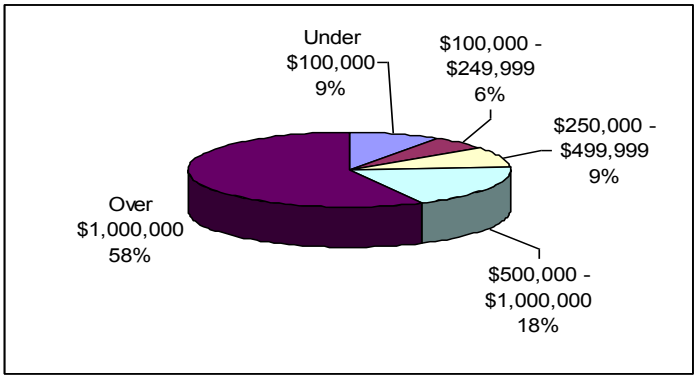
There were 250 surveys sent directly to grape producers; 93 of the producers submitted information for the survey. Another 47 producers from other commodities indicated they grew grapes. Every industry that was directly sampled except for the dairy industry had a group of producers that indicated they grew grapes. There were four from the berry industry, one from the strawberry industry, three from the pepper industry, three from the melon industry, seven from the tomato industry, two from nursery, three from greenhouse, 12 from the hay industry, and 12 from the orchard industry. This brings the number to a total of 140 producers representing the grape industry. This group accounted for 56,080 acres of grape production. A majority of producers in this industry indicated they did not use agricultural plastic. Out of the 140 producers representing the grape industry, 107 of them reported that they did not use agricultural plastic. The other 33 producers indicated that they did use agricultural plastic. This means 24 percent of grape producers who responded to the survey utilize agricultural plastic in their operation. The plastic users in the grape industry controlled 24,760 acres. Table 6 displays the counties and number of representatives that use agricultural plastic to produce grapes.

Table 6: County and Number of Representatives Who Used Agricultural Plastic for the Grape Industry

County	#	County	#	County	#	County	#
Contra Costa	1	Mendocino	1	San Joaquin	2	Sonoma	5
Fresno	4	Merced	1	San Luis Obispo	1	Tehama	1
Kern	3	Monterey	1	Santa Barbara	1	Tulare	2
Madera	1	Napa	5	Santa Clara	1	Yolo	3

The 33 grape producers in this study who used agricultural plastic reported spending $625,400 per year on plastic. This equates to an average amount of $0.12 per acre and a median of $0.05 per acre spent on agricultural plastic. While this may seem low, the drip lines that grape producers use can last up to 25 years. The amount of money spent per year is on the maintenance of this system. Figure 14 shows the income distribution of grape producers using agricultural plastic. A majority of these producers, 58 percent, earned an average gross income that exceeded $1,000,000. Another 18 percent reported earning between $500,000 and $1,000,000. The percentage of producers who had an average gross income ofless than $500,000 was 24 percent.

Figure 14: Average Gross Income Distribution of Grape Producers Using Agricultural Plastic

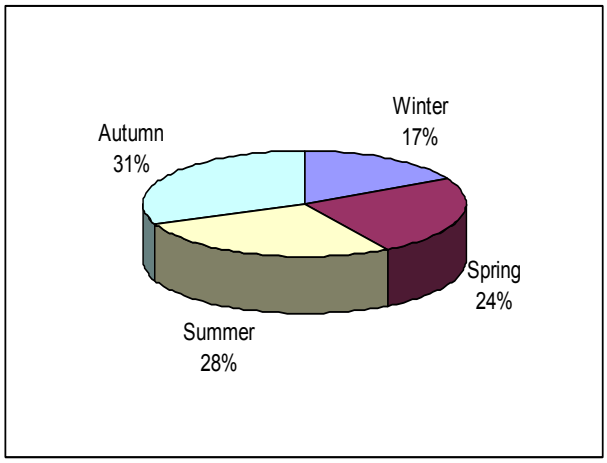


Producers in the grape industry provided sparse usage data of agricultural plastic for mulch film, drip tape, micro sprinklers, and other plastic. Much of the data that these producers gave was incomplete and had a wide variation. The most complete information given was for drip tape, which in terms of grape producers may also mean drip lines. Examining the data carefully gives the impression that grape producers are replacing and disposing of very little agricultural plastic per year. The range of drip tape used per year was between 0.1 linear feet to 3,955 linear feet per acre. The lower end of this range represents producers who are making repairs to their existing drip lines, while the upper end is likely made up of producers who are replacing their whole irrigation system over an approximate three to five year span.

Most producers indicated that they discarded their plastic on a yearly basis. One producer indicated that he disposed of his plastic every three years, while another producer indicated he replaced it every five years. This disposal data indicates that most producers are discarding their agricultural plastic on a yearly basis, while a few producers are saving it for longer periods of time.

The primary method grape producers used to eliminate their agricultural plastic is to take it to a landfill. The other method used by these producers was to take it to a recycling collection facility. Figure 15 shows the primary season that these producers disposed of the largest volume of their agricultural plastic. The autumn and summer seasons comprise almost 60 percent of the producers who disposed of their agricultural plastic. Only 17 percent of producers indicated that they discarded their agricultural plastic in the winter months.

Figure 15: Primary Season Grape Producers Disposed of Their Agricultural Plastic



Twenty grape producers out of the 33 who participated in the study indicated how much agricultural plastic they discarded per year. This group indicated that they disposed of 31,904 pounds of plastic per year. These 20 producers controlled 13,800 acres, giving a disposal of approximately 2.3 pounds per acre. Since this question related all the plastic for the farm, and not just the plastic discarded for grapes, this result should represent a higher average than a producer who does grapes only. One grape producer who reported his plastic disposal also produced strawberries. Since strawberries are high-end users of plastic, this should pull the average up. The average disposal of agricultural plastic drops to 1.4 pounds per acre once this producer is factored out. The disposal that was reported is considered a marginal change. Since grape producers are using a type of plastic for irrigation that has a long useful life, at some point these producers will dispose of a large quantity of agricultural plastic at one time. It is beyond the scope of the survey to obtain long-term agricultural disposal information.

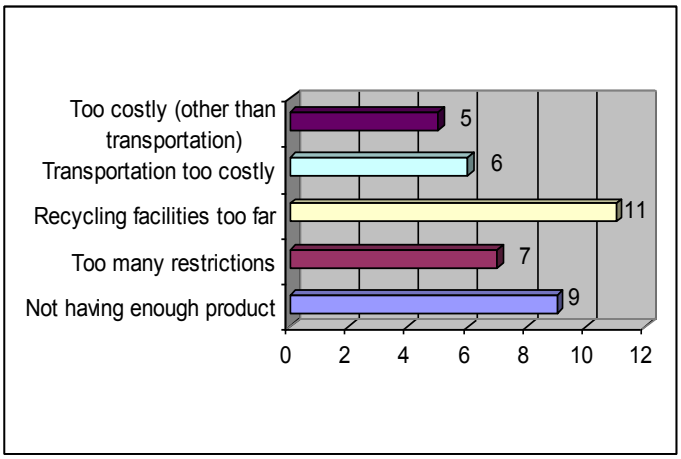
Grape producers reported that they travel an average of 14 miles to discard their agricultural plastic. It takes these producers an average of 1.75 trips to dispose of their yearly agricultural plastic accumulation. These producers spend approximately $366 per year on tipping fees and an estimated $99 per ton to haul their agricultural plastic to the landfill. Producers would travel an average of 33 miles if they could recycle their agricultural plastic at no charge. This suggests that these producers are willing to travel an extra 19 miles just to recycle their plastic for free. Producers would pay on average $71 per ton if they were required to sort it and $111 per ton if they did not have to sort the plastic with a pick-up service available for both options.

Fourteen grape producers indicated that they currently recycle their agricultural plastic, while another 18 reported that they did not. This suggests that over 43 percent of the grape producers in this study recycle at least a portion of their agricultural plastic. Thirteen producers knew of recycling programs in their county for agricultural plastic, while 14 indicated that they knew of recycling facilities that would take their plastic. Eight producers mentioned that there were no

recycling programs in their county, while another eight indicated that they did not know of recycling facilities that would take their plastic.

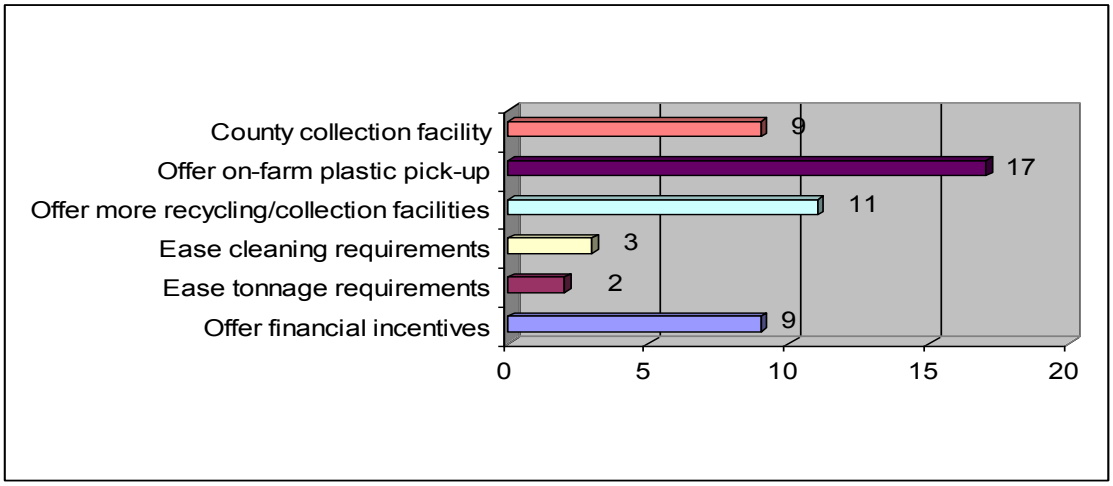
Figure 16 shows the results to the question on what difficulties producers have experienced or expected to experience with recycling their agricultural plastic. Eleven grape producers indicated that recycling facilities were too far away. In contrast, only five producers indicated that recycling was too costly when factoring out transportation costs. As expected from the disposal and production information, nine producers indicated that not having enough product made it difficult to recycle. This result was expected considering producers reported generating less than 2.5 pounds of plastic per acre per year. The average-size producer in this study controlled 750 acres of grapes, which suggests that they are generating less than a ton of agricultural plastic per year to recycle.

Figure 16: Identified Difficulties by Grape Producers for Recycling Agricultural Plastic



Grape producers were asked to indicate which incentives would encourage them to recycle their agricultural plastic. Figure 17 shows that on-farm plastic pick-up had the highest amount of producers, over half of the agricultural plastic users, indicating that this incentive would encourage them to recycle. Offering more recycling and collection facilities and having county collection facilities were strong enticements to cause grape producers to recycle their agricultural plastic. The incentives with the least results for grape producers were easing tonnage and cleaning requirements. This outcome is expected, given that grape producers are not generating a large quantity of plastic per acre annually.

Figure 17: Incentives for Encouraging Recycling of Agricultural Plastics for Grape Producers



Results for the Melon Industry

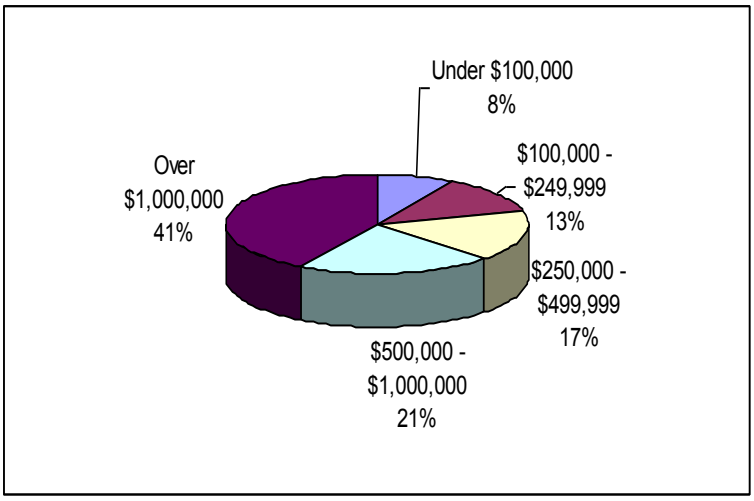
Out of the 150 surveys sent to melon producers, 23 of these surveys were returned. Another 15 surveys were returned by producers from other industries that also produce melons. These producers include one from the berry and dairy industries, six from the pepper industry, five from the tomato industry, and two from the orchard industry. This group represents 38 melon producers utilizing 4,921 acres in California. Twenty-four of these producers indicated they used agricultural plastic, while another 14 stated that they did not use agricultural plastic. This equates to a participation rate of 63 percent using agricultural plastic. The melon producers who used plastic control 3,259 acres out of the 4,921 of all melon producers who participated in the survey. Table 7 provides the number of representatives using agricultural plastic from each county. Four of these melon producers are from Yolo County, while three are from Riverside and another three are from Imperial. The rest of the counties in the table had either one or two representatives.

Table 7: County and Number of Representatives Who Used Agricultural Plastic for the Melon Industry

County	#	County	#	County	#	County	#
Fresno	2	Riverside	3	San Joaquin	2	Yolo	4
Imperial	3	Sacramento	1	San Luis Obispo	2		
Kern	1	San Benito	2	Sonoma	1		
Madera	1	San Bernardino	1	Tehama	1		

The distribution of income for the melon producers using agricultural plastic is represented in Figure 18. This figure shows that 41 percent of the producers using agricultural plastic make over $1 million in gross income. Another 21 percent identified that they earned between $500,000 and $1,000,000. While the survey was targeted at producers who earned over $100,000, eight percent of the plastic users reported that they were under this gross income.

Figure 18: Average Gross Income Distribution of Melon Producers Using Agricultural Plastic



There are two primary forms of agricultural plastic that are used by melon producers—mulch film and drip tape. Out of the 24 melon producers who identified themselves as plastic users, five producers indicated that they used 4.1 million square feet of plastic on 453 acres. Five producers provided the quantity of mulch used, and nine producers indicated the thickness of the plastic. Five producers indicated that their mulch film was one mil thick, three producers indicated that they used two mil plastic, while a single producer reported using nine mil thick plastic. Seven producers reported their frequency of discarding the plastic. Four of these producers disposed of their plastic twice a year, one producer removed his mulch plastic on a monthly basis, and two producers disposed of their plastic on a yearly basis.

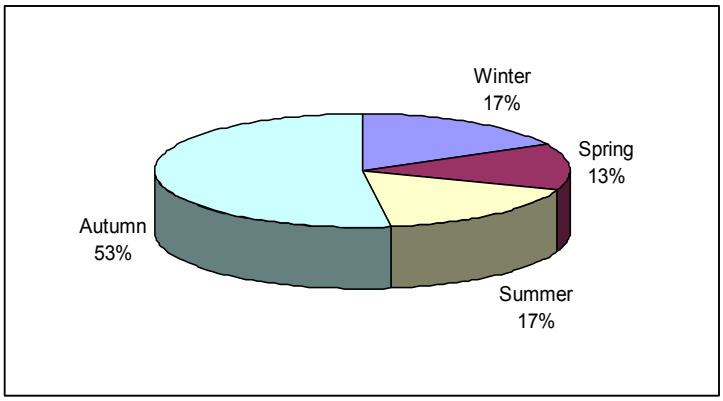
The other major form of plastic used by melon producers is drip tape. Seven producers reported using 2.04 million linear feet of drip tape on 914 acres of melons. The average usage is 2,232 linear feet of drip tape per acre. The median usage is 4,350 linear feet per acre. This drip tape had a range in thickness from two mils to eight mils with the median thickness at five mils. The average usage of drip tape is highly skewed by one producer who reported using 562,500 linear feet of drip tape on seven acres of land. This particular producer is either an outlier or intensively farming a small parcel of melons. Factoring out the high user gives an average usage of 1,629 linear feet of drip tape per acre. Ten producers stated how frequently they discarded their drip tape. Three of these producers indicated every six months, while another three reported every 12 months for disposal rates. Two producers throw out their drip tape every three years, while two other producers discard their plastic on a monthly or quarterly basis.

Nineteen producers representing 2,948 acres indicated the amount they spent yearly on agricultural plastic. As a group, these producers spent $490,450 per year on agricultural plastic. This averages out to $166 spent annually per acre. Thirteen producers reported the total amount of plastic they disposed of annually. The average weight was calculated at 2,088 pounds per acre, while the median was at 140 pounds per acre. Examining the data discloses that one producer reported disposing of 25,000 pounds per acre. The average amount disposed of calculates to 179 pounds per acre when factoring out this outlier. This result is much closer to the median. Twenty melon producers indicated that they disposed of their plastic at a landfill, while only one producer indicated that he recycled his agricultural plastic. The average distance traveled to dispose of their

plastic was 15 miles, while the median was ten miles. It is estimated that the producers spent an average of $394 per ton on travel costs to haul their agricultural plastic to the landfill. These producers made an average of 3.62 trips per year to remove their agricultural plastic and spent an average of $1,932 per year on tipping fees.

Figure 19 shows the primary season that melon producers disposed of their plastic. This figure highlights that the majority of producers discarded their plastic in the autumn months. The winter and summer seasons garnered the same amount of producers choosing these seasons as their primary months of removal, while spring was the least likely season for melon producers to eliminate their plastic.

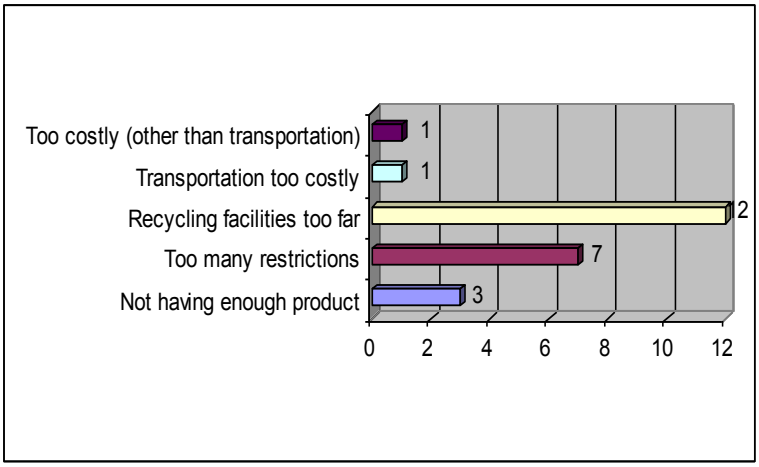
Figure 19: Primary Season Melon Producers Disposed of Their Agricultural Plastic



If melon producers had the opportunity to recycle their plastic for free, these producers would travel an average of 41 miles to recycle their plastic. This suggests that melon producers are willing to travel an extra 26 miles to recycle their plastic at no charge. These producers will pay an average of $67 per ton if they are required to sort their plastic or $76 per ton if no sorting was required. These amounts include that a collection service is provided. This suggests that producers are willing to pay an additional $9 per ton for the convenience of not sorting the agricultural plastic.

When the melon producers were asked to indicate their knowledge of recycling facilities for plastic in their county, only one producer reported being aware of one. Eleven producers said that there were none, while 12 producers did not know if there was one or not. These results are nearly the same when the melon producers were asked if they knew of any recycling facility that would take their agricultural plastic. While only one producer knew of a facility that takes agricultural plastic, three producers revealed that they recycle their plastic. This indicates that some producers in the melon industry are reusing some or all of their plastic products. The rest of the producers, 20 of them, indicated that they did not recycle their agricultural plastic.

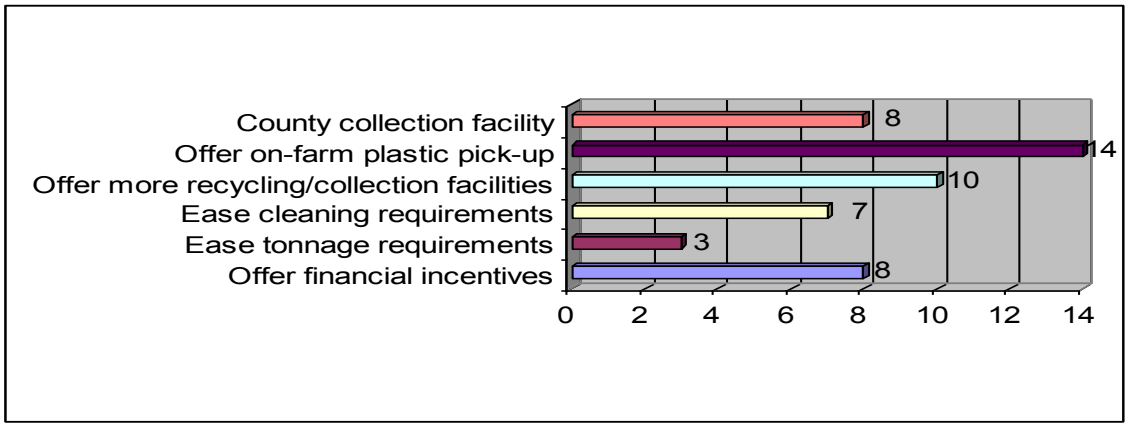
Figure 20: Identified Difficulties by Melon Producers for Recycling Agricultural Plastic



Examining Figure 20 shows that the greatest difficulty identified by melon producers for recycling agricultural plastic is that recycling facilities are too far away from their facilities. Twelve producers in the melon industry indicated that this was a difficulty with recycling their agricultural plastic. The second largest difficulty perceived is that there are too many restrictions placed on the agricultural plastic that is recyclable. The two difficulties that had the least amount of producers identifying it as a difficulty were related to the cost of recycling. One producer was concerned with transportation costs and one producer was worried with recycling costs other than transportation.

Figure 21 provides a look at what the producers believe are the incentives that would encourage them to recycle their agricultural plastic. Results shown in this figure indicate that a majority of the producers prefer the on-farm pick-up service incentive. Fourteen out of the 24 producers indicated that this was an enticement that encourages them to recycle. The next best inducement indicated is providing additional recycling and collection facilities. This confirms the results that the largest perceived difficulty of recycling for melon producers is that recycling facilities are too far away. The incentive that was considered the least was easing the tonnage requirements. Since few melon producers currently recycle, there is little experience in service denial due to a large amount of plastic; therefore, this incentive may not seem important.

Figure 21: Incentives for Encouraging Recycling of Agricultural Plastics for Melon Producers



Results for the Orchard Industry

There were 300 producers selected in the orchard industry to participate. Of this group, 118 actually took part in this study. Another 163 producers from other industries selected for this study also indicated that they contributed to the orchard industry results. This group of other producers was comprised of eight producers from the berry industry, three from the strawberry industry, 11 from the pepper industry, 14 from the melon industry, 43 from the tomato industry, 17 from the nursery industry, ten from the greenhouse industry, 11 from the dairy industry, 18 from the hay industry, and 28 from the grape industry. These 281 producers farm 126,042 acres of orchards. Out of this group, 63 producers indicated that they incorporate agricultural plastic on their operations, while the rest of these producers responded that they did not use agricultural plastic. This suggests that 22 percent of producers in this industry have adopted using agricultural plastic in their operation. Table 8 provides a look at the number of producers who used agricultural plastic in the orchard industry by county. Merced and San Joaquin counties represent over a quarter of these producers, with Merced having ten respondents and San Joaquin having seven respondents.

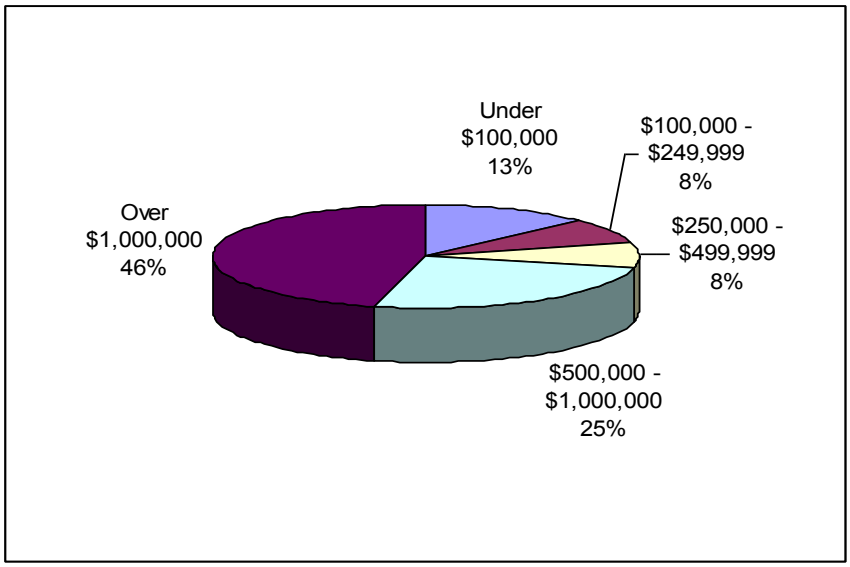
Table 8: County and Number of Representatives Who Used Agricultural Plastic for the o Industry

County	#	County	#	County	#	County	#
Butte	2	Madera	4	San Joaquin	7	Tehama	1
Colusa	1	Merced	10	Santa Clara	2	Tulare	3
Contra Costa	1	Nevada	1	Solano	1	Ventura	1
Fresno	5	San Bernardino	1	Stanislaus	6	Yolo	5
Kern	4	San Diego	4	Sutter	1	Yuba	1
Kings	2						

Figure 22 provides a look at the distribution of gross income from the producers who used agricultural plastic in the orchard industry. Over 70 percent of these producers indicated they earned an average yearly gross income of $500,000 or more. Fifty-two producers in the orchard industry reported how much of their total gross income was devoted to purchasing agricultural

plastic on a yearly basis. This group represented 20,422 acres and reported spending as a group nearly $2 million a year on agricultural plastic. This equates to an average expenditure of approximately $96 per acre. The highest average spent per acre was $3,636, while the lowest was under $1 per acre. The median spent per acre was nearly $18. One possible reason for such a wide range spent on agricultural plastic per acre is that some producers are repairing irrigation lines, while others are replacing them.

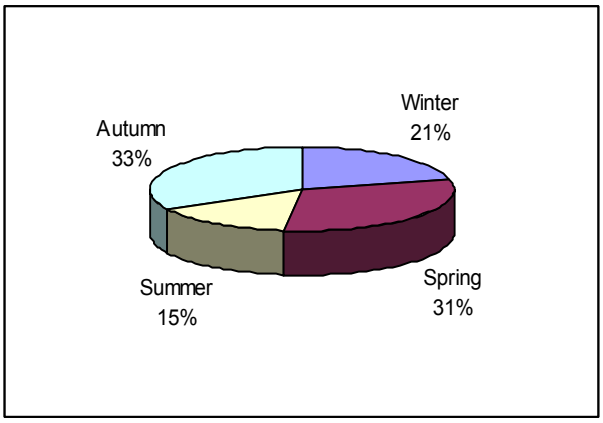
Figure 22: Average Gross Income Distribution of Orchard Producers Using Agricultural Plastic



There are two types of agricultural plastic that were primarily reported by the orchard industry: drip tape and micro-sprinklers. Six producers reported usage of drip tape, while nine producers indicated that they used micro-sprinklers. One producer in these two groups reported using both drip tape and micro-sprinklers. The group of producers that utilizes drip tape used between 125 to 40,909 linear feet per acre. It appears that this upper end is either an outlier response or is a producer who just put in a drip tape system. The second highest usage of drip tape per acre was 3,333 linear feet. The average drip tape used per acre is 920 linear feet per acre if the highest value is factored out. These producers reported that they typically discarded their plastic on a yearly basis. The orchard producers who used micro-sprinklers ranged from approximately three to 1,333 linear feet per acre. The lower range probably represents the amount repaired on a yearly basis rather than how much was used per acre. The average usage per acre of this group was 239 linear feet. The typical producer discarded this plastic on a yearly basis. Two producers indicated that they disposed of this type of plastic every six months, while one producer indicated quarterly disposal and one producer reported monthly disposal.

Figure 23 shows the primary season that producers in the orchard industry disposed of their agricultural plastic. The autumn and spring seasons have approximately the same amount of producers which indicate that they primarily discard the agricultural plastic during this time period. Summer had the least amount of producers at 15 percent, while the winter season garnered 21 percent. The producers generally chose to take the plastic to the landfill as a method of disposal. There were 32 producers who indicated that they used a landfill in comparison to 18 producers who indicated that they recycle their agricultural plastic. None of the producers from this industry indicated that they bury or burn their agricultural plastic.

Figure 23: Primary Season Orchard Producers Disposed of Their Agricultural Plastic



Forty-one producers indicated how many pounds of agricultural plastic they discard from their farm on a yearly basis. Forty of these producers indicated that they disposed of approximately 356,000 pounds of plastic a year. One producer was not factored into this calculation because he reported disposing of 3,000,000 pounds of plastic in a year, which is clearly an outlier result. Examining plastic disposal on an acreage basis shows that an average of 54.76 pounds of plastic disposed of per acre, while the median is 4.72 pounds per acre. Producers took an average of 6.67 trips per year with the median at one trip per year to throw away the plastic. These producers traveled an average of 12.04 miles to dispose of the plastic, while the median distance traveled was ten miles. The producers estimated that they pay $389.34 per year in tipping fees and pay approximately $95.74 per ton to haul the plastic.

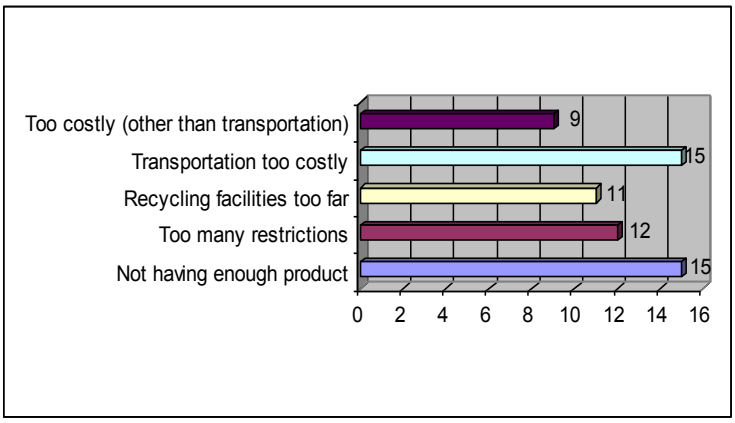
When given the option, producers on average travel up to 22.28 miles to recycle their agricultural plastic at no cost. Given that they currently travel approximately 12 miles to dispose of their plastic, this result indicates that producers are willing to travel an extra ten miles to recycle their agricultural plastic for free. If a pick-up service existed for their agricultural plastic, producers in the orchard industry would pay $552.88 per ton if they were required to sort their plastic and $396.31 per ton if they were not required to sort. These figures are high because three producers reported values over $1,000 per ton. Factoring this group out, the average willingness-to-pay for a pick-up service where the producers have to sort the plastic is $53.03 per ton, while their willingness-to-pay is $58.86 per ton if they were not required to sort. The median in both of these cases is $15 per ton, which suggests that there are a few producers who are willing to pay higher than the average.

Thirty-eight percent of the agricultural producers in the orchard industry who used agricultural plastic indicated that they recycle their plastic. This same percentage knew of recycling facilities that took their agricultural plastic, while only 32 percent indicated that they knew of recycling programs for their agricultural plastic in their county. There was an even split of producers indicating that there was either no recycling program in their county or they did not know of one. Thirty percent of producers reported that they did not know of any recycling facilities for their plastic.

Figure 24 identifies the difficulties that producers have encountered or expect to encounter with recycling their agricultural plastic. The two main difficulties expected by producers in the orchard industry are that transportation is too costly and they do not have enough plastic to recycle. Each

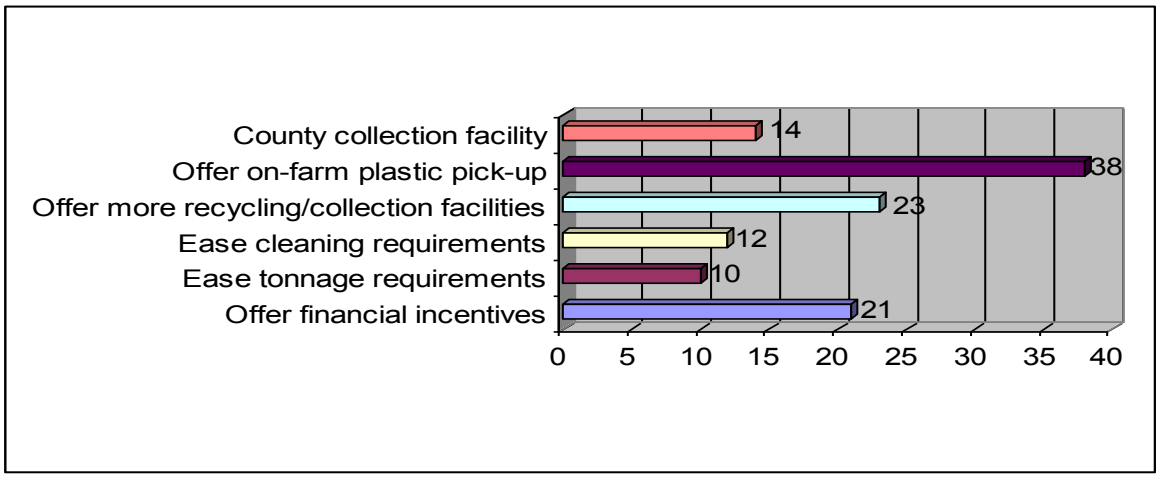
of these difficulties garnered 15 producers. The next highest difficulty is too many restrictions placed on recycling agricultural plastic. The least of the difficulties identified is recycling other than transportation costs is too costly.

Figure 24: Identified Difficulties by Orchard Producers for Recycling Agricultural Plastic



When the producers in the orchard industry were asked to identify what incentives would encourage them the most to recycle the plastic, they overwhelmingly chose having an on-farm pick-up service. Figure 25 shows that 38 producers chose this incentive, while 21 producers indicated that financial incentives would encourage them to recycle. The least preferred incentive that producers identified was easing the tonnage requirements. This correlates with the previous result that producers perceive that one of the biggest difficulties they have with recycling is having enough material to recycle.

Figure 25: Incentives for Encouraging Recycling of Agricultural Plastics for Orchard Producers



Results for the Pepper Industry

The sample drawn for the survey representing the pepper industry had 150 producers, 35 of which actually responded to the survey. There were 17 other producers representing various industries that indicated that they also produced peppers. This group comprised of one berry producer, two strawberry producers, seven melon producers, five tomato producers, one nursery producer and one greenhouse producer. There are 52 pepper producers identified in this study. This group

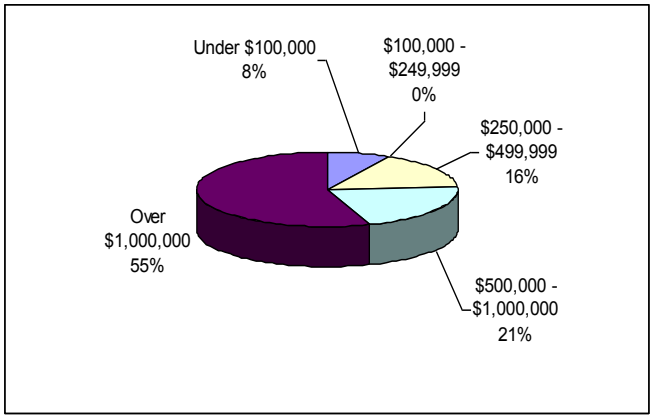
represents 3,203 acres of pepper plants. Thirty-eight of these producers identified themselves as plastic users, while the remainder indicated that they did not use agricultural plastic. This suggests that over 73 percent of producers in the pepper industry are using agricultural plastic. The pepper plastic users represent 2,465 acres of peppers and 17 counties as shown in Table 9. San Benito County had the highest number of producers corresponding to it with five producers indicating that they used agricultural plastic. Fresno, Santa Clara, and Yolo counties each had four representatives from the survey who indicated they used agricultural plastic, while the rest of the counties had three or less.

Table 9: County and Number of Representatives Who Used Agricultural Plastic for the Pepper Industry

County	#	County	#	County	#	County	#
Fresno	4	Monterey	1	San Benito	5	Santa Barbara	3
Kern	1	Orange	2	San Bernardino	1	Santa Clara	4
Los Angeles	2	Riverside	2	San Diego	1	Ventura	2
Madera	1	Sacramento	1	San Luis Obispo	3	Yolo	4
Merced	1						

Figure 26 presents the income distribution of the pepper producers who used agricultural plastic. A majority of these producers, 55 percent, indicated that they earned an average gross income above $1 million. Only 8 percent of the producers indicated they earned less than $100,000. Out of the 38 pepper producers who indicated using agricultural plastic, 27 of them reported their yearly plastic expenditure. These producers indicated that they spent nearly $1.4 million a year on plastic which equates to $51,215 per producer. The average amount spent per acre was calculated to be $2,102 per acre, while the median was $854 per acre.

Figure 26: Average Gross Income Distribution of Pepper Producers Using Agricultural Plastic

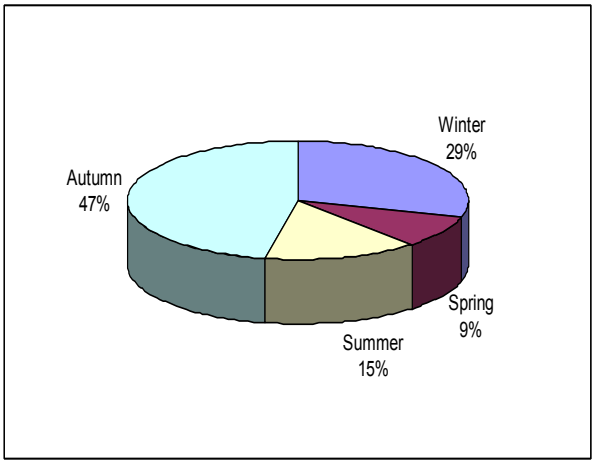


The two primary plastics that pepper producers used were mulch film and drip tape. Seven producers reported using 17.8 million square feet of plastic. This equated to an average of 28,548 square feet used per acre. The median reported acreage usage of mulch film was almost identical at 28,708 square feet. Three quarters of the pepper producers reported using plastic that was one mil thick, while the rest of the producers reported using plastic that was two mil thick. Seven producers reported as a group that they disposed of 68,370 pounds of plastic mulch per year. Seven individual producers indicated the amount of plastic mulch that they threw out per year. Fourteen producers

indicated the frequency of disposal; nine producers of those stated they discarded the mulch film on a yearly basis, while one producer indicated he disposed of his mulch plastic every two years. Four other producers evenly split indicated they disposed of their mulch on either a monthly basis or every six months.

Out of the 38 pepper producers who reported in the survey that they used agricultural plastic, 15 of these producers stated how much drip tape they used. There were two producers in this group that reported heavy usage of drip tape per acre. One producer indicated that he used 130,000 linear feet of drip tape per acre, while another reported using 12.4 million linear feet per acre. The average amount of drip tape used per acre was 16,501 linear feet, if these two producers are excluded. The median reported drip tape usage was then 17,000 linear feet per acre. Seventeen producers reported the thickness of the drip tape used, which ranged from four mils thick to ten mils thick with six producers indicating that they used five mil drip tape and another six indicating they used six mil tape. Three different producers reported using drip tape that was eight, nine, or ten mil thick respectively, while two producers reported using four mil drip tape. Twelve producers indicated that they discarded 24,387 pounds of drip tape per year. Twenty-four producers reported their frequency of disposal. Fourteen producers said the frequency of disposal was 12 or more months, with nine indicating they disposed of their plastic annually.

Figure 27: Primary Season Pepper Producers Disposed of Their Agricultural Plastic



Twenty-one producers indicated their yearly plastic disposal. This group reported disposing of 436,305 pounds of plastic per year from their farming operation. This equates to approximately 20,800 pounds per producer. Figure 27 provides the seasonal distribution which producers primarily disposed of their agricultural plastic. Nearly 50 percent of these producers indicated that they discarded their plastic in autumn. Another 29 percent of these producers reported winter as their primary elimination period. Twenty-seven producers indicated that they disposed of their plastic at a landfill, while only seven producers reported taking their agricultural plastic to a recycling facility. Pepper producers take an average of 4.35 trips per year and travel an average 14.59 miles per trip to get rid of this plastic. The producers estimated that they paid on average $2,087 per year in tipping fees and $343 per ton in transportation.

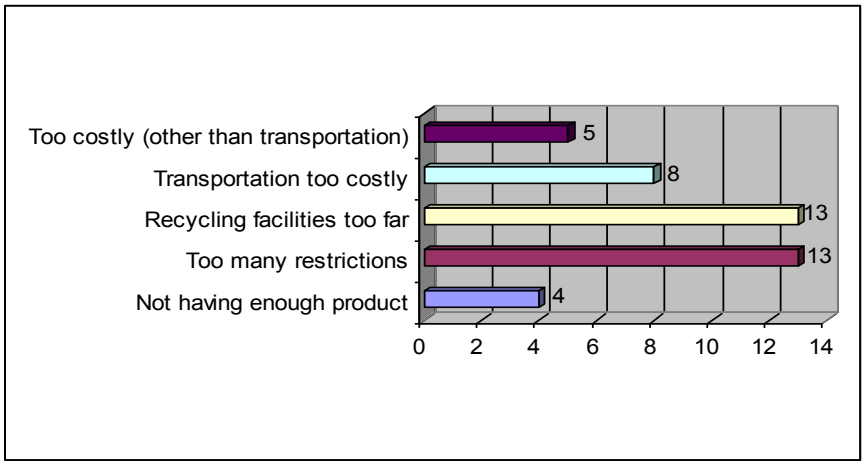
Pepper producers would travel on average up to 26.29 miles if they had the opportunity to recycle their agricultural plastic at no charge. This suggests that producers would travel an extra 12 miles to recycle their agricultural plastic for free. Given the opportunity to have their plastic picked up for them as long as it is sorted, the producers on average indicated they would pay $112.40 per

ton. The median willingness-to-pay for this service was $50 per ton. The producers are willing to pay an average of $119.55 per ton if they do not have to sort their plastic. The median estimate for unsorted plastic pick-up service was $100 per ton. One producer was excluded from the calculation because he stated he would pay $5,000 per ton for both sorted and unsorted pick-up services.

Out of the 38 pepper producers in this study, ten of them indicated that they recycle some of their agricultural plastic. Ten producers stated they knew of recycling facilities that can take agricultural plastic, while six producers reported that there were recycling facilities in their county for agricultural plastic. Most of the pepper producers did not know of any recycling facilities in their county, or of any that would take their agricultural plastic.

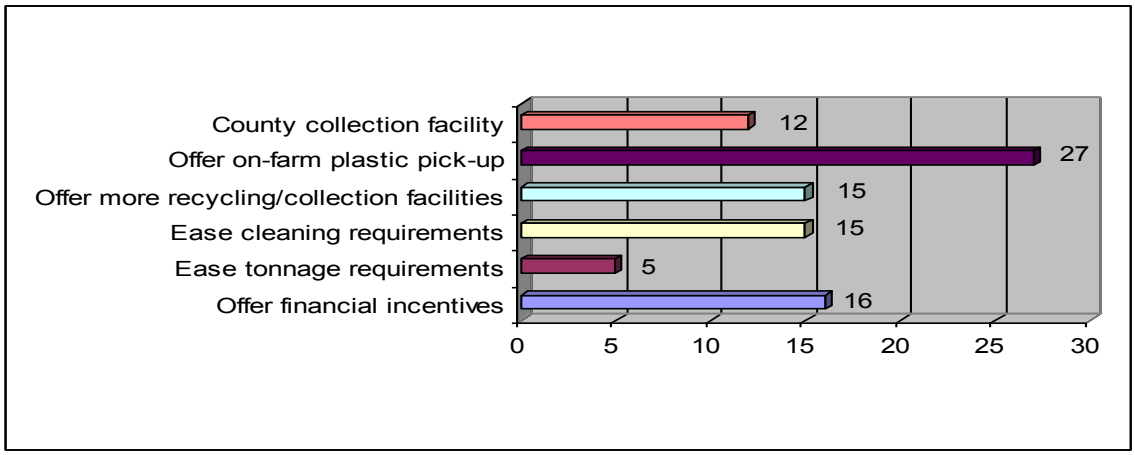
Figure 28 provides a look at what difficulties pepper producers have experienced or anticipate with recycling agricultural plastic. Producers identified that the biggest difficulty with recycling is that the recycling facilities are too far from their operation or there are too many restrictions on the type of plastic it will accept. The least perceived difficulty is not having enough material to recycle; five producers indicated this as a difficulty. These producers do not seem to think that the costs of recycling, factoring out transportation expenses, were too high. These producers are more concerned with the cost of transportation.

Figure 28: Identified Difficulties by Pepper Producers for Recycling Agricultural Plastic



While there are many incentives that would encourage pepper producers to recycle, Figure 29 illustrates that twenty-seven producers mostly preferred on-farm plastic pick-up service. Sixteen producers were encouraged to recycle with a financial reward. This incentive had 59 percent fewer respondents than the pick-up service incentive. This was closely followed by offering additional recycling facilities and less cleaning requirements. Both of these received support from 15 producers in the pepper industry. The least preferred inducement was the easing of tonnage requirements.

Figure 29: Incentives for Encouraging Recycling of Agricultural Plastics for Pepper Producers



Results for the Tomato Industry

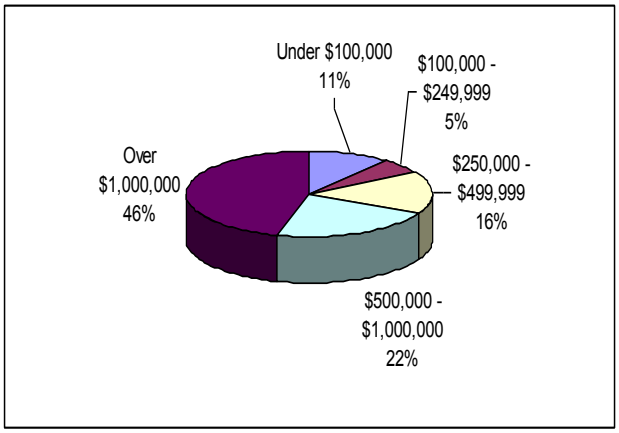
Three hundred tomato producers were sent the survey on agricultural plastic usage. Sixty-four of these producers returned information on their agricultural plastic usage, while another 38 from other commodity producers also returned information regarding their usage of agricultural plastic for producing tomatoes. This group of other commodities included two from the berry industry, one from the strawberry industry, 14 from the pepper industry, 15 from the melon industry, three from the nursery industry, two from the greenhouse industry, and one from the hay industry. These 102 producers represented 41,836 acres of tomatoes. Out of the 102 tomato producers, 37 indicated that they used agricultural plastic, while the rest of the producers responded that they did not use plastic on their operations. This equates to a participation rate of approximately 36 percent who used agricultural plastic. These 37 producers farm 10,150 acres of tomatoes and represent 19 different counties. Table 10 presents the number of sampled producers by county using agricultural plastic. Fresno and Yolo counties had the highest number of representatives from the survey who indicated using agricultural plastic.

Table 10: County and Number of Representatives Who Used Agricultural Plastic for the Tomato Industry

County	#	County	#	County	#	County	#
Fresno	8	Riverside	1	San Luis Obispo	2	Sonoma	1
Los Angeles	2	Sacramento	1	San Mateo	1	Sutter	1
Madera	1	San Benito	2	Santa Barbara	1	Ventura	1
Merced	3	San Bernardino	1	Santa Clara	3	Yolo	5
Monterey	1	San Joaquin	1	Solano	1		

Figure 30 illustrates that over two-thirds of the agricultural plastic users in the tomato industry earned an average yearly gross income over $500,000. The smallest percentage of tomato producers in this industry range in income from $100,000 to $249,999, while the largest percentage made over $1,000,000. There were 25 out of the 37 tomato producers which spent as a group $394,316. This equates to an average of $15,772 per producer. Focusing on a per-acre basis demonstrates that these producers spend an average of $798.63 per acre, while the median producer spends $200 per acre.

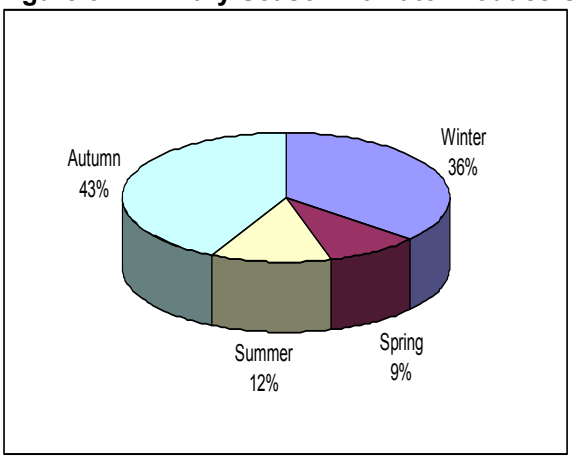
Figure 30: Average Gross Income Distribution of Tomato Producers Using Agricultural Plastic



The tomato producers in the survey provided vague information on their usage of agricultural plastic. Three producers indicated that they used plastic mulch, but only one provided the actual usage. One producer reported using a hoop/tunnel house covering. The best information provided pertained to utilizing drip tape. Nine producers provided some information regarding their usage of drip tape, while five producers provided the amount of drip tape that was applied. The average amount of drip tape used per acre was 7,761 linear feet, while the median amount was 7,500 linear feet per acre. Four producers indicated that they utilized drip tape that is six mils thick, while three producers reported using five mil drip tape. One producer reported using ten mil tape, while another producer indicated using 13 mil drip tape. Ten producers identified how often they disposed of their agricultural plastic. Half of these producers indicated that they disposed of their plastic on a yearly basis. The other frequencies of disposal reported were every three, six, 24, 36 and 96 months.

Figure 31 shows the distribution of when tomato producers primarily disposed of their agricultural plastic. The preferred season for 43 percent of producers was in the autumn months. Another 36 percent of the producers indicated that they primarily discarded their plastic in the winter months. Spring and summer had a much smaller number of producers removing their agricultural plastic, 12 percent each in the spring and summer.

Figure 31: Primary Season Tomato Producers Disposed of Their Agricultural Plastic



Out of the 37 producers who filled out the survey, 19 of them reported the total amount of plastic they disposed of per year. These producers reported that they collectively discarded 138,803 pounds. This equates to an average of 7,305 pounds per producer. The primary method of disposal of agricultural plastic for the tomato industry is to take it to a landfill. Twenty-five producers indicated that they disposed of their agricultural plastic at a landfill, while only four said that they used a recycling collection facility to get rid of their plastic. Producers typically take 1.88 trips per year to dispose of this plastic, traveling an average of 12.55 miles or a median of eight miles. These producers estimate that they spend an average of $572 per year on tipping fees to dispose of their plastic and $140 per ton to haul agricultural plastic to a landfill.

Tomato producers would travel 26.94 miles to the recycling facility or a median distance of 17.5 miles if they were able to recycle their plastic at no charge. This suggests that producers would travel on average an extra 14 miles to recycle the plastic for free. If a pick-up service existed for the producers' agricultural plastic, they would spend an average of $72.50 per ton if they were required to sort their plastic, and $84.72 per ton if they did not have to sort it. This calculation was made by excluding one producer who reported that he was willing to pay $5,000 per ton whether he had to sort the plastic or not. The median producer reported that he would pay $37.50 per ton if required to sort the plastic and $45 per ton if no sorting was necessary.

Tomato producers were asked if they currently recycle any of their agricultural plastic. Nine producers, who comprised 25 percent of the respondents to this question, reported recycling some of their agricultural product. The same number of producers who reported that they recycle also reported knowing of recycling facilities that would take their agricultural plastic, while only eight producers knew of recycling facilities in their counties. Fifteen producers indicated that there was no recycling facility in their county, while 14 producers indicated that they did not know of any facility that would take their recycling.

Figure 32 illustrates that tomato producers perceived two difficulties with recycling agricultural plastic. These producers indicated that recycling facilities are too far. The other obstacle perceived by tomato producers is that there are too many restrictions placed on recycling agricultural plastic. The least of the difficulties identified was that transportation of plastic is too expensive. Eight producers believed that one of their problems with recycling was that they did not have enough material to recycle.

Figure 32: Identified Difficulties by Tomato Producers for Recycling Agricultural Plastic

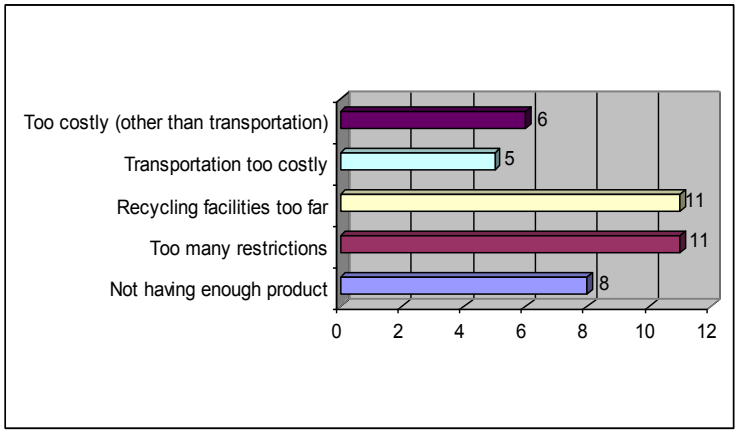
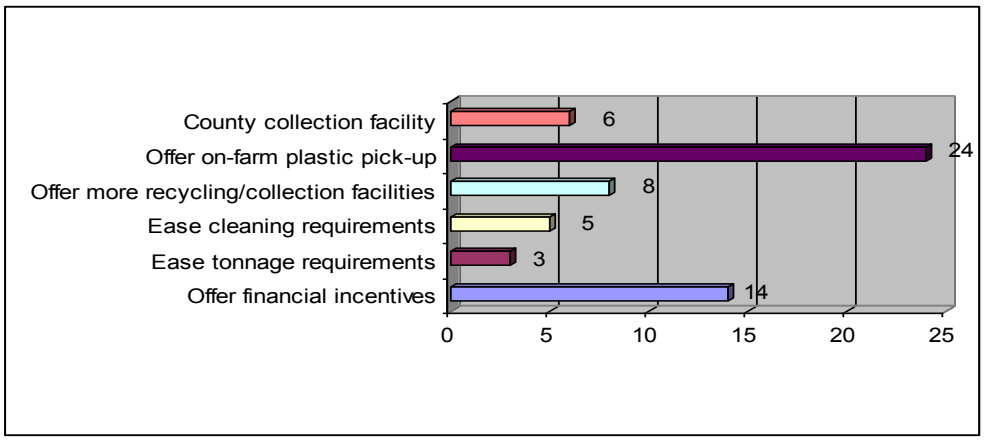


Figure 33 shows the incentives that tomato producers identified that would encourage them to recycle their agricultural plastic. The biggest incentive that would get producers to recycle their agricultural plastic is offering an on-farm pick-up service. A distant second incentive was offering a financial incentive to producers for recycling their agricultural plastic. The smallest incentive is lowering the limits on tonnage restrictions. The results were expected since a group of producers believed one of the difficulties with recycling was that they did not have enough product available to recycle.

Figure 33: Incentives for Encouraging Recycling of Agricultural Plastics for Tomato Producers

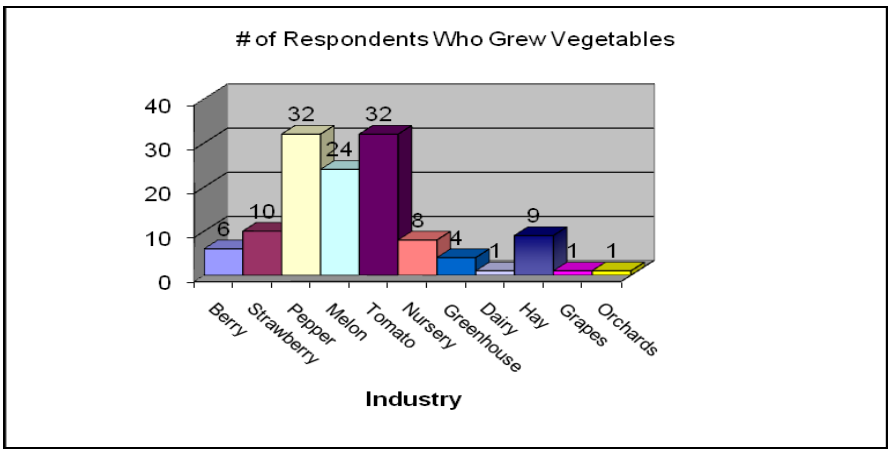


Results for the Vegetable Industry

Although there was no attempt made at deriving a sample specifically for vegetable growers who were not in the pepper or the tomato industry, a section of the survey was set aside for producers growing other vegetables than the ones primarily focused on in this survey. The commodity producers that responded to the acreage question regarding this category represented 52,759 acres of vegetables excluding pepper and tomato acreage. Figure 34 demonstrates the number of respondents in each industry that indicated they grew vegetables other than peppers and tomatoes. Sixty-seven of these producers indicated they were plastic users, while 61 producers responded

that they did not use agricultural plastic. This equates to a 52 percent participation rate utilizing agricultural plastic.

Figure 34: Number of Respondents in Each Industry Growing Vegetables



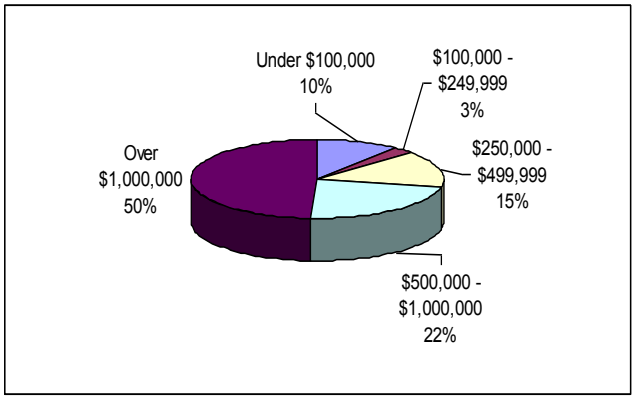
The vegetable producers who used agricultural plastic farmed 32,944 acres and represented 25 counties. The counties and the number of vegetable growers representing the county are illustrated in Table 11. The largest representations of vegetable producers who used agricultural plastic were from Monterey, Santa Barbara, and Fresno counties. Out of the 67 producers who identified themselves as plastic users, 48 of these growers reported that they collectively spent approximately $2.24 million on agricultural plastic yearly. This equates to an average of $46,594 per producer.

Table 11: County and Number of Representatives Who Used Agricultural Plastic for the Vegetable Industry

County	#	County	#	County	#	County	#
Fresno	7	Nevada	1	San Diego	1	Sonoma	1
Imperial	1	Orange	2	San Joaquin	1	Stanislaus	1
Kern	1	Placer	1	San Luis Obispo	2	Ventura	3
Kings	2	Riverside	2	Santa Barbara	8	Yolo	5
Los Angeles	2	Sacramento	3	Santa Clara	5		
Madera	2	San Benito	3	Santa Cruz	1		
Monterey	9	San Bernardino	2	Shasta	1		

Figure 35 shows the average gross income of the producers who indicated they grow vegetables using agricultural plastic. This figure demonstrates that 50 percent of the producers earn a gross income over $1,000,000 per year. The next largest group at 22 percent brings in between $500,000 and $1,000,000. The smallest group receives a range between $100,000 and $249,999. This group represented 3 percent of all the respondents in this income level.

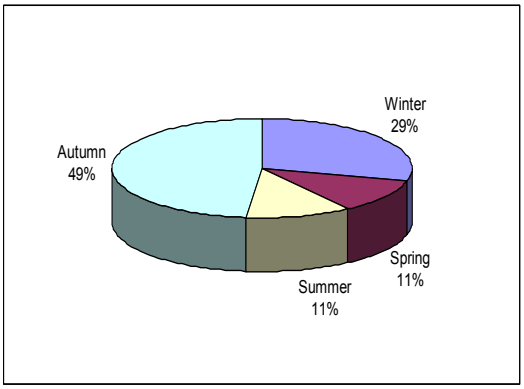
Figure 35: Average Gross Income Distribution of Vegetable Producers Using Agricultural Plastic



There were two primary types of agricultural plastics that the vegetable producers provided information on, mulch film and drip tape. Ten producers provided either partial or full information regarding their plastic mulch usage. Seven producers provided the actual amount of plastic mulch they used on their vegetable crops. This group reported using 5.15 million square feet of mulch on 3,385 acres, which equates to an average of 15,221 square feet per acre. Overall, the average usage per acre was 10,317 square feet with a median of 8,000 square feet per acre. The producers were almost evenly split on the numbers in terms of utilizing either one mil plastic versus two mil plastic for their mulch needs. Most producers, approximately 73 percent, indicated that they disposed of this plastic annually, while the rest indicated that they disposed of this plastic monthly.

There were 29 vegetable producers that provided at least partial information on their usage of drip tape. Out of this group, 19 producers reported that collectively they used 28.79 million linear feet of drip tape on 4,790 acres, which equates to an average usage of 6,010 linear feet per acre and 1.5 million linear feet per producer. Focusing on the average amount of drip tape per acre, these producers used 10,740 linear feet. The median producer used 2,000 linear feet per acre. There was a wide range of thickness that vegetable producers used for their drip tape. The thinnest drip tape was reported at two mils thick, and the thickest at ten mils. Most producers reported using between four to six mils thick drip tape and reported discarding their drip tape annually. Following the next most common response was disposal on a monthly basis. Other disposal frequencies reported were three, six, 36, and 48 months.

Figure 36: Primary Season Vegetable Producers Disposed of Their Agricultural Plastic



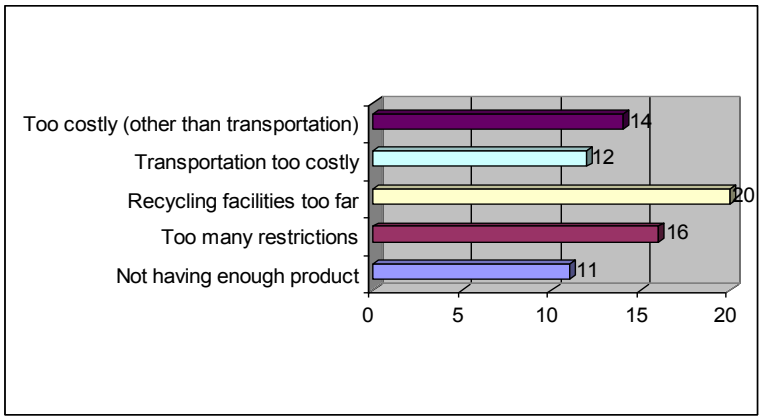
The two methods vegetable producers use to eliminate their agricultural plastic are either taking it to a landfill or a recycling facility. Forty-five vegetable producers indicated that they currently disposed of their plastic at a landfill, while 17 producers indicated that they take their plastic to a recycling facility. As shown in Figure 36, the primary season that vegetable producers disposed of the largest volume of their plastic is in the autumn months. Forty-nine percent of vegetable producers indicated that this season was when the plastic was removed, while 29 percent indicated winter. Both summer and spring garnered only 11 percent each. Thirty-five producers in this study indicated that they collectively discarded 1.06 million pounds of plastic each year. This equates to an average of 30,157 pounds per producer. The median producer reported a disposal amount at 2,000 pounds of plastic per year.

The vegetable producers in this study reported traveling an average of 15.12 miles per trip to discard their agricultural plastic, and traveled an average of 4.28 trips per year. The median producer indicated traveling 8.5 miles per trip and taking one trip annually. On average, vegetable producers spent $1,259 per year on tipping fees and $528 per ton on hauling costs to dispose of their agricultural plastic. Given the opportunity to recycle their agricultural plastic at no charge, producers would travel up to an average of 30.39 miles to the facility. The median producer would travel 20 miles to recycle their plastic. If a pick-up service was available, they are willing to pay an average of $66 per ton if they have to sort the plastic, and $79 per ton if no sorting was necessary. The calculation of these values excluded one producer who indicated he would pay $5,000 a ton under either scenario.

Out of the 67 vegetable producers who indicated they used agricultural plastic, only 20 reported that they recycle some of their plastic. Eighteen producers indicated that they knew of facilities that would recycle their agricultural plastic, while 14 producers indicated they knew of a recycling program in their county. These results would indicate that two producers are in some manner reusing their plastic. The highest percentage of producers indicated that they did not know whether there were recycling programs in their county (48 percent) and whether there were recycling programs for their agricultural plastic (45 percent).

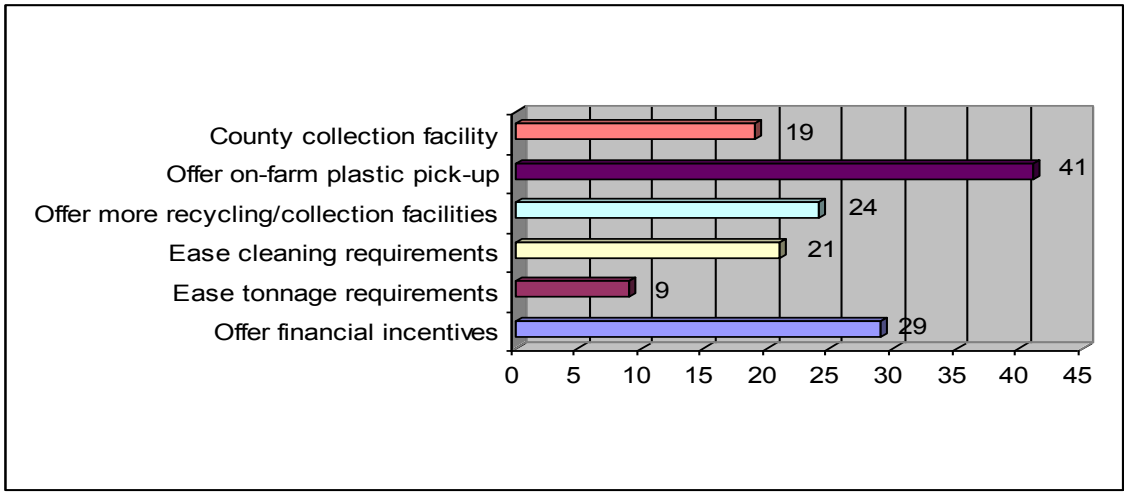
Figure 37 presents the identified difficulties that vegetable producers perceive or have encountered with recycling agricultural plastic. The biggest difficulty identified was that recycling facilities are too far away from the producers operation. While 20 producers recognized distance as an obstacle, the next difficulty that 16 producers identified was that there are too many restrictions to recycling. The least identified problem was not having enough material to recycle. Producers rated recycling costs as a bigger challenge than transportation costs. Coupling this with the result of too many restrictions suggests that vegetable producers perceive that recycling is a costly venture.

Figure 37: Identified Difficulties by Vegetable Producers for Recycling Agricultural Plastic



Examining Figure 38 illustrates the incentive that would encourage the largest amount of producers to recycle their agricultural plastic is offering an on-farm plastic pick-up service. Forty-one producers indicated a preference for this inducement. The one that garnered the second highest amount of producers was to offer a financial incentive. This enticement was 30 percent less than the top rated one. The incentive that was least interesting for this group was easing the tonnage restrictions. Nine producers indicated that this would encourage them to recycle.

Figure 38: Incentives for Encouraging Recycling of Agricultural Plastics for Vegetable Producers



Results for the Dairy Industry

The sample size selected for the dairy industry was 220 producers. Out of this group, 55 producers returned information regarding their plastic usage. One producer in the nursery industry, one in the fruit and nut industry, and eight producers in the hay industry also identified themselves as dairy producers. The total number of dairies represented is 65, and accounted for 73,597 dairy cows. The average herd size was 1,132, while the median producer reported having 750 cows. The largest dairy was 4,150 and the smallest dairy was 62 cows. Out of the 65 dairies that completed the survey, 39 of them indicated that they used agricultural plastic. This suggests that 60 percent of the producers in the dairy industry use some form of agricultural plastic in their operation. The average-size dairy for this group was 1,083, while the median-size dairy had 600

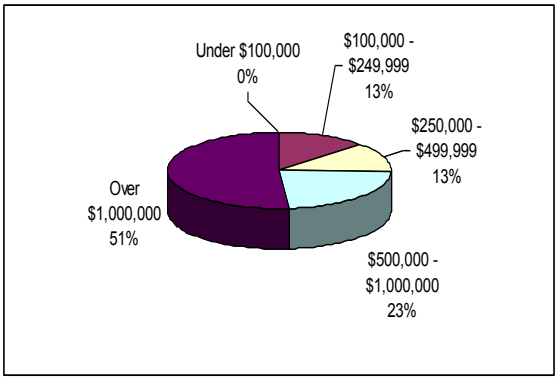
cows. The maximum and minimum herd sizes are the same for plastic users and non-plastic users. Table 12 shows how many dairy producers in the survey used agricultural plastic categorized by county. Stanislaus County had the highest number of representatives at nine producers, while Merced had the second highest representation with seven producers. These two counties represented just over 41 percent of the dairy producers who reported plastic usage in the survey.

Table 12: County and Number of Representatives Who Used Agricultural Plastic for the Dairy Industry

County	#	County	#	County	#	County	#
Fresno	4	Kings	3	San Joaquin	5	Tulare	4
Glenn	2	Merced	7	Sonoma	3		
Humboldt	1	Sacramento	1	Stanislaus	9		

Figure 39 displays the income distribution of the dairy producers who used agricultural plastic. Over 50 percent of these producers reported an income over $1,000,000, while none of the producers indicated having an income less than $100,000. Thirty-three dairy producers indicated in the survey how much income was spent per year on agricultural plastic. This group collectively spent $407,600 on plastic which equates to approximately $12,352 per producer annually. The cost per cow ranged from $0.11 to $75. The average cow cost $11.91, while the median producer indicated that he spent $6.25 per cow on agricultural plastic. Seventeen producers reported how much agricultural plastic they disposed of each year. As a whole, this group reported disposing of 3,191,810 pounds of plastic per year. This result was highly skewed by one producer who indicated that he disposed of 3,000,000 pounds of plastic annually. This producer reported that this plastic was from silage bags. Factoring this person out as an outlier reconfigures the average plastic discarded annually by a producer as 11,988 pounds per year. The median producer reported disposing 4,000 pounds of plastic per year.

Figure 39: Average Gross Income Distribution of Dairy Producers Using Agricultural Plastic



According to the survey results, there are many types of plastic used on dairies in California. The producers in the survey reported using: 1) manure/compost pile covers, 2) haystack covers, 3) silage bags, and 4) plastic twine. Also, many producers in the survey consistently indicated that they used plastic to cover their silage. None of the dairy producers indicated that they used plastic to cover their lagoons.

There were six dairy producers that reported how much plastic they used to cover their manure piles. This group reported an average plastic usage of 21,090 square feet per producer. The average square footage used for manure piles was 15.19 per cow. Two of these producers indicated using plastic that was six mils thick, while the other producers did not report on the thickness of the plastic they used. Four producers indicated the frequency of the disposal of this type of plastic. Two producers specified that they disposed of this plastic yearly, one producer reported quarterly, and another producer reported twice a month.

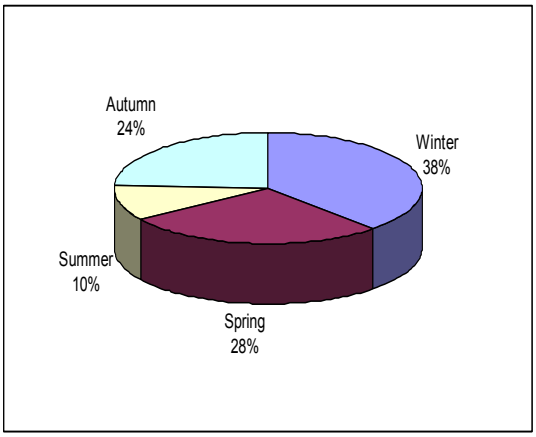
Out of the 13 dairy producers who indicated that they used plastic to cover their haystacks, 11 indicated the amount of plastic they used. These 11 producers also collectively reported using 297,950 square feet of plastic, which equates to 27,086 square feet of plastic per producer. Examining this usage shows that 34.08 square feet of plastic is utilized per cow to cover the haystack on the dairy. Out of the 11 producers who reported their plastic usage, six identified the thickness of the plastic they used to cover their haystack. Six mils plastic garnered half of the responses in this area, while two mils, ten mils, and 11 mils plastic were also reported. Nine producers reported the frequency that they disposed of their plastic. The responses ranged from every month to every three years. Annual disposal garnered one-third of the respondents, while monthly had two-ninths of the responses. The rest of the responses (two, three, six, and 36) had only one producer each.

Eleven producers reported using plastic silage bags on their operations. Six producers reported the quantity used per square feet, while two producers reported the quantity used on a linear feet basis. The total square footage of silage bags reported by the six producers was 215,155 square feet, which equates to an average of 35,859 square feet per producer. One producer indicated that they used 400 linear feet of silage bags, while another producer reported 30,000 linear feet. There were two producers who provided the thickness of the silage bags they used. One producer reported using a silage bag that was four mils thick; while the other producer indicated that they used eight mils thick plastic. Seven producers reported the frequency in which they disposed of their silage bags. Three producers indicated that they discarded these bags on a monthly basis, two producers reported disposal twice a year, and two producers indicated yearly disposal.

While the survey asked dairy producers to indicate their silage bag usage, it did not explicitly ask about any other plastic usage related to silage. These producers were given an opportunity in the survey to offer information on other types of plastic they used. Twelve producers took this opportunity to specify using silage covers. As a group, these producers reported using 608,813 square feet of silage covers, which equates to 50,734 square feet per producer. The most common thickness reported for this cover was six mils; eight mils and ten mils. Five out of eight producers indicated that they discarded this plastic on a monthly basis; six months, 12 months, and 18 months were also given as the frequency of disposal.

The dairy producers who used agricultural plastic indicated two primary methods of eliminating their agricultural plastic. Seventeen producers indicated that they disposed of their plastic at a landfill, while eight producers reported taking their plastic to a recycling collection facility. When asked what was the primary season for discarding their agricultural plastic (results shown in Figure 40), 38 percent of producers indicated they disposed of their largest volume of plastic during the winter. Twenty-eight percent picked spring as the primary disposal season, while another 24 percent chose autumn.

Figure 40: Primary Season Dairy Producers Disposed of Their Agricultural Plastic



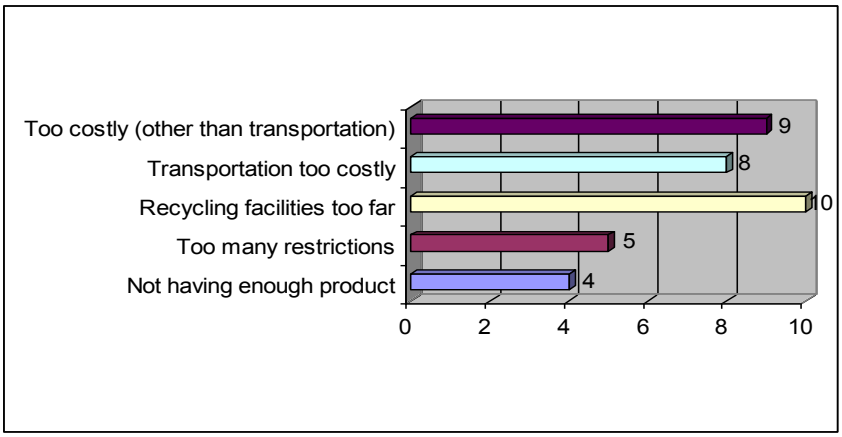
Dairy producers in this study reported that they travel an average of 6.83 miles per load to dispose of their agricultural plastic and make an average of 13.7 trips per year. The median reported trip length was 0.5 miles while the median number of trips was zero. The low median results for each of these are due to a high number of zeroes reported for each. These producers indicated that they spent an average of $391 annually in tipping fees and $18.70 per ton in hauling cost.

If dairy producers had the ability to recycle their agricultural plastic for free, producers in this study indicated that they would travel 10.41 miles. This suggests that the average dairy producer would travel no more than an additional four miles to recycle their agricultural plastic at no charge. Given the option of having a pickup service for their agricultural plastic, dairy producers indicated that they would pay an average of $134.16 per ton if they had to sort the plastic and $126.56 per ton if they did not. This average was calculated by eliminating an outlier response where one producer indicated they would pay $20,000 per ton if a pickup service existed for sorted agricultural plastic and $10,000 per ton if the plastic did not need sorting. The median producer indicated that they would pay nothing for a pick-up service whether the plastic required sorting or not. Examining the data closely shows that one dairy producer in this study responded that he would pay $1,200 per ton to get rid of his sorted plastic and nothing for unsorted plastic. Factoring this producer out changes the average willingness to pay for a pickup service to $89.75 per ton for sorted plastic and $131.83 per ton for unsorted plastic.

Most dairy producers in the study who used agricultural plastic indicated that they did not recycle their agricultural plastic. Twenty-eight percent responded that they recycled their plastic. Nineteen percent of the producers indicated that they knew of a recycling program for their plastic inside their county of operation, while 62 percent said that no recycling program was in their county. When asked if they knew of any recycling facilities that would take their plastic, 38 percent of the producers indicated they did.

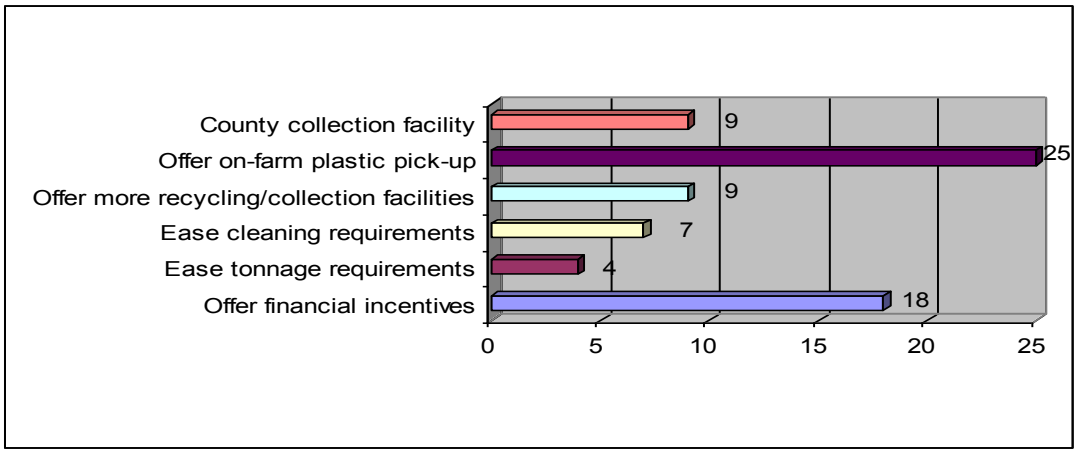
Figure 41 provides information on what dairy producers have experienced or perceived as difficulties with recycling agricultural plastic. The greatest difficulty identified is that recycling facilities are too far from the dairy producers operation. This result provides additional evidence that dairy producers do not want to travel far from their operation to get rid of their agricultural plastic. The next highest difficulties identified were that recycling and transportation are too costly. It appears in a relative sense that the least perceived difficulties identified in the survey are too many restrictions and that producers do not have enough product.

Figure 41: Identified Difficulties by Dairy Producers for Recycling Agricultural Plastic



Examining Figure 42 shows that there are two primary incentives that would induce dairy producers to recycle their agricultural plastic. The response that garnered the highest number at 25 was to offer an on-farm pick-up service. The next highest enticement, which was a distant second with 18 respondents, was to offer financial assistance. Two incentives had nearly three times less than the most preferred incentive. These were offering a county collection facility and offer more recycling facilities. It appears the least important incentive for dairy producers is an easing of the tonnage requirement.

Figure 42: Incentives for Encouraging Recycling of Agricultural Plastics for Dairy Producers

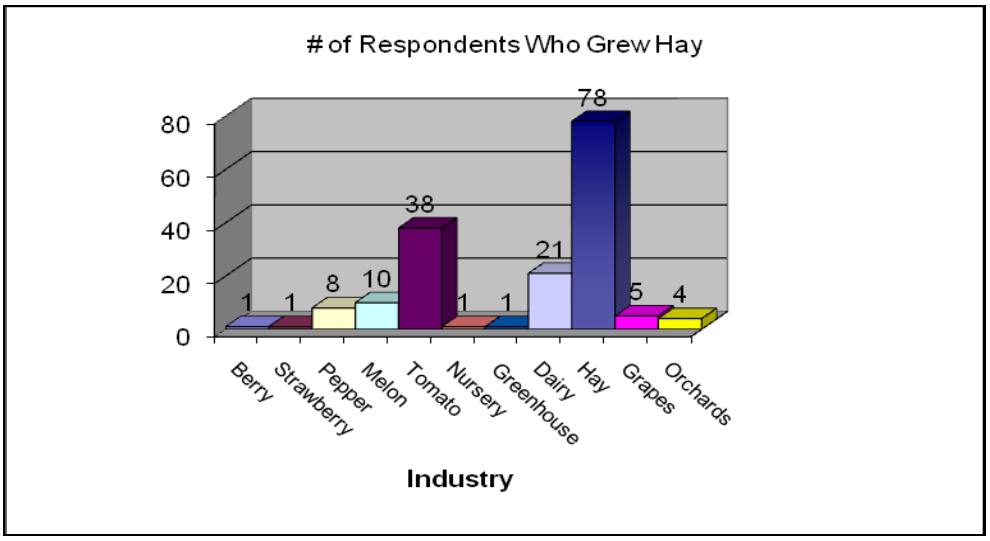


Results for the Hay Industry

There were 250 producers chosen from the hay industry to participate in this study. Seventy-eight of these producers provided feedback on their usage of agricultural plastic. Another 90 producers from the other sampled commodities also indicated that they grew hay. Figure 43 shows how many producers in each industry sampled produced hay. This group of 168 producers represented 115,874 acres of hay and alfalfa. Sixty-seven of these producers indicated that they used agricultural plastic in production, while the other 101 producers identified themselves as non-plastic users. This suggests that nearly 40 percent of hay producers used some form of plastic on their operation. These plastic users represent 41,137 acres of hay and alfalfa production. Out of these 67 producers, 39 reported the amount of plastic they discarded. This group indicated that

they disposed of a collective 152,471 pounds, which equates to approximately 3,910 pounds per producer. The median amount of plastic disposed of per year was 666 pounds. The average yearly disposal of plastic baling twine is 522 pounds with a median response of 400 pounds. This equates to an average per acre disposal of 31.80 pounds and a median of 0.23 pounds per acre.

Figure 43: Number of Respondents in Each Industry Growing Hay



Producers in the survey who used agricultural plastic and represented the hay industry were scattered across 27 counties. Table 13 provides the distribution of these producers across the different counties they represented. The largest representation of producers was from Merced County, which had eight hay producers who indicated that they used agricultural plastic. Nine counties only had one representative, five counties had two representatives, eight counties had three representatives, and four counties had four representatives.

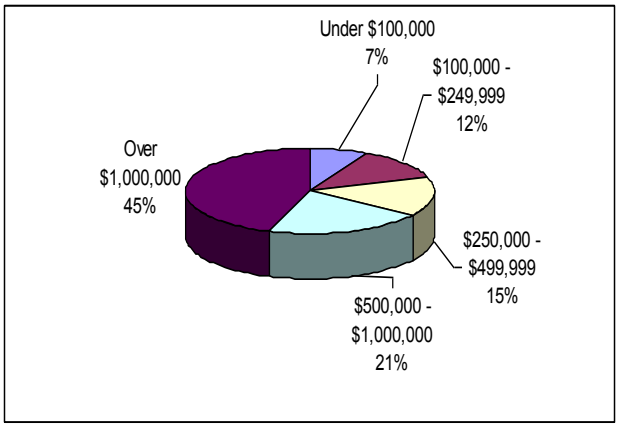
Table 13: County and Number of Representatives Who Used Agricultural Plastic for the Hay Industry

County	#	County	#	County	#	County	#
Alameda	1	Kings	4	Riverside	1	Solano	1
Contra Costa	1	Lassen	2	Sacramento	4	Sonoma	3
Fresno	3	Madera	1	San Joaquin	4	Stanislaus	4
Glenn	3	Merced	8	San Luis Obispo	3	Tehama	2
Humboldt	2	Modoc	1	Santa Clara	1	Tulare	3
Imperial	3	Placer	1	Shasta	2	Yolo	3
Kern	2	Plumas	1	Siskiyou	3		

Figure 44 provides the average gross income distribution of the hay producers who used agricultural plastic. Examining this figure shows that approximately two-thirds of the hay producers who used agricultural plastic generated an income over $500,000. Another 7 percent indicated that they made less than $100,000 per year. The average hay producer using agricultural

plastic reported that he spent $13,784 per year on plastic. The median producer only spent $3,456 per year.

Figure 44: Average Gross Income Distribution of Hay Producers Using Agricultural Plastic



There are two types of plastic that hay and alfalfa producers normally used on their operation according to the results of this study. These are plastic for covering the hay/alfalfa and plastic twine used for baling. Fifteen producers gave information suggesting they used covering for their hay and alfalfa, while 39 producers provided either partial or full information on their usage of plastic baling twine.

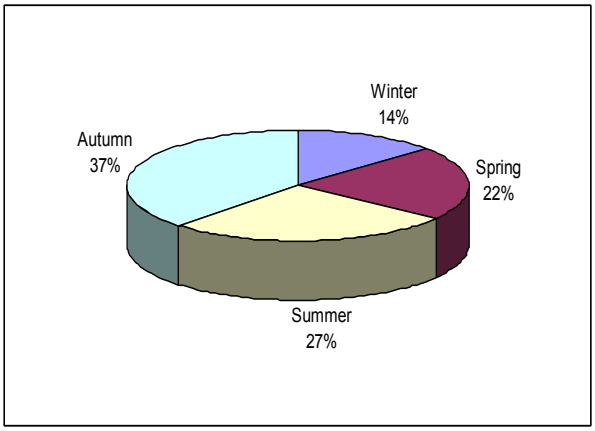
There were nine producers out of the 15 that provided the amount of plastic they used for covering their hay and alfalfa. The average amount used per farm was 43,544 square feet, which equates to 152 square feet per acre. The median producer reported using 25,000 square feet of plastic and the median per acre usage was 89 square feet per acre. There were four responses to the query on the thickness of the plastic utilized for covering. Two producers indicated that they used six mils plastic, while one producer reported using eight mils plastic and another reported using two mils plastic. Six producers indicated the amount of plastic covering they disposed of per year. The average amount per farm was 2,651 pounds and the median was 833 pounds. On a per-acre basis, the average disposal was 20.65 pounds and the median disposal was 0.53 pounds. There were 12 producers who indicated the frequency of disposal of this plastic. These responses ranged from monthly to every 3.5 years. The most common response by these producers was yearly. This response garnered five producers. Other responses given were every two, six, ten, 24, and 36 months.

Plastic baling twine received a much higher response on usage than haystack coverings. Out of the 39 producers who indicated that they used agricultural plastic, 20 of these producers provided information on the amount of baling twine used. The average amount of plastic baling twine used per farm was 563,076 linear feet. On a per-acre basis, the amount of twine used was 1,051 linear feet. The median producer reported using an average of 55,500 linear feet per farm and 481 linear feet per acre. A larger group, 28 producers, reported the amount of baling twine they disposed of on a yearly basis. This group reported disposing of an average 4,570 pounds of plastic per farm and 31 pounds per acre. The median producer indicated that he disposed 22.5 pounds of plastic per farm and 0.23 pounds of plastic per acre. The frequency of disposal ranged from one month to two years. Ten producers indicated they disposed of their baling twine on a monthly basis, three

producers reported disposing of this plastic every six months, nine producers indicated annual disposal, and one producer reported disposal of plastic baling twine every two years.

Figure 45 provides the primary season that hay producers disposed of the largest volume of their agricultural plastic. At 37 percent, autumn was the season that hay producers discarded the largest volume of their plastic. This was followed by summer at 27 percent and spring at 22 percent. The season with the least percentage of disposal was winter. Examining how these producers eliminated their agricultural plastic reveals that 35 producers took their plastic to a landfill, while 15 producers took their plastic to a recycling collection facility. In addition, one producer reported that he buried his plastic, while two others indicated that they burned it.

Figure 45: Primary Season Hay Producers Disposed of Their Agricultural Plastic



Hay producers on average traveled 9.38 miles to dispose of their agricultural plastic making an average of 6.31 trips. One of the producers indicated that he makes 300 trips per year. Factoring this potential outlier out gives an average of 1.42 trips per year. The median hay producer reported traveling eight miles to dispose of his agricultural plastic and making zero trips per year. Hay producers reported spending $277 on tipping fees per year to dispose of their plastic and $177 per ton to haul that plastic to the landfill.

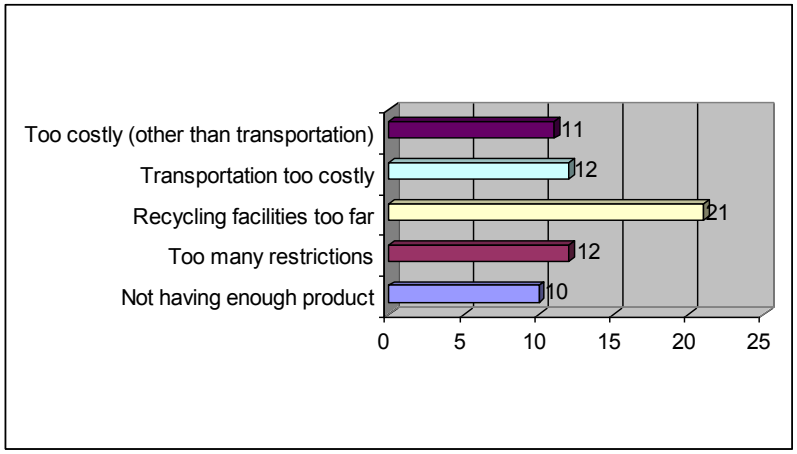
Hay producers in this study indicated that they would travel 22.7 miles if they could dispose of their agricultural plastic at no charge. The median producer would travel 15 miles to recycle agricultural plastic for free. Hay producers indicated that they would pay $54 per ton if a pick-up service existed for their agricultural plastic and they had to sort the plastic, if they do not have to sort the plastic, they are willing to pay $79 per ton for a pick-up service.

When asked whether they recycled their agricultural plastic, 15 producers indicated that they did recycle some of their plastic. A vast majority of the producers, 51 of them, reported that they do not recycle their agricultural plastic. Fifteen producers knew of a recycling program for agricultural plastics in their county and 20 producers indicated that they knew of a recycling facility that would take their agricultural plastic. There were 28 producers who indicated that there was no recycling program in their county, while 23 were not sure.

Figure 46 provides the identified difficulties either experienced or perceived by hay producers for recycling their agricultural plastic. The biggest difficulty identified is that the recycling facilities are too far from the producers operation. This response garnered 21 producers which is nearly double the next closest response. Interestingly, the four other difficulties that were reported by the

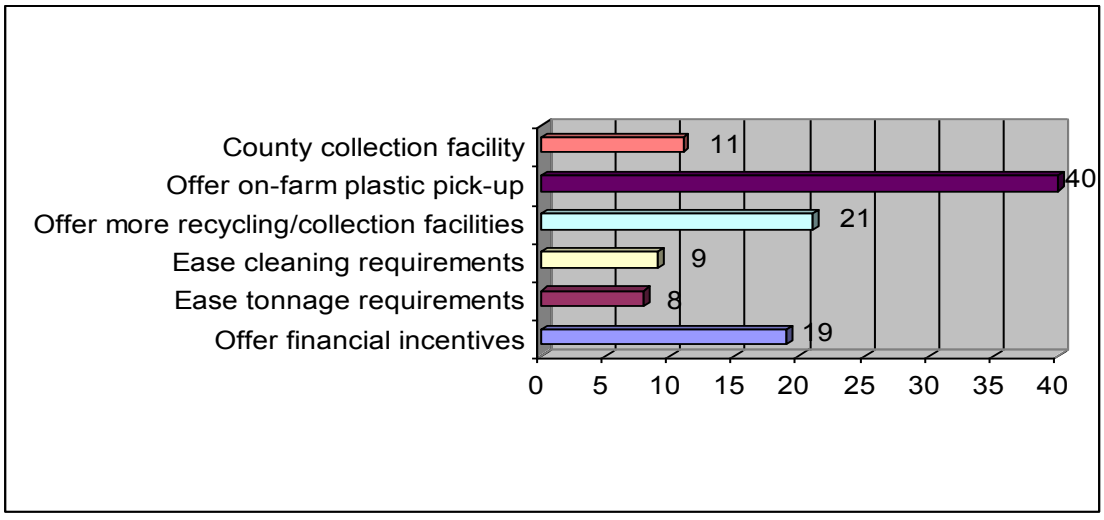
producers had approximately the same number of responses with a difference of no larger than two responses. This suggests that hay producers perceive these difficulties as roughly equivalent to each other.

Figure 46: Identified Difficulties by Hay Producers for Recycling Agricultural Plastic



Incentives that encourage hay producers to participate in recycling their agricultural plastic were examined. The preferred incentive is offering producers a pick-up service for their agricultural plastic. This response (see Figure 47) achieved nearly double the next highest incentive, offering additional recycling facilities. Close to this second highest incentive, 19 producers identified that offering financial incentives would encourage them to participate in a recycling program. The least encouraging incentives of the ones presented are easing the tonnage restrictions and the cleaning requirements.

Figure 47: Incentives for Encouraging Recycling of Agricultural Plastics for Hay Producers



Results for the Greenhouse Industry

A sample size of 300 producers was drawn for the greenhouse industry of which 58 producers returned information. A berry producer, one tomato producer, one hay producer, two pepper producers, three melon producers, and 28 nursery producers from the other samples reported they

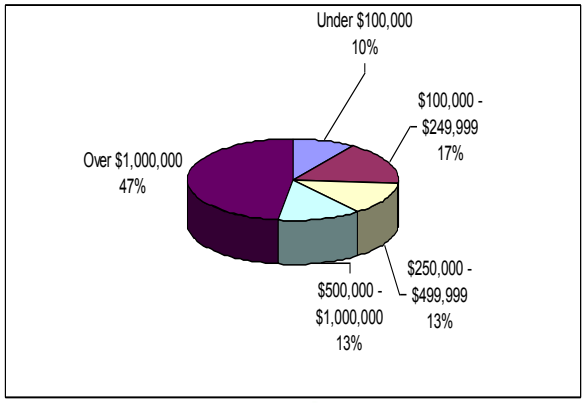
also participated in the greenhouse industry; this brings the total response to 93. Producers were asked to identify either how many acres they are producing on or the square footage of their facilities. There were 38 producers who indicated their production on a per-acre basis. This group represents 747 acres of greenhouses and horticultural crops. Another 56 producers reported their production on a square foot basis. These producers reported the usage of 7,214,499 square feet of greenhouses and horticultural crops. Out of the 94 producers who indicated they operated in the greenhouse industry, 71 reported that they used agricultural plastic, while the remainder indicated that they did not use agricultural plastic. This suggests that over 75 percent of the greenhouse producers in the study utilized some form of agricultural plastic. Table 14 provides information on what counties are represented by these agricultural plastic users. The largest representation came from San Diego, Monterey, and Santa Barbara counties. San Diego had 12 representatives, while Monterey and Santa Barbara each had eight.

Table 14: County and Number of Representatives Who Used Agricultural Plastic for the Greenhouse Industry

County	#	County	#	County	#	County	#
Fresno	2	Napa	1	San Joaquin	2	Shasta	1
Kern	1	Orange	1	San Luis Obispo	3	Sonoma	5
Los Angeles	3	Riverside	3	San Mateo	5	Stanislaus	1
Madera	1	Sacramento	1	Santa Barbara	8	Tulare	1
Mendocino	1	San Bernardino	1	Santa Clara	4	Ventura	3
Monterey	8	San Diego	12	Santa Cruz	1	Yolo	2

Figure 48 provides the distribution of income for the producers in the greenhouse industry who used agricultural plastic. Sixty percent of the producers indicated an average gross income greater than a $500,000. While the survey attempted to obtain information from producers who earned over $100,000, the sample of agricultural plastic users in the greenhouse industry contained a group of producers who earned less than this amount. Out of the 71 producers who reported their average gross income information, 59 of these producers provided information on how much money they spent every year on agricultural plastic. This group as a whole reported spending $2,999,366, which equates to approximately $50,837 per farm. At $8,000, the median producer spent a much smaller amount than the average producer.

Figure 48: Average Gross Income Distribution of Greenhouse Producers Using Agricultural Plastic



The greenhouse industry used a wide range of agricultural plastic. The plastic that is used for greenhouses is categorized into two general areas—a) containers and b) plastic used for hoop houses, tunnel houses and greenhouses. Since producers reported their operations in terms of acres or square feet, all results are presented on a per farm basis.

Table 15 provides the average and median usage of plastic containers by greenhouse producers. Also presented in this table is the number of producers who reported a value for the corresponding container. The container types that had the highest number of respondents were the trays/flats, while the ten-gallon container had the fewest respondents. The average count on the number of containers ranged from 2,407 for the ten-gallon containers to 142,275 for the one-gallon containers. The median count ranged from a low of 1,000 up to a high of 35,000. The median usage was at least half the quantity of the average, suggesting there are a few large producers who used the bulk of the containers.

Table 15: Average and Median Usage of Plastic Containers by Greenhouse Producers

Use/Type of Plastic	Average	Median	Number Reporting
6-Pack Containers	84,679	35,000	12
Trays/Flats	131,514	4,000	32
1 Gallon Containers	142,275	27,500	28
2 Gallon Containers	30,700	4,000	14
3 Gallon Containers	27,250	12,500	6
5 Gallon Containers	41,579	5,000	23
10 Gallon Containers	2,407	1,000	5
15 Gallon Containers	4,057	1,400	17

While the count of each type of plastic given in the previous table is useful information, the more valuable information for this study is found in Table 16 below. This table presents the average and median disposal of each type of plastic container on a per-pound basis. This table also contains the number of producers who provided information on the removal of each of the containers, as well as the number of zeros reported. The containers that had the highest average disposal rates were trays/flats. Producers in the greenhouse industry reported that they discarded these containers on average of 2,228 pounds per year. The second highest average occurred for the three-gallon containers. This result is misleading because there were only two large producers who indicated their disposal weight on this item. One producer indicated that he discarded 500 pounds of plastic, while the other producer indicated a disposal of ten pounds. The three-gallon container also had the highest median value but is problematic for the above stated reasons. The second highest median disposal occurred with the trays/flats. Similar to the previous table the median reported value is smaller than the average. Excluding the three-gallon containers, the median is no more than a third of the average, which suggests that there are a few large producers who dominated the results.

Table 16: Average and Median Disposal in Pounds of Plastic Containers by Greenhouse Producers

Use/Type of Plastic	Average	Median	Number Reporting	Number Reporting 0's
6-Pack Containers	35.89	3.00	9	4
Trays/Flats	2,228.63	62.50	24	9
1 Gallon Containers	793.95	40.00	19	6
2 Gallon Containers	20.00	0.00	8	5
3 Gallon Containers	255.00	255.00	2	0
5 Gallon Containers	53.88	17.50	16	6
10 Gallon Containers	132.50	15.00	4	1
15 Gallon Containers	42.27	0.00	11	6

Beyond the plastic containers, the greenhouse industry reported two other types of plastic used and discarded. There were 12 producers who reported using 9,249,777 square feet of plastic for hoop houses and tunnel coverings. This equated to an average of 770,815 square feet per producer. This value is highly skewed due to one producer reporting that he used 6,534,000 square feet of plastic for this purpose on his operation. The median producer reported using 42,500 square feet. Half the producers indicated they used six mils plastic for this purpose, while two producers indicated that they used four mils plastic. The other thicknesses reported were two and three mil plastic. The average disposal amount per year for this type of plastic was 5,390 pounds, while the median producer reported eliminating 200 pounds of plastic. Note that only five producers reported the amount of plastic that they disposed.

The other type of plastic reported beyond the plastic containers was greenhouse plastic. Thirty-nine producers indicated that they used 3,201,550 square feet of this plastic. This equates to 82,091 square feet of plastic per producer per year. The median plastic usage for this type was 30,000 pounds. Thirty-one producers reported that the thickness of this plastic was six mils; four producers reported four mils plastic, and one producer used eight mils plastic. The average annual amount of this plastic disposal is calculated at 11,480 pounds. The median producer indicated that he disposed 300 pounds of plastic per year.

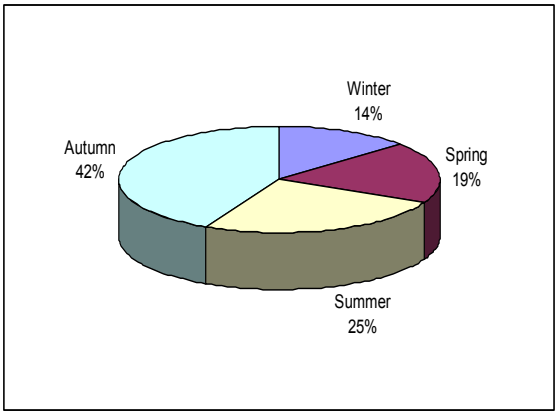
Table 17 provides information on how often greenhouse producers disposed of their agricultural plastic. The table shows that many producers cluster around the monthly and yearly disposal time periods. Another cluster of producers reported 0 months for the frequency of disposal. This response may represent producers who sell their product in a plastic container to a customer and do not view this as a discard. Another result to notice in the table is that the use of greenhouse plastic and hoop/tunnel coverings were discarded on a yearly basis or longer.

Table 17: Number of Greenhouse Producers Who Identified the Number of Months Disposal for Each Type of Plastic They Used

Type of Plastic	Frequency of Disposal in Months											
	0	1	3	6	10	12	24	36	48	54	60	72
6-Pack Containers	4	2	0	2	0	1	0	0	0	0	0	0
Trays/Flats	9	6	5	2	0	4	0	1	0	0	0	0
1-Gallon Containers	6	3	1	2	1	8	0	1	0	0	0	0
2-Gallon Containers	4	2	0	1	0	2	0	0	0	0	0	0
3-Gallon Containers	0	1	1	1	0	2	0	0	0	0	0	0
5-Gallon Containers	6	3	1	1	1	6	0	0	0	0	0	0
10-Gallon Containers	1	0	0	0	0	3	0	0	0	0	0	0
15-Gallon Containers	6	1	1	1	0	4	0	0	0	0	0	0
Hoop/Tunnel House Covering	0	0	0	1	0	5	2	3	1	0	0	0
Greenhouse Plastic	3	3	1	1	0	15	1	5	5	1	4	1

Figure 49 provides information on the season that greenhouse producers remove their largest volume of agricultural plastic. The period that had the highest percentage of greenhouse producers discarding their plastic was autumn. This season garnered 42 percent of the greenhouse producers who used agricultural plastic. Summer was next, which had 25 percent of the producers indicating this season as the primary removal time. Winter had the lowest percentage of producers with 14 percent of the greenhouse producers preferring this term to eliminate the highest volume of agricultural plastic. The typical method for getting rid of plastic for these producers is taking the agricultural plastic to a landfill. While 46 producers indicated that they used a landfill to dispose of their plastic, 17 producers reported that they eliminated their plastic by taking it to a recycling facility. One person identified that he buried his plastic as a method of disposal.

Figure 49: Primary Season Greenhouse Producers Disposed of Their Agricultural Plastic



There were 44 producers who indicated how many pounds of plastic they disposed of per year. As a whole, this group reported discarding 298,870 pounds of plastic per year. This equated to an average removal per farm of 6,793 pounds annually. The median producer reported that he

disposed of 450 pounds of agricultural plastic per year. The greenhouse producers indicated they took an average of 3.86 trips per year to a landfill that is on average 11.55 miles from their operation to dispose of their plastic. The median producer took one trip a year traveling a mean distance of nine miles to the landfill. The average annual estimate for tipping fees was $549.23. These producers estimate that they spent $758.17 per ton to haul the plastic to the landfill.

Given the option to recycle their agricultural plastic at no charge, greenhouse producers indicated that they would travel an average of 32.43 miles. This is approximately 21 miles beyond where they are currently disposing of their agricultural plastic. The median producer reported a willingness to travel 20 miles to recycle the plastic for free. Producers will pay on average $107.15 per ton if they had to sort the plastic and $113.09 per ton if they were not required to sort the plastic before it was picked-up, if a pick-up service was available. The median producer indicated that he would pay no more than $1 per ton for a pick-up service whether it had to be sorted or not. This suggests that the median producer does not value a pick-up service.

When asked whether the producer recycled any agricultural plastic, 29 producers indicated in the affirmative while 41 reported that they did not recycle agricultural plastic. Ten producers indicated that they knew of recycling programs in their county for agricultural plastic, while 34 stated that there was no recycling program in their county. Another 27 producers were not sure if a program existed or not in their county. Nineteen producers specified that they knew of a recycling facility that would take their plastic, while the rest indicated that they did not know of one. With 29 greenhouse producers stating that they recycled their agricultural plastic, and 19 producers knew of facilities that would take their plastic suggests that there is a group of producers who are reusing some of their plastic. This result may imply an unmet demand.

Greenhouse producers have identified multiple concerns they believe make it difficult to recycle agricultural plastic. As shown in Figure 50, the issue identified as the top difficulty to recycling is that producers perceive that recycling facilities are too far away from their operation. While 21 producers believed that these facilities were too far away, 17 producers identified not having enough material to recycle was a problem. The next highest difficulty was that there were too many restrictions. The least two difficulties with recycling were the cost of recycling and the cost of transportation.

Figure 50: Identified Difficulties by Greenhouse Producers for Recycling Agricultural Plastic

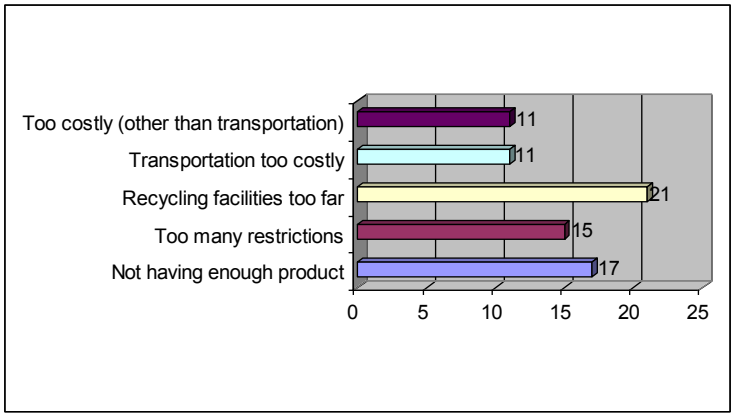
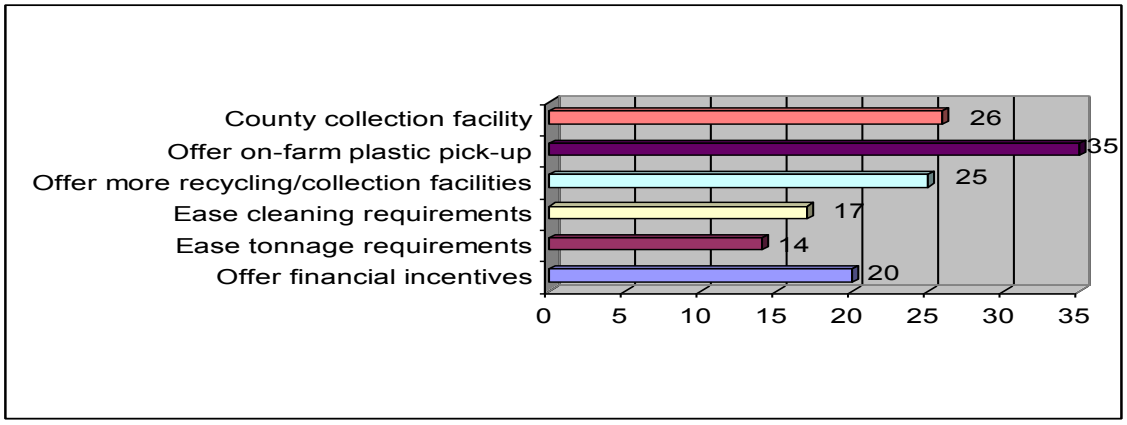


Figure 51 provides a graph on the incentives for encouraging greenhouse producers to recycle their agricultural plastic. The inducement that garnered the highest response rate was offering on-

farm pick-up services. Thirty-five producers indicated that this would encourage them to recycle. Following the pick-up service response was proposing county collection facilities. While offering county collection facilities had 26 responses, offering additional collection facilities was a close third at 25 responses. The previous results showed that the lowest ranked incentive is easing the tonnage requirements.

Figure 51: Incentives for Encouraging Recycling of Agricultural Plastics for Greenhouse Producers



Results for the Nursery Industry

Three hundred nursery producers were sent a survey on their usage of agricultural plastic. Out of this group, 84 producers returned information regarding the survey. One pepper producer and one melon producer each indicated that they also produced in the nursery industry. Two producers in the grape industry and 66 producers in the greenhouse industry also indicated that they produced in the nursery industry. This group, like the greenhouse producers, was asked to indicate either how many acres they utilized or the square footage of their facilities. There were 113 producers who indicated their production in terms of acres, while 41 producers reported their production in terms of square footage. The group that reported on an acreage basis represent 12,340 acres. The producers who reported by the square foot indicated they used 2,676,227 square feet.

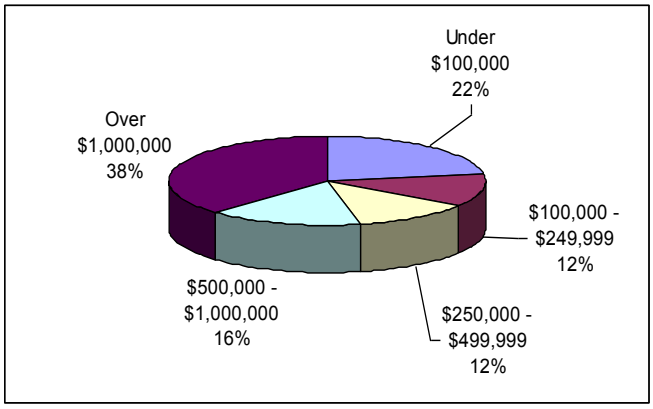
Out of the 154 producers who indicated they were in the nursery industry, 107 producers reported using agricultural plastic, while the remainder responded that they did not use agricultural plastic. This represents a participation rate of over 69 percent of nursery producers using agricultural plastic. Table 18 provides a distribution of nursery producers across the different counties in California who used agricultural plastic. Twenty-eight counties stretching the entire length of the state had producers who indicated plastic usage. Two counties, Los Angeles and San Diego, made up nearly one-fourth of the representation of the nursery producers.

Table 18: County and Number of Representatives Who Used Agricultural Plastic for the Nursery Industry

County	#	County	#	County	#	County	#
Butte	2	Monterey	7	San Bernardino	2	Shasta	3
Del Norte	1	Napa	1	San Diego	17	Siskiyou	2
Fresno	5	Orange	3	San Joaquin	4	Sonoma	6
Lake	1	Placer	1	San Mateo	2	Stanislaus	1
Los Angeles	10	Riverside	4	Santa Barbara	6	Sutter	1
Madera	2	Sacramento	4	Santa Clara	6	Tulare	2
Mendocino	3	San Benito	1	Santa Cruz	6	Ventura	4

The average gross income distribution of the agricultural plastic users in the nursery industry is represented in Figure 52. Thirty-eight percent of these producers indicated that they have an average gross income over $1,000,000. Another 16 percent reported an income between $500,000 and $1,000,000. While the sample was primarily intended for those producers who earned over $100,000, 22 percent of the nursery producers who used agricultural plastic indicated that they had an average gross income under $100,000. Examining the plastic purchasing of these producers demonstrates that the average nursery spent approximately $65,816 per year and discarded 2,874 pounds of agricultural plastic annually. The median nursery spent $6,000 annually and disposed of 200 pounds of plastic per year.

Figure 52: Average Gross Income Distribution of Nursery Producers Using Agricultural Plastic



Similar to the greenhouse industry, the nursery industry uses a variety of agricultural plastics. Table 19 provides the primary types of plastic containers that the nursery industry used on a per-count basis. This table also has the number of producers who reported using each type of plastic in the survey. There were seven producers that reported using ten-gallon containers, which had the lowest number of respondents. Fifty-seven producers reported using one-gallon containers, which was the highest number of respondents. Trays and flats had the highest average yearly usage at 295,007 containers. The median producer's highest usage on a quantity basis was six-pack containers. The least used item by both the average and median producer was the ten-gallon containers. Comparing the median to the average shows that the median producer used a much smaller quantity of each item than the average producer. Examining the ratio of average to

median usage shows there is a 2.5:1 ratio for the three-gallon containers, while the trays/flats have a ratio of 118:1. This suggests the nursery industry has a group that is pulling the average above the median.

Table 19: Average and Median Usage of Plastic Containers by Nursery Producers

Use/Type of Plastic	Average	Median	Number Reporting
6-Pack Containers	137,157	19,000	20
Trays/Flats	295,007	2,500	38
1-Gallon Containers	217,381	10,000	57
2-Gallon Containers	17,744	2,000	18
3-Gallon Containers	43,750	17,500	10
5-Gallon Containers	224,190	5,500	48
10-Gallon Containers	1,748	500	7
15-Gallon Containers	29,632	2,500	43

Table 20 shows how much agricultural plastic is disposed of by type. There was a range of five to 40 producers who provided specific information on each type of plastic. Trays and flats represented the type of plastic that had the highest amount disposed of on a yearly basis. Producers in the nursery industry reported that they removed approximately 549 pounds of this type of plastic. The 15-gallon container had the lowest average weight of disposal at 19 pounds. The median disposal weight had a much tighter distribution of values. These ranged from 1.5 pounds to 12.5 pounds with most of the median values reported at ten pounds. Approximately one-third to one-half of the producers responding to this question indicated that they did not dispose of any of these containers. This represents the group of producers who sold the container as a package to the product and does not require disposal by the producer.

Table 20: Average and Median Disposal in Pounds of Plastic Containers by Nursery Producers

Use/Type of Plastic	Average	Median	Number Reporting	Number Reporting 0's
6-Pack Containers	211.18	3.00	11	5
Trays/Flats	549.12	10.00	26	11
1 Gallon Containers	525.33	12.50	40	13
2 Gallon Containers	21.67	10.00	9	4
3 Gallon Containers	105.00	10.00	5	2
5 Gallon Containers	76.50	10.00	30	11
10 Gallon Containers	90.00	10.00	6	2
15 Gallon Containers	19.15	1.50	26	13

The other two types of plastic reported by the nursery producers, which are not represented in the previous table, are hoop/tunnel house covering plastic and greenhouse plastic. There were 16 producers who reported how much hoop/tunnel house covering plastic they used. These producers reported using an average of 50,950 square feet of this plastic, while the median

producer reported 5,500 square feet of plastic. The typical thickness of this plastic as reported by ten producers was six mils. Other thicknesses reported were one, two and four mils. Out of these 16 producers, 13 indicated the amount of plastic that they disposed. The average amount reported was 9,481 pounds. This value was greatly influenced by two producers who reported removing 94,000 and 26,000 pounds of plastic from their operation. The median producer reported eliminating 400 pounds of this plastic on an annual basis.

There were more nursery producers that reported using greenhouse plastic than the hoop/tunnel house covering plastic. Thirty-four producers reported using an average of 79,109 square feet of greenhouse plastic. The median producers stated that they used 12,500 square feet of this plastic. There were 24 producers who indicated that the thickness of this plastic was six mils. Five producers reported using four mils plastic, while two producers indicated two mils plastic. Other values given for thickness were eight, ten, and 30 mils. Out of the 34 nursery producers who gave information regarding the quantity of greenhouse plastic they used, 16 producers reported the amount of greenhouse plastic they removed yearly. The average producer indicated disposing of 8,210 pounds of this plastic on an annual basis, while the median producer reported 200 pounds.

Table 21 below provides a look at the frequency that nursery producers disposed of each type of agricultural plastic they used. These occurrences ranged from zero to 72 months. The two frequencies that many producers gravitated towards were zero and 12 months. Hoop/tunnel house coverings and greenhouse plastic had producers indicating 36 months or longer for disposal. Every other type of plastic was removed more frequently.

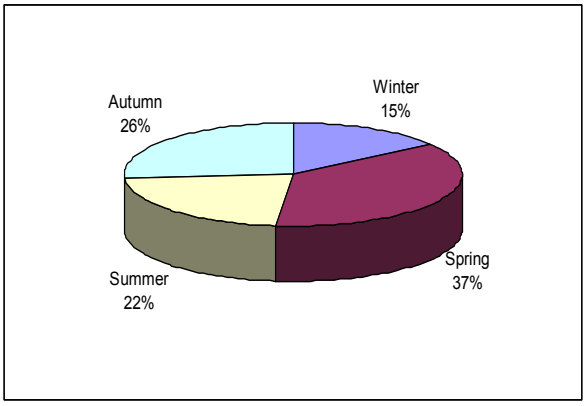
Table 21: Number of Nursery Producers Who Identified the Number of Months Disposal for Each Type of Plastic They Use

Type of Plastic	Frequency of Disposal in Months													
	0	1	2	3	6	10	12	15	24	36	48	54	60	72
6-Pack Containers	5	3	1	1	3	0	2	0	0	0	0	0	0	0
Trays/Flats	11	5	1	2	3	0	8	0	1	0	0	0	0	0
1 Gallon Containers	13	5	1	1	4	1	19	0	1	0	0	0	0	0
2 Gallon Containers	3	2	1	1	3	0	3	0	1	0	0	0	0	0
3 Gallon Containers	2	1	0	0	1	0	3	0	1	0	0	0	0	0
5 Gallon Containers	11	5	0	2	2	1	12	1	1	0	0	0	0	0
10 Gallon Containers	2	0	0	1	1	0	3	0	0	0	0	0	0	0
15 Gallon Containers	13	3	0	2	2	0	10	1	1	0	0	0	0	0
Hoop/Tunnel House Covering	0	0	0	0	2	0	12	0	0	3	1	0	0	0
Greenhouse Plastic	2	3	0	1	2	0	9	0	2	3	4	2	4	1

While the previous table presented the rate of disposal for each type of plastic that nursery producers used, Figure 53 shows the primary season nursery producers removed their largest volume of plastic. Thirty-seven percent of these producers reported spring as the time they got rid of the largest volume of agricultural plastic. Autumn and summer had 26 percent and 22 percent of producers, respectively, indicating these seasons as the disposal period for their plastic. The average producer reported disposing approximately 2,873 pounds of plastic yearly, while the median producer reported disposing 200 pounds of plastic per year. This plastic was taken to a

landfill by 51 producers; however, two producers reported taking their plastic to a recycling facility.

Figure 53: Primary Season Nursery Producers Disposed of Their Agricultural Plastic



There were 90 nursery producers who provided information on the distance they traveled to a landfill for their agricultural plastic, while 96 producers indicated the number of trips they made annually to remove their agricultural plastic. Nursery producers reported that they traveled an average of 9.16 miles to a landfill and made approximately 3.90 trips per year to discard the plastic. The median producer traveled five miles to get rid of agricultural plastic making only one trip per year. Eighty-four producers reported spending an average of $594 annually in tipping fees, while the median producer spent $27.50 a year. Eighty-one producers indicated that the hauling costs, which excluded tipping fees to get their agricultural plastic to a landfill, were $559 per ton. The median producer reported paying no hauling costs.

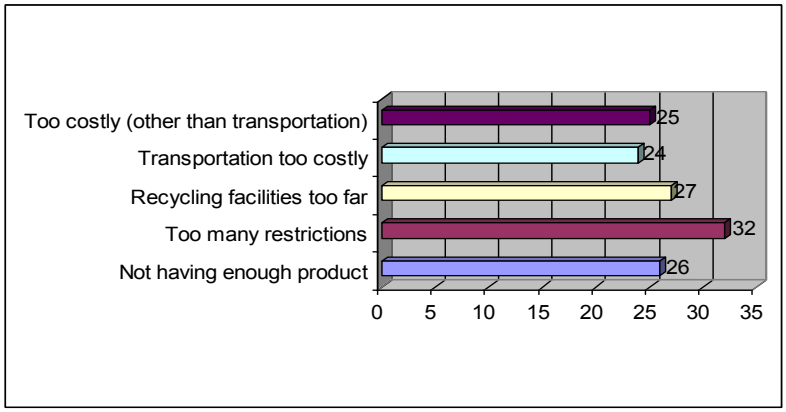
When producers were asked how far they would travel if they could recycle their agricultural plastic at no charge, the average nursery producer reported 28.06 miles, while the median producer indicated 15 miles. The average nursery producer would pay approximately $100 per ton if the plastic was sorted and$160 per ton if the plastic did not require sorting, if a recycling pick-up service came to take the plastic. The median producer reported a willingness to pay less than $1 per ton whether or not he had to sort the plastic. This suggests that the median producer does not seem to value a recycling pick-up service.

There were 49 producers indicating that they recycle their agricultural plastic. This represents 46 percent of the producers stating that they recycle some portion of their agricultural plastic. Twenty-two producers knew about recycling facilities for agricultural plastic in their county, while 27 producers knew of a recycling facility that would take their agricultural plastic. Fifty nursery producers described that there was no recycling program for agricultural plastics in their county. Another 35 producers did not know whether or not a recycling facility for agricultural plastic existed in their county. Eighty producers did not know of a recycling facility that would take their agricultural plastic.

Figure 54 provides information on nursery producers' actual and perceived difficulties with recycling their agricultural plastic. This figure demonstrates that the difficulties presented to producers received approximately the same number of responses. The item that garnered the highest number of responses at 32 was there are too many restrictions to recycling agricultural plastic. The second highest indication was that recycling facilities were too far from the

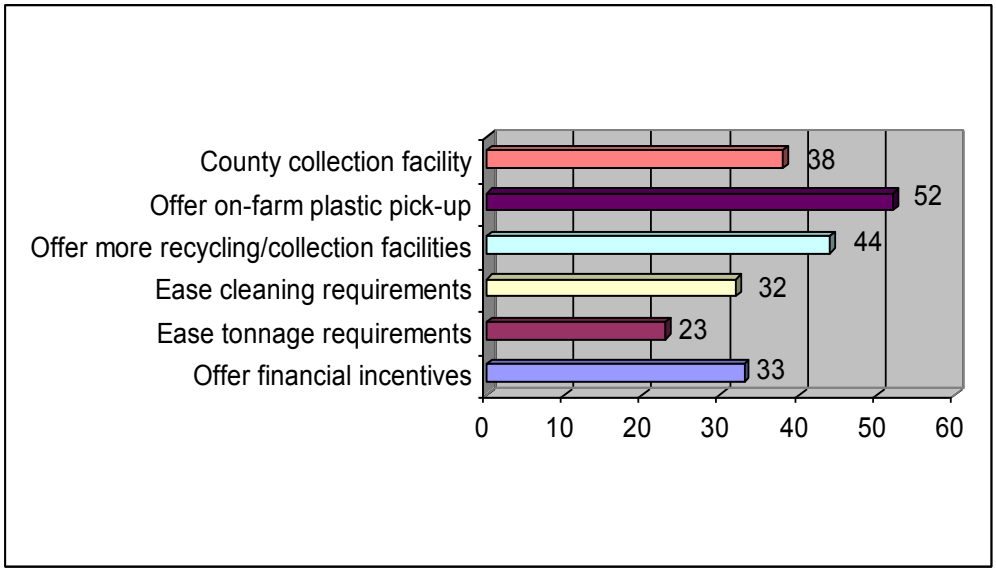
producer's operation. This result garnered 27 respondents. The item receiving the lowest response was that transportation was too costly to take the plastic to a recycling facility.

Figure 54: Identified Difficulties by Nursery Producers for Recycling Agricultural Plastic



The incentives that would encourage nursery producers to recycle their agricultural plastic are presented in Figure 55 below. The incentive that gathered the highest response rate was offering an on-farm pick-up service. This result had 52 producers. The next best result was offering more collection facilities. While 44 producers reported they would like more collection facilities, 38 producers indicated that having a county collection facility would promote recycling. The item that received the least responses from producers was easing tonnage restrictions. Offering financial incentives ranked as the fourth best way to persuade nursery producers to recycle.

Figure 55: Incentives for Encouraging Recycling of Agricultural Plastics for Nursery Producers



Estimated Annual Disposal of Agricultural Plastics for California

There are three primary approaches for estimating the amount of agricultural plastic that is disposed of annually in California using the data set acquired for this study. The first estimate takes the average per-farm disposal of agricultural plastic and multiplies it by the number of farms in California. The second approach takes into account that farms are not uniform and that the survey represents the farms that produce a majority of the agricultural product in the state. The third approach takes into account that different industries use agricultural plastic with different intensities. To make an estimate of the amount of agricultural plastic that is disposed of yearly, an approximation is generated regarding the quantity that is discarded by each industry.

A First Estimate of Agricultural Plastic Disposal: All Farms are Equal

This estimate starts with the assumptions that: 1) all size farms in California use agricultural plastic on average in a uniform fashion; 2) the information represented in the survey is indicative of the average producer; and 3) the percentage of producers who reported using plastic represents the agricultural population. Using these assumptions provides an unrealistic estimate of agricultural plastic disposal in the state totaling 198,289 tons per year. Based on the survey, this is the upper extreme of how much agricultural plastic is annually discarded in the state by producers; it is also an unlikely depiction of the actual situation. The reason this is considered an off-base estimate is that 96 percent of agricultural gross income is generated by less than 25 percent of the farms in California (2002 Agricultural Census).

This value was developed by multiplying the number of farms in California in 2005 (documented by CDFA, (2006)) by the percentage of producers in the survey reported using agricultural plastic. This amount was multiplied by the average disposal per farm as stated in the survey. The estimate for the disposal is 8,705.6 tons per year if the median producer is used rather than the average producer. This amount of disposal is also unlikely and highlights that California farm production is partial to the large producer.

A Second Estimate of Agricultural Plastic Disposal: Accounting for Farm Size

A better estimate of how much agricultural plastic is disposed of in the state takes into account that the survey represents the larger producers who generate over $100,000 in gross income annually. According to the 2002 California Agricultural Census, this group represents approximately 24.6 percent of the producers and generates approximately 96 percent of the farm gross income. The producers that earn less than $100,000 in income represent a negligible amount of agricultural plastic disposal. The estimated amount of agricultural plastic disposed is 48,768 tons per year.

This refinement improves the estimate, but the drawback assumes that producers dispose of a uniform amount of plastic. This assumption suggests that a strawberry producer on average disposes the same amount of agricultural plastic as an orchard producer. This is unlikely given how each of these producers use agricultural plastic; one for mulching purposes and the other for irrigation purposes. Results from this study emphasize that the assumption of uniform usage across industry is not valid.

A Third Estimate of Agricultural Plastic Disposal: Accounting for Non-Uniformity in Plastic Usage by Industry

The best estimate of agricultural plastic disposal takes into account that producers use and dispose of this plastic at different rates. The base unit of production and distribution, e.g., acres, number of cows, square feet, etc. was taken into consideration. Information was examined at the industry level and a three-step process was undertaken. The first step developed an estimate of the average usage for each industry. The next step multiplied the average usage by the total production units for the industry of interest. The last step summed together all of the industries disposal amounts to get a total amount for the state.

The first step in this process was developing an assessment of the amount of plastic that is discarded by each producer in a particular industry. There were two sources of disposal information. The first source came from sections two through four of the survey, where producers were asked to provide the amount of each plastic type they disposed of on a yearly basis. The plastic disposal was estimated with the sum of the responses for each type of plastic. This sum represents the total amount of plastic disposed of for a particular industry. One major issue with this data is that many producers did not provide adequate information, thereby providing a poor representation.

The second source of disposal information came from section five in the survey where producers were asked to indicate how much agricultural plastic their operations disposed of on a yearly basis. This question had a much higher response rate than the previous questions regarding the disposal of each particular type of plastic. At first glance, it seems natural to use this value as the estimation for the farm. The problem with using this value is that some farms produce multiple crops that use plastic. Hence, if this number was used for those producers who produce in multiple industries, then the amount of plastic being disposed of would be an overstatement. To handle this issue, the total plastic disposal by the multiple crop producers was dropped from this estimation and was replaced with information received in sections two through four if it existed.

Once a value was developed from each of these sources of information, a comparison was made between the values. A value for two potential sources was used as the estimate for that particular producer. Producers with multiple enterprises would have only one value from both sources of disposal information. Theoretically the producers who participated in multiple industries should have information about the amount of plastic disposal from the first source of information equal to the amount reported in the second source. This was not always so, in which case the amount chosen was the larger of the two sources of information.

Each producer was assigned a value for the amount of agricultural plastic disposed, then the amount was divided by the number of acres, cows, or square feet the operation reported. The unit chosen depended on the industry of interest. This unit was multiplied by the total that CDFA (2006) had reported for 2005 production levels in California. The nursery and greenhouse industries' producers had the option to report their size by square feet or acres. This information was not found in CDFA's statistics, so the 2002 Agricultural Census information was used instead. It was necessary to account for the difference in the years the data was collected for CDFA and the 2002 Agricultural Census. Participation rates in utilizing agricultural plastic was calculated for each industry and used in the estimation. A calculation was then made regarding how much plastic is disposed per year for each industry of interest.

The strawberry industry represented a unique challenge in obtaining an accurate figure on the amount of agricultural plastic that is disposed since the industry uses fumigation plastic which is

usually handled by an outside vendor. The estimation of how much fumigation plastic is used and disposed relied on the assumption that the amount of this plastic disposal was equal to the amount of mulch plastic that was discarded. An estimation was made from the percentage of total agricultural plastic disposal to derive the amount of plastic mulch that was discarded. This estimation was made using disposal information for the strawberry industry from section four. It was estimated that 62.3 percent of the total agricultural plastic disposal is from mulch plastic. This percentage was multiplied by the total disposal to obtain how much fumigation plastic was discarded.

Another challenge was that the orchard and other vegetable industries did not have specific commodity information for the agricultural plastic that was used. Table 22 details the trees and crops that were produced for orchard and other vegetable industries. Some of the commodities represented in the calculation of each industry may not utilize agricultural plastic. Recognizing this, the estimate obtained for these industries' disposal rate is high.

Table 22: Commodities Used to Estimate the Amount of Plastic Disposal for the Orchard and Other Vegetables Industries

Commodity Used For Orchards			Commodity Used For Other Vegetables		
Almonds	Grapefruit	Pears	Artichokes	Cauliflower	Onions
Apples	Kiwi	Pecans	Asparagus	Celery	Pumpkins
Apricots	Lemons	Pistachios	Beans	Corn	Spinach
Avocados	Nectarines	Plums	Broccoli	Cucumbers	Squash
Cherries	Olives	Plums-dried	Cabbage	Garlic	Other vegetables
Dates	Oranges	Tangerines et al.	Carrots	Lettuce	
Figs	Peaches	Walnuts			

One of the key assumptions of this estimate is that the sample is indicative of the average population. The estimates given in this section do not necessarily represent the total usage of agricultural plastic in the state. The focus of this study was to examine the industries that were the largest users of agricultural plastic with a focus on producers who earn an average gross income above $100,000. This suggests that there are some farms that utilize a relatively small amount of agricultural plastic on their operations. It is expected that these industries do not represent an appreciable amount of plastic.

Table 23 provides the estimated amount of agricultural plastic disposed of per year by the industries in this study. These values represent the best estimate given the data from the survey. This table shows that as a group the agricultural industries represented in this study are estimated to dispose approximately 55,507 tons of agricultural plastic annually. The estimate is based on the average producer's responses to the survey. Basing an estimate on the media producers results provides an estimate of 21,015 tons annually. Both the average and the median estimate using industry specific data increase the assessment of plastic disposal in comparison to the second approach. The industry average is approximately 6,738 tons greater than the non-industry specific information. The difference between the two median figures is over 12,300 tons, which establishes the importance of accounting for industry differences when examining plastic disposal.

Table 23: Estimated Tonnage of Agricultural Plastic Disposed of on a Yearly Basis by Industry

Industry	Tons of Agricultural Plastic Disposed of Annually	
	Estimate Based on Average Producer	Estimate Based on Median Producer
Other Vegetables	12,194.29	4,101.06
Greenhouse and Nursery	11,799.81	927.21
Strawberries with Fumigation Plastic	10,484.31	9,555.00
Dairy	7,902.53	1,185.21
Orchards	4,544.79	51.55
Tomatoes	4,196.70	2,653.45
Hay	2,187.14	765.44
Peppers	1,536.94	1,433.32
Grapes	340.04	273.29
Melons	193.29	5.65
Berries other than Strawberries	126.84	63.88
Total	55,506.70	21,015.05

Focusing on the industries demonstrates that the other vegetable industry has the largest average disposal, discarding 12,194 tons of plastic annually. This is an unexpected result and occurs due to the wide dispersal of commodities used when estimating this industry's value. The next highest average disposal is from the greenhouse and nursery industry combined, discarding 11,800 tons of plastic per year. This is closely followed by the strawberry industry, which is estimated to remove 10,484 tons of plastic per year including fumigation plastic. The dairy industry, which is ranked fourth in disposal of agricultural plastic, was estimated to eliminate approximately 2,500 tons less plastic than the strawberry industry. The rest of the industries combined make up 13,126 tons of plastic disposed per year, which is close to the total disposal estimate for the other vegetable industry.

The estimates based on median producer results ranges from a low of 5.65 tons annually in the melon industry to a high of 9,555 tons per year for the strawberry industry. The only two industries where the average estimate is relatively close to the median estimate are the strawberry industry and the pepper industry. These two industries averages and medians are within a 10 percent difference.

The previous table provided an estimate of the total plastic disposal by industries given the current usage practices by producers in the survey. Since there was a group of producers that indicated they did not use agricultural plastic, an attempt was made to examine the usage of plastic if every producer in each of the industries followed the average or median producers.

Table 24 provides the estimation of the tons of plastic disposed per year by each industry if every producer in the industry used and disposed their agricultural plastic. If every producer followed the averages developed in the survey, then it is estimated that approximately 107,794 tons of plastic would be removed from California operations per year by the agricultural industry in California. This is nearly twice the amount of the current plastic estimate. The estimate based on

the median producers' disposals in each industry provides an annual total of 35,981 tons of agricultural plastic.

Table 24: Estimated Tonnage of Agricultural Plastic Disposed of on a Yearly Basis by Industry Given a 100% Adoption of Agricultural Plastic Usage in the Industries

Industry	Tons of Agricultural Plastic Disposed of Annually	
	Estimate Based on Average Producer	Estimate Based on Median Producer
Greenhouse and Nursery	19,648.89	1,521.49
Other Vegetables	19,528.86	6,567.75
Tomatoes	17,297.85	10,936.90
Orchards	17,171.83	194.76
Dairy	13,766.72	2,064.71
Strawberries with Fumigation Plastic	10,817.97	9,859.08
Hay	6,160.69	2,156.09
Peppers	1,997.09	1,862.44
Grapes	829.51	666.67
Berries other than Strawberries	283.00	142.52
Melons	291.86	8.53
Total	107,794.28	35,980.95

The highest quantity of agricultural plastic is estimated to come from the greenhouse and nursery industry. If all producers in this industry followed the average, then 19,649 tons of agricultural plastic are disposed of every year. The other vegetable industry ranks second when 100 percent of its producers adopt the average plastic disposal reported in the survey. This industry had 120 tons less than the top ranked greenhouse and nursery industry. The third and fourth largest estimates of agricultural plastic disposal under the 100 percent adoption assumption were the tomato industry and the orchard industry. Both of these industries eliminated approximately 17,000 tons. This is assuming that the producers in these industries performed similar plastic usage practices as the average producers did in the survey. This result demonstrates how the adoption of a new procedure can propel an industry into utilizing more plastic on a yearly basis.

Recycling Strategy

This document provided an in-depth examination of the usage and disposal of agricultural plastic by California agricultural producers. Information analyzed in this report was from a survey that was developed by focus groups of producers and administered to California agricultural producers.

The participation rate for recycling agricultural plastic by average gross income levels from the survey respondents is presented in Table 25. This table displays the recycling participation rate for all incomes at 35.94 percent. Focusing on income level from this table shows that the participation rate for recycling ranged from a low of 30.43 percent to a high of 38.67 percent.

Producers at the highest gross income bracket ranked as the highest users of recycling practices, while producers at the lowest income level ranked the lowest.

Table 25: Participation Rate in Recycling Agricultural Plastic by Gross Income Level

Under $100,000	$100,000 to $249,999	$250,000 to $499,999	$500,000 to $1,000,000	Over $1,000,000	All incomes
30.43%	31.82%	36.96%	32.39%	38.67%	35.94%

There are two major implications derived from this table. The first is that a group of agricultural producers were recycling some of their agricultural plastic at the time the survey was administered. This is an encouraging finding demonstrating that some producers find a value recycling their agricultural plastic. This table also suggests that there is room for growth in the participation rate for recycling agricultural plastic.

Focus on the Large Producers

A major finding from this survey was that most industries were dominated by a group of large producers who use a majority of the agricultural plastic. The results from the median producer were significantly smaller than that of the average producer in most industries examined. If this sample statistic holds true for the population, this would suggest that the key to developing a successful recycling strategy relies heavily on the participation of the large producers in the state. While this group has the highest participation rate for recycling, it also has room to develop.

Developing a plan for a particular industry and building upon its success toward other industries is a way to expand the recycling of agricultural plastic. Given the results from the survey, it is expected that the strawberry industry is the best candidate for developing a recycling program. There are three key factors that make this industry preferable to other industries:

- The strawberry industry has a large concentration of producers in a few counties.
- This industry indicated that it has a recycling participation rate of 31 percent. This suggests that there is room for growth in this industry to recycle.
- The strawberry industry is a natural industry to develop a recycling program due to its large usage of agricultural plastic.

Even though it was estimated to be the third largest user of agricultural plastic in the state, the plastic usage by this industry is relatively concentrated in a small region of the state in comparison to the other industries examined.

Incentives and Difficulties Which Need Addressing

It appears from the results of this study that creating a successful recycling strategy revolves around the convenience to the producer. The producers in this study indicated that the greatest difficulty that they perceive with recycling agricultural plastic is that the recycling facilities are too far from their operation. Setting up more collection facilities across the state will overcome this problem. This was followed closely by producers mentioning that there were too many restrictions as a major difficulty to recycling. According to the strawberry focus group, these restrictions include the amount of plastic accepted, the color of the plastic, and the level of cleanliness of the plastic. Too many restrictions was also mentioned in the focus groups as an issue and thus confirmed by the results from the survey. A concerted effort to encourage the reduction of these challenges as part of its recycling strategy needs to be addressed.

Producers indicated in the survey that the greatest incentive they could receive for recycling is offering on-farm pick-up for agricultural plastic. This incentive had the highest number of respondents over all other options given, including financial incentives. The preferred inducement chosen by each industry surveyed had a group of producers that would pay for a pick-up service for the plastic. The amounts that producers were willing to pay depended upon their industry type. How much they were willing to pay also relied upon whether or not they had to sort their agricultural plastic. This is evidence that producers are looking for convenience as a factor to their recycling decision and that there is a willingness to pay for this convenience.

While many producers in this study identified a pick-up service as a preferred enticement to encourage them to recycle, a recycling strategy needs to take into account the level of convenience. Some producers, especially strawberry producers, do not necessarily have the ability to store used plastic. A producer's desire to recycle is dependent upon whether the used agricultural plastic is taken away in a timely manner.

Different industries, as well as producers, find various incentives and difficulties important in regards to recycling. A "one size fits all" strategy for incentives statewide is not appropriate. This is especially true in a state that produces a set of diverse agricultural commodities that use a variety of agricultural plastic. Potentially multiple incentives are necessary to encourage various producers to recycle their agricultural plastic.

Recognition

Since a high proportion of agricultural plastic is in the hands of a relatively small group of producers, a strategy for recycling should start with increasing the participation rate for this particular set of producers. Focusing on the large producers will improve the recycling program's ability to collect the amount of plastic needed to maintain viability. One method that might encourage these large producers to recycle is to provide acknowledgement from an agency like CIWMB for their sustainability practices. The producers can use the acknowledgement to demonstrate that they are stewards of California and its agricultural land.

Resources

It is recommended that an easily accessible website be developed to list all the recyclers and recycling programs within the state. This site would post information about what products the recyclers are willing to accept from producers. This website should be developed in cooperation with the County Agricultural Commissioners, the California Department of Food and Agricultural, and/or the UC Cooperative Extension. The key to this website is to make it visible to the producer. Benefits would accrue to the producer if an educational campaign focused on how and where producers could recycle their agricultural plastic.

Future Research

The producers identified that their greatest difficulty with recycling agricultural plastic is that the current recycling facilities are too far from their operation. This suggests further analysis is needed to understand how far producers would travel to recycle their agricultural plastic. This study examined how far producers would travel if recycling was free. Further studies should focus on how far producers would travel if they had to pay to recycle their agricultural plastic or if they were compensated for bringing their plastic to the recycling facilities. It is expected that the cost and convenience of the service will dictate the true number of producers who would opt in to a pick-up service for their agricultural plastic.

A major difficulty cited by producers in their perception of recycling is that there are too many restrictions by the recyclers. The study did not examine what restrictions are causing difficulties for producers. It is recommended that a study be undertaken to identify the specific restrictions that are causing difficulties for producers. Further, this study should examine what the benefits and costs are to relaxing the restrictions imposed by the recycler. It should also be examined how much each restriction needs to be relaxed to encourage producers to recycle.

Given that the other vegetable industry, as defined in this study, had the highest amount of disposal, future studies should focus on examining the usage and disposal of agricultural plastic by each commodity in this industry. It is conjectured that the reason the other vegetable industry had such a large disposal rate was due to the large acreage devoted to that industry. Some producers indicated they knew of recycling programs that would take their agricultural plastic, but many others did not. It was shown that 22 percent of producers indicated they knew of recycling programs in their county, while 27 percent knew of recycling facilities that would take their agricultural plastic. Given that only 27 percent of the producers knew of recycling facilities and 35 percent indicated that they recycle some of their agricultural plastic, it appears to indicate that some producers are reusing some of their plastic rather than taking it to a recycling facility. This would suggest that there is potentially unmet demand for agricultural plastic recycling facilities, which may require additional research.

Summary

This document provides an in-depth examination of the usage and disposal of agricultural plastic by California agricultural producers. This survey was categorized into five different sections. The first section of the survey collected information regarding the producers operation, i.e., general demographic information. Sections two through four gathered specific information by type of plastic regarding producers' usage and disposal of agricultural plastic. Section five explored general information regarding producers' disposal and recycling of agricultural plastic.

The producers in the survey were represented by the following industry groups: berries other than strawberries, strawberries, peppers, melons, tomatoes, nursery, greenhouse and horticulture, dairy, hay, grapes, and orchards. Information was also collected regarding plastic usage by other industries that produce a variety of vegetables besides the ones listed. These groups are believed to use the bulk of the agricultural plastic in the state.

Surveys were sent out to 3,000 producers in the state. Of that number, 2,206 of the producers responded to the survey by mail, by phone, or verbally declined over the phone to participate. There were 895 producers who responded to at least a portion of the survey, with 389 respondents indicating that they used agricultural plastic. Hence, 43 percent of the producers who filled out a portion of the survey indicated they utilized some form of agricultural plastic. Examining this usage rate by industry showed that the orchard industry had the lowest participation rate at 22 percent and the strawberry industry had the highest usage rate at 94 percent.

There currently is a group of producers who indicated that they are recycling some of their agricultural plastic. This group represents 35.94 percent of the plastic users in the survey. This suggests that there is a group of producers who have found value in recycling their agricultural plastic and are currently undertaking the practice. Examining the recycling rate by industry shows that the melon industry has lowest recycling rate at 13 percent, while the nursery industry has the highest recycling rate at 46 percent. These results suggest that there is a current demand for recycling services.

Producers indicated in the survey that the greatest incentive for recycling is to offer on-farm pick-up for agricultural plastic. It was discovered that a large group of producers would be encouraged to recycle if this type of service existed. As a group and by industry, this incentive had the highest number of respondents over all other options given, including financial incentives. There was a group of producers in the survey who indicated they would pay for a pick-up service for their agricultural plastic. The amounts that producers were willing to pay depended upon what industry they were from. How much they were willing to pay also depended upon whether or not they had to sort the plastic.

As a group, the producers in this study indicated that the greatest difficulty they perceive or have encountered with recycling their agricultural plastic is that the recycling facilities are too far from their operations. This would suggest that one way to increase the recycling rate is to provide recycling facilities closer to the operation of producers. Another top identified difficulty was that there are too many restrictions on recycling agricultural plastic.

Examining the survey responses revealed that the average results were substantially higher than the median results. This indicates that there are a few producers at the upper end of the distribution of each answer that pull the average away from the median. This suggests that the agricultural plastic usage is concentrated on larger farms which utilize relatively large amounts of plastic. This indicates that a successful recycling strategy can target getting these large producers to participate in a recycling program.

The survey uses a refined estimate that takes into account that plastic disposal is dependent upon the different industries that utilize agricultural plastic. Utilizing industry information provides an estimate that 55,506.7 tons of agricultural plastic is disposed of annually. However, if there was 100 percent participation in usage by producers in each industry, this estimate would increase to 107,794.3 tons per year. This estimate provides a clear representation of agricultural plastic disposal given current production methods in California.

Appendix A
Producer's Survey Instrument

Survey of California Producers Using Agricultural Plastics

March 2007

Dear Producer:

This survey is being conducted by the California Department of Food and Agriculture and California Polytechnic State University, San Luis Obispo. Your participation in this survey is voluntary and greatly appreciated. All information will be kept confidential. Information obtained from this survey will assist in analyzing the impact disposal of agricultural plastics has on California producers and will be used to determine a plan for more efficiently disposing agricultural plastics. Within this study, agricultural plastics are defined as but not limited to: mulch film, greenhouse coverings, nursery pots, baler twine, plastic for crop protection *(i.e., covering haystacks, temperature control, etc.)*, irrigation components, PVC, lagoon and/or manure covers, and plastic used for fumigation. Since this survey covers a wide array of producers, some of the questions may not be pertinent to you.

Please make corrections to name, address, and Zip Code, if necessary.

PLEASE MAIL BY MARCH 30, 2007

Please complete and return this survey in the postage-paid envelope enclosed for your convenience. If you have any questions, please call Tom McNair at 1-800-851-1127, Ext. 117 or Sean Hurley at 1-805-756-5050. Please reference this survey when you call. Thank you for participating!

SECTION 1: ALL PRODUCERS' ACREAGE AND COUNTY INFORMATION

1. For your farm/ranch operation, please list the total acreage planted, or standing in 2006, per crop listed below for each county where grown *(OR square footage for greenhouse and nursery crops; number of cows for dairies)*.

	Office Use			
	001 _____	002 _____	003 _____	004 _____
	County: *(specify)* _____	County: *(specify)* _____	County: *(specify)* _____	County: *(specify)* _____
Strawberries ..... Acres	011	012	013	014
Berries *(other than strawberries)* ..... Acres	041	042	043	044
Grapes ..... Acres	071	072	073	074
Melons ..... Acres	101	102	103	104
Orchards *(include all nut and stone fruit)* .. Acres	131	132	133	134
Peppers ..... Acres	161	162	163	164
Tomatoes ..... Acres	191	192	193	194
Other Vegetables ..... Acres	221	222	223	224
Dairy *(dairy facilities only)* ..... Number of Cows	251	252	253	254
Hay *(include alfalfa and all other hay)* ..... Acres	281	282	283	284
Greenhouse ..... Acres	285	286	287	288
OR				
Sq. Ft.	289	290	291	292
Nursery ..... Acres	293	294	295	296
OR				
Sq. Ft.	297	298	299	300

2. Over the last three years, what has been your average annual gross income from your farm/ranch operation?

(Check (✓) one box)

Less than $100,000	☐	$250,000-$499,999	☐
$100,000-$249,999	☐	$500,000-$1,000,000 . . .	☐
		More than $1,000,000 . . .	☐

Office Use
401

3. Do any of your enterprises, listed in Question 1, use agricultural plastic? *(Check (✓) one box)* ☐ Yes, go to Section 2 ☐ No, continue

Office Use
402

a. In the next five years, are you planning on using agricultural plastic? *(Check (✓) one box)*
☐ Yes, continue ☐ No, go to Section 6 ☐ Do not know, go to Section 6

Office Use
403

b. If yes to a., what are the types of plastic you plan to use *(i.e., irrigation pipe, mulch film, greenhouse coverings, etc.)*?

404	405	406
407	408	409

Go to Section 6 if you currently do not use agricultural plastic.

SECTION 2: DAIRY AND HAY PRODUCERS

1. If you operate a dairy or produce hay, please complete the following table.

Use/Type of Plastic	Quantity Used Per Year			Amount Disposed of Per Year	Frequency of Disposal
	Square Feet	*Linear Feet*	*Mils Thick*	*Pounds*	*Number of Months (e.g., every 3 months, 6 months, etc.)*
Lagoon Cover	255		256	257	258
Manure/Compost Pile Cover . .	259		260	261	262
Haystack Cover	263		264	265	266
Silage Bags Used Per Acre . .	267	268	269	270	271
Twine Used Per Acre		272		273	274
Other (specify): _____ . .	275	276	277	278	279

SECTION 3: NURSERY AND GREENHOUSE PRODUCERS

1. If you operate a nursery or greenhouse, please complete the following table.

Use/Type of Plastic	Quantity Used Per Year			Amount Disposed of Per Year	Frequency of Disposal
	Number of Containers, Trays/Flats	*Square Feet*	*Mils Thick*	*Pounds*	*Number of Months (e.g., every 3 months, 6 months, etc.)*
6-Pack Containers	301			302	303
Trays/Flats	304			305	306
1 Gallon Containers	307			308	309
2 Gallon Containers	310			311	312
3 Gallon Containers	313			314	315
5 Gallon Containers	316			317	318
10 Gallon Containers	319			320	321
15 Gallon Containers	322			323	324
Hoop/Tunnel House Covering .		325	326	327	328
Greenhouse Plastic		329	330	331	332
Other (specify): _____ . .	333	334	335	336	337
_____ . .	338	339	340	341	342

SECTION 4: BERRY, VEGETABLE, TREE FRUIT, NUT, AND GRAPE PRODUCERS

1. If you grow any of the crops listed below, please complete the following table.

Crop	Use/Type of Plastic	Quantity Used Per Year			Amount Disposed of Per Year	Frequency of Disposal
		Square Feet	*Linear Feet*	*Mils Thick*	*Pounds*	*Number of Months (e.g., every 3 months, 6 months, etc.)*
Strawberries	Mulch Film	015		016	017	018
	Drip Tape		019	020	021	022
	Micro-sprinklers		023	024	025	026
	Other	027	028	029	030	031
Berries *(other than strawberries)*	Mulch Film	045		046	047	048
	Drip Tape		049	050	051	052
	Micro-sprinklers		053	054	055	056
	Hoop/Tunnel House Covering	057		058	059	060
	Other	061	062	063	064	065
Grapes	Mulch Film	075		076	077	078
	Drip Tape		079	080	081	082
	Micro-sprinklers		083	084	085	086
	Other	087	088	089	090	091
Melons	Mulch Film	105		106	107	108
	Drip Tape		109	110	111	112
	Micro-sprinklers		113	114	115	116
	Other	117	118	119	120	121
Orchards *(include all nut and stone fruit)*	Mulch Film	135		136	137	138
	Drip Tape		139	140	141	142
	Micro-sprinklers		143	144	145	146
	Other	147	148	149	150	151
Peppers	Mulch Film	165		166	167	168
	Drip Tape		169	170	171	172
	Micro-sprinklers		173	174	175	176
	Hoop/Tunnel House Covering	177		178	179	180
	Other	181	182	183	184	185
Tomatoes	Mulch Film	195		196	197	198
	Drip Tape		199	200	201	202
	Micro-sprinklers		203	204	205	206
	Hoop/Tunnel House Covering	207		208	209	210
	Other	211	212	213	214	215
Other Vegetables	Mulch Film	225		226	227	228
	Drip Tape		229	230	231	232
	Micro-sprinklers		233	234	235	236
	Hoop/Tunnel House Covering	237		238	239	240
	Other	241	242	243	244	245

2. Are your fields fumigated? *(Check (✓) one box)*
☐ Yes, I fumigate my own fields ☐ Yes, I contract to have my fields fumigated ☐ No

Office Use
250

SECTION 5: ALL PRODUCERS WHO USE AGRICULTURAL PLASTIC/FILM

1. How much money do you spend per year to purchase agricultural plastics? . . . . . Dollars 501

2. In which season do you dispose of the largest volume of your agricultural plastic/film? *(Check (✓) one box)*

				Office Use
Winter	☐	Summer	☐	502
Spring	☐	Autumn	☐	

3. How do you currently dispose of your agricultural plastic/film? *(Check (✓) all that apply)*

Dump-site	503	Burn	506
Bury	504	Other *(specify)*	507
Recycling collection facility	505	_____	

4. How much agricultural plastic, on average, do you dispose of each year? . . . . . Lbs. 508

5. How many miles away from your operation is the disposal site that you take your agricultural plastic to? . . . . . Miles 509

6. How many trips per year do you take to dispose of your agricultural plastic? . . . . . Trips 510

7. How much per year in tipping/dump fees do you pay to dispose of this plastic/film? *(Do not include transportation or labor costs.)* . . . . . Dollars 511

8. How much do you pay each year, on average, to haul agricultural plastics to a disposal site? *(Do not include dump/tipping fees.)* . . . . . $/Ton 512

9. If you could recycle your agricultural plastic for free, how far would you be willing to travel? . . Miles 513

10. If there were a pick-up company for your agricultural plastics, how much would you be willing to pay to use the service:

    a. If the company **required** you to **sort** the plastic? . . . . . $/Ton 514

    b. If the company **did not require** you to **sort** the plastic? . . . . . $/Ton 515

11. Are there any recycling programs for agricultural plastics in your county? *(Check (✓) one box)* ☐ Yes ☐ No ☐ Do not know — Office Use 516

12. Do you know of any recycling facilities that would take the plastic you use? *(Check (✓) one box)* ☐ Yes ☐ No ☐ Do not know — Office Use 517

13. Do you currently recycle any of your agricultural plastics? *(Check (✓) one box)* ☐ Yes ☐ No — Office Use 518

14. What difficulties would you expect or have you experienced with recycling agricultural plastics? (Check (✓) all that apply)

Not having enough product	519	Transportation too costly	522
Too many restrictions	520	Too costly *(other than transportation)*	523
Recycling facilities too far	521	Other *(specify)* _____	524

15. What would encourage you to recycle your agricultural plastics? (Check (✓) all that apply)

Offer financial incentives	525	Offer on farm plastic pickup	529
Ease tonnage requirements	526	County collection facility	530
Ease cleaning requirements	527		531
Offer more recycling/collection facilities . .	528	Other *(specify)* _____	

SECTION 6: CONTACT INFORMATION

Reported by: _____ Date: _____ Phone: _____

E-mail: _____ Fax: _____

Appendix B
Summary of County Information

Table B1: Summary of the Number of Participants from Each County Who Were Contacted, Those Indicating They Used Plastic, and Those Indicating They Did Not Use Plastic

County	Number of Participants from Each County Who Were Contacted	Number of Producers Indicating They Used Plastic	Number of Producers Indicating They Did Not Use Plastic
Alameda	7	1	4
Butte	26	4	12
Calaveras	1	0	0
Colusa	18	1	4
Contra Costa	7	1	2
Del Norte	3	1	0
El Dorado	6	0	1
Fresno	258	22	69
Glenn	25	4	6
Humboldt	26	2	5
Imperial	52	5	9
Kern	93	6	21
Kings	55	7	14
Lake	5	1	2
Lassen	3	2	0
Los Angeles	47	14	6
Madera	62	8	12
Marin	8	0	2
Mendocino	15	4	4
Merced	111	18	31
Modoc	7	1	1
Mono	1	0	1
Monterey	120	30	9
Napa	23	6	4
Nevada	4	1	1
Orange	25	7	1
Placer	7	2	1
Plumas	2	1	0
Riverside	65	9	15
Sacramento	24	9	7
San Benito	23	5	6

Table B1 Cont.: Summary of the Number of Participants from Each County Who Were Contacted, Those Indicating They Used Plastic, and Those Indicating They Did Not Use Plastic

County	Number of Participants from Each County Who Were Contacted	Number of Producers Indicating They Used Plastic	Number of Producers Indicating They Did Not Use Plastic
San Bernardino	42	6	8
San Diego	104	28	15
San Joaquin	166	21	60
San Luis Obispo	54	10	11
San Mateo	11	6	1
Santa Barbara	61	27	7
Santa Clara	37	15	7
Santa Cruz	60	16	6
Shasta	8	5	1
Sierra	2	0	1
Siskiyou	14	5	4
Solano	34	1	15
Sonoma	53	17	7
Stanislaus	98	14	25
Sutter	24	4	8
Tehama	14	2	3
Trinity	2	0	0
Tulare	130	11	37
Tuolumne	2	0	0
Ventura	87	16	15
Yolo	61	9	18
Yuba	10	1	6

Bibliography

Amidon Recycling. "Use and Disposal of Plastics in Agriculture." A report prepared for the American Plastics Council, April 1994.

Bolda, M., L. Tourte, K. Klonsky, and R. De Moura. "Sample Costs to Produce Strawberries." University of California Cooperative Extension, Paper No. ST-SC-04, 2004.

California Department of Food and Agriculture (CDFA). "California Agriculture Resource Directory 2006." 1220 N Street, 4th Floor, Sacramento, CA, 95814, 2006.

Clarke, S. "Recycling Farm Plastic Films." A Factsheet from the Ministry of Agricultural Food and Rural Affairs, Ontario, Canada, February 1995.

Clarke, S. and C. Fletcher. "Agricultural Plastics Recycling Handbook." A report prepared for the Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario, Canada, June 2002.

Da Costa, C., J. Franklin, S. Jordan, S. Rainey, and D. Short. "Agricultural Market Research Study for New York State: Part One." A report prepared for Cornell Cooperative Extension and Cornell Waste Management by Canadian-US Business Consulting Service at Clarkson University, May 14, 1996a.

———, "Agricultural Market Research Study for New York State: Part Two." A report prepared for Cornell Cooperative Extension and Cornell Waste Management by Canadian-US Business Consulting Service at Clarkson University, May 14, 1996b.

DSM Environmental Services, Inc. "Best Management Practices for Agricultural Forage Film Waste: Lessons Learned for Recycling and Composting." A report prepared for the American Plastic Council, Spring 1999.

Ennis, R. S. "Plastigone™,A New Time-Controlled Photodegradable Plastic Mulch Film**."** *Proceedings of the National Agricultural Plastics Congress,* 20, 83-90, 1987.

Environmental and Plastic Council. "Best Practices Guide for Agricultural Plastic Film." A guide prepared for the Canadian Plastics Industry Association, Ontario, Canada, http://www.cpia.ca/files/files/files_best_practices2.pdf, website accessed August 15, 2006, no publication date.

Garthe, James W. (2002). "Used Agricultural Plastic Mulch as a Supplemental Boiler Fuel." Penn State University Cooperative Extension, University Park, PA, no date.

Garthe, J. and J. McCoy. "Recycling Your Used Agricultural Plastics." Agricultural and Biological Engineering Solid Waste Management Bulletin C-22, Penn State University Cooperative Extension, University Park, PA, September 2002.

Garthe, J. and P. Kowal. "Recycling Plastics: The Process and Terms." Agricultural and Biological Engineering Solid Waste Management Bulletin C-10, Penn State University Cooperative Extension, University Park, PA, June 1994.

Garthe, J. and P. Kowal. "Resource Recovery: Turning Waste into Energy." Agricultural and Biological Engineering Solid Waste Management Bulletin C-11, Penn State University Cooperative Extension, University Park, PA, June 1993.

Garthe, J. and P. Kowal. "Recycling Used Agricultural Plastics." Agricultural and Biological Engineering Solid Waste Management Bulletin C-8, Penn State University Cooperative Extension, University Park, PA, no date.

Goldy, R. Baling Used Agricultural Plastic. Southwest Michigan Research and Extension Center, 1791 Hillandale Road, Benton Harbor, MI 49022, 311 Agriculture Hall, Michigan State University, East Lansing, MI 48824, Electronic copy located at: http://www.maes.msu.edu/swmrec/publicationsfolder/SWMRECOnlineReports/veggiereports/Baling%20Used%20Agricultural%20Plastic.pdf#searh='baling%20used%20agricultural%20plastic, no date.

Hussain, I and H, Hamid. "Plastics in Agriculture." In *Plastics and the Environment* edited by Anthony Andrady, John Wiley & Sons, Inc., pp. 185-210, 2003.

Hemphill, Delbert D. (1993). "Agricultural Plastics as Solid Waste: What Are the Options for Disposal?" *HortTechnology*, v. 3(1), 70-73, 1993.

Jaeger, W. "Economic Analysis of the Cost of producing Juniper-Plastic Fuel Cubes in the Upper Klammath Basin." A report prepared for ORE-CAL RC&D, PO Box 785, Dorris, CA, accessed August 27, 2006, January 30, 2006.

Jensen, M. H. "Plasticulture in the Global Community - View of the Past and Future**."** *15th International Congress for Plastics in Agriculture held concurrently with 29th National Agricultural Plastics Congress in 2000 at Hershey, PA*, 2000. http://www.plasticulture.org/history_global_community.htm.

Kasperbauer, M. J. "Strawberry Yield over Red versus Black Plastic Mulch." *Crop Science*, Vol. 40, January–February, 2000.

Kwak, S., S. Yoo, and C. Kim. "Measuring the Economic Benefits of Recycling: The Case of the Waste Agricultural Film in Korea." *Applied Economics*, v. 36, July 2004, pgs: 1445-1453.

Levitan, L. and A Barros. "Recycling Agricultural Plastics in New York State." A research report prepared for the Environmental Risk Analysis Program, Cornell University, Ithaca New York, March 11, 2003.

Levitan, L., D. Cox, and M. Clarvoe. "Agricultural Plastic Film Recycling: Feasibility and Options in the Central LeatherStocking-Upper Catskill Region of New York State." A research report prepared for the Environmental Risk Analysis Program, Cornell University, Ithaca New York, January 2005.

Orzolek, M. D. Plasticulture in North America. *Plasticulture* (4) v. 122, 2003, pgs: 33-47.

Parish, R., R. Bracy, and J. McCoy. "Evaluation of Field Incineration of Plastic Mulch." *Journal of Vegetable and Crops Production*, v. 6(1), 2000.

Randall Conrad and Assoc. LTD. The Market Feasibility of Recycling/Recovering Post Consumer Polypropylene Baler Twine in Alberta. A research report submitted to the Poly-Twine Market Feasibility Steering Committee, http://www.cpia.ca/files/files/files_baler_twine_study.pdf, accessed August 12, 2006, March 15, 2006.

Roos, D and D Jones. “Season Extension.” North Carolina Cooperative Extension, Chatham County Center, http://www.ces.ncsu.edu/chatham/ag/SustAg/SeasonExtensionOctober2005a.pdf, no date.

Splittstoesser, W, and J. Brown. “Current Changes in Plasticulture for Crop Production.” *Proceedings of the National Agricultural Plastics Congress,* 23, 241-253, 1991.

United States Department of Agriculture—National Agricultural Statistical Service. “Table 38. Nursery, Greenhouse, Floriculture, Mushrooms, Sod, and Vegetable Seeds Grown for Sale: 2002 and 1997.” 2002 Census of Agriculture. Washington, DC.

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