



Montanas future in recycling: A geographic study of factors contributing to the viability of recycling municipal solid waste
by Juliann Livingston

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Earth Sciences
Montana State University
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Abstract:

Montana state legislation indicates that municipal solid waste (MSW) should be managed by recycling waste materials prior to choosing disposal in landfills or by-incineration. The place specific factors which contribute to costs and benefits associated with recycling MSW reveal whether or not a recycling system is viable in Montana.

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The combination of location, system infrastructure, demographic and political geography contribute to the costs and benefits associated with a recycling system for MSW in Montana. The impact of each of these characteristics upon a recycling system was determined through questionnaires, correlation analyses of select study states, and by mapping components of a MSW recycling system in relation to one another. Montana's MSW recycling system was assessed, based on these studies, to determine the viability of recycling select materials in Montana.

Montana has a strong collection and processing infrastructure for the materials of interest. Due to clustering of a significant portion of the population, the costs associated with collection are not uniquely high. Although, the isolation of Montana from neighboring areas of commerce reduces the effectiveness of MSW recycling. State policies for recycling show an interest and provide reasonable support for developing a more efficient MSW recycling system in Montana. The lack of local end-users for most materials is the most significant obstacle which must be overcome. End-users are located far from the state which increases transportation costs and reduce the manufacturing benefits which Montana can claim. Because the MSW recycling system for Montana lacks a complete infrastructure within the state, it is not an independent unit and therefore is not currently viable. Yet, the system is functioning, developing, and has a reasonable chance of succeeding.

With support from individuals, private business, and public officials who direct their efforts towards developing a more efficient system the goals of landfill diversion through recycling can be achieved. Market development is the most effective means to support recycling. Public policy and finances should be directed towards incentives for manufacturing of recovered materials. Individuals should establish habits for purchasing high post-consumer content products.

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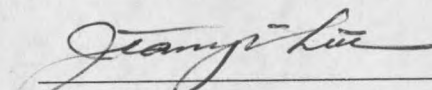
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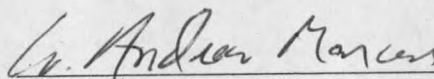
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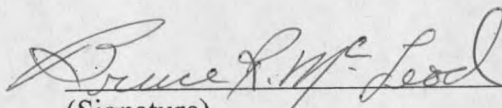
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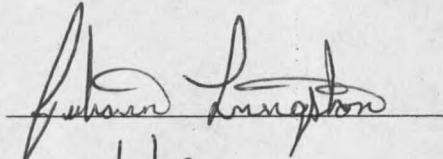
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TABLE OF CONTENTS

	Page
WASTE MANAGEMENT CONCERNS	1
Introduction	1
Methods and Sources	3
UNDERSTANDING THE RECYCLING SYSTEM	9
Background	9
Material Generation and Characteristics	15
Paper	17
Plastic	20
Glass	22
Steel	22
Aluminum	24
The National Environment	25
Basic Economic Principles Influencing the Recycling System	25
A History of Public Involvement	27
Geographic Influences Upon Components	30
EXISTING MSW ACTIVITIES IN MONTANA	34
Introduction to Questionnaires	34
The County Municipal Solid Waste Stream / Recycling Questionnaire	37
C MSW RQ Response	37
Summary of C MSW RQ Results by Question Number	39
C MSW RQ Discussion	63
The Municipal Solid Waste Stream Recycling Questionnaire for Private Business	68
MSW RQ PB Response	68
Summary of MSW RQ PB Results by Question Number	69
MSW RQ PB Discussion	81

TABLE OF CONTENTS - Continued

	Page
SOURCE AREA CHARACTERISTICS AND INFRASTRUCTURE	84
Introduction to Study States	84
Effects of Population Distribution Upon MSW Recycling	86
Summary of Demographic Distribution	105
Effects of Population Economics Upon MSW Recycling	106
Political and Social Effects on MSW Recycling	108
Political Background of Montana's Recycling System	110
Study State Legislative Profiles	114
END-USER CHARACTERISTICS AND LOCATION RELATIVE TO SOURCE AREAS	133
Introduction to End-users	133
Paper	137
Plastics	146
Glass	149
Steel	151
Aluminum	155
End-user Summary	160
CONCLUSIONS	172
REFERENCES CITED	182
APPENDICES	187
Appendix A - Recycling Contacts and Resources	188
Contacts	189
Internet Resources	192
Appendix B - County Municipal Solid Waste Stream/ Recycling Questionnaire	194
Appendix C - The Municipal Solid Waste Stream Questionnaire for Private Business	198
Appendix D - Landfill Capacity Regression Analyses	201
Appendix E - Principle Industries and Manufactured Goods of Study States	204

LIST OF TABLES

	Page
1. Material Recovery Facilities in Montana, By County	48
2. Number of Recycling Centers in Montana, By County.....	50
3. Municipal Solid Waste Recycling Budgets in Montana.....	55
4. Municipal Solid Waste Recycling Grants & Subsidies in Montana.....	57
5. Recovered Material Exports in Montana, By Percentage of Total Weight...	61
6. Municipal Solid Waste Operations Performed By Respondent Businesses...	71
7. MSW Materials Collected, Processed, or Recycled in Montana.....	75
8. Characteristics of Study States.....	88
9. Municipal Solid Waste (MSW) Management in the Study States - 1997.....	96
10. Pertinent Government Policies of Study States.....	115

LIST OF FIGURES

	Page
1. MSW Recycling Rates Across the United States - 1997.....	5
2. Interaction Between Recycling System Components.....	11
3. Heirarchy of Solid Waste Management Options.....	13
4. Generation of Municipal Solid Waste in the United States - 1996.....	16
5. Recovery of MSW for Recycling in the United States - 1996.....	19
6. County Municipal Solid Waste / Recycling Questionnaire Responses.....	38
7. MSW Generation Levels Across Montana.....	40
8. Generation of Municipal Solid Waste in Montana - 1998.....	42
9. MSW Landfill Fees Across Montana.....	44
10. MSW Disposal Service Fees Across Montana.....	45
11. Recycling Centers, Rural, and Curbside Services Across Montana.....	51
12. MSW Recycling Rates Across Montana.....	53
13. Destination of MSW Materials Recovered From Montana By County.....	60
14. Municipal Solid Waste Stream Recycling Questionnaire for Private Business Responses By County	70
15. Service Area Boundaries For Private MSW Facilities in Montana.....	73
16. The Volume of MSW Materials Recycled in Montana, as a Percentage of Current Volume (ton/year).....	77

LIST OF FIGURES - Continued

	Page
17. Destination of MSW Materials Recovered From Montana	
By Private Business.....	78
18. Selected Study States	85
19. Distribution of Densities for United States versus the Study States.....	87
20. Regression Analysis of National and Study State Density.....	90
21. Population Density Across the Study States.....	91
22. Percentage of Urban, Farm, and Rural Non-farm Population	
in the Study States - 1990.....	93
23. Population by Place Size Within the Study States.....	94
24. Curvilinear Regression Analysis of Unemployment versus	
Recycling Rate for the Study States (except Minnesota).....	107
25. Curvilinear Regression Analysis of Median per Capita Income	
versus Recycling Rate for the Study States (except Minnesota).....	109
26. States Without Manufacturing Regions or Districts.....	135
27. Distribution of Paper Mills and Manufacturers Across the United States....	143
28. Distribution of Recycled Plastic Product Manufacturers	
Across the United States.....	148
29. Distribution of Glass Cullet Processors Across the United States.....	152
30. Distribution of Steel Mills Across the United States.....	154
31. Distribution of Aluminum Mills and Fabricators Across the United States..	158
32. Market Price Trends for Old Corrugated Cardboard and Aluminum.....	163

LIST OF FIGURES - Continued

	Page
33. Market Price Trends for Aluminum	165
34. Market Price Trends for Plastic.....	166
35. Market Price Trends for Steel	167
36. Market Price Trends for Paper	168
37. Market Price Trends for Glass.....	169

ABSTRACT

Montana state legislation indicates that municipal solid waste (MSW) should be managed by recycling waste materials prior to choosing disposal in landfills or by incineration. The place specific factors which contribute to costs and benefits associated with recycling MSW reveal whether or not a recycling system is viable in Montana.

A recycling system is comprised of a source area (consumers and waste generators) and an end-user component which interact through economic market transactions for the purpose of producing products to fulfill demand. Paper, glass, plastic, steel cans, and aluminum cans are common products of manufacturing which are later recovered from municipal solid waste for recycling. Profiles of these materials were developed to show their significance to municipal solid waste recycling in terms of costs and benefits accrued by the source area, manufacturers, and the nation.

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WASTE MANAGEMENT CONCERNS

Introduction

In this study I attempted to determine where Montana stands in its progress toward a healthy municipal solid waste (MSW) recycling industry. Montana's recycling system operates within the constraints of the national industrial practices aimed toward recycling but appears to operate under some unique conditions. The State faces similar per capita accumulation of waste and adheres to the same landfill regulations as other states in the nation. Montana similarly faces public resistance for new landfill and incineration construction and struggles to cover the costs of disposal from a relatively small per capita tax base. Yet, it has the lowest rate of recycling in the nation. The objective of this thesis was to determine what unique conditions make municipal solid waste recycling in Montana so difficult. The answer seems to lie with Geography, a combination of the cultural environment, demographics, and location acting upon the efficiency of recycling system operations.

The state of Montana is located along the northern border of the contiguous United States with the Rocky Mountains forming the state's western border. Montana has the third lowest population density spread across a vast area of land, the fourth largest land area of the United States. In fact, most people responded to my initial queries by claiming that low density and long distances to manufacturers make recycling of MSW infeasible in Montana. I wished to test these claims, along with others, by analyzing the

state's recycling system and comparing it to others in the nation to determine what unique factors exist which contribute to the viability of recycling MSW in Montana.

Recycling of waste materials has been a function of industrial operations since the beginning of industry. Beginning in the 1960's and flourishing in the 1970's, pollution prevention became a national concern and recycling became one alternative to the constant disposal of potentially useful materials as waste. Industrial recycling took on a new meaning with the introduction of pollution prevention strategies developed by federal initiative. For the individual, recycling of household waste materials often took the form of a well meaning fad, or a constant struggle to promote grassroots recycling. Community leaders began to recognize local benefits of MSW recycling subsequent to facing the impact of stringent landfill regulations in the 1980's. These regulations led to a stronger community desire to recycle larger amounts of municipal solid waste to reduce costs associated with constructing, maintaining, and closing landfill facilities.

Approaches to promoting and developing recycling have varied. Many have failed while some have succeeded. The experience of pioneers in MSW recycling programs offer some insights for developing a viable MSW recycling system, but the unique characteristics of each place requires local analysis and design. From the perspective of a Geographical Planner, I have studied the geographic, demographic, and economic characteristics which contribute to the phenomenon of Montana's recycling system. I have then compared those characteristics to those of other states and studied others' success at recycling so that I might gain a basis upon which to recommend an appropriate course of action for the people of Montana to achieve a healthy or more efficient MSW

recycling industry.

Throughout this thesis, I intend to help the individual (or household generator) to gain an understanding of the recycling industry. As a result, those who wish to recycle empty food or drink containers will be in a better position to support the future growth of the recycling industry by being able to understand where an individual's efforts will help the most. This thesis will also contribute to the private business owners and government officials who deal with issues of waste management every day by supplying them with information about current activities in Montana. In addition, this thesis will supply comparative geographic analyses between Montana and several states with similar demographic and geographic characteristics, most of which appear to have better success at recycling. From these analyses we can all gain insight to help determine how to best achieve a healthy or more efficient MSW recycling industry. We have the ability to direct the future of Montana's solid waste activities in the right direction, toward sustainable MSW management practices which include recycling.

Methods and Sources

My hypothesis states that recycling of municipal solid waste is a viable activity in Montana. Hence, the focus of this thesis is upon geographic, demographic, and political factors which contribute to the viability of a recycling system, and specifically, the impact of those factors in Montana.

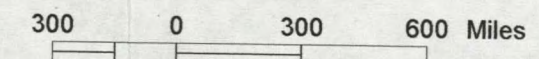
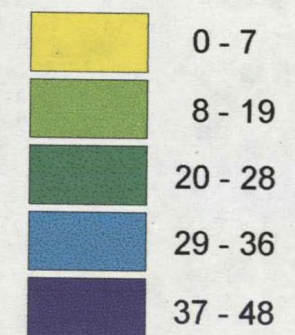
"Full cost accounting" is one way to more accurately assess the *economic* viability of operating a recycling system within a specific locale (Blumberg and Gottlieb 1989, 213

- 218; Tietenberg 1984, 553 - 562). This type of accounting analysis requires data, specific to each location, on costs related to production, consumption, and collection. Accurate data of this nature is currently unavailable due to proprietary rights, and incomplete monitoring records because of a lack of standardized data collection methods. Therefore, this study will look at primary components of the recycling system in the United States, the interactions between components, and the impacts of place and relative location of components on the viability of recycling. Borrowing from Webster's definition for 'viable', a viable recycling system is one which is a.) "capable of working, functioning, or developing adequately", b.) "capable of existence and development as an independent unit", and c.) "ha[s] a reasonable chance of succeeding" (Merriam-Webster 1989). Therefore, the primary concern of this thesis is to study the potential of Montana's MSW recycling system to sustain itself.

The balance of costs and benefits attributed to Montana due to recycling determine the success and potential sustainability, or viability, of the system. One measure of success for recycling on a state level is the percent of MSW diverted from the waste stream for recycling. This amount is called the recycling rate. Most states have been reporting their recycling rate since the early 1990's, although many are only estimates. Due to the availability of records across time and each state, recycling rates were used extensively as a standard of comparison (Figure 1).

I proceeded to collect information about the structure of a recycling system, the current status, and the future outlook of recycling activities in Montana by contacting the Montana State Department of Environmental Quality (MT DEQ) early on in the research.

Recycling Rate
(% of MSW)



Individuals with this department supplied numerous references for reports and opened their files to my searches. The MT DEQ also supplied extremely helpful lists of contacts in the state including individuals working with Headwaters Cooperative Recycling, Keep Montana Clean & Beautiful, Recycle Now, and all County Sanitarians. Phone interviews were conducted to learn about recycling activities in Montana and local concerns associated with these activities. Each of those interviewed supplied additional references and contacts.

County Sanitarians, along with private recycling professionals helped to portray Montana's recycling system through their responses to a questionnaire developed to gather county-level information about current recycling and waste management practices. Appedix A has contact information for many of the people with which I have spoken:

The Montana State University Extension Service, Solid Waste Program, also became an important resource for this thesis. Lara Dando, the Training Coordinator has been very helpful in answering questions, supplying contacts, reviewing my work, and inviting me to conferences pertaining to recycling and waste management. The extension service also maintains a library with an ample selection of waste management journals. Many of the journals are not available elsewhere in Montana but are invaluable sources of current information for the national waste management industry.

Many of the waste management professionals with whom I spoke referred me to a number of the same journals for information. Several particularly informative journals have been Waste Age, Resource Recycling, and Biocycle, which publishes the results of annual surveys on waste management and recycling practices. Numerous other journals

were accessed in preparation for this thesis and each of those referenced within this thesis are included in References Cited.

The private sector plays an important role in Montana's recycling infrastructure and public officials are not always fully aware of the private sector activities. Interviews with individuals from private recycling organizations were conducted via telephone and through a second questionnaire designed specifically for private businesses in an effort to assemble a complete picture. In addition, I have had the honor of working with Jim Hassler at Recycle It and Rick Meis at Treecycle, both located in Bozeman, Montana. I have been able to gain a first hand glimpse into the operations, concerns, and struggles associated with processing recovered materials and retail recycled paper sales by working with these small businesses.

State agencies and recycling coordinators for each of the states chosen for specific comparison to Montana were also contacted. Many states responded with a variety of useful reports, directories, and further contacts within their states. The Internet also became an invaluable source of information on individual state activities. Most states have a web site for the appropriate state department which handles waste management and recycling issues. In addition, the Environmental Protection Agency (EPA) maintains an extensive database on the Internet which provides data profiles for each state. The EPA also publishes numerous reports, bulletins, and pamphlets discussing national recycling and pollution prevention strategies and factoids, many of which are available for a nominal price.

Another resource for information pertaining to recycling and industrial practices

has been industry associations and organizations such as the American Forest and Paper Association, the Glass Packaging Institute, The American Plastics Council, and the Steel Recycling Institute.

Geographic analyses of certain states, including Montana, required demographic and economic data which was obtained from the 1990 and 1995 Census of Population and Housing. Many characteristics were mapped for a visual analyses, such as population density, while other characteristics were statistically assessed, such as unemployment rates. In addition, the distribution of industries of interest were mapped using Arcview, a Geographic Information Systems software program, with data obtained through industry associations, or Excite and GTE Yellow Pages accessed through the Internet.

Utilizing all of these sources demographic, and geographic characteristics of select states (study states), including Montana were compared along with their respective recycling achievements. The relationship of Montana, as a source area, to end-users was also assessed. Correlations between these characteristics were used to determine what, if any, unique qualities affect Montana's MSW recycling industry. From these analyses, a discussion of the consequences of geography upon viability of MSW recycling in Montana were developed to test the hypothesis of this thesis.

UNDERSTANDING THE RECYCLING SYSTEM

Background

This thesis is concerned with the viability of recycling certain portions of municipal solid waste, or MSW. Therefore, we must first understand what is meant by the terms recycling, MSW.

There are many definitions for "recycling". After reading many, it is apparent that there is a consensus that recycling encompasses many people at many stages of a process. One definition that seems to sum it all up in a concise manner is from a report by the Sound Resource Management Group, Inc. titled The Economics of Recycling and Recycled Materials (1996, 3). It states: "Recycling refers to a series of activities that diverts used materials from waste disposal and returns them to productive use". The Final State of Montana Solid Waste Management Plan goes further to list these activities as "the collection, storage, sorting, shredding, shearing, baling, and chipping of recyclable material ...; the processing of recyclables to prepare them for resale; the marketing of recovered material for use in the manufacture of similar or different products; and the purchase of products containing recycled material" (Montana Department of Health and Environmental Sciences 1994, 62). These activities are achieved by generators of the material, waste managers, collection agencies, processing facilities, transportation services, brokers, manufacturers, and consumers. From these definitions we can conclude that recycling is a system, composed of a variety of components, an infrastructure, and a

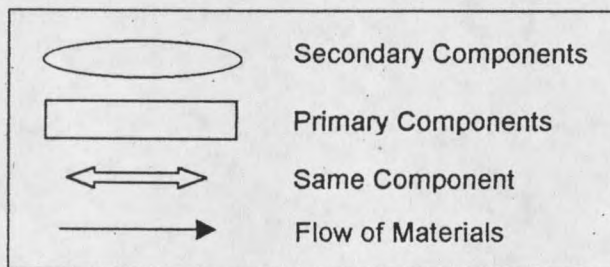
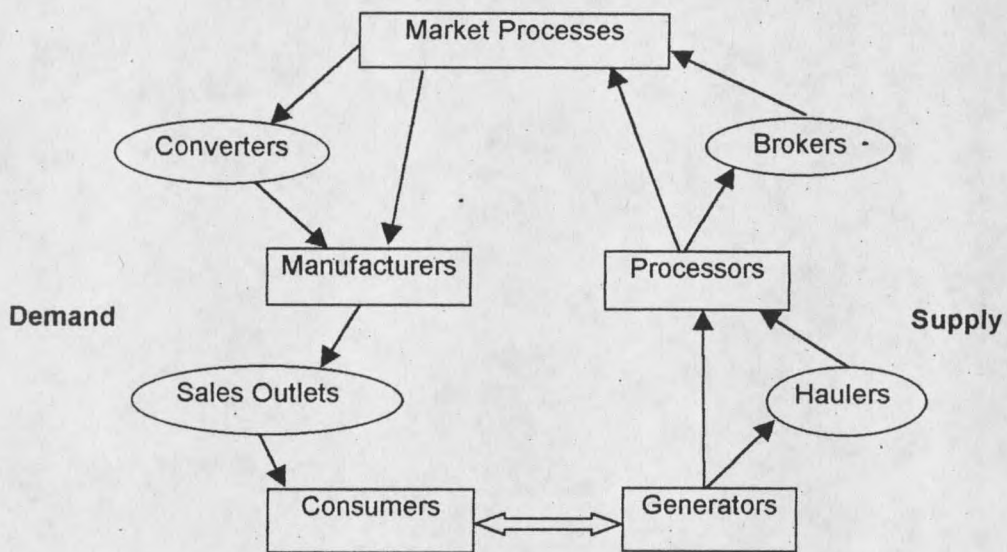
purpose. The purpose of the system is to divert materials away from waste disposal and utilize the diverted resources to produce another product. Figure 2 depicts the components of a recycling system and the interaction between these components.

Whereas materials can be recovered prior to leaving a manufacturing facility, 'mill broke', or can be recovered as pre-consumer waste materials (ie. old paper styles from printers, called 'de-inked', or returned damaged goods), this thesis is concerned with post-consumer materials from municipal solid waste. Solid waste is defined as "all solid and semi-solid wastes, including trash, garbage, yard waste, ashes, industrial waste, demolition and construction waste, and household discards such as appliances, furniture and equipment" (Montana State University Extension 1991).

Municipal solid waste is the portion of solid waste which "includes wastes such as durable goods, nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources ... MSW does not include wastes from other sources, such as construction and demolition debris, automobile bodies, municipal sludges, combustion ash, and industrial process wastes that might also be disposed in municipal waste landfills or incinerators" (United States Environmental Protection Agency 1996, 4).

MSW is usually handled by local entities which must decide how to best manage the never ending supply of waste generated by it's citizens. Recycling is just one method of municipal solid waste management. Others are composting, energy recovery, incineration, landfilling, source reduction and reuse. According to the United States Environmental Protection Agency (EPA), the way to deal with the unlimited supply of

Figure 2 : Interaction Between Recycling System Components



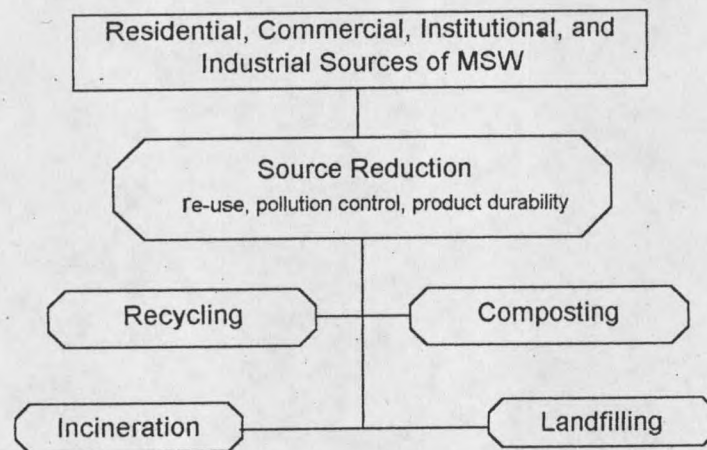
solid waste is through a technique called "Integrated Solid Waste Management". They have developed a hierarchy of options, or alternative methods of waste disposal, in order to most effectively meet the needs of local areas and the nation (United States Environmental Protection Agency 1995, xxvii). (Figure 3). The hierarchy places source reduction as the alternative with the highest priority. Source reduction can include methods such as re-use, increased durability of products, and pollution control. Through source reduction materials do not reach the waste stream and therefore do not need to be incorporated into the rest of the management decisions. Source reduction averts the problems of disposal needs and pollution abatement. It also increases the efficiency of industry and the public sector by reducing disposal costs and material purchases (Denton, Keith D. 1994). Public education and business assistance towards recognizing and avoiding waste are the best means to accomplish this goal.

The next choice in the EPA hierarchy is recycling of waste materials. This EPA category includes the composting of yard and food wastes as well as remanufacturing processes. Composting is a significant method of waste disposal practiced by the states under study in this thesis. Yet, for the purposes of this thesis, composting activities are treated as separate from recycling when possible.

To complete the hierarchy there are disposal methods such as waste combustion and the traditional method of landfilling. These last options handle those materials that can not be dealt with by the previous management methods.

In this report I am concerned with the ability of recycling to remove materials from the waste stream, after source reduction, for the purpose of utilizing those materials as

Figure 3 : Heirarchy of Solid Waste Management Options



Source : United States Environmental Protection Agency

resources for production while reducing the waste stream to relieve pressure on landfilling and incineration. The other options of an integrated waste management system mentioned above will not be discussed in detail but will be mentioned where relevant. They cannot be ignored because they are each interconnected. Choices related to the method of management will effect the volume of materials handled by another method.

Choices made by public managers and citizens concerning solid waste disposal can be made due to economic, environmental, and psychological reasons. Recycling can  reduce energy consumption in the manufacturing process, reduce the consumption of resources, reduce industrial pollution, reduce the need for costly landfills and space to build them, provide jobs and bring revenue into a local area. In addition, individuals often feel accomplishment by supporting recycling in their communities. There are also many economic costs associated with recycling such as equipment for collection, processing, and manufacturing, labor, and transportation costs. The ability to balance recycling benefits with costs has become an important image to uphold for public organizations, private business, and industry. Each reason for or against recycling must be weighed to determine if recycling is economically feasible in a specific location. For more information on psychological reasons which motivate individuals to recycling, see Schultz et al. 1995 and Knapp 1995. Psychological, economic and environmental benefits and costs associated with recycling are discussed in detail by David H. Folz, 1995, D. Keith Denton, 1994, Judd Alexander, 1993, Frank Ackerman, 1997, Edgar O. Hale, 1994, and Tom Tietenberg, 1984. The factors contributing to costs and benefits incurred by community recycling programs will be examined throughout this text and those which can

be applied directly to Montana will be determined based on the demographic and geographic characteristics of the state.

So to reiterate, recycling is:

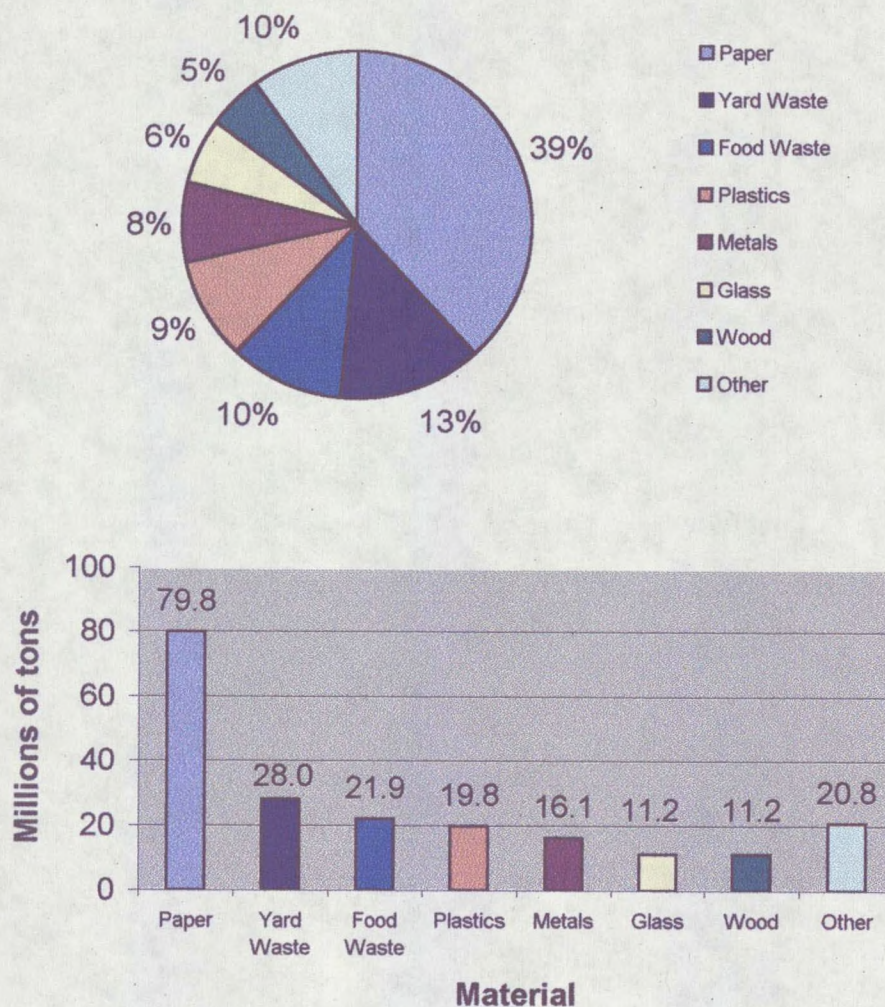
- A portion of an overall solid waste management system
- An industrial process which includes consumers, manufacturers, generators, and others in a continuous system
- Remanufacturing of useful products from waste materials that would otherwise go to a landfill or be incinerated
- A means to greater efficiencies in the form of savings in energy, disposal, remediation, etc.

Material Generation and Characteristics

The purpose of this section is to introduce the characteristics of materials under discussion and to impart some recognition of the significance of the impacts of each material on MSW disposal in the U.S. Municipal solid waste includes many materials which could potentially be recovered for recycling. As was discussed, MSW includes post-consumer materials from residential, commercial, institutional, and industrial sources.

According to the EPA, the total MSW generation for the U.S. in 1996 was 209.7 million tons, or, an average of 4.3 pounds per person per day. Figure 4 shows the Characterization of MSW in the U.S. in millions of tons and as a percent of the total tons. This thesis is largely concerned with select materials generated by residential and commercial sources. Those materials are: papers, plastics, glass, aluminum, and steel

Figure 4 : Generation of Municipal Solid Waste
in the United States - 1996



Source : U.S. Environmental Protection Agency In Boucher, Marie 1998.

cans. These are materials commonly collected by recycling programs around the country.

Other scrap metal and materials recovered for the purpose of composting are not an issue of this thesis. Yet, yard waste and food waste contribute substantially, 23%, to total MSW numbers with 28.0 and 21.9 million tons, respectively. The quantity of scrap metal excluded from the above materials is difficult to determine from the data available, although it can be said that scrap metal recovery is a thriving sector of the industry.

In the following text, characteristics of each of the selected materials are discussed. The material with the highest generation is discussed first, followed by those with successively lower generation levels.

Paper

We all generate paper from copy and writing papers to napkins and toilet paper to newspaper, boxes, and much more. By far the material with the greatest generation rate is paper. Paper materials totaled 79.8 million tons, or 39 % of total U.S. MSW, in 1996 (See Figure 4). Records from 1992 show that the commercial sector generated 57.9% of paper, while the residential sector generated 42.1% (Franklin Associates, Ltd. 1994). Generally a greater quantity of materials are recovered from commercial sources in the U.S.

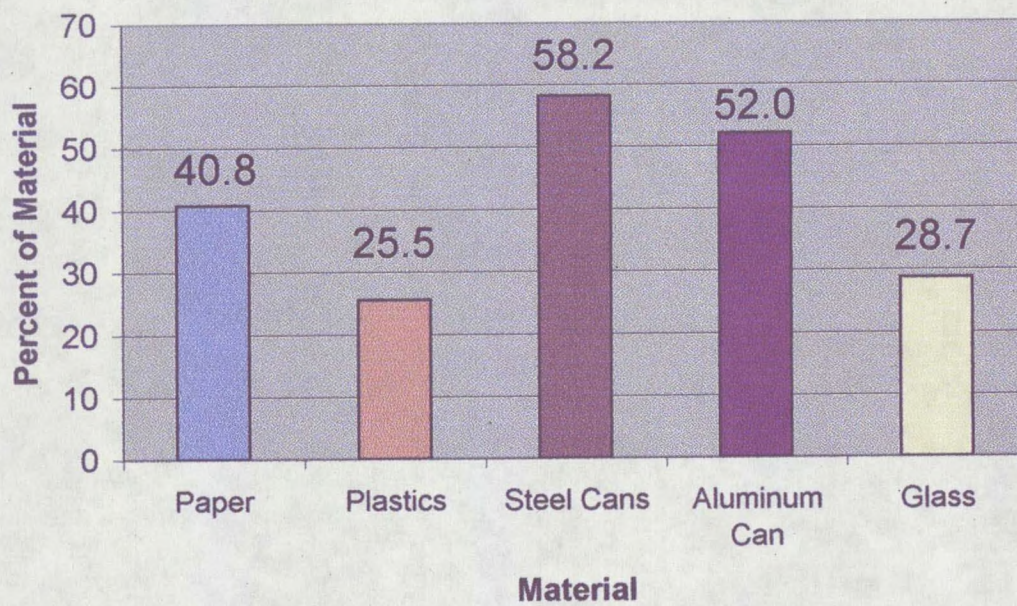
Papers are one of the best places to assert your buying power. We buy a lot of paper, and the post-consumer content within paper varies dramatically. Paper can be made out of wood, alternative fibers, and post-consumer fibers. If we want to recycle paper, to keep materials out of the landfills and save resources, then we must create a

demand for paper with a high post-consumer content. Otherwise there will be no market for recovered paper materials and no economic incentive for recycling paper. Figure 5 shows that in 1996, only 40.8% of the paper generated was recovered from the waste stream. And, "at the height of it's success recycled paper only had about 10% of the printing and writing paper market and even that had mostly virgin content" (Conservatree 1998). Unless post-consumer is specified then the label 'recycled' can consist of material collected from mill scrap or 'de-inked' printing papers which have always been re-used for pulp and thus do not reduce MSW.

Manufacturing capacities for utilizing recovered papers have steadily increased in the U.S. and industry outlook is supportive. As early as 1989, The American Forest and Paper Association (AFPA) instituted a goal for recovering and recycling 40% of the paper generated in the U.S. By 1993, AFPA met the goal and established a new goal of 50% by the year 2000. Conservatree, a pioneer in distributing recycled and chlorine-free printing and writing papers, has worked to establish an infrastructure whereby recycled paper is available for those who want it. For extremely informative discussions on the history, availability, market security, and quality of recycled papers see the Conservatree Website (Conservatree 1998).

Papers recovered at the local level are generally broken down into subcategories. The subcategories correlate to paper industry classification grades and determine the process by which the materials will be recycled and the price at which recovered materials will be purchased by end-users. The subcategories that are commonly collected in recycling programs are old corrugated cardboard, office paper, old magazines, mixed

Figure 5 : Recovery of MSW for Recycling
in the United States - 1996



Source : U.S. Environmental Protection Agency In Boucher, Marie 1998.

paper, and newspaper. These materials comprise the bulk of recovered paper sold to end-users as "secondary fibers" (Franklin Associates, Ltd. 1994).

Paper manufacturing requires a high quality resource fiber meaning that very little contamination of dirt, oil, other materials, or other grades of paper are allowed.

Contamination can cause damage and shutdowns therefore apparent contamination of a load lowers the price paid for recovered materials. Recovered paper which is not sorted to fit a particular subcategory, or mixed paper, can be used for some remanufacturing processes. It is considered the lowest acceptable grade and must still be free of contaminants. The processing of paper generally entails sorting and baling. The recovered fiber is then transferred on a per ton basis, with a ton being a standard 2000 pounds.

Plastic

As Figure 4 shows, MSW included 19.8 million tons of plastic, 9% of the total. In 1996, the recovery (recycling rate) reached 25.5%. (See Figure 5). Residential generation surpasses commercial with over 60% of the total (Franklin Associates, Ltd. 1994).

The common plastic resins include : polyethylene terephthalate (PET), high density polyethylene (HDPE), polystyrene (PS), polyvinyl chloride (PVC), low density polyethylene (LDPE), and polypropylene (PP). The common household plastics collected through recycling programs are PET, such as soft drink containers, and HDPE, such as milk jugs, laundry detergent jugs, and a variety of other packaging.

Plastic resins must be separated prior to remanufacturing. "Each resin has a unique collection of properties that determines how it is used" (Plastics Resource 1998). The melting temperatures of resins vary tremendously. Contaminant resin will reduce the efficiency of the remanufacturing process by creating burnt or non-melted material and can "produce non-standard fluidity levels" (Plastics Resource 1998).

The plastic industry has developed a classification and marking system so that products can be easily and accurately sorted. The American Plastics Council acknowledges that PET is classified as #1 and HDPE is classified as #2 resin. A distinguishing mark is usually located on the bottom of plastic containers consisting of the classification number within a triangle. A variety of plastics are often used to produce one product and these have to be separated. The marking is applied only to the material making up the majority of the product. Removing lids and pop bottle rings is required during the collection stage of recycling for this reason.

Plastic resins are often sorted by product and color as well. This is due to the fact that contaminants such as adhesives, dyes, pigments, and others won't come out of the resin, requiring the batch to be remanufactured into the same product each cycle. PET is generally not sorted by color whereas HDPE is usually sorted by color for the highest quality commodity.

A sector of plastics showing recent evidence of great expansion is in the manufacture of plastic lumber. The process can utilize large amounts of mixed resins and products without typical problems associated with package manufacturing. In addition, plastic technology is constantly evolving and has the potential to become a much larger

player in the national recycling system.

Glass

In 1996, glass contributed 11.2 million tons to MSW, 6% of the total generated. The rate of recovery reached 28.7% of that generated. See Figures 4 & 5. In 1992, 80% was generated by the residential sector and 20.0% was from the commercial sector (Franklin Associates, Ltd. 1994).

Recovered glass is usually sold as cullet, or crushed glass. Cullet can be recycled endlessly without losing its original "quality". Processing to prepare the materials for sale to remanufacturing plants usually requires that the glass be sorted by color. Specifications are stringent because too much of any color other than intended is considered a contaminant in the process. The Glass Packaging Institute maintains a database for cullet end-users around the country and tracks the activities of bottle manufacturers. Some types of glass end-users, secondary markets, can use a mixed color cullet such as road base mixtures. In this case the composition or color is not a contaminant as it is used as a filler rather than as an ingredient (ie. in the remanufacturing of glass containers).

Steel Cans

The quantity of steel cans generated in U.S. MSW is not broken out by the EPA characterization report. The EPA reports a total tonnage for all metals of 16.1 million tons.

This total includes post-consumer products and packaging, major appliances usually referred to as 'white goods', and other ferrous and non-ferrous scrap metals.

The sub-category of metals comprised of steel, or ferrous metals, accounted for 91% of the recovery of all metals from sources in 1990, not just post-consumer sources (United States Department of the Interior 1993). Steel only accounted for 68% of the value of these recovered metals.

This thesis is directed at steel cans, only a portion of the metals category. Cans are made up of steel with a tin coating so actually both steel and tin can be recovered. Less and less tin is added as a coating so steel is the main material of interest. Tin contributed less than 1% to the total metals recovered as well as the value of those metals in 1990.

The recovery rate for steel cans has been quite high. In 1996 steel cans were recycled at a rate of 58.2%, Figure 5, and rose to 60.7% by the end of 1997 (Franklin Associates, Ltd. 1994).

There is an extensive infrastructure in place for the recovery and recycling of steel. In 1988, the Steel Recycling Institute (SRI) developed a network of offices throughout the country to work on a local level "to ensure access to end markets for the steel cans being included in [recycling] programs" (Crawford 1998, 44). Subsequently, there has been an increase in recovery of steel cans with the greatest increases experienced between 1989 and 1993. The SRI has continued this work as well as the promotion of other steel recovery and recycling education spanning all materials (Crawford 1998).

"Steel is intensively recycled because of the sheer size of the market, which makes possible a vast scrap collection and processing industry, and at the same time makes non-recovery far too burdensome to the economy and the environment" (United States Department of the Interior 1993, v). Also, "with processing improvements, mills and

foundries now have less internal scrap. The industry is actively seeking to augment supplies by recycling steel cans ..." (Arrandale 1991, 42). Steel can be processed time and again without losing the character of the material. It is marketed based on gross tons, or 2,240 pounds (Franklin Associates Ltd. 1994).

Aluminum

One of the non-ferrous metals included in the EPA total of metals is aluminum. Aluminum cans have the lowest generation rate of all the materials under study. The recovery of aluminum from any source in the U.S., (not just post-consumer), is just 4% of all of the metals recovered. This material also accounts for 11% of the total value, second only to steel which is recovered in vast amounts (United States Department of the Interior 1993). In 1992, 79.9% of aluminum can generation was attributed to the residential sector while 20.1% was generated in the commercial sector (Franklin Associates, Ltd.).

The recovery rate for aluminum cans exceeds all other recyclable materials except steel cans at 52 % of cans generated. (See Figure 5). Again, the aluminum industry has been very involved in promoting the recycling of aluminum and developing an infrastructure to support this system.

Aluminum is a 'precious commodity' and the infrastructure for aluminum scrap recovery and recycling has been in place since the late 1940's. But, only since the mid-1970's has the aluminum beverage can been a component of the aluminum scrap supply to end-users (United States Department of the Interior 1993). The aluminum industry has been especially involved in recovery programs for the aluminum beverage can (Arrandale

1991). By 1993, "The major component [approximately 55%] of processed old scrap [was] aluminum beverage can scrap" (United States Department of the Interior 1993, 3).

Recycled aluminum can be substituted directly in place of virgin materials with minor preparation and the high value of the resource lends to high recovery rates. Consequently "recycled content for new aluminum containers has increased steadily from 47 percent in 1992 to 51.6 percent in 1996" (Boucher 1998, 28).

The National Environment

Basic Economic Principles Influencing the Recycling System

Components of the recycling system interact through a dynamic economic system, driven by capitalism. The system revolves primarily around market transactions between consumers and manufacturers, and secondarily around transactions between manufacturers and suppliers. Manufacturers are the pivot point between supply and demand, playing the role of supplier (of products) and consumer (of resources). The principles of supply and demand explain the relationship between price level and quantity supplied.

Traditionally economic principles, such as supply and demand, explain the relationship between price level as a response to consumer demand for a product and manufacturing response in quantity supplied. Demand for a product is what drives manufacturing. A product would not be produced if no one was willing to buy it, for at least the cost of producing it. The market is a means of allocating scarce resources. Scarcity of supply increases the willingness to purchase a certain quantity at a price, and

the price adjusts to meet the need. Scarcity of demand also increases the price for a product, by increasing the per unit cost of producing the product. Competition forces the individual manufacturers to respond to changes in consumer demand or a competitor will capture more of the market share (Tietenberg 1984, 553 - 559; Hyman 1994, 20 - 127).

The market price for resources used in the manufacturing process, virgin or recovered, are affected by the ongoing adjustments to supply and demand on the consumer side. The manufacturer creates demand for resources and the supplier adjusts the quantity provided. Recovered MSW materials compete with virgin material prices in the market. When the resources are abundant, the price paid to obtain them will be lower than at times of scarce supply. Manufacturers, or end-users, will purchase supplies at the lowest cost while maintaining the quality required.

What this implies is that in order to maintain satisfactory market prices for recovered materials, there must be adequate demand to utilize both virgin and recovered materials. When recovered materials are introduced to a virgin material market, either the price goes down or the supply of virgin materials must be reduced. One goal of recycling is to reduce natural resource consumption. Unfortunately, consumers have not always changed their buying preferences as fast as recovered material suppliers have come on-line in the U.S. The consequence is that some products produced with post-consumer recycled materials are not in demand and therefore not produced, often leaving recovered material suppliers with no demand or influence towards setting market prices.

A History of Public Involvement

Public policy has also influenced the accomplishments of the U.S. recycling system. Policies directed at recycling specifically and those indirectly associated with recycling contribute both positive and negative impacts upon the system.

Historically, recycling took place naturally as demanded by the scarcity of resources. One example is the recycling of rags to make paper. In the 1840's the process for producing paper from wood was developed and rag recycling diminished. Demand for metal drove aluminum and steel recycling in the war years. Increased recycling of industrial and municipal wastes took place in the 1960's, but for the first time was driven by social pressure as a response to wide-scale pollution and health issues.

The national political environment began to focus on the problems associated with solid waste. The Solid Waste Disposal Act of 1965 was the first legislation to focus on the development of solid waste disposal programs by offering technical and financial assistance to states and local entities (Ackerman 1997). In 1970, recycling was included with waste-to-energy as a broader focus for waste management versus disposal. The Environmental Protection Agency (EPA) which was formed in the early 1970's worked to promote waste management. These acts were completely revised in 1976 to form the Resource Conservation and Recovery Act. The Act states that "Congress finds... the problems of waste disposal... have become a matter national in scope and in concern and necessitate Federal action..." (Office of the Law Revision Council 1995, 798). "The Resource Conservation and Recovery Act of 1976 (RCRA) protects the quality of

groundwater, surface water, land, and air from contamination by solid waste" (New Mexico Environment Department 1997, 8). Through this Act, national environmental standards for landfills, including protection for all of the above, were developed and EPA was given authority to regulate and enforce landfill policies. One alternative to enduring the costs associated with landfill upgrades and closures was to reduce dependence on landfills by increasing the amount of MSW recycled.

Recycling in the 1980's was largely led by grassroots efforts along with some state and local governments. Nationally, programs were able to expand the variety of materials targeted for recycling and the "first facilities designed to process mixed recyclables" were established (Ackerman 1997, 17).

In 1984 the Hazardous and Solid Waste Amendments (HSWA) strengthened the portion of RCRA which protects groundwater. In 1988, the EPA produced the RCRA Subtitle D Landfill Regulations which would change the outlook of existing waste management practices. "The federal government sets minimum national standards applicable to municipal solid waste disposal, but state, tribal, and local governments are responsible for actually implementing and enforcing waste programs" (New Mexico Environment Department 1997, 9). The issue of requirements on tribal waste programs has been reviewed by a Federal Court and is yet undetermined whether EPA can enforce Subtitle D through tribal entities. Subtitle D regulations had a dramatic impact on landfill costs. Closures of landfills which do not have pollution prevention and monitoring equipment is very costly as is siting and constructing a new landfill to regulation specifications. Many landfills, or dumps, were closed following the issuance of Subtitle D

creating a landfill shortage, or 'crisis'. In many areas of the nation the shortage did not amount to a crisis, but it did raise awareness towards issues of waste management versus landfilling all waste for the future.

In 1993, President Clinton issued a series of Executive Orders requiring federal agencies to develop environmental programs and meet certain purchase and prevention needs. Executive Order 12873: Federal Acquisition, Recycling and Waste Prevention listed five methods in which agencies should promote recycling of waste materials (Office of Federal Register 1994). To "increase the acquisition and use of environmentally preferable products and services" was one of the methods (The President 1994, 662). This order was directed at increasing demand for recycled products so that increased MSW recovery would support end-user capacities. Agencies were directed to use Comprehensive Procurement Guidelines published by the EPA. Minimum requirements and consequences for not meeting goals were not mentioned (PRO-Act 1994). Governmental purchases including very little post-consumer content have not yet achieved the intended result.

Government policies towards virgin material or energy subsidies also impact the economic system of recycling, allowing the competitive edge to be shifted. Frank Ackerman argues quite persuasively that subsidies for virgin material prices "are not important barriers to recycling" (Ackerman 1997, 25). Energy subsidies, on the other hand can adversely affect recycling achievements. Recycling produces huge energy savings during the manufacture of some materials, such as aluminum. Removing this competitive edge is a significant loss for recycling.

Legislation at state and local levels also have an impact on the operations of the recycling industry. Local initiatives such as bottle bills, product taxes, landfill bans, public program grants, and manufacturing tax breaks alter the economic balance of operations. Legislation varies a great deal from place to place. The effects of these local policies will be discussed in more detail through assessment of the actions of individual states.

Geographic Influences Upon Components

In order to determine if Montana has a viable recycling system, I will consider select characteristics of existing components and the location of the source of materials, end-users, and consumer populations. The interrelationships between these components and the effects of relative location will also be analyzed. Through these methods it can be determined what part Montana plays in the national system and which obstacles must be overcome by the state.

Factors which effect the viability of recycling stem from the location of the source of materials (generation community) and their destination (end-user). (Throughout the remaining text of this thesis, consumers are treated as the same entity as generators and both will be referred to as the source area). Demographic, social, and political characteristics of the source area influence viability of recycling in a locale. End-user locations relative to the source area, as well as the capacity of end-users for recovered materials also contribute to the viability of MSW recycling.

While there are several modes of transportation which could be used to ship recovered MSW materials, materials are generally shipped via truck. Unpredictable

schedules are the most frequently stated reason against shipping by train. Processors cannot count on catching the best price when loading their materials onto a train that may or may not be full enough to leave the station. The specifics of transportation costs associated with infrastructure, material specifications, and individual shipping company rates are generally equal among all states and will not be discussed in detail. The most important consideration of transportation for this thesis is the effect of distance on the overall transportation costs associated with marketing materials and how this contributes to the viability of recycling in a particular locale. The section titled "End-user Characteristics and Location Relative to Source Areas" assesses the effect of distance on transportation costs in more detail.

The source population size and distribution, the social acceptance of recycling (both by individuals and the government), and legislative actions determine operating costs of collection programs. The population size influences the overall quantity of MSW generated, the available tax base from which to procure funds, and the human resources available for public programs. Larger populations operating MSW recycling programs are able to achieve some economies of scale which smaller populations cannot claim.

Generally, economies of scale refer to the phenomenon of lower per unit costs as a result of a larger scale of operation (Hyman 1994). A wave of regional cooperative programs have surfaced in the recent past as one method of gaining economies of scale in rural areas. Some have been successful, while others have simply generated supply while ignoring demand (William M. Park, 1997 and Sara L. Bixby, 1993 provide further discussion of regional recycling).

Social acceptance of recycling influences the level of participation in MSW recycling programs and thus the recovery level and the consistency of supply, both in quantity and quality. Each of these conditions effects the ability for processors to contract for stable market prices. Consistent high volumes of materials are rewarded by sincere interest and negotiable long-term contracts with fixed purchase prices. Otherwise, suppliers are dependent upon 'spot' market prices, which change daily if not by the hour.

Local legislative policies can have a wide variety of effects, either directly or indirectly, upon recycling program costs and sustainability. Local benefits from recycling can also help to balance operating costs in the long run. But it is difficult for towns or counties to grasp all of the benefits. Many benefits are seen in the manufacturing phase of recycling and impact individuals on a national scale.

End-user locations relative to a source area also influence the costs and viability of MSW recycling in a locale. Regional market price variations and the cost of transportation to those markets contribute to the marginal profit or loss for a recycling program. The availability of end-user markets also effect recycling costs. The amount of material that an end-user can accept is dependent on the capacity of the technology in-place and the demand for a final product. Industry locations are often developed in relation to the source of materials, usually virgin, energy supplies, or the location of consumer populations. These locations do not correlate to the location of all of the available municipal solid waste for many areas in the U.S.

The interaction between the source area and the end-users produce the MSW recycling system. This process is based on the infrastructure in place for collection and for

remanufacturing of recovered MSW materials. It is generally accomplished by the marketing transaction which exchanges market prices for a raw material. Variations of end-user capacities and recovery infrastructure are reflected through a regional variation of market prices. Therefore, the physical location of a source area within the United States can also effect the viability of a particular locale by influencing the gross profit received by marketing recovered materials.

The following sections will assess source area and end-user characteristics for Montana. Furthermore, details about the national infrastructure for recycling certain materials and a comparative study between select states will provide a measurement of the viability of Montana's MSW recycling system.

EXISTING MSW ACTIVITIES IN MONTANA

Introduction to Questionnaires

Two questionnaires were developed to obtain current information about Montana's MSW recycling. The County Municipal Solid Waste Stream / Recycling Questionnaire gathered primary data from county sources. It addressed issues of solid waste management and recycling specifically. A copy of the questionnaire was sent to each of fifty-four County Sanitarians. Contacts in the recycling arena for Jefferson and Yellowstone counties were sent questionnaires as recommended by knowledgeable parties. Thus, all fifty-six (56) counties in Montana were sent questionnaires. The County Municipal Solid Waste Stream/ Recycling Questionnaire can be found in Appendix B.

Those contacted were asked to return the questionnaire in approximately a month. A self-addressed stamped envelope was sent with each questionnaire. Follow-up of all counties with no response by the deadline was conducted by e-mail, when available, and with additional questionnaires by mail. Many questionnaires were returned partially answered or without being filled out, but usually with the names of additional contacts with knowledge about the county solid waste issues. These contacts were also sent questionnaires.

A second questionnaire was developed in an effort to reach some areas of the state which were lacking complete data at the close of the first questionnaire. Logistical and proprietary factors affect the ability for county officials to gather detailed quantitative data

about recycling activities. With these constraints better identified by the first questionnaire, a new questionnaire was developed to fill the data gaps. The new questionnaire was directed towards private recycling organizations. The Municipal Solid Waste Stream Recycling Questionnaire For Private Business (MSW RQ PB) requested information pertaining to the organizations' history and current activities. The services provided by these organizations do not conform to county boundaries, therefore county level data was not requested. In addition, the questions were developed with a conscious effort to avoid requesting information which would reveal sensitive or proprietary data. The MSW RQ PB is in Appendix C.

A questionnaire was sent to each pertinent business in the counties for which gaps existed in data from the first questionnaire. Gaps were defined as those counties for which no data had been returned. Often the gaps were associated with rural counties due to the lack of county structure for solid waste management. Counties with large urban populations were also targeted due to the complexity of solid waste management structure, rather than lack of any data. In these counties, several recycling providers were contacted in an attempt to get a comprehensive picture for the area.

By researching the Environmental Protection Agency (EPA) on-line, I was able to use the postal zip code of communities located in areas of the state which would be sent the MSW RQ PB to search for addresses of centers which recycle common materials in MSW. These private centers were each sent a copy of the questionnaire for private businesses. A self-addressed stamped envelope was included and the contact was asked to reply within two weeks. Several contacts were also selected from those attending the

1998 Montana Solid Waste Training Conference. In all, the MSW RQ PB was sent to thirty-five private companies, one city and five county solid waste facilities. A follow-up copy was sent, at the end of two weeks, to those from which there was no response.

In some instances, data reported by several respondents from the same county was averaged in order to accommodate the summarization of data. This method was used only when summarizing the C MSW RQ.

Census data for county populations in 1990 were used to provide a total of the population represented by questionnaire responses. For practical use of the questionnaire responses, populations for counties which yielded no useable data were removed from the total.

A commonly used measure of MSW generation in a particular place is the pounds of MSW generated per person per day. In order to promote comparison between Montana and other places, data pertaining to the amount of MSW generated in tons per year was first converted to pounds per day. This amount was then used in conjunction with 1995 population data to calculate the pounds per person per day of MSW generation for each county.

In order to calculate an accurate average for MSW generation across Montana, statistical analyses of county data was performed using a five-number summary technique. This technique requires that quantitative data be arranged in an array from low to high numbers. Five values associated with position within the data are then determined. The minimum value, first quartile or Q1 (25% of observations fall at or below this value), median, third quartile or Q3 (75% of observations fall at or below this value), and

maximum value present a summary of the data set. Outliers of the data set were defined as any value 1.5 X the interquartile range (Q3 - Q1). Outliers were removed from the data set prior to calculating the average per capita MSW generated in Montana (Neter, Wasserman, and Whitmore 1993).

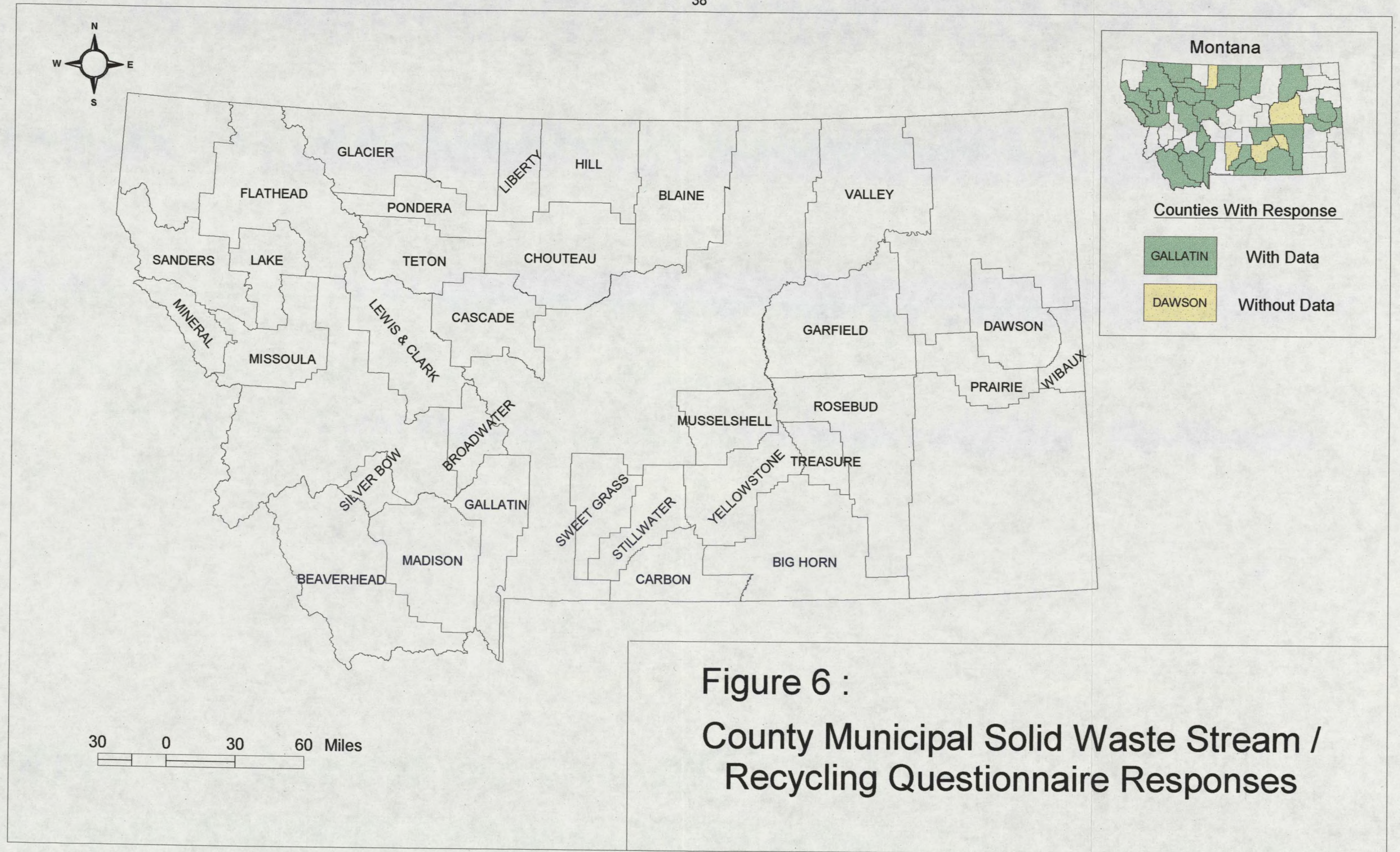
In addition to mathematical and statistical summarization of responses, some data were depicted geographically utilizing mapping techniques available by Environmental Systems Research Institute (ESRI) ArcView.

The County Municipal Solid Waste Stream / Recycling Questionnaire

C MSW RQ Response

Of the fifty-six counties contacted, thirty-two counties returned questionnaires. Figure 6 geographically depicts all counties which returned questionnaires for this portion of the study. There was a 57.1% response rate on a county basis.

However, useable data was obtained from only 27 counties, or 48.2% of those contacted. Three questionnaires (Liberty, Garfield, and Treasure counties) were returned stating simply that no information was available for that county. Two more counties, Yellowstone and Sweet Grass, yielded no information because all solid waste management activities in these areas are privately controlled. Five others were returned partially completed, but generally with qualitative responses only. This explains the lack of some quantitative data, including solid waste generation rates, for Flathead, Musselshell, Teton, Carbon, and Glacier, although these counties did contribute substantially with information relevant to trends across Montana. Twenty-two questionnaires were returned complete



with answers to most questions. Responses for Choteau, Cascade, Valley, and Missoula were compiled from data returned by two or more respondents for each county.

As the figure illustrates, responses were not returned for a number of counties in central Montana. Some counties in the west-central portion of the state as well as the northeast, southeast, and far northwest corners are also lacking representation. Useable data was compiled from 64.6% of the population of Montana, based on 1995 census estimates.

Responses were representative of both the urban and rural populations. Twenty-three percent of counties in Montana have a higher percent of urban dwellers, while C MSW RQ data was obtained from counties with a greater urban population 18.5% of the time. This leaves 81.5 % of the response counties with a greater rural population, a close reflection of the entire state.

Summary of C MSW RQ Results by Question Number

Municipal Solid Waste (MSW)

Question 1 : What is the total weight (tons) of municipal solid waste (MSW), or garbage, generated in your county?

Figure 7 shows the reported amount of MSW generated per county, and the resulting per capita generation, by county. Per capita generation is more readily comparable than total tons of MSW. The pounds (lbs)/ person /day of MSW generated in each county was calculated by the method discussed above. Calculations yielded county

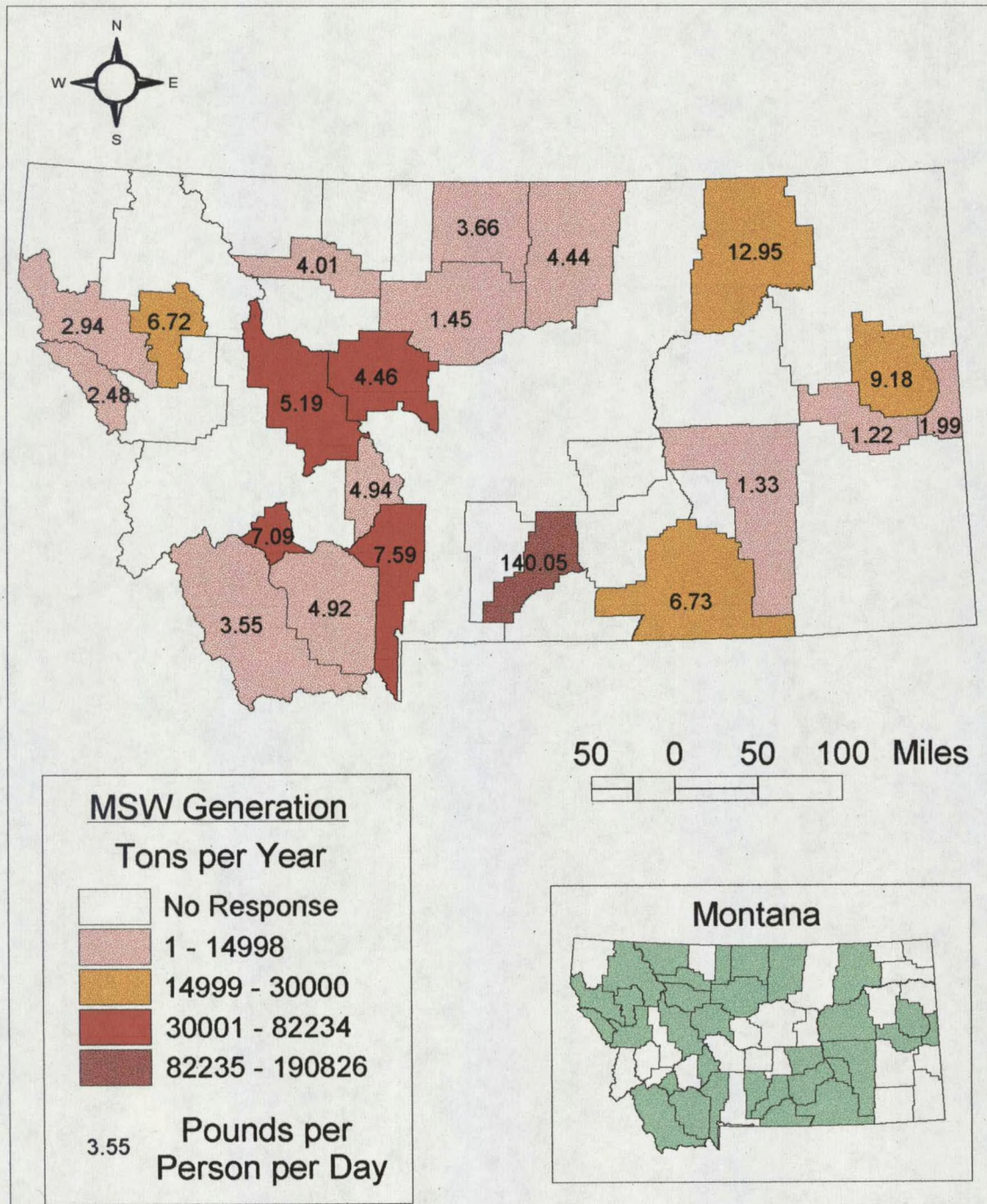


Figure 7 :

MSW Generation Levels Across Montana

Source : The County Municipal Solid Waste / Recycling Questionnaire, 1998

figures ranging from approximately 1 - 140 lbs/person/day. Fourteen of the twenty responses were 5 lbs/person/day or less. Five ranged from 6 - 9 and one was 140 lbs/person/day. Based on the reported figures the average pounds/person/day for Montana as a whole is 11.62. But, the county figure resulting in 140 lbs./person/day was deemed an outlier as defined above. Therefore, I removed this figure from the calculation which resulted in an average of 4.86 pounds generated per person per day across Montana.

Question 2 : In your opinion, what percentage of the total weight of the solid waste stream generated within your county would fall into each of [several material categories provided]?

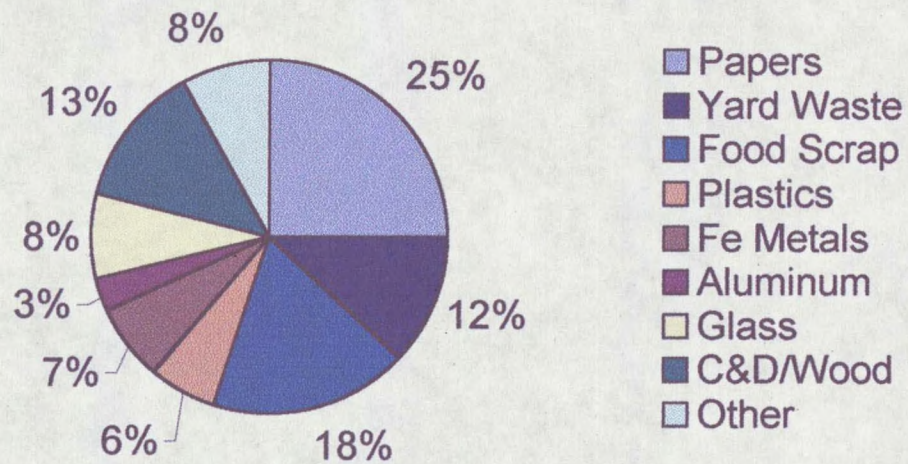
A total of fourteen counties responded with their own estimates. Several more referred to the national average, presumably those presented by the EPA. The following results are based on the supplied quantitative data: Figure 8.

Paper, food scraps, yard trimmings, and construction debris/wood prove to make up the highest percentages of the MSW in Montana. The remaining categories contribute less than 10% each to the total composition of MSW. These categories included, plastics, glass, aluminum, ferrous metals, rubber/hide, textiles, and other materials.

MSW Disposal Facilities

Question 3 : How many licensed solid waste facilities in your county have opened or closed in 1997?

Figure 8 : Generation of Municipal Solid Waste
in Montana - 1998



Source : The County Municipal Solid Waste Stream / Recycling Questionnaire

Approximately 3/4 of respondents answered this question. The results show that seven facilities were opened in 1997, three of which were in the same county. No facilities were closed during this year.

Question 4 : What kind of municipal solid waste disposal facilities are located within your county?

The types of facilities reported include transfer stations, Class II & III landfills (both private & public), and container sites for collection and transfer, burn sites, roll-off sites, illegal dumps, and compost sites. Carbon and Chouteau counties reported that no disposal sites were located within their counties but private collection services were available.

Disposal Fees

Question 5 : What is the average landfill gate fee (\$ per ton)for disposal of a load of household municipal solid waste (MSW)?

The average MSW disposal fee was reported by twenty-three counties. Most responses were not returned in dollars per ton as requested because most residents are charged on a per household per year basis. Some respondents supplied both \$/ton and \$/household/year disposal fees. See Figures 9 & 10. Answers ranged from \$17 - 45 /ton or \$48 - 308/household/ year. Most household units were charged between \$48 and \$110 per year, with an average of \$79. Three rural areas claimed costs of \$180, \$270, and \$308 per year.

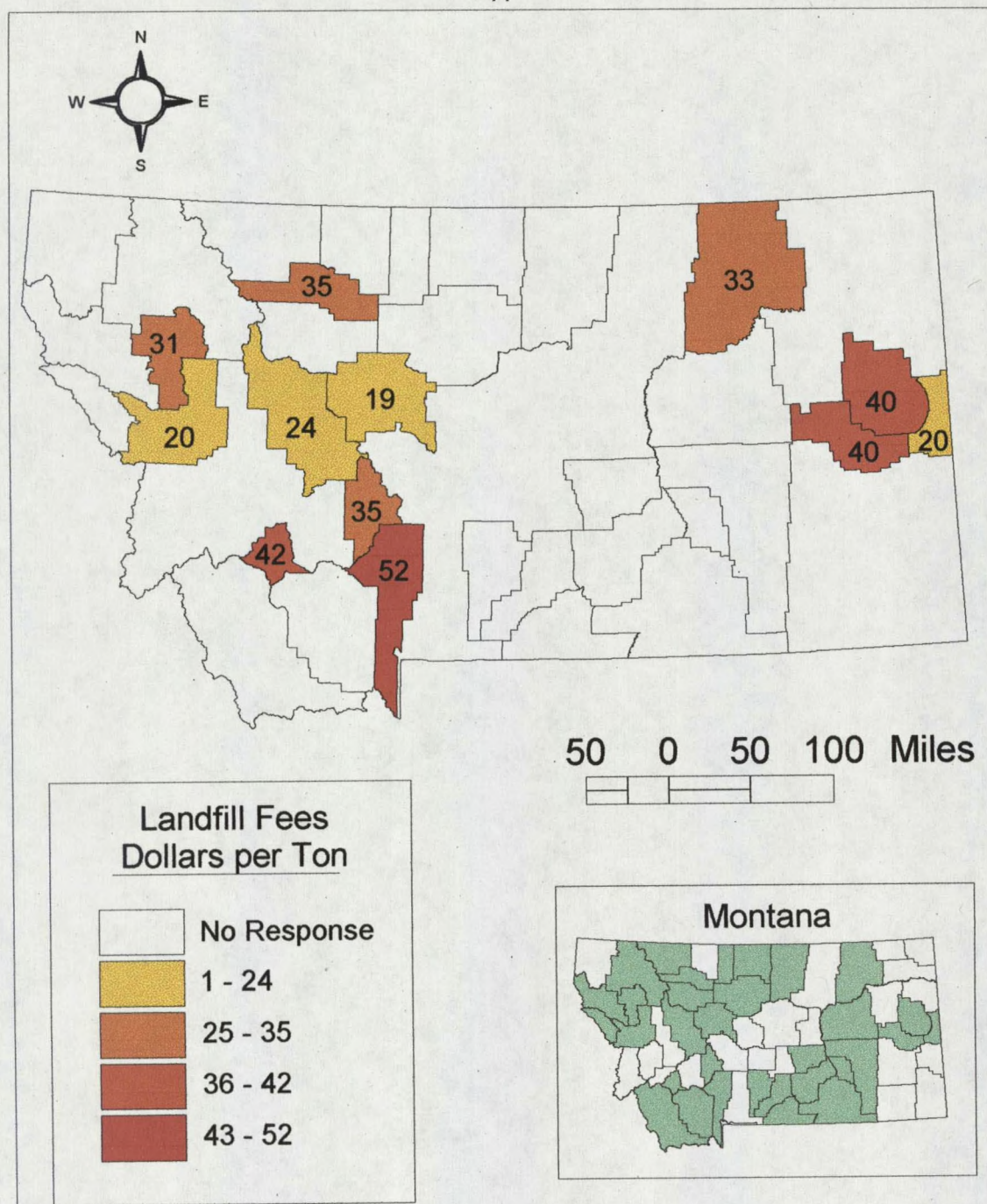
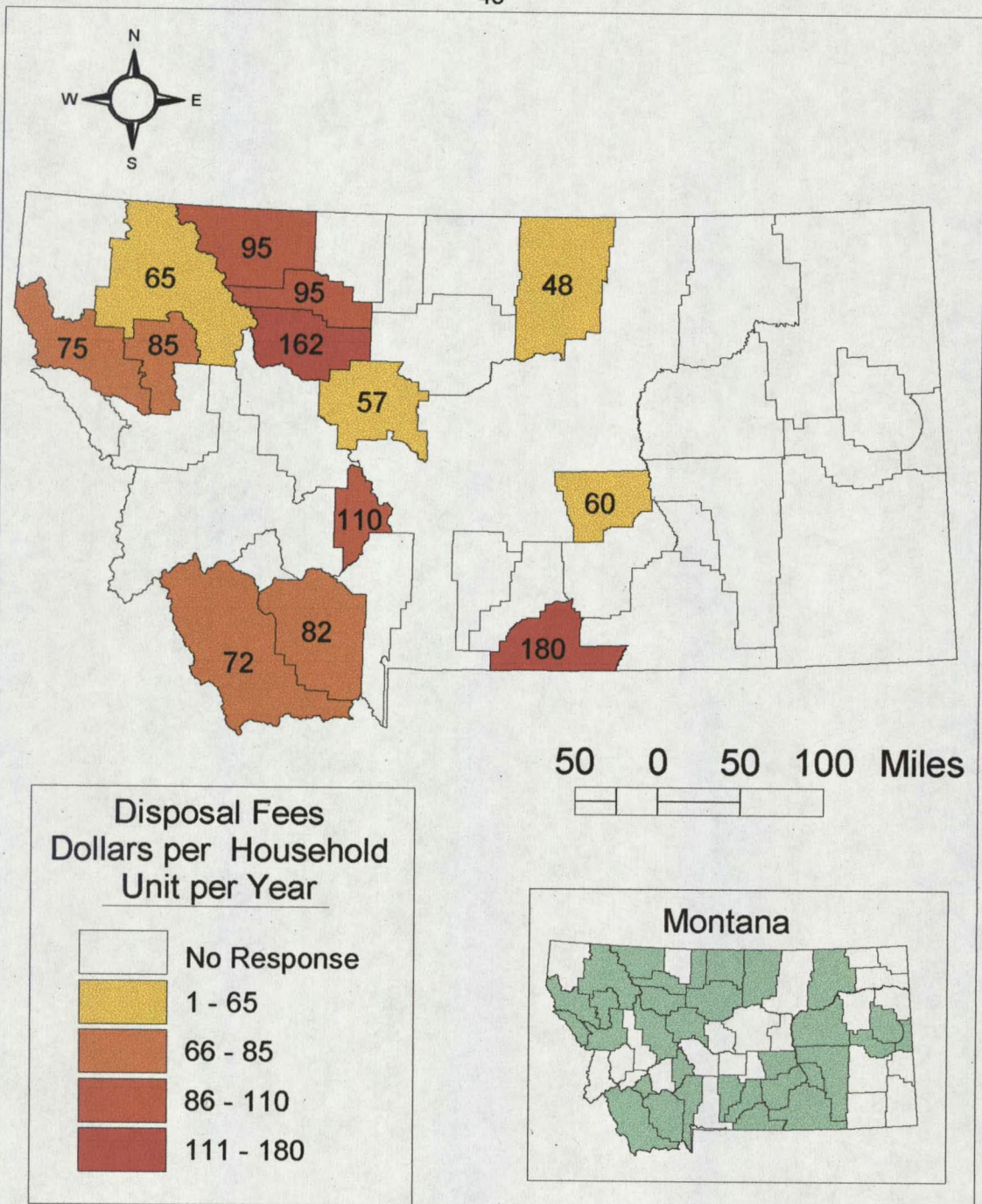


Figure 9 :

MSW Landfill Fees Across Montana

Source : The County Municipal Solid Waste / Recycling Questionnaire, 1998



Question 6 : What is the average landfill gate fee (if different from above) for a load of : [several categories of recyclable materials provided]?

This question proved not to be very valuable except for tires. Eight counties which responded charge a special fee for tires. The fee is charged per tire, per cubic yard, or per ton. The fees range from \$1- \$10 per tire and are sometimes based on the type of tire, ie. car, truck, or tractor. The fees per ton range from \$34 (shred) - \$150. One county responded with a \$7.62/cu yd fee charged for tires.

Additional items which are charged a special disposal fee are white goods (appliances) at \$45 - \$100/each. Ferrous Metals and Cardboard are disposed at \$5.00/ cu yd. in two counties.

Question 7 : Is there a surcharge in addition to the tipping fee? If so please list the surcharge for county MSW and for out-of-county surcharge.

Three counties responded with additional charges for the disposal of materials from out of county. Another county charges extra for materials from out of their solid waste district, and one county places a surcharge on materials from out of state. The charges are minimal in all accounts.

Compost

Question 8 : Are there any public composting facilities in the county? If yes, please do not include composting data in any questions which refer to recycling.

Twelve counties responded affirmative to this question. An additional sixteen counties responded in the negative.

Recovering Recyclable Materials

Question 9a : Do you believe that recycling of household solid waste is feasible in your county?

Seven counties answered yes to this question while eighteen answered no. Two additional respondents stated that recycling MSW was not feasible at this time. Another specified that within the city the answer would be yes, but no in rural areas. One respondent also commented that feasibility was currently unknown since a project to recycle household solid waste had just begun.

Question 9b, 10, 11 : Material recovery facilities (MRF) were defined, within the C MSW RQ, as "an established recycling facility which utilizes crushing, bailing, shredding, or other compaction equipment to prepare materials for market. Unstaffed facilities are not included." Question 9b requested the number of MRFs, based on the above definition, located within each county.

Twenty-seven MRF's were reported in fifteen counties. Many respondents also supplied the names of companies which operated the noted MRFs, as requested in Question 10. See Table 1 for results.

For the purposes of this study, a recycling center was defined, within the C MSW RQ, as "an established location at which household MSW materials can be brought by the public or private hauler for the purpose of recycling those materials. It can include both staffed and unstaffed drop-off facilities as well as MRFs." Question 11 requested the number of recycling centers located within each county.

**Table 1 : Material Recovery Facilities in Montana
By County**

County	Facility Name
Beaverhead	Beaverhead Recycling Center
Big Horn	City of Hardin
Blaine	New Horizons Unlimited
Broadwater	Name Not Reported
Cascade	BFI - Great Falls Recyclery Great Falls Convenience Center Filipower Brothers Pacific Steel & Recycling Weissman & Sons
Dawson	Border Steel and Recycling
Flathead	Pacific Steel & Recycling Evergreen North Valley
Hill	Havre Day Recycling Center Pacific Steel and Recycling
Lake	Folkshop, Inc.
Madison	Madison County
Missoula	BFI Waste Systems of ND, Inc. Pacific Hide & Fur
Mussellshell	BFI Mussellshell Transfer Site
Sanders	Sander County Transfer Station
Silver Bow	A S Metals Pacific Hide and Fur Rosin Brothers Recycling
Valley	Buttrey & IGA (cardboard)
Source : The County Municipal Solid Waste Stream / Recycling Questionnaire	

Sixty-five recycling centers were reported in twenty-one counties. Table 2 lists the number of centers reported, by county, Figure 11 portrays them geographically.

Question 12 : Is the rural population of your county specifically served by recycling centers? In other words are there recycling centers located outside the urban portion of your county? Provide additional comments.

Fifteen counties answered that no rural facilities are available and twelve counties answered yes to the question on available rural service. See Figure 11.

Question 13 : How many curbside or "blue bag" recycling programs are active in your county?

A total of twenty-eight counties responded to question 13 (Figure 11). Twenty-three of these reported 0 curbside services, and one county claimed N/A. Four other counties, Cascade, Gallatin, Lewis & Clark, and Missoula, reported from 1 to 3 curbside services operated within their county.

Question 14 : Do any groups (ie. Boy Scouts) collect materials for recycling? If so, which materials?

Twenty-eight counties responded, but three were either questionable answers or were reported as unknown. Nine counties do not have any recyclable collection by groups. Sixteen counties responded that there is collection by groups, twelve of which listed aluminum cans as the material collected. Other materials collected were metals and papers including: shredded office paper, newspaper, and unsorted paper. Several counties

**Table 2 : Number of Recycling Centers
in Montana, By County**

Flathead	8	Pondera	0
Lake	2	Blaine	1
Sanders	5	Chouteau	0
Glacier	0	Hill	2
Missoula	2	Cascade	* 4
Mineral	0		
		Prairie	0
Gallatin	6+	Valley	2
Madison	6	Dawson	1
Lewis & Clark	3	Wibaux	1
Broadwater	1		
Silver Bow	3	Rosebud	0
Beaverhead	4	Mussellshell	1
		Carbon	2
		Big Horn	2
		Stillwater	5

* Several responses were averaged.
Source : The County Municipal Solid Waste Stream / Recycling Questionnaire

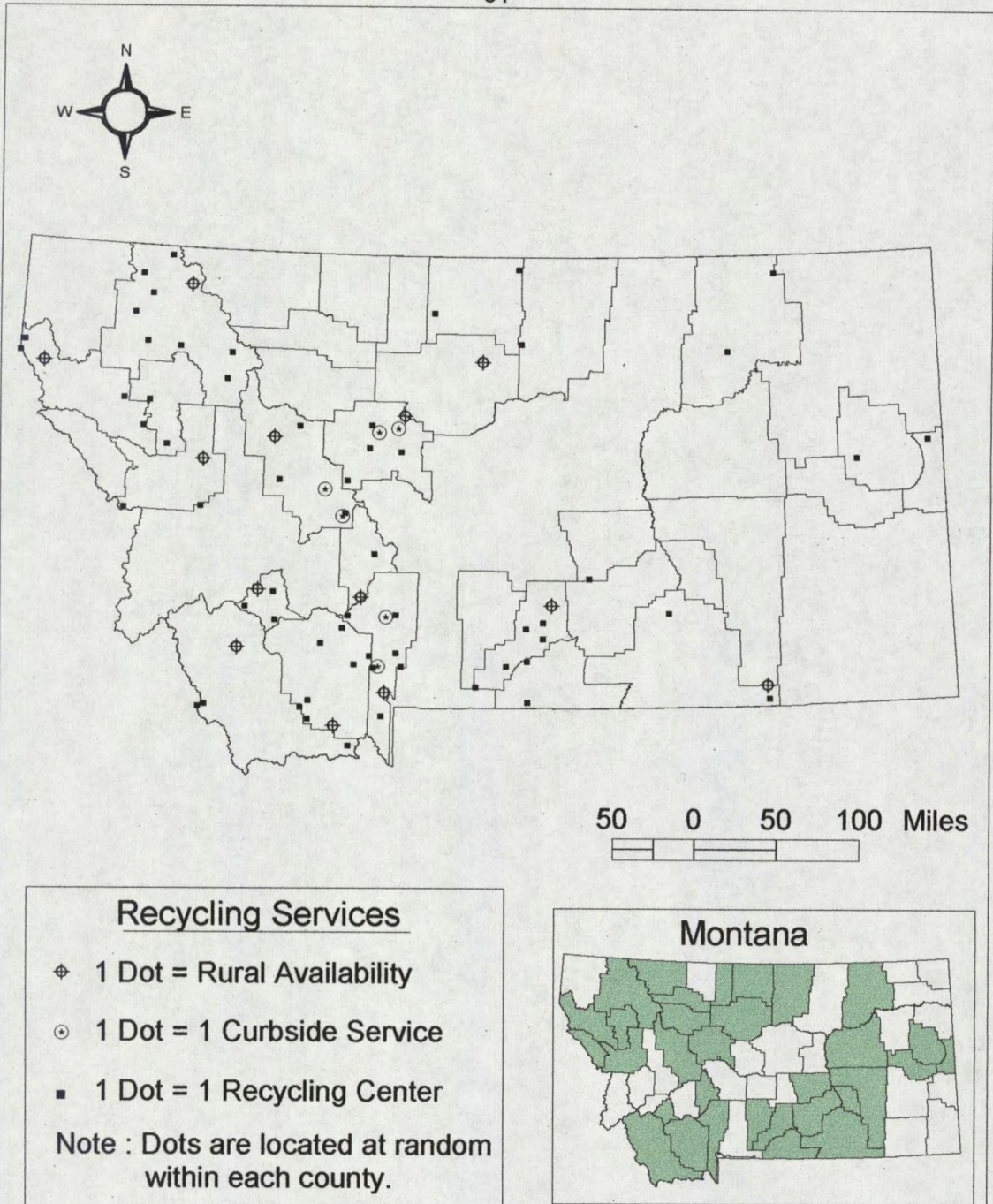


Figure 11 :
Recycling Centers, Rural, and Curbside Services Across Montana

Source : The County Municipal Solid Waste / Recycling Questionnaire, 1998

also stated that the materials collected were "limited".

Question 15 : Which household waste materials are collected by recycling centers or programs in your county, not including the above groups? (materials list provided)

The materials collected by established recycling centers and programs were listed by each of twenty-two counties. Materials collected in each county for recycling include all of the common municipal solid waste. The materials collected within the most counties include aluminum (16), newspaper (15), and corrugated cardboard (14). Steel cans (9) and clear glass (7) are collected by fewer counties, while brown glass, green glass, PET, clear HDPE, white paper, and phone books are each collected in only six respondent counties. Yellow glass (5), magazines/gloss paper (5), paperboard (5), all other glass (4), all other materials not listed (4), and colored HDPE (1) are the least commonly collected materials.

Question 16 : What percentage, by weight, of the total waste stream of the county is recycled? Each respondent was given the option of reporting an actual, or measured value, or giving an estimate of the percentage recycled.

One county reported an actual percentage of 10%. Seventeen counties reported estimates. See Figure 12 for a geographical depiction of the results. Nine counties reported an estimated recycling rate between 5 and 12%. Seven counties reported estimates between 0.5 and 3% and one county reported an approximate 35% recycling rate. Two additional respondents stated that the recycling rate was unknown and two responses were zero.

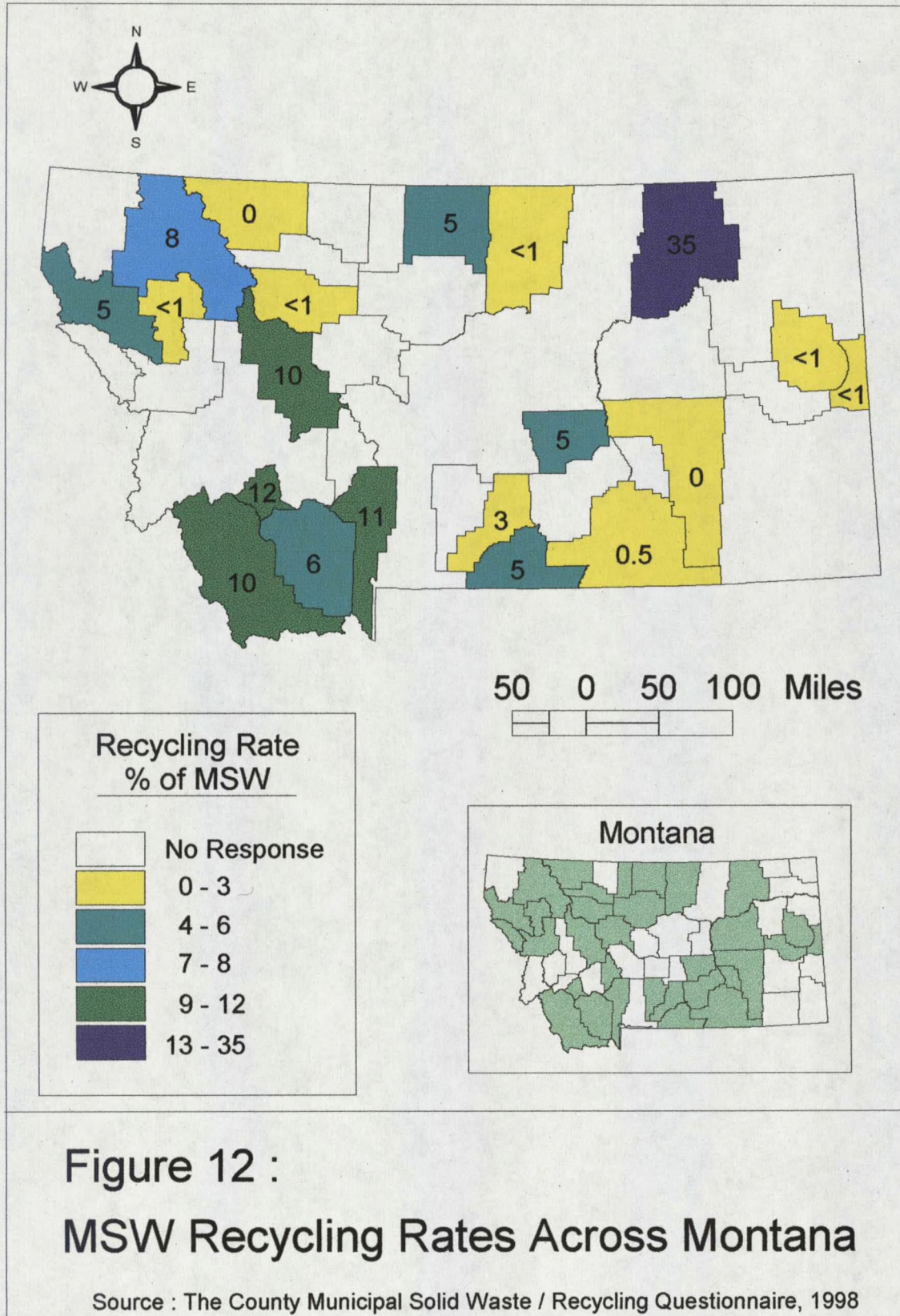


Figure 12 :
MSW Recycling Rates Across Montana

Source : The County Municipal Solid Waste / Recycling Questionnaire, 1998

Question 17 : Does the county license MRFs?

Twenty-seven counties in Montana which responded to the C MSW RQ do not license MRFs and two counties do.

Question 18 : Does the county require MRFs to submit reports on the tons of materials processed?

There are no county requirements for MRFs to report the tons of materials processed by their facilities according to respondents.

County Recycling Actions

Question 19 : Has your county established any recycling goals for the county?

Madison, Valley, and Silverbow counties have established recycling goals to direct the county towards increased recycling of MSW materials. Seventeen other respondents answered that their county did not have any recycling goals. Eight respondents stated that it was unknown. And, two additional counties claimed that this topic was being considered at the time of the questionnaire.

Question 20 : How much money has your county budgeted for recycling in 1997 and 1998?

Twenty-three counties responded to this question (Table 3). Sixteen of the twenty-three claimed \$0 were budgeted specifically for recycling. The seven remaining counties had budgets ranging from \$1,000 to \$64,680 in 1997, with four counties at \$10,000 or less. The range for 1998 was from \$2,000 to \$64,680, with an average of

**Table 3 : Municipal Solid Waste Recycling
Budgets in Montana**

County	Amount of Budget (\$)	
	1997	1998
Lewis & Clark	64,680	64,680
Beaverhead	1,000	2,000
Gallatin	33,000	42,000
Flathead	30,000	40,000
Sanders	N/R	7,800
Madison	10,000	10,000
Big Horn	3,000	3,000
N/R indicates Not Reported Source : The County Municipal Solid Waste Stream / Recycling Questionnaire		

\$24,211. At least three counties increased their recycling budgets from 1997 to 1998. Many counties commented that recycling does not specifically receive a portion of the budget, but county programs do exist.

Question 21 & 22 : Do any organizations in your county take advantage of grants or subsidies to fund recycling activities? If yes, please list the source and/or dollar amounts provided.

Seven counties reported that organizations within their boundaries have received grants or subsidies for recycling activities (Table 4). Seventeen others reported no grants or subsidies in effect and two responded as "unknown". Sources for these funds were received from the U.S. Forest Service, WalMart, the EPA, the Mid-Continent Recycling Association (MCRA), a Pal Grant, as well as a few unreported sources. Many of the grants went to the Headwaters Recycling Cooperative, one went to the city of Great Falls, and one to the Beaverhead County Recycling Board. Assistance ranged from \$555 to \$53,000.

Question 23 & 24 : Are there established markets for secondary (recycled) materials located within your county? If yes, please list the industry(ies) and type of post-consumer waste utilized (ie. JTL Gravel Group/glass).

Twenty-three counties responded that there were no local markets established in their area. Three responded affirmative to the question. These included Flathead, Cascade, and Missoula. Flathead did not specify what type of industry offered a market for recovered materials. Missoula County is the home of Stone Container which utilizes

**Table 4 : Municipal Solid Waste Recycling
Grants & Subsidies in Montana**

County	Source of Financial Support	Amount (\$)
Blaine	New Horizons	N/R
Broadwater	Source not reported	N/R
Beaverhead	Beaverhead Co. Recycling Board	\$2,000
Cascade	Pal Grant (City of Great Falls - Glass)	\$6,000
Gallatin	Forest Service	\$49,000
	MCRA	\$3,500
	EPA	\$53,000
	(All for Headwaters Cooperative)	\$105,500
Madison	Forest Service	\$7,700
	WalMart	\$555
Silverbow	Source Not Reported (for Headwaters)	N/R
N/R indicates Not Reported Source : The County Municipal Solid Waste / Recycling Questionnaire		

recovered cardboard to produce paperboard products. Cascade County is the home of United Materials which now takes recovered glass to use as a road base. A comment was added to the Cascade response stating that United Materials really couldn't be considered "established" because it was too young.

Question 25 & 26 : What percentage, by weight, of recycled materials processed in your county are exported out of the county to market? Does that percentage include materials collected from other counties?

One county responded "unknown", and many did not respond. Results from twenty respondents who did answer ranged from 0 to 100%. Ten counties ship 100% of their recovered materials out of county. Two others export 97 & 99%. Two others export zero%. The remaining six counties export between 0.5 and 15%, but at least three of these responses were questionable due to inconsistencies in the answers.

Three counties responded affirmatively that materials counted did include those collected from outside their county, while thirteen responded negatively, for a total of sixteen responses.

Question 27 : Where do the exported materials go? (Specific or generally by region)

Twenty-one responses to this question gave a fair idea of where recovered materials go on their way to market. Missoula, Billings, and Havre were the three most listed destinations. Other areas within Montana included Helena, Butte, Great Falls, Belgrade, Bozeman, Glendive, and Miles City. Exports travel to Salt Lake City, Utah,

Washington, the West Coast, overseas, Canada, Plymouth, Utah, Dickinson, North Dakota, and Regina, Saskatchewan, according to the questionnaire responses. One response also stated simply "all over". Figure 13 displays the flow of recovered MSW materials by county.

Question 28 : What percentage, by weight, of the entire exports fall into which category? (Materials list provided)

For another characterization of materials, specifically recovered materials, each respondent assigned a percentage of the total exports to each material category. This characterization, as was that for all MSW, is based on total weight rather than volume. (Table 5). Responses from one county were not used due to the inability to interpret their meaning. Data from another county were adjusted (multiplied by a factor) to bring them close to a total of 100%.

Aluminum, cardboard, and scrap metal were the majority of recovered materials exported out of the state. Nine counties claimed to export aluminum, ranging from 0.5 to 100% of their recovered material exports, averaging 44.17%. Seven counties export cardboard, from 3 - 60%, with an average of 31.43%. Scrap metal exports were reported by three counties and range from 15 to 83% with an average of 39.3%.

In addition, five counties export newspapers, from 5 - 20% of their total exports, averaging 10.6%. Two counties each export glass and steel cans. Steel cans have an average of 5.25% exports and glass averaged 5.0%. One county responded to each of the HDPE - clear, magazine/junk mail, office paper, and other plastic categories. The

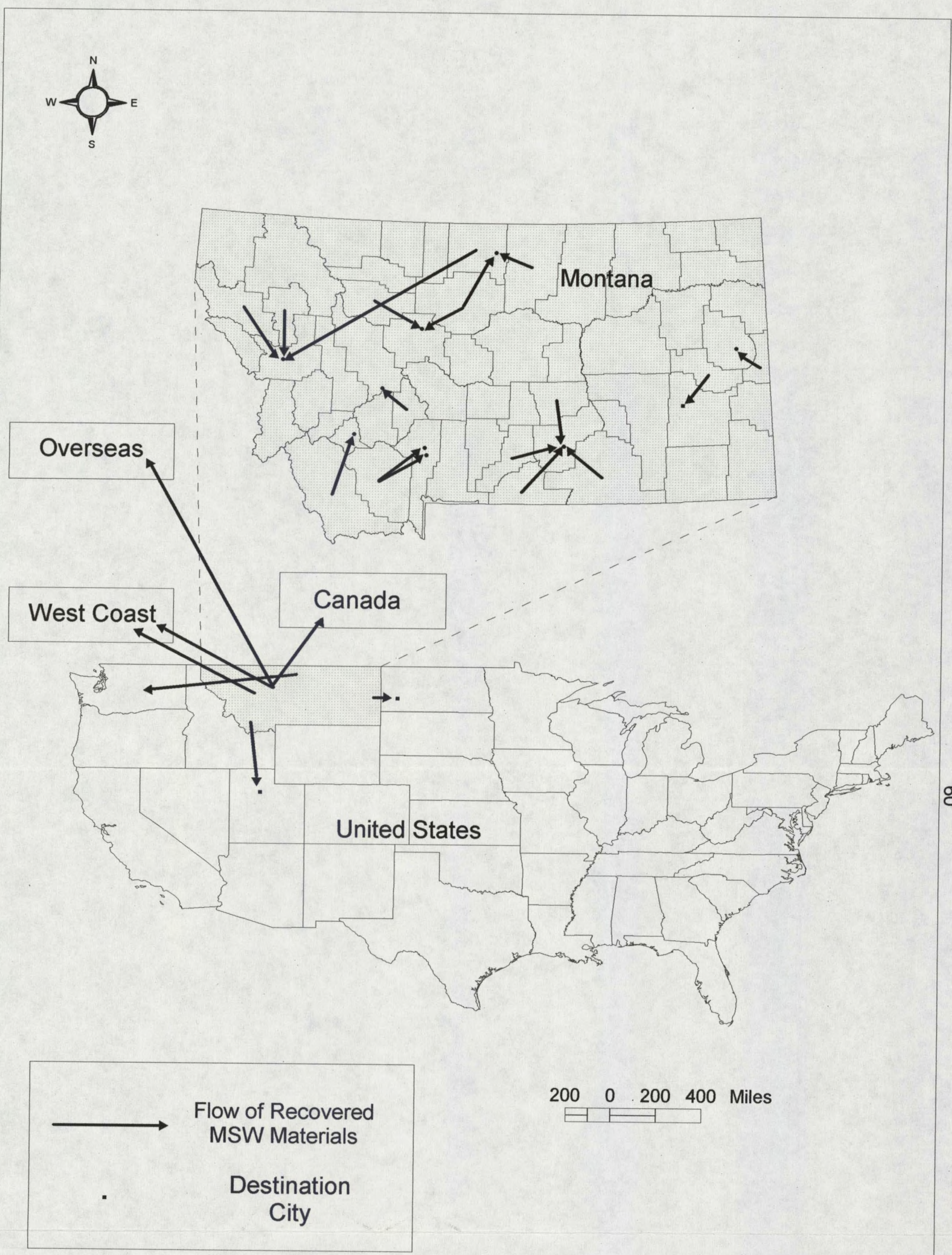


Figure 13 :

Destination of MSW Materials Recovered From Montana By County

Source of Data : The County Municipal Solid Waste Stream / Recycling Questionnaire, 1998

Table 5 : Recovered Material Exports in Montana, By Percentage of Total Weight

Recovered MSW Material	County With Response									
	Hill	Sanders	Blaine	Beaverhead	Cascade	Stillwater	Madison	Wibaux	Carbon	Big Horn
Aluminum	40	20	100	20		10	0.5	100	80	27
HDPE clear									10	
Office Paper				20						
Mag./Junk mail						10				
Steel cans				10			0.5			
PET										
Newspaper	10	20				10	8		5	
Paper Board										
Scrap Metal						20	83			
Other Plastic	10									
Cardboard	35	60		30		50	3		5	37
Glass	5						5			
Other				* 20	**100					* 37
Total % of weight	100	100	100	100	100	100	100	100	100	***101

* White Goods

** With exception to glass

*** Each response was multiplied by a factor of 1.7 for total near 100%

Source : The County Municipal Solid Waste Stream / Recycling Questionnaire

percentages of exports were listed as 10% for each material, except office paper, which was 20%. No responses were tallied for PET plastic.

Four counties also listed materials in the "Other" category. These materials included white goods (appliances) and tires. No percentage was given for the tires, while white goods were listed as being 20 or 100% of the total exports. Some counties may have placed white goods in the scrap metal category as well.

Question 29 : What percentage of the tons of recyclable material exports are shipped by each of the following modes of transportation? (Several modes provided)

How are the materials shipped, by what mode of transportation? No recovered material exports leave Montana via water. Nine counties use trucks with a direct rate (full rate). Three counties use trucks for 100% of their shipping. The remaining six were just marked with an X, as were other categories for these counties. Four counties marked the category for trucks using a back haul rate (discount rate for filling an empty truck on its return home) with 50%, 100%, and two Xs. One respondent noted that rail was used for 50% of shipments. Four counties responded in the "Other" category. Two wrote "all truck" and two were "unknown".

Question 30 : Please list two persons which you feel are the most knowledgeable about recycling in your county ("Myself" is acceptable as one). How may I contact them?

This question was used in verifying and collecting data. The persons listed have not approved the use of their name for contact purposes. Therefore I will not list these responses at this time.

C MSW RQ Discussion

The C MSW RQ was designed to gather data about municipal solid waste and the role recycling activities play in the management of MSW in Montana. Recycling activities are taking place within the state and the distribution of those activities were revealed by responses to the questionnaire. In addition, the results of this questionnaire can be compared to national averages for solid waste and recycling to gain a perspective for Montana's activities.

The MSW generated across Montana was 4.86 pounds per person per day as reported by the C MSW RQ. According to the Characterization of Municipal Solid Waste in the United States, (United States Environmental Protection Agency 1996), the per capita generation rate for the United States was 4.4 and 4.3 pounds per day in 1995 and 1996 respectively. Based on the limited questionnaire data, it appears that Montana generates municipal solid waste at approximately the same per capita rate as the average for the United States. We may be concerned that the figure for Montana is 0.46 - 0.56 lbs/person/day greater than the U.S. average. But, more detailed and complete data for the entire state is required to confirm this difference. The figures should also be calculated using generation and population figures from the same year. The increase in population from 1995 to 1998 in Montana could change the calculation of lbs/person /day enough to diminish the difference between the figures for Montana versus the United States.

An analysis of the characterization of MSW is commonly stated throughout the literature as being an important factor when considering the implementation of a recycling

program in any locale. Requests for estimates on the percentage of MSW within each material category were designed to test the assumption that MSW in Montana is of the same composition, or character, as that of the national average.

The EPA characterization of MSW in the United States in 1996 was shown in Figure 5. The national percentages of total MSW for total metals, plastics, glass, food scrap, papers, and yard trimmings are comparable to Montana's solid waste composition. The percentage of MSW contributed by yard trimmings is very similar between the two studies. Plastic and glass are reported as contributing less than 10% each to the total weight of MSW according to both studies. Yet, Montana claims a greater portion in glass while the U.S. average reveals a greater portion from plastic. Notable differences between U.S. and Montana averages are in the percent of food scraps (10.4% U.S., 17.28% MT) and total metals (7.7% U.S., 10.55% MT) which are each estimated quite high by the respondents of C MSW RQ as compared to the EPA figures. Paper estimates also show a substantial difference of 13%. Paper remains the largest category of MSW in both Montana and the United States as a whole.

Again, the results of this question were based on data collected by only fourteen counties. Computing the results with numbers for those counties who responded with "national average" would of course bring the state closer to the EPA findings. Additional estimations, or actual measurements, are still required to draw a complete picture of the composition of MSW in Montana.

The MT Department of Environmental Quality database on licensed solid waste facilities indicated that in 1996, 103 facilities were licensed in Montana. They included

Class II, III, and IIIM facilities. Including the results of the questionnaire, there were 110 solid waste facilities open in 1998. The respondents were not questioned as to the specific class of the facilities about which they were responding.

The cost of disposal varies across the state. An average of \$34 per ton compares to the national average of approximately \$30/ton. The national gate fee ranged from \$10 - \$80 per ton in 1997 as compared to Montana's range of \$17 - 45/ton (Glenn 1998 April).

On a per ton basis, three of the four lowest rates of disposal coincide with counties having the largest urban populations. As might be expected, the highest disposal fees, based on annual household payments, coincide with high percentages of rural populations.

Although the correlation is not direct across all counties, the distribution demonstrates that low density contributes to increased disposal costs. Higher rates can likely be traced to the costs associated with increased travel and reduced volumes handled per mile. This phenomenon holds true for recovering MSW materials for recycling as well.

Several counties reported that some portion of their MSW was handled by compost facilities in their areas. According to Biocycle (1998), Montana has 32 yard trimmings composting facilities. Throughout the rest of the United States there is an average of 58 facilities per state. Compost is an important technique for handling portions of MSW, however, it is not a focus of this study. Respondents to the C MSW RQ were asked not to include compost data with information on recycling. This separation of compost and recovered materials could become a problem issue, because composting is sometimes included within the recycling category and the inclusion of both is not always specified. Therefore, data on recycling may or may not include composting figures in

comparative studies.

Besides recycling by local clubs, collection or processing services for recycling are available in at least twenty-one counties in Montana. Biocycle (1998) reports that Montana had only 38 drop-off sites for recycling and 9 transfer stations, or MRFs in 1997. It appears that Montana's number, 65 according to the questionnaire, has been understated in the annual review of the nation or perhaps the definitions are non-compatible. All of the materials of interest to this thesis are collected in Montana, with aluminum, newspaper, and corrugated cardboard being the most frequently recovered MSW materials. Still, respondents to the C MSW RQ lack consensus of opinion about the economic feasibility of recycling. The majority of respondents do not feel that recycling is economically feasible in their county at this time.

Methods used by counties to monitor or cultivate recycling activities can include recycling goals, budgets, and funding programs. Very few county-level recycling goals have been established in Montana, but at least sixteen counties have specifically budgeted for recycling expenses. The questionnaire also shows that grants are available through federal, regional, and local sources. As reported, very few counties or organizations have taken advantage of these opportunities.

The lack of available markets for most recovered materials creates an additional cost of shipping over long distances. Results of the C MSW RQ show recovered materials are commonly shipped as far as the West Coast, and overseas. It is difficult from the responses to track specific materials to market. But a general portrayal of the flow of materials from Montana was developed in Figure 13. More specific information along

these lines is usually proprietary and therefore difficult to compile.

The average recycling rate for Montana is estimated at approximately 5% according to Biocycle's (1998) annual review. Respondents answers ranged from 0 - 35% with an average very near 6%, a reflection of the diversity of demographics and support as well as common market conditions.

Although the results of the C MSW RQ represent a slim majority of Montana's population, there are many areas of the state which were unrepresented by the results. In addition to the lack of data for some counties, the data retrieved is not always complete.

Several factors contribute to this problem. Solid Waste is not often a county-level issue in Montana, although the questionnaire was most often directed to County Sanitarians. There are also solid waste disposal districts which handle MSW, some are county-wide while others are multi-county. Private collection and disposal organizations also play a large part in the recovery and processing of MSW. Private businesses attempt to maintain a competitive edge by withholding sensitive information about their operations. Therefore, it is very difficult for county officials or the public to obtain accurate numbers for private recycling activity. In addition, large cities have a complex of service providers so no one organization can answer for the county in general. The total picture must be compiled from several sources. In rural counties, a providers' service region may not conform to county boundaries either. One provider may cover portions of several counties.

There is also a lack of data for the state since the questionnaire was not sent to any tribal communities residing within reservation boundaries. Reservations cover

approximately 46,000 square miles in Montana and in 1990 provided residence for 47,679 persons (KIII Reference Corporation 1997, 550). Reservations fall outside of the county solid waste infrastructure and it has not been determined if data is even available in these areas. "States are required to develop their own programs based on the federal regulations [of Subtitle D]. EPA was offering the same opportunity to tribes, however a Federal Court recently ruled that the EPA does not have the authority to approve tribal Subtitle D programs for primacy. EPA's role is to evaluate states' programs and decide if they are adequate to ensure safe disposal of municipal solid waste. In the case of tribes, it is unclear at the present if the court ruling requires the EPA to provide enforcement" (The New Mexico Environment Department 1997, 9). One sanitarian who responded to the C MSW RQ commented that landfill regulations were not enforced on the nearby reservation and therefore an unknown amount of MSW was taken across the boundary for disposal in "illegal dumps". This issue was not verified through this thesis, but implies that county-level records of disposal are not always complete.

Additional information about MSW recycling was deemed necessary to develop a more complete picture of recycling activities within the state. The second questionnaire targeted private businesses in an effort to fill in some data gaps.

The Municipal Solid Waste Stream Recycling Questionnaire for Private Business

MSW RQ PB Response

Of the forty-one contacts sent a Municipal Solid Waste Stream Recycling Questionnaire for Private Business, twenty-two were returned. Three of these were

returned undeliverable and another stated simply that the business had closed in March of 1998. Eighteen questionnaires were returned complete which resulted in a data from 43.9 % of private businesses contacted with the MSW RQ PB.

The responses originated from thirteen counties as shown in Figure 14, although the providers do not necessarily conform to county boundaries. There is some overlap between providers and undefined boundaries surround them. Data gaps were essentially filled in the southern, mid-eastern, and northwestern regions of Montana. A data gap still exists for Central Montana.

Summary of MSW RQ PB Results by Question Number

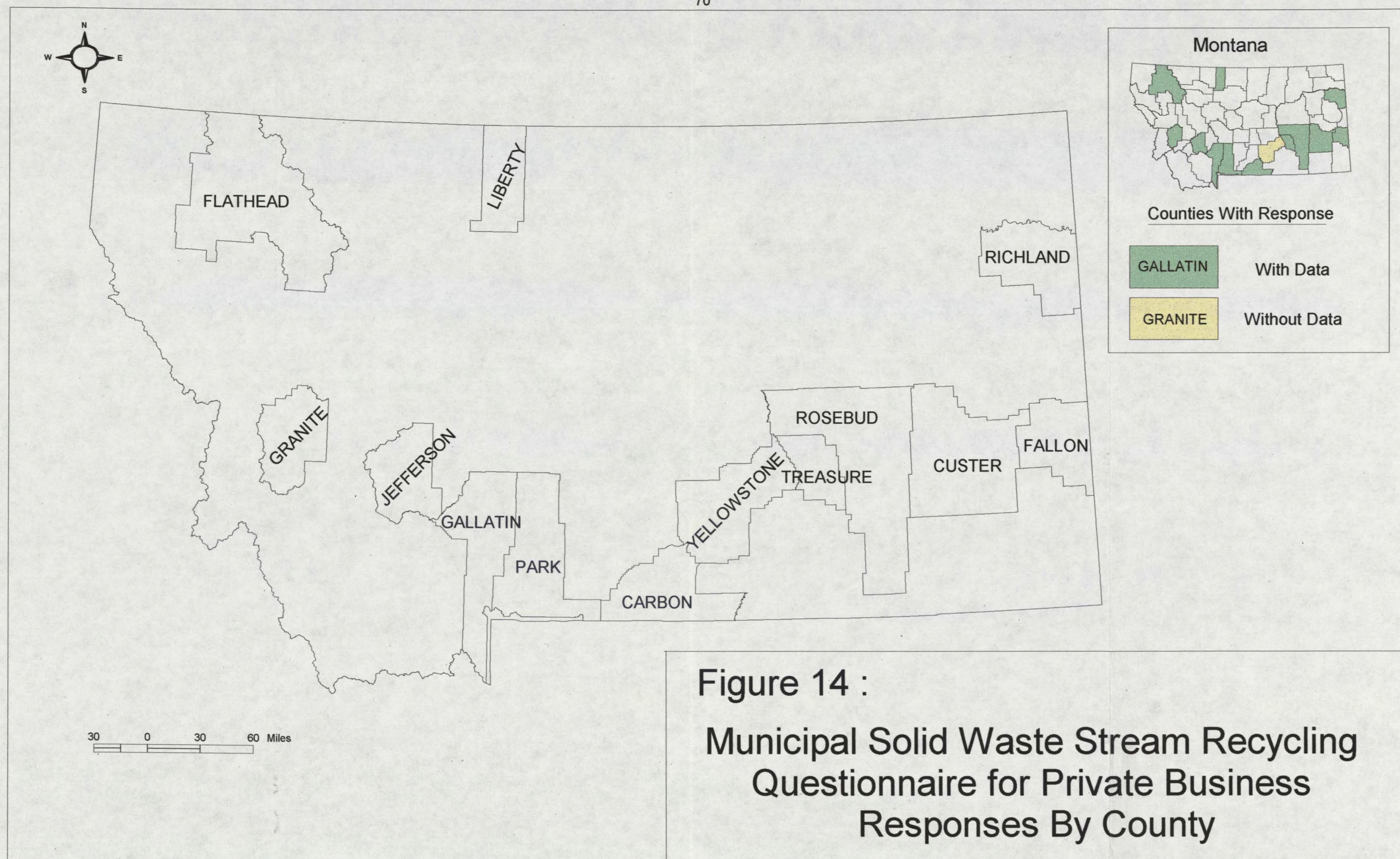
General Operating History

Question 1 : How long has your organization been in business in Montana?

The businesses contacted through this questionnaire began operating anywhere from 1918 to 1998.

Question 2 & 3 : What are the primary operations of this business? (activities related to solid waste handling provided) Please show the importance of each activity as a percent of total operations.

Five of the eighteen respondents provide MSW collection as a portion of their services. (Table 6). The portion of total activities devoted to collection ranged from 15 to 100%, with an average of 55%. Industrial solid waste collection services, provided by



**Table 6 : Municipal Solid Waste Operations Performed
By Respondent Businesses**

Operation	Average Percent of Total Operations	Number of Respondents
Municipal solid waste collection	55	5
Industrial solid waste collection	51.25	4
Landfill operations	84	5
Processing MSW for material sales to end to end users	84	5
Processing industrial SW for material sales to end to end users	38.33	3
Production of consumer products from recycled materials	27.5	2
Compost services	7.5	2
Other	0	0
Source : The Municipal Solid Waste Stream Recycling Questionnaire for Private Business		

four respondents, had a range from 25 to 100% of services averaging 51.25%. Landfill operations are provided by five respondents as 50 to 100% of their operations, averaging 84%. Five respondents also process MSW for recovered material sales to end users. This is 100% of operations for four respondents and only 20% of the fifth. Only three businesses processed industrial solid waste for material sales. These operations averaged 38.33%, ranging from 10 to 80% of total activities. Production of recycled products and compost services are each conducted by two respondents. The average portion of total operations for these categories were 27.5 and 7.5%, respectively.

Seven respondents devote 10 - 75% of operations towards providing other services. These include: garbage incineration, government consulting, maintenance of container sites, supervising the separation of recyclables, collecting scrap iron, treatment of contaminated soils combined with composting, and providing residence and employment services for disabled adults.

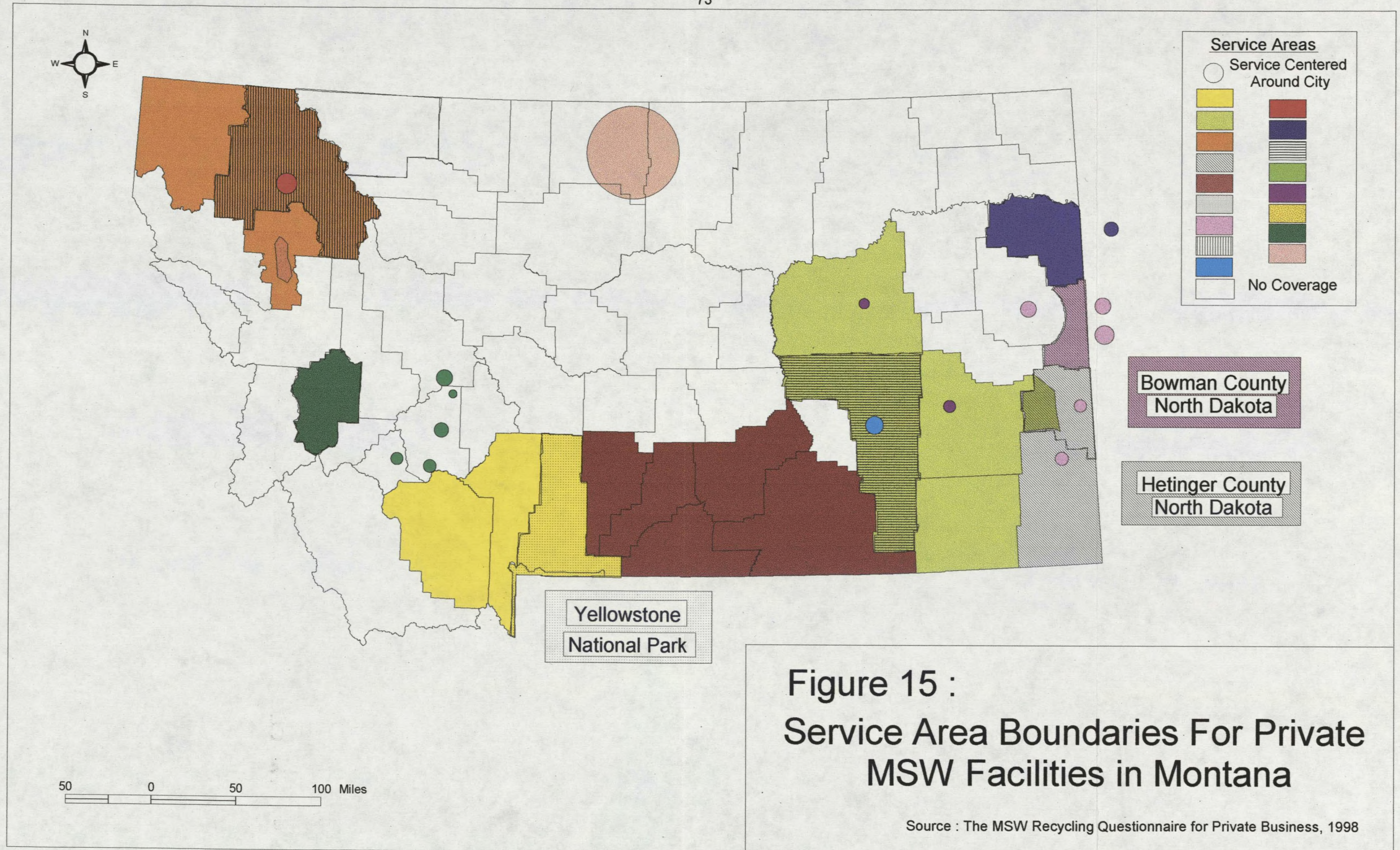
Question 4 : What are the geographic boundaries of your typical service area (ie. Counties or cities served by this facility)?

All eighteen respondents answered this question. Figure 15 depicts the results.

MSW Recycling Operations

Question 5 : How long has municipal solid waste recycling been a part of your business?

Fourteen businesses responded that MSW recycling has been a part of their



activities for as long as 80 years. Six have recently incorporated recycling into their operations within the last 5 years. Three businesses have recycled for 6 - 8 years and four from 11 - 25 years. One operation has included MSW and scrap metal recycling for 80 years.

Question 6 : Which municipal solid waste recyclables does your business collect, process, or recycle? (materials list provided)

Aluminum, corrugated cardboard, and newspaper are the three most widely collected MSW materials in Montana, as indicated by the questionnaire responses. (See Table 7). Out of eighteen respondents, 14 businesses handle aluminum, newspaper is handled by 13, and corrugated cardboard by 11. Responses for MSW materials also included steel cans (9), HDPE #2 clear/natural (7), PET #1 (7), magazines/gloss paper (7), white paper (7), phone books (6), paperboard (3), glass (2), clear glass (2), green glass (2), yellow glass (1), other glass (1). "Other" responses included the handling of textiles, scrap metals, and white goods.

Question 7 : What is the current volume (tons / year) of municipal solid waste handled by your organization? Graph the approximate change in the volume of municipal solid waste recyclables handled by your organization from the time mentioned in question Number 5 until the present. Also please explain each point at which the slope of the line changes. (example provided)

Question 7 requested three items of data from each business. Eleven respondents answered at least one part of this question. Eight responses were received with current

**Table 7 : MSW Materials Collected,
Processed, or Recycled
in Montana**

Material	Number of Respondents
Glass	3
Brown	2
Clear	2
Green	2
Yellow	1
Other	1
PET #1	7
HDPE #2	0
Clear	7
Colored	2
Newspaper	13
Paperboard	3
Cardboard	11
Magazine/Gloss	7
White Paper	7
Phone Books	6
Aluminum	14
Steel cans	9
Other	7
Source : The Municipal Solid Waste Stream Questionnaire for Private Business	

volume estimates, averaging 3,425 tons/yr with a range from 3 to 13,000 tons/yr. Ten people sketched graphs. A total of seven respondents also noted reasons for each change in the trend of the graph which was the last item requested. Based on the available data, a single graph was created to represent the trend of recycling in Montana through time.

(Figure 16).

Competition and Markets

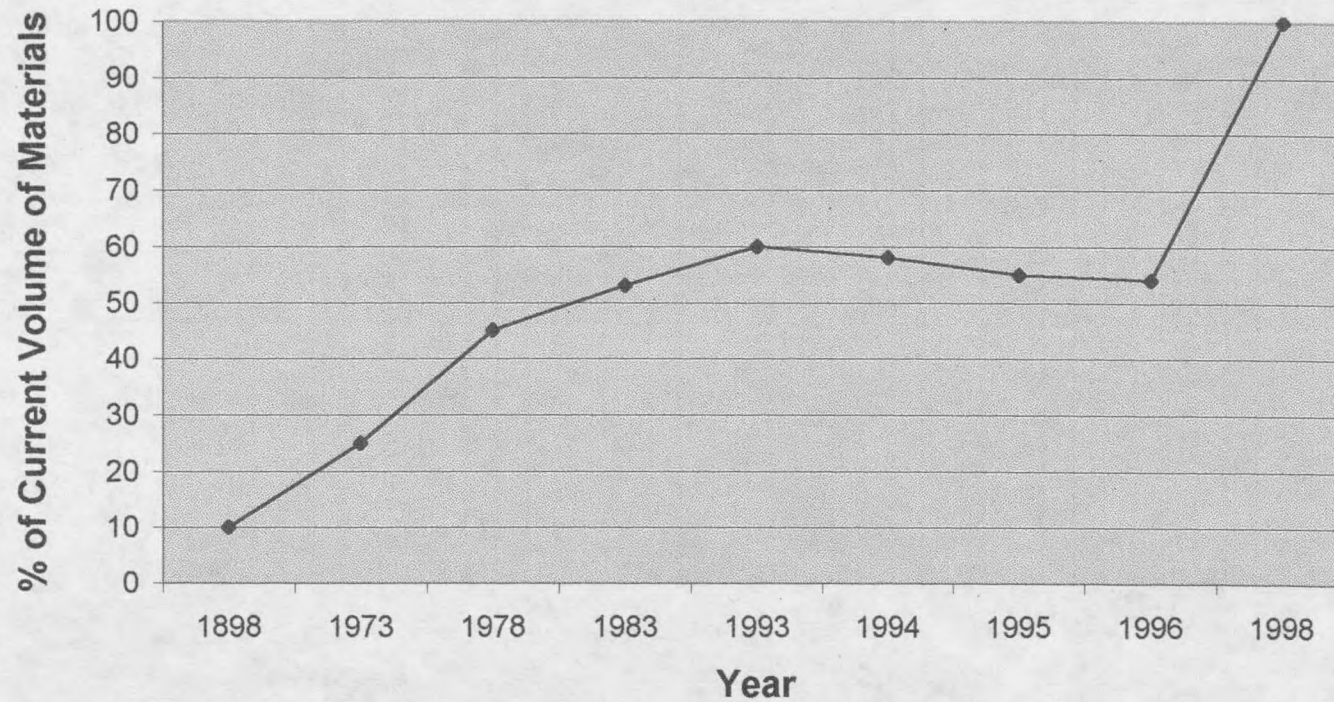
Question 8 : Where are the recyclable materials shipped when they leave your site to market (Specifically or generally by region)?

The materials recovered from Montana are shipped to locations both near and far for further processing or as raw materials for production. (See Figure 17). Many of the questionnaire respondents gather materials to ship to a larger in-state facility such as in Billings (5 respondents), Missoula (4), Butte (2), Bozeman, Helena, Custer County, and Glendive. Recovered materials are also sent to Frenchtown where Stone Container is located, the only fully established end-use market for recyclables in Montana. Out-of-state markets include Seattle, Spokane, Portland, Salt Lake City, Denver, Chicago, Regina, Los Angeles, Oakland, Tennessee, Colorado, and the East and West coasts at large.

Question 9 : Currently, how many local competitors do you have in the household municipal solid waste recycling business?

Sixteen respondents reported the number of competitors in their locale as being from 0 to 6. Five respondents each claim 0 and 1 competitor. One additional business

**Figure 16 : The Volume of MSW Materials Recycled in Montana,
as a Percentage of Current Volume (tons / year)**



Source : The Municipal Solid Waste Stream Questionnaire for Private Business

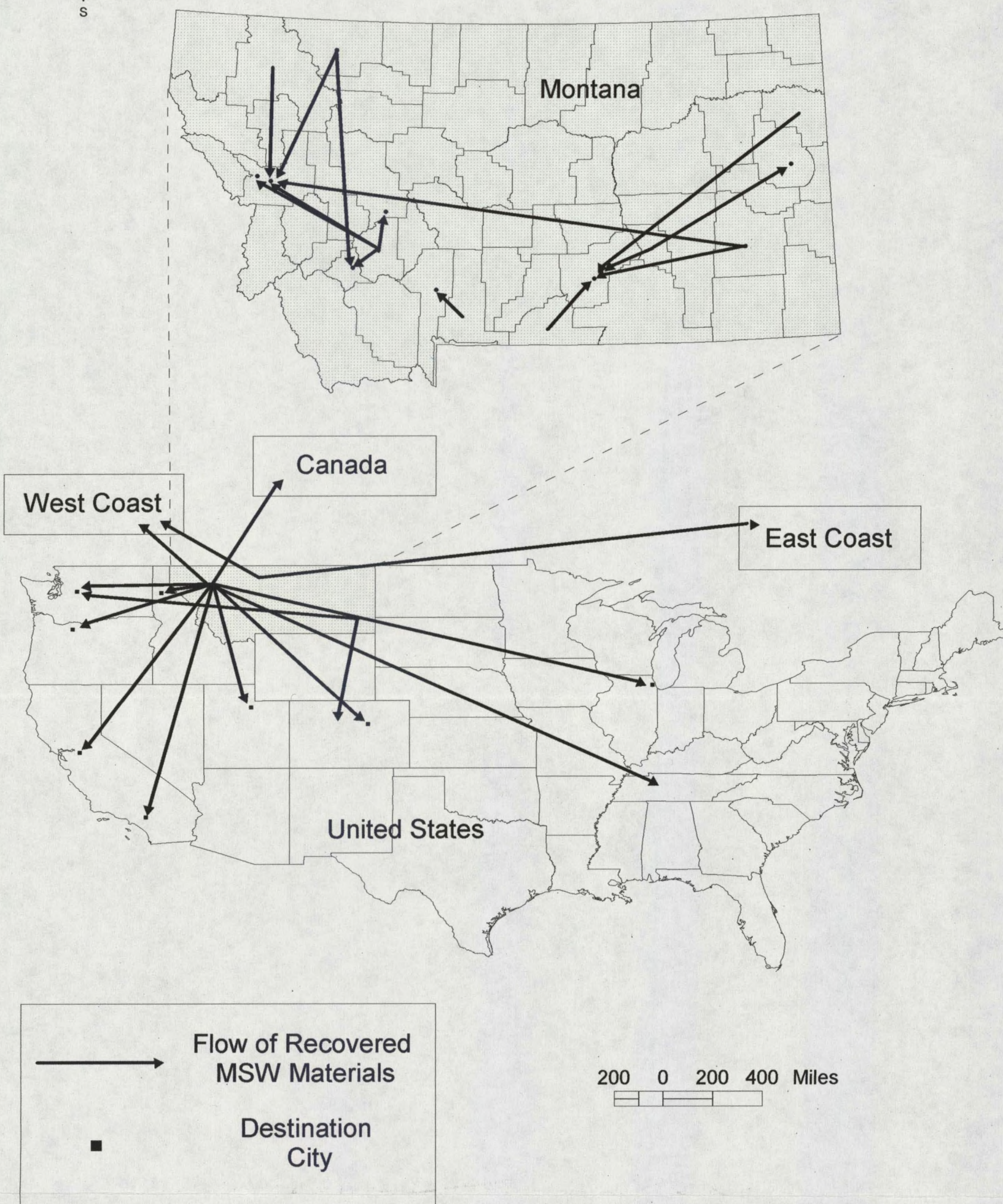
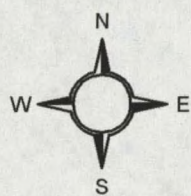


Figure 17 :

Destination of MSW Materials Recovered From Montana By Private Business

Source of Data : The MSW Recycling Questionnaire for Private Business, 1998

only competes with donations to the county. Those respondents with 2 and 6 competitors each total one and the remaining three responses indicate 3 local competitors.

Question 10 : How many local competitors are you aware of that have left the recycling market in 1998, 1997 - 1996, and 1995 - 1990?

There were nine responses to this question. In 1998 alone three businesses saw 1 of their competitors leave the MSW recycling arena and one business saw 4 leave. The other five businesses who responded were not aware of competitors who left the recycling field, some did not have competitors. From 1997 to 1996 five respondents had 1 to 2 competitors close doors. In the five years from 1995 to 1990 three businesses saw 1 of their competitors leave and one saw 4 leave.

Question 11 : Are you optimistic about the future of recycling household municipal solid waste materials in your locale?

This question was developed to get a picture about how those people most closely related to recycling feel about the future of the industry. Nine responded that they were optimistic about the future in their locale while six were not optimistic. The remaining three did not respond to this question. The optimistic group pointed towards less competition and faith that recycling will get better. One optimist claimed that it doesn't pay to be a pessimist and another allowed his view to waiver by pointing out that better markets were required for operations to stay in the black.

The pessimists listed mostly economic concerns to explain their position on future of MSW recycling in Montana. The high cost of transportation to distant markets, falling

prices, and low compliance with separation and delivery of recyclables due to the lack of legislative requirements were strong arguments provided in response to this question.

Question 12 : Which municipal solid waste materials do you feel are the most economically viable materials for recycling in your locale?

According to the MSW RQ PB, the most economically viable material for recycling across Montana is aluminum with fifty-seven percent, or eight of fourteen responses. All metals, cardboard, and newspapers were also considered viable materials, while one northwestern county also included plastics and a variety of other waste paper. Compost and tires were also mentioned, although these materials are not being evaluated through this study.

Question 13 : Which municipal solid waste materials do you feel are the least economically viable material for recycling in your locale?

The least economically viable material was glass, mentioned by eleven of fourteen respondents. Plastic was close behind according to eight respondents. Paper and mixed (unseparated) commodities were also mentioned.

Request for Additional Comments :

Five of the businesses that received the MSW RQ PB responded with comments which further explain the current situation of recycling of MSW in their vicinity. One response, from south-central Montana, explained the lack of any data for the questionnaire because her recycling business had closed in Spring, 1998. Recycling in the county had

previously deflected materials from the landfill with the help of many volunteers. The county also joined the Headwaters Cooperative only to pull out in June, 1998 for unexplained reasons unexplained.

Four respondents from eastern Montana reflected on the high level of interest and support in their areas, yet recognized that without better markets, recycling is a economic hardship. A non-profit organization admitted to taking materials that have no value and therefore the materials do not cover the cost of processing and shipping. Community involvement supports the program. A county solid waste district has decided against recycling in the area because they are against subsidizing the program. The county is "quite sure" that it will require additional funds beyond revenue from material sales to cover costs. In addition, two other respondents are struggling to continue their present recycling operations in the face of few markets and low market prices for their recovered materials.

MSW RQ PB Discussion

Another important sector of the recycling community, private business, was represented by responses to the second questionnaire. A comparison between Figures 6 and 14 shows that several of the areas with missing data after the first questionnaire appear to have been filled by the second questionnaire, although gaps remain. There were no respondents from central Montana and due to the undefined boundaries between providers, it is difficult to determine where data is lacking in other areas. Still, the MSW RQ PB successfully contributed to the overall picture of solid waste management and

recycling operations across the state. The results did this from a historical, current, and future perspective.

One scrap metal recycler has been in business in Montana for 80 years according to this questionnaire. However, most other businesses contacted began recycling within the last 10 years. All of the materials of interest to this thesis are handled by private recycling operations, with aluminum, newspaper, and corrugated cardboard being the most frequently listed materials. These results match those recorded for the C MSW RQ.

A close look at Figure 16 shows that from the time of the earliest recycling operations there has been a steady increase in the volume of materials handled. Increased population allowed new businesses to enter the industry, and established businesses to increase their service area. The 1990's brought new businesses at an increased rate and several companies initiated recycling of new material types as markets allowed. By the mid 1990's, most operations reflected increased competition, few available markets, and poor market prices, by dropping materials and reducing the volumes processed. Results of the county questionnaire, previously discussed, support the fact that some recycling businesses were closing their doors during this period. Then, in 1996, volumes rebounded. New more efficient equipment allowed many to handle larger volumes at lower cost and to initiate additional material programs. Still, some recycling operations continued to close their doors and others struggled to continue accepting certain materials. Many hardships affect the ability to maintain recycling activities. Factors include the high cost of transporting materials out-of-state to market and the low market prices received for many materials. Still, sixty-six percent of respondents were optimistic about the

future of recycling in Montana.

Both the questionnaire directed toward county officials and the one directed toward private businesses reveal the difficulty in collecting detailed information.

Recycling is a complex activity in Montana. It is driven from several sectors of the population including grassroots, county, and private interests. Often data is not recorded, or is not structured to be readily comparable across the state. This fact is a major constraint in determining the status of recycling activities and developing a plan to support them. Lack of standardized records for quantitative accounts of recycling activities are not unique to Montana.

SOURCE AREA CHARACTERISTICS AND INFRASTRUCTURE

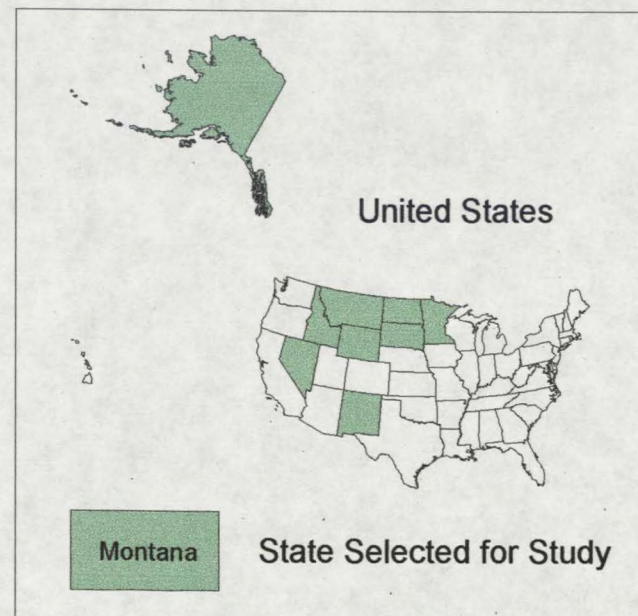
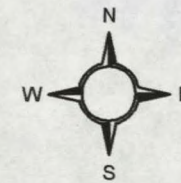
Introduction to Study States

In order to assess what impact certain defining characteristics of a place, (such as demographic distribution, economic indicators of the population, and state policies), might have upon the recycling system for that place, a group of states were chosen for comparison to Montana. The variability between states was reduced for the sake of comparing similar entities by selecting states with similar source area populations. The effects of the select other defining characteristics could then be studied through correlations between these study states. A state's recycling rate indicates the level of achievement obtained by a MSW recycling system, and therefore it is used as a comparative measure between the selected states.

States were initially selected on the basis of their 1990 populations in relation to Montana. The population range selected is somewhat arbitrary. Fifteen states have populations range from 453,589 to 1,515,069 people, including Montana at 799,065. By this measure it is assumed that a roughly comparable municipal solid waste generation is taking place. In other words, a similar amount of materials are available for recycling. Subsequently, the field was narrowed by eliminating states with less than 68,000 square miles of land. This process provided eight study states: Montana, Wyoming, Alaska, North Dakota, South Dakota, Idaho, Nevada, and New Mexico (Figure 18).

Consequently, the states selected have the lowest densities in the nation, from 1.0 -

Figure 18 :
Selected Study States



300 0 300 600 Miles

A horizontal scale bar with markings at 300, 0, 300, and 600 miles.

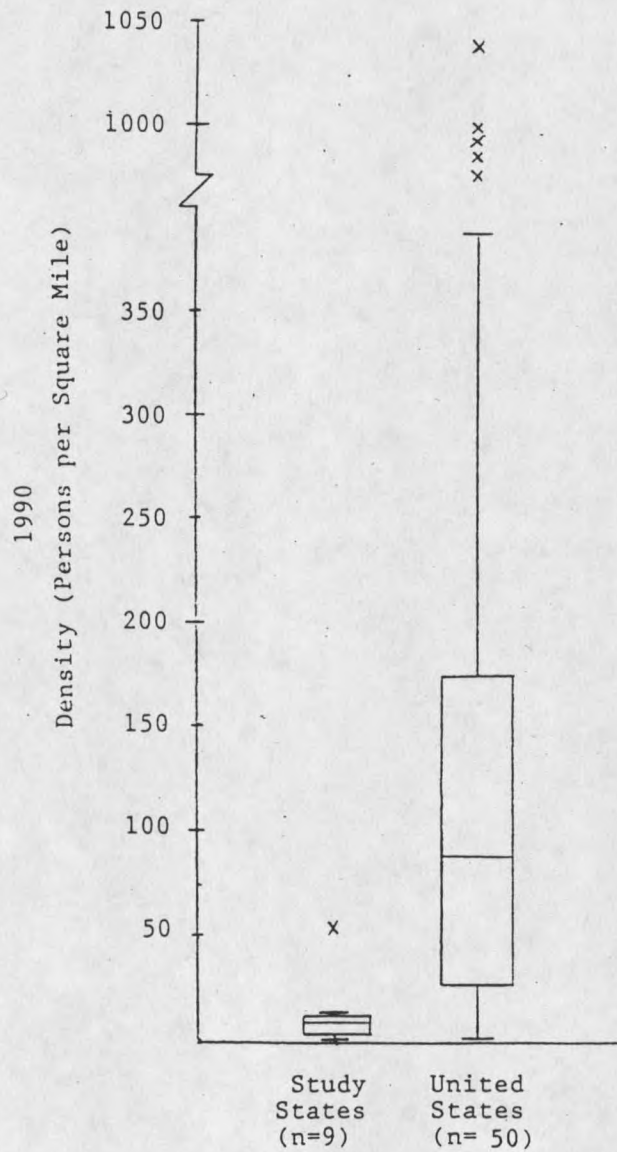
12.5 persons per square mile, including Montana at 5.5. A comparison of densities for the study states and for all 50 United States is shown as a statistical boxplot of data in Figure 19. The study states also share a common characteristic by being located in the interior western United States with one major exception, Alaska. Another special significance of Alaska is that it is the only study state with a larger service area than Montana. Table 8 lists land area and select population characteristics for the study states.

In addition to Montana and these seven states, Minnesota was chosen as a study of contrast. Although, Minnesota is similar to Montana in that it is located inland, near the Canadian border, the total population, density, and high urban distribution create a very different setting from Montana. The operating environment of Minnesota also contributes to a very different sense of place from that in Montana. Public policies towards recycling and Minnesota's relative position with reference to major U.S. markets accentuates the differences between the two states. Minnesota has been at the forefront in developing recycling legislation and technology, which is in great contrast to Montana's approach to recycling.

Effects of Population Distribution Upon MSW Recycling

Public opinion commonly holds low population density accountable for low recycling levels in Montana. It is true that collection services operate at higher costs when a fixed volume of material is collected over a greater distance, or requires greater man-hours. But, average population density does not explain why Montana has the lowest recycling rate in the nation. Montana has the third lowest average density in the U.S., at

Figure 19 : Distribution of Densities for United States
versus the Study States



Explanation :

n = number of data points (states)

x = outlier

— = minimum and maximum data points

— = 25% quartile, median, and 75% quartile

☐ = interquartile range (mid 50% of data points)

Source : United States Bureau of Census 1993.

Table 8 : Characteristics of Study States

Study State	Land Area in Square Miles	1990 Population	Person per Square Miles (Density)	Percent of Rural Population	Median per Capita Income (\$)	Percent of Population Unemployed
Alaska	570,373.60	550,043	1	32.8	17,610	7
Idaho	82,751	1,006,749	12.2	47.1	11,457	5.9
Minnesota	79,616.50	4,375,099	55	35	14,389	4.9
Montana	145,556.30	799,065	5.5	53.1	11,213	6
Nevada	109,805.50	1,201,833	10.9	12.1	15,214	4.9
New Mexico	121,364.50	1,515,069	12.5	28.1	11,246	6.5
North Dakota	68,994.30	638,800	9.3	56.1	11,051	4
South Dakota	75,896	696,004	9.2	60.9	10,661	3.9
Wyoming	97,104.60	453,588	4.7	38.6	12,311	5.5
Source : 1990 Census of Population, U.S. Department of Commerce, 1993.						

5.5 persons per square mile, with Wyoming (4.7), and Alaska (1.0), having lower densities. The remaining six states, ranked from low to high, as follows: South Dakota (9.2), North Dakota (9.3), Nevada (10.9), Idaho (12.2), New Mexico (12.5), and Minnesota (55.0). Alaska has a recycling rate which is 2% higher than Montana, and South Dakota has one of the highest rates in the nation at 42%.

The relationship between density and recycling rate is a very weak one as shown through regression analysis of data for all 50 states. (Figure 20a) The graph shows a great deal of scatter about the line which implies that other unknown factors contribute to the recycling rate. Linear regression analysis of the eight states of lowest density in the nation reveals a slightly stronger relationship between density and recycling rates (Figure 20b). This may be the result of similarities in overall population, land area, and location, coincident with low densities, which contribute to a particular environmental factor which was not directly analyzed. Still, the relationship is not strong.

Many other characteristics have a stronger influence on the recycling rate and the viability of a MSW recycling system. These could include the existing infrastructure for MSW collection and management, distribution of population within each state, public policies regarding MSW, the public perception of recycling, the availability of technical and financial support, and the location of the state relative to markets.

Demographic distribution is an important key in determining the actual impact of density upon the costs associated with collection of MSW materials. The locations of density clusters, (greater than 10 persons per square mile), are revealed by mapping density across a state. Figure 21 illustrates such clustering by depicting persons per

Figure 20 : Linear Regression Analyses
of Density versus Recycling Rate

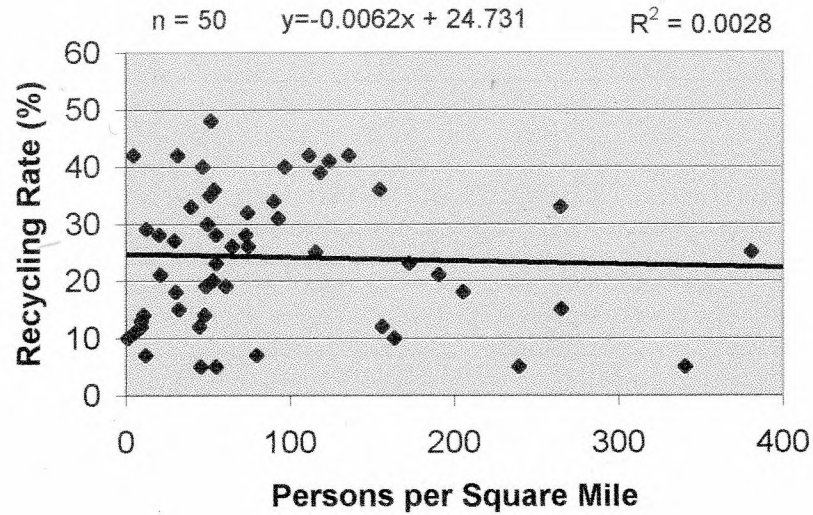


Figure 20a : National Correlation

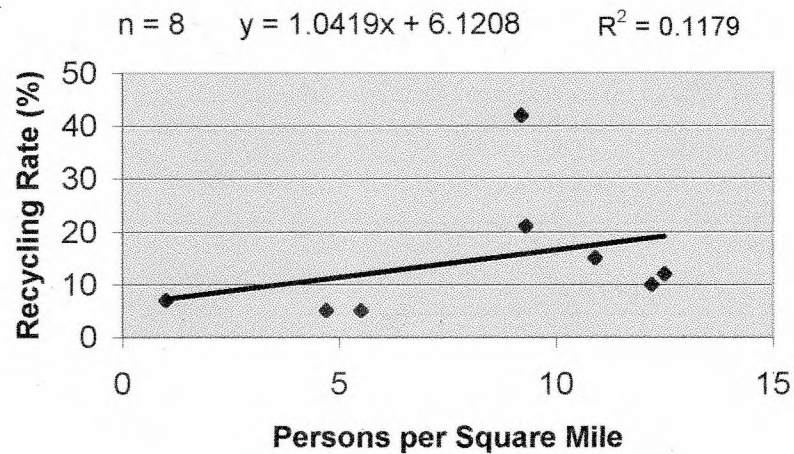
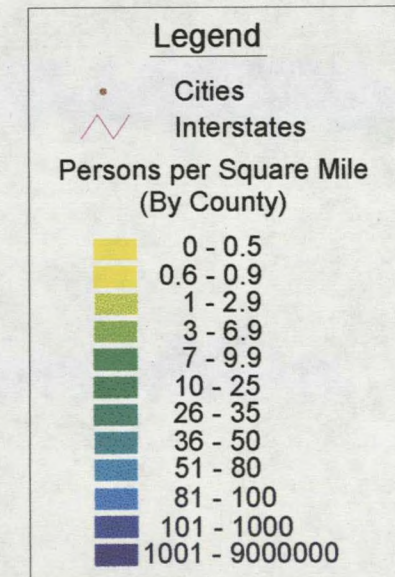
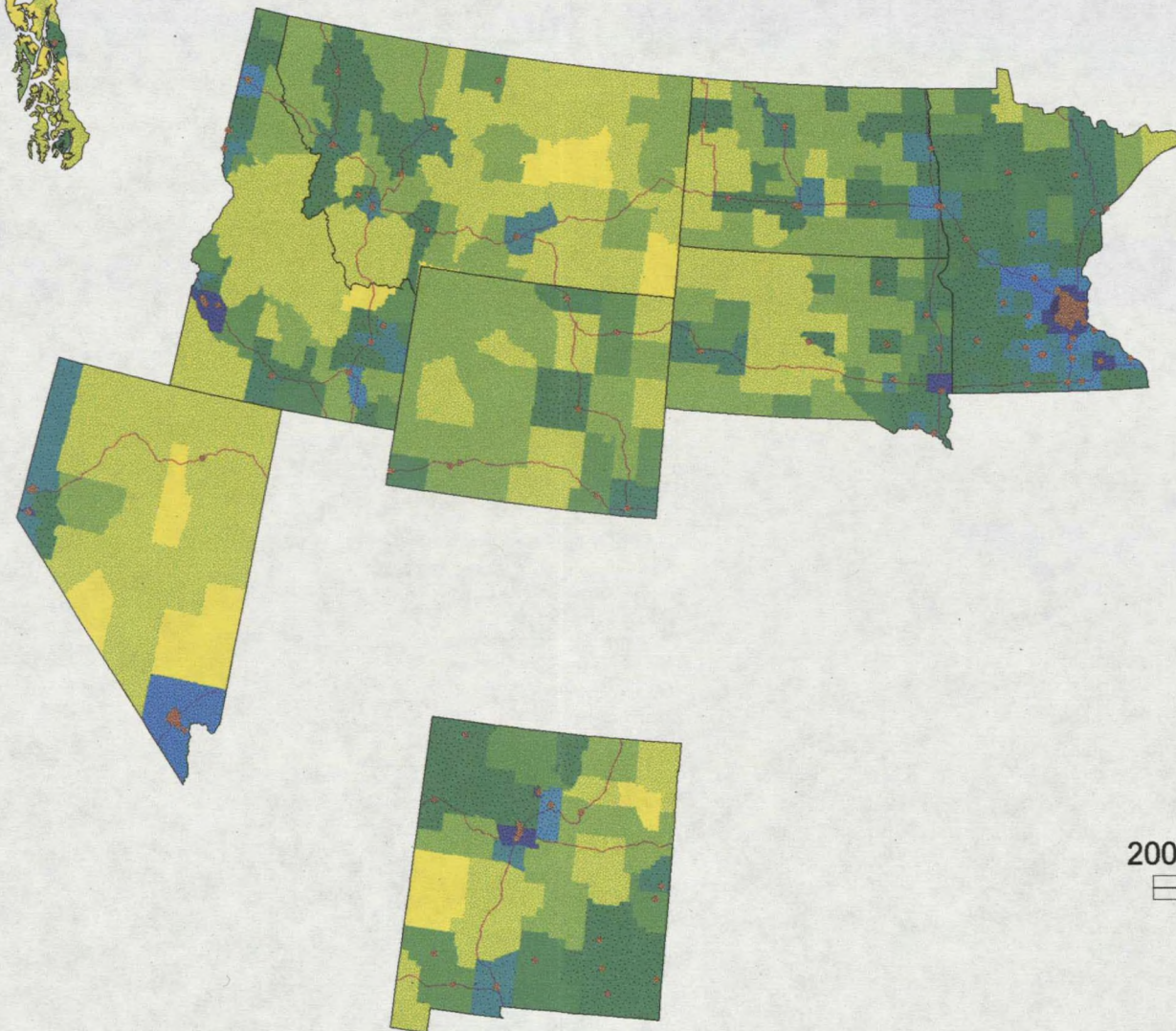
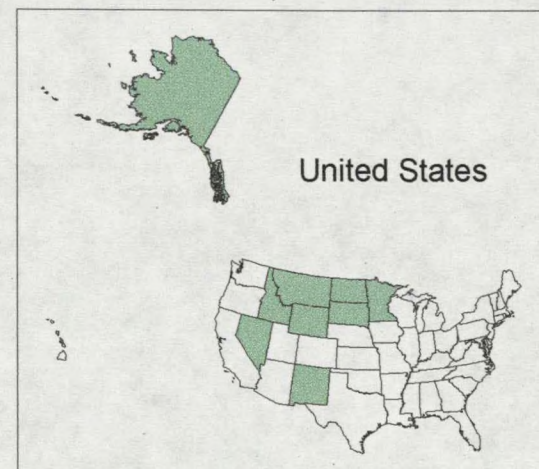
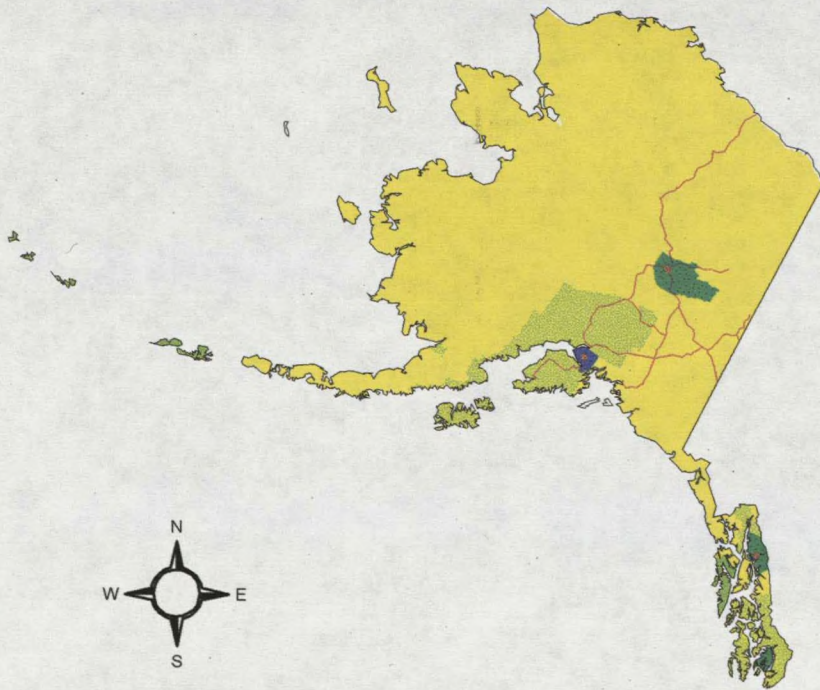


Figure 20b : Study State Correlation (except Minnesota)

Source : U.S. Census Bureau, 1993 and Glenn, Jim 1998 May.

Figure 21 : Population Density Across the Study States

Source of Data : Environmental Systems Research Institute Inc. (ESRI)
based on Bureau of Census by County, 1990



200 0 200 400 Miles

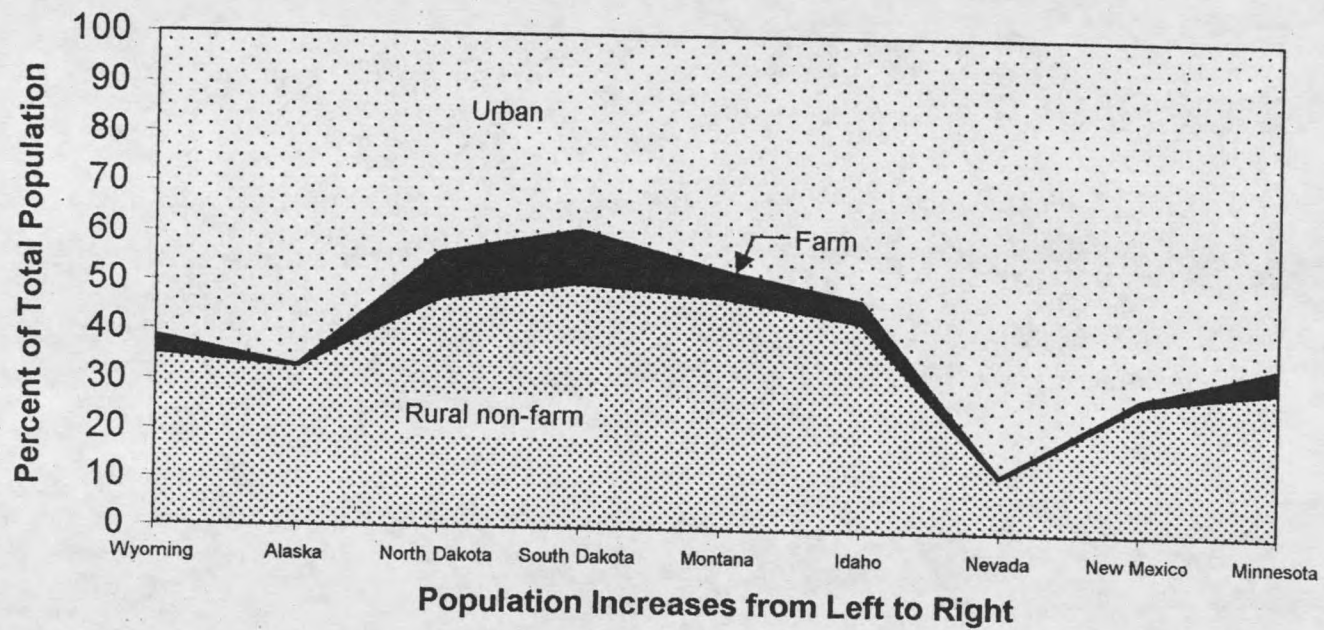
Alaska Not To Scale

square mile by county, for each study state, based on the 1990 census. Montana's population is clustered around cities in the western half of the state, with Billings being the one exception. Billings is located in Yellowstone County where an average 43.0 persons per square mile resided at the time of the 1990 Census. In the west, the cities generally lie along a Northwest to Southeast axis which is coincident to the easternmost Rocky Mountains. Kalispell, Great Falls, Missoula, Helena, Butte, and Bozeman contribute to average county densities ranging from 11.6 to 46.5 persons per square mile. These counties are interspersed with counties having average densities of less than 5.0. The central and eastern portions of the state have densities below 6.5 with the one previously mentioned exception. The population of Montana is 53.1% rural, including farm residents. (Table 8, p88 ; Figure 22).

The northern-most continental states under comparison include North Dakota, Idaho, South Dakota, Wyoming, and our contrast, Minnesota. North Dakota and South Dakota have a higher portion of rural persons than Montana with 56.1% and 60.9% respectively. However, both states have average densities higher than Montana.

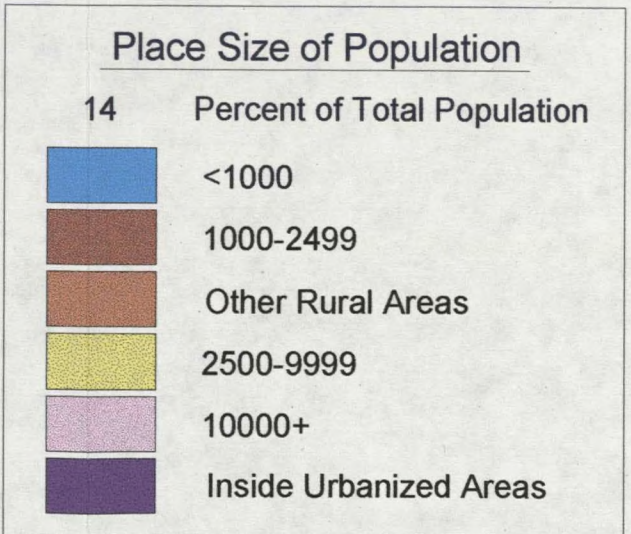
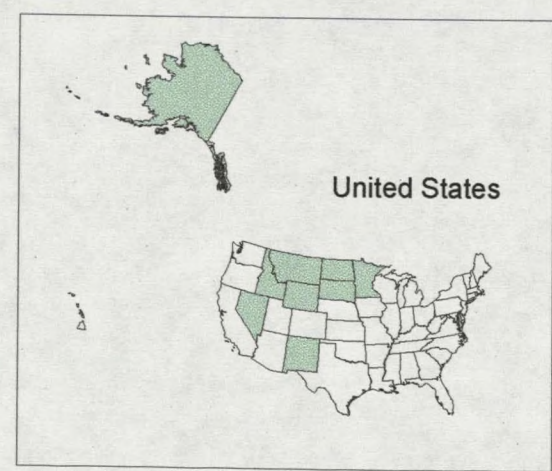
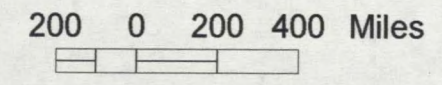
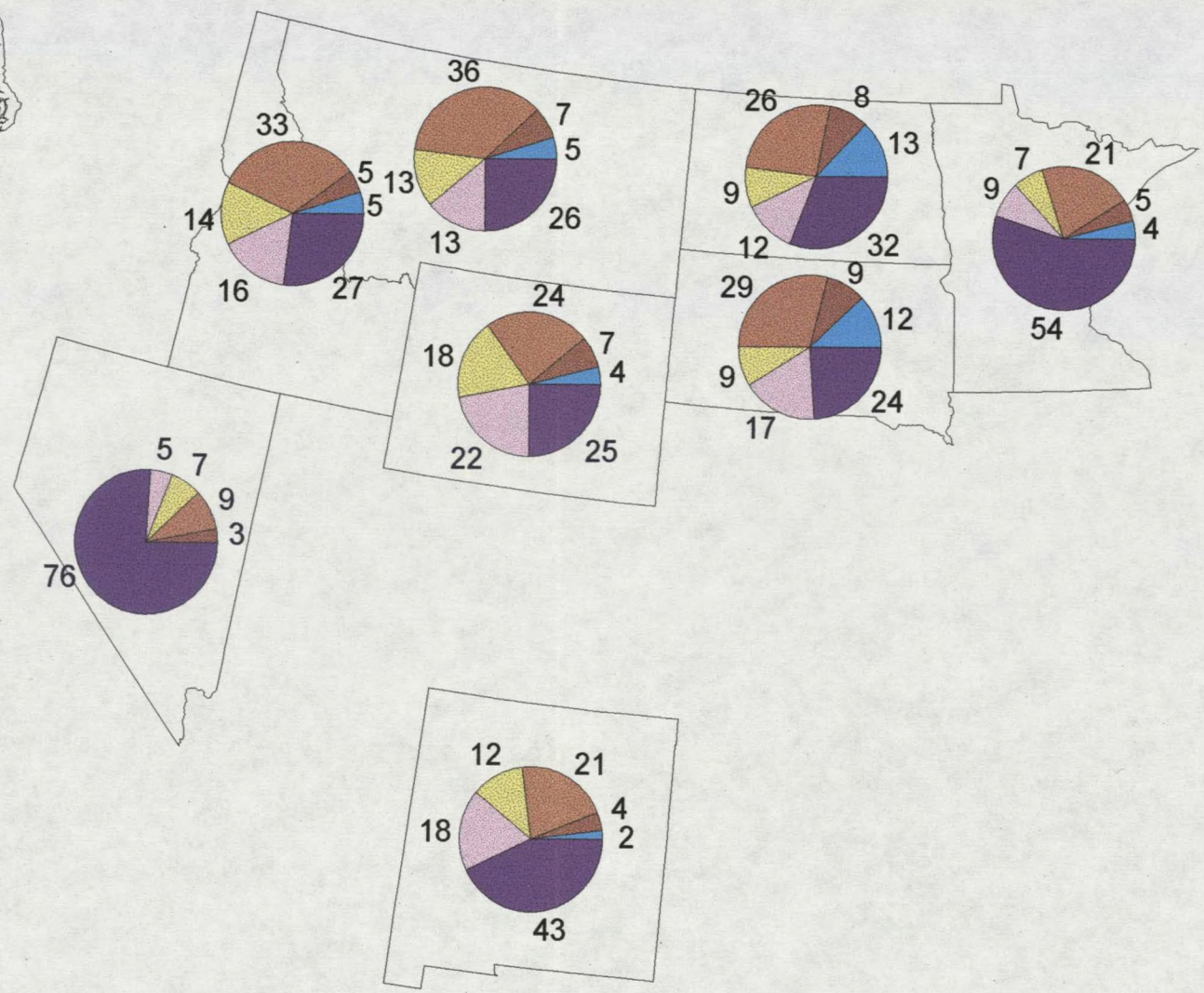
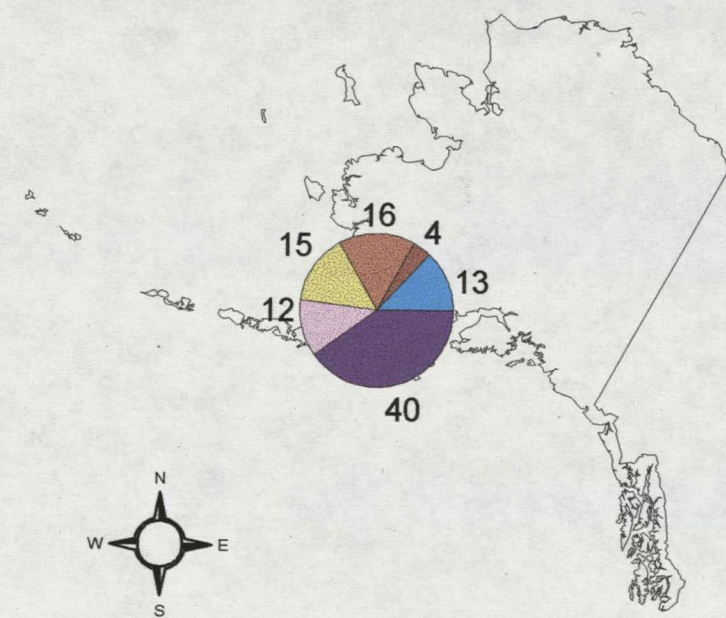
Figure 23 displays the percent of the population residing in several categories of place sizes for each of the study states. North and South Dakota have similar distribution of the population within each category. Each also have extensive population centers in the eastern third of the state as Figure 21 depicts. As will be discussed in detail in the section on end-users (pp133 - 171), this orientation allows them to take advantage of the marketing region to the east. Additional high density cells are located in the central and western portions of these states along Interstates 90 and 94. An additional population cell

Figure 22 : Percentage of Urban, Farm, and Rural Non-farm Population
in the Study States - 1990



Source : United States Department of Commerce 1993.

Figure 23 :
Population By Place Size
Within the Study States



is located in central South Dakota along the Missouri River.

Montana, North Dakota, and South Dakota have some very similar demographic features. One might assume that their level of MSW generation, management practices, and recycling achievements would be similar, but they are not. Data pertaining to Solid Waste and Recycling activities within the study states are located in Table 9. According to The State of Garbage in America (Glenn, Jim 1998 April), North and South Dakota each produce 510,000 tons of MSW per year. Montana generates 1,039,000 tons per year, twice that of either state. South Dakota had a 42% recycling rate with no incineration in the most recent annual reporting. In comparison, North Dakota recycles 21% with no incineration, and Montana recycles only 5% with an additional 2% of MSW incinerated. Clearly there are unique factors other than population size and density which influence the viability of recycling in each of these places. The effects of economic population characteristics, public policy, and relative location to end-user markets will be analyzed in subsequent sections of this text.

Idaho is also located in the northern reaches of the U.S. It is comprised of both the Rocky Mountains and the Snake River Plain and shares its eastern border with Montana. The population density averages 12.2 persons per square mile, while central and the extreme southwest corner of Idaho contain densities of less than five persons per square mile. Furthermore, the rural portion of Idaho's population comprises 47.1% of the state.

The population of Idaho is distributed generally in two bands of high density (Figure 21). The percentage of population by place size is extremely similar to that of

**Table 9 : Municipal Solid Waste (MSW) Management
in the Study States - 1997**

Study State	Municipal Solid Waste (tons)	Percent of MSW Recycled	Percent of MSW Incinerated	Percent of MSW Landfilled	Landfill Capacity (Years)	Municipal Solid Waste (tons) Import / Export
Alaska	560,000	7	15	78	N/A	0 / 13,000
Idaho	886,000	10*	0*	90*	N/A	N/A
Minnesota	4,780,000	42	30	28	10	0 / 412,000
Montana	1,039,000	5	2	93	20	43,000 / 0
Nevada	3,955,000	15	0	85	75	215,000 /
New Mexico	1,400,000	12	0	88	20+	305,000 / 0
North Dakota	510,000	21	0	79	40+	N/A
South Dakota	510,000	42	0	58	10+	N/A
Wyoming	530,000	5	0	95	>100	N/A

Study State	Number of Compost Facilities	Number of Landfill Facilities	Number of Dropoff Facilities	Number of Curbside Services	Number Served by Curbside	Recycling Goal (%)	Recycling Goal Deadline
Alaska	1	296	1	1	10,000	N/A	N/A
Idaho	7	27	35	6	200,000	25	1995
Minnesota	433	26	1,456	731	3,520,000	50 / 35	1996
Montana	32	23	38	6	8,000	25	1996
Nevada	0	23	N/A	8	1,300,000	25	1995
New Mexico	15	93	45	3	400,000	50	2000
North Dakota	15	15	75	26	90,000	40	2000
South Dakota	10	15	25	3	158,000	50	2001
Wyoming	8	70	42	2	24,000	25/35	2005

Source : Glenn, Jim 1998 April & May

* Reported in 1994

N/A indicates Not Available

Montana. (See Population by Place Size for Idaho in Figure 23). Idaho Falls, Pocatello through to Twin Falls, and Boise form the population centers along Interstates 84 and 15. Lewiston and Coeur d'Alene are the major urban centers in the north, both near the western border. Coeur d'Alene is located on Interstate 90, and Lewiston on the Snake River bordering Oregon. The observed demographic similarities between Idaho and Montana likely lends to similarities between the transportation costs associated with collection, as well as processing costs for the two states.

One contrast between Montana and Idaho is the distribution of population centers relative to market areas for recovered materials. Idaho's population density allows the state to direct it's commerce toward the south and west. There is some transportation advantage in being on the western side of the Rockies. This is an advantage that Montana lacks. In addition, Idaho can more readily relate to Nevada and west coast states, a region of high trade and influence. Consumers in Idaho generated 886,000 tons of garbage in 1997 and according to 1996 data the state had a 10% recycling rate for MSW with no incineration (See Table 9).

Wyoming maintains the closest average density to Montana of any state. While bordering Montana to the south, it encompasses territory from the Rocky Mountains to the Great Plains. And like Montana the state shares a northern continental climate. They each also maintain a 5% recycling rate, the lowest in the nation.

The amount of MSW generated in Wyoming, 530,000 tons in 1997, is approximately half that of Montana. This amount is generated by a population comprised of 38.6% rural and 61.4% urban residents. Yet, only two locations of densities over 10.0

persons per square mile are found surrounding the cities of Casper and Cheyenne. In contrast, most of the state has densities of less than five persons per square mile as shown in Figure 21. The distribution of the population of Wyoming by place size, Figure 23, reflects the higher percentage of urban population versus Montana. The greatest differences are seen where Wyoming has a larger urban portion in places of 10,000 or more people and a smaller portion in the 'other rural' category. Urban populations can minimize costs associated with collection due to a more compact collection route, although it is not apparent from Wyoming's recycling rate. A higher urban population also has not given Montana an edge over North or South Dakota as far as can be seen. It may be that the differences are so slight in these examples and so many unknown factors are at work that a higher urban population is not a significant advantage for MSW recycling viability.

Minnesota, the demographic contrast to Montana has a rural population between those of Wyoming and Alaska, with 35.0% of the state dedicated to rural populations. Actually, the proportion of rural to urban dwellers in Minnesota falls near the middle of those for all of the study states, as shown in Figure 22. Yet, the average density for Minnesota is 55.0 persons per square mile which is in great contrast to all of the other study states. This value is mostly a result of a difference in total population between Minnesota and the remaining study states.

The density map of the study states shows that only five of the northernmost counties in Minnesota have below 5.5 persons per square mile. Recall that greater than two-thirds of the state of Montana have densities this low. The distribution of the

population by place size is also in contrast to Montana's as shown in Figure 23. The figure shows that most urban dwellers in Minnesota live within urbanized areas rather than small urban communities.

Minnesota is located in the northern portion of the contiguous United States and shares its western border with both North and South Dakota. The bulk of the urban population is in and around Minneapolis - St. Paul, a thriving metropolis located on the Mississippi River. Minnesota generates 4,780,000 tons of MSW per year, almost ten times that of its neighbors, although per capita generation in Minnesota is only around 30% greater. The estimated recycling rate for Minnesota in 1997 was 42%. Recall that South Dakota also maintains a 42% recycling rate. In startling contrast is the landfill rate of Minnesota (28%) versus the other study states where the lowest rate of landfill is 58% and the average is over 80%. One explanation is that incineration accounts for 30% of the MSW generated in Minnesota. Montana has a 2% incineration rate and is the only other study state with a portion of MSW being handled through this method. It should also be noted that Minnesota exported 412,000 tons of MSW in 1997. It is not clear how this amount is reflected in the reported rates for MSW management options (See Table 9).

The remaining study states are Nevada, Alaska, and New Mexico. All three fit the criteria of population and density detailed above but have more unique physical locations as compared to Montana and the states already discussed.

Nevada is positioned in the Great Basin, bordering five states, the south and west bordering California. It's population of 1,201,833 people live in desert and desert scrub habitats at an average density of 10.9 persons per square mile. Seventy-six percent of the

population lives within urbanized areas, another twelve percent within other urban communities for a total of 88% urban, the highest of all study states. Much of the state resembles Montana's population distribution with two-thirds having a density of less than 5.0, and much of that area less than 1 person per square mile. Yet, the bulk of the state's population are in dense urban centers in contrast to Montana (See Figure 21). One major center of population surrounds Las Vegas and Lake Mead in the southeast corner of the state along Interstate 15. Other population centers are found in Washoe County, the northwestern most county where Reno and Lake Tahoe are located.

Nevada manages 3,955,000 tons of MSW per year, 215,000 tons of this is imported from elsewhere. Approximately 15% was recycled (in 1996), the rest was landfilled. Nevada didn't report any drop-off facilities nor are compost facilities available. Table 9 shows that over 30% of population in Nevada was served by curbside services in that year. South Dakota and Idaho have comparable curbside with 31% and Idaho 23% of population served, respectively. Minnesota has a much larger proportion served by curbside (74%) and the remaining states have only a small percent of their populations served by curbside services. Curbside services enhance the volume of materials collected for recycling by providing convenience. At the same time this type of service increases collection costs because a truck must visit each residence. The structure of individual programs determines to what extent the MSW materials must be sorted and whether one truck will pick up both waste and recyclables or whether these will be serviced separately. (Refer to references listed on p14 for more detail on program costs).

Besides the clustering of most of Nevada's population, the state also appears to

have a direct connection to the commerce of California. Both of these factors should influence the costs associated with collection, processing, and marketing of MSW for recycling in a beneficial manner by reducing transportation costs and increasing profit margins associated with high capacity and demand in the larger consumer markets of California. Still, the MSW recycling achievements in Nevada, as measured by its recycling rate, are only about average among study states and are lower than average for the U.S.

New Mexico covers a range of habitats from the Rocky Mountains to desert in the Colorado Plateau and the steppe of the Great Plains. The State has the highest population, (1,515,069), and density, (12.5), of the eight states being studied with similar characteristics. New Mexico is just below average in recycling achievements with 12% recycled of 1,400,000 tons generated in 1997. Almost a quarter of total MSW is imported.

The rural population makes up only 28.1% of the residents. (See Figure 23 for a depiction of New Mexico's population by place sizes). As Figure 21 shows, population centers are located in the northwest, around Albuquerque and Santa Fe. Interstates 40 and 25 intersect near Albuquerque, and Santa Fe lies along I 25. Additionally, Clovis, Carlsbad, Roswell, and Las Cruces contribute to a band of higher density population across east-central and southern New Mexico. Within this area, only Las Cruces is located along major interstates, Interstates 25 and 10 intersect at the city. Roswell and Carlsbad are situated near the Pecos River. Some commerce likely takes place with larger population centers in Colorado, but the distribution of New Mexico's population does not appear to nurture interstate trade.

Alaska is the study state with the lowest population density, 1.0 persons per square mile. Though, it has a higher recycling rate than both Montana and Wyoming at 7%. Surprisingly, only 32.8% of the state is rural with a total population of 550,043 and it is almost four times the land area of the next largest study state, Montana. The population is focused in the southeast corner of the state, from Fairbanks to Anchorage, and around Juneau and Ketchikan. The Alaska Highway links Anchorage and Fairbanks directly to Canada and the contiguous lower 48. Montana's population by place size is comparable to Alaska's in a few categories, but the high percentage of Alaskan residents in urbanized areas contrasts with the highest percentage of residents in Montana located in other rural places. Furthermore, Alaska's location relative to the national recycling system is the most remote of all the study states. Commerce between Alaska and the contiguous U.S. must incorporate and overcome the high transportation cost of materials.

Solid waste managers in Alaska report approximately 560,000 tons of MSW per year of which to dispose. Fifteen percent is incinerated and 13,000 tons are exported. Even with the incredible size of Alaska and the disadvantage of its relative location, the recycling rate reached 7% in 1997, leaving 78% for landfills. According to the annual Biocycle report, (Glenn 1998 April), Alaska has 296 landfills, and the average cost of using them is \$80 a ton. The rest of the study states have between 15 (North and South Dakota) and 93 (New Mexico) landfills with an average cost of about \$35 per ton for disposal (Table 9). Landfill capacities will be discussed in more detail in the study state policy section.

As the comparison between study states shows, the percentage of rural versus

urban population within a state also does not appear to determine the viability of operating a MSW recycling system. For example, North and South Dakota have a percentage of rural population above 50% and still maintain high MSW recycling rates (21 and 42%). While Montana, with rural population above 50%, has the lowest recycling rate in the nation. In addition, New Mexico has only 28% rural population along with a relatively low recycling rate of 12%. Again, the percentage of population in urban versus rural places is not unique to Montana and does not explain the potential viability of a MSW recycling system within it's borders.

The significance of demographics upon the achievements of MSW recycling in the study states is due mostly to the amount of population clustering within a state and the relative location of these clusters to states with significantly higher population and thus greater commerce. To assess the impact of population distribution in more detail, each state was grouped within one of three categories developed to explain the importance of populations clusters and their relative location within a state.

First, those states which are relatively isolated from large population centers, such as the west coast and the northeast, have some of the lowest recycling rates (Montana and Alaska). Yet, both states have significant clustering of their populations, Alaska more so than Montana. Secondly, states which buffer large population centers and also have populations clustered toward higher commerce (North Dakota, South Dakota, Nevada, and Minnesota) gain advantages from these areas of higher commerce. Still there are some large variations between recycling rates (21, 42, 15, and 15% respectively), in these states which cannot be explained by demographics. Minnesota actually creates the

advantage for North and South Dakota but also fits the characteristics outlined.

Lastly, Idaho, New Mexico, and Wyoming do not fit the characteristics of either of the previous categories due to a lack of one of the aforementioned requirements. Idaho must gain an advantage from it's neighbors to the west with Washington maintaining the highest recycling rate in the nation at 48% and Oregon exhibiting 28%. Yet, the majority of Idaho's population centers are spread across it's southern area instead of being concentrated in the west. New Mexico also has population centers focused more intra-state rather than inter-state. But, New Mexico has domestic neighbors on several sides with significantly higher populations. This may contribute to a recycling rate 2% higher than that of Idaho. Wyoming borders some of the same neighbors as Idaho but it's population is spread somewhat evenly across place sizes and therefore lacks the benefits of both clustered population centers and centers focused toward areas of greater commerce.

This classification scheme demonstrates the importance of having both clustered populations and a relative association with areas of higher population for commerce. Each provides some benefit, but without both characteristics the benefit is limited and a MSW recycling system is not as effective. In addition, as can be seen from the variety of recycling achievements within each category, additional factors, other than demographic distribution, contribute to the overall viability of operating a MSW recycling system. The impact of select economic characteristics of source area populations, public policies, end-user locations, and regional market prices for recovered materials are assessed in the following sections.

Summary of Demographic Distribution

Although density can affect costs associated with collection and processing of recovered MSW materials, the affect varies greatly based on the structure of individual collection programs and individual places and therefore average density for a state is not a significant factor in determining the viability of a MSW recycling system for a state. This point was shown through both statistical analysis (regression) of recycling rate and density data, as well as through comparative analysis of nine study states. Therefore, the potential for sustainable MSW recycling in Montana is not dependent upon its average density.

The achievements of MSW recycling programs, as measured by recycling rates, also do not appear to be directly linked to the percentage of rural versus urban population within a state. The percentage of rural versus urban does not display enough detail to adequately account for unique structural characteristics within a state which contribute to operating costs and benefits for a MSW recycling system. Therefore, the viability of a MSW recycling system in Montana is also not determined by the percentage of rural versus urban population within the state.

The distribution of population in clusters and the relative location of population centers toward greater populations, and the commerce of other states, appear to play a more significant role in determining the overall viability of operating a MSW recycling system. The implications for Montana are that population clusters may provide some benefit, by concentrating the materials generated for recycling, for operating a MSW recycling system. Yet, the isolation of these clusters from large population centers in

other states deter local recycling operations. In addition, demographic distribution is only one factor contributing to the viability of recycling MSW in Montana. The effects of additional cultural and locational factors upon the viability of recycling MSW will be assessed in the remaining portion of this thesis.

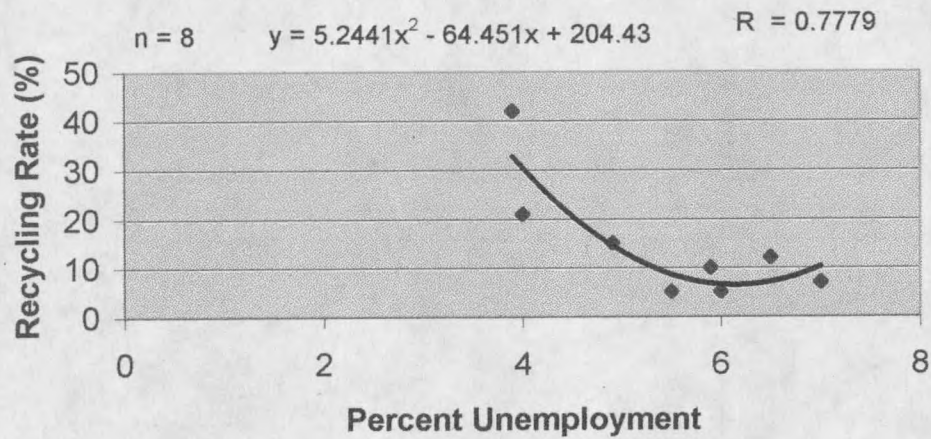
Effects of Population Economics Upon MSW Recycling

Economic characteristics of each place under examination may also contribute to the success of MSW recycling. The variables which affect the behavior of individuals toward recycling and environmental concerns of individuals have been a topic of much discussion in journals. (A starting point for this type of research should include Schultz, et al., 1995 and David W. Moore, 1995). The impact of variables on a state-wide recycling rate does not appear to be readily assumed from these discussions. Two economic indicators of potential significance to state recycling achievements are unemployment rates and median incomes.

The percentage of unemployment for the study states in 1990 ranged from 3.9% (South Dakota) to 7.0% (Alaska). (Table 8, p88). Montana ranked third from the top with 6.0% unemployment while New Mexico (6.5%) came in second. North and South Dakota have the lowest unemployment rates in the study, 3.9 and 4.0 percent respectively.

Regression analysis between recycling achievements and unemployment rates for each study state revealed a negative curvilinear correlation. (See Figure 24). The trend implies that recycling rates are lower when unemployment rates are higher. It is not clear why this correlation exists, but it may be a reflection of state-wide economic conditions

Figure 24 : Curvilinear Regression Analysis of Unemployment
versus Recycling Rate for the Study States
(except Minnesota)



Explanation :

y = trendline equation

n = number of data points (states)

R = regression coefficient

(1 indicates direct relationship)

Source : U.S. Census Bureau, 1993 and Glenn, Jim 1998 May.

which influence both unemployment and recycling activities. There is still a significant random variable which contributes to the relationship between these values as is shown by the scatter about the curve. This variable may be a result of a combination of several other influences and the degree to which they are present in a particular place.

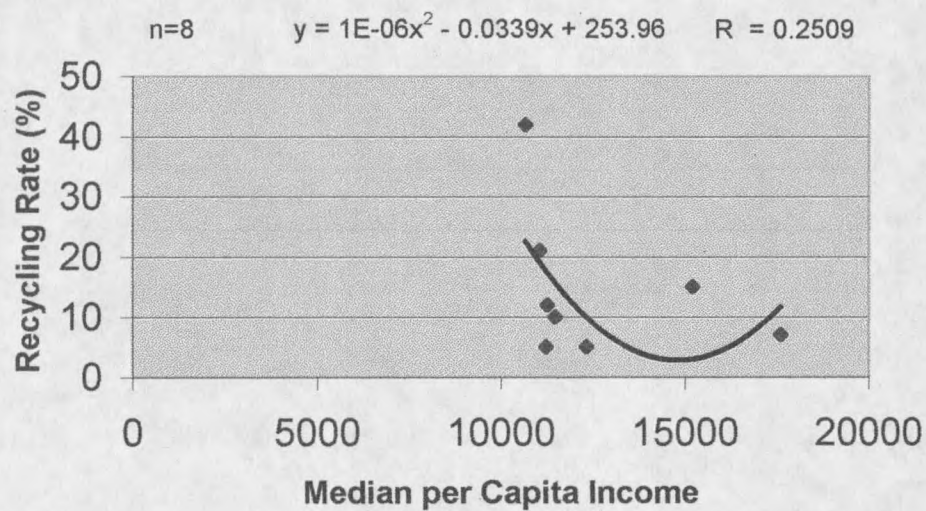
The range of per capita median income for all of the study states was \$10,661 to \$17,610 with Montana falling towards the bottom of the spectrum. Nevada, Alaska, and Minnesota rank highest, each with incomes at least \$3000 higher. (See Table 8).

The correlation between recycling rates and per capita median income reveal a very weak trend (Figure 25). Thus we can conclude that per capita median income is not likely a significant influence upon the achievements of recycling activities in these states.

Political and Social Effects on MSW Recycling

As previously discussed in "A History of Public Involvement", (pp27 - 30), the national environment surrounding the solid waste management and recycling industry promotes techniques for reducing environmental pollution, which in turn has increased pressure on community disposal practices and encouraged industry to reassess manufacturing techniques. Still, these policies leave it up to states to set levels of concern by examples for the public, and to direct local waste management and recovered material market development. States in-turn direct local entities to carry out a variety of activities to meet the needs of solid waste management. These directives contribute to the effectiveness of recycling activities on both the supply and demand side. Some directives have proven to be positive approaches to waste management and recycling while others

Figure 25 : Curvilinear Regression Analysis of Median per Capita Income versus Recycling Rate for the Study States (except Minnesota)



Explanation :

y = trendline equation

n = number of data points (states)

R = regression coefficient

(1 indicates direct relationship)

Source : U.S. Census Bureau, 1993 and Glenn, Jim 1998 May.

have proven to cause hardships. For example, recycling mandates without market development can sometimes provide a surplus of recovered materials which burden available manufacturing capacities. As a result, market prices for recovered materials fall, leading to greater difficulties in operating sustainable recycling programs.

State policies vary based on individual expectations and needs. Landfill pressure can be the primary force behind recycling. In addition, some states view recycling as an investment in jobs, industrial pollution control, and economic expansion. Some of the common methods utilized by state policies include recycling goals, landfill bans, recycled content procurement preferences, tax incentives, assessment and monitoring requirements, education, market development assistance, and funding or providing assistance with procuring funds (grants, loans), etc.

In an attempt to determine the viability of Montana's MSW recycling system, the policies of this state will be compared to those of the other study states. By analyzing each in comparison to its respective recycling achievements, or recycling rate, a list of individual state policies which seem most beneficial can be compiled. In turn, the policies of Montana can be assessed.

Political Background of Montana's Recycling System

Montana has responded to national and local waste issues based on the specific needs of its situation, as all states did. During the same year as the Federal Solid Waste Disposal Act, the Montana Department of Health and Environmental Sciences (MDHES) took a position to promote sanitary disposal such as applying daily soil cover and

controlling litter instead of openly burning materials.

In 1969, The Refuse Disposal District Law was enacted to allow counties to create refuse districts, with waste management plans, and "to implement fees for waste disposal" (MDHES 1994, p17). The Solid Waste Management Program (SWM) was formed as part of MDHES in the 1970's and operated with matching funds from the United States Environmental Protection Agency (EPA). The SWM had the authority to license disposal facilities and enforce operational criteria set by the state.

Recycling was not a public concern well into the 1970's, although there was private trade and industrial recycling of many materials as early as 1916. Household MSW was generally landfilled until "Montana Recycling Inc. [currently Montana RecycleNow] pioneered household recycling operations in 1971" (MDHES 1994, p20).

The MDHES, with support from the EPA, funded a study to assess the feasibility of utilizing materials from the waste stream as an energy source and recovering materials for resale. This study found that "metals are the only secondary materials which can presently be recovered and marketed effectively from processed solid waste" (Henningson, Durham, and Richardson 1976, p4). It also found that newsprint and corrugated paper could be recovered but that the market prices of the time would not support the effort. The final recommendations stated that continued landfilling and regionalization of waste management to support waste-to-energy incinerators should be the chosen methods of waste management for Montana. It additionally recommended steps for implementation. These conclusions were taken into account during future solid waste management decisions and are reflected in the lack of recycling interest on the part of the state.

Improved solid waste management strategies were still a priority. Amendment to the Solid Waste Management Act in 1977 required a state solid waste management plan and gave local governments authority to create and maintain solid waste management systems (MDHES 1994). Prior to these amendments, local governments were "not...authorized to own or operate solid waste processing and resource recovery facilities, nor [were] they permitted to market resource recovery products on an open market basis except" under certain specific circumstances (Henningson, Durham, and Richardson, p14). These amendments are significant in that they gave local governments authority to "enter into agreements for marketing recovered materials" (MDHES 1994). During this period, some funds were appropriated to assist counties with local and regional planning. Yet, planning was still directed mainly at disposal.

During the 1980's, Federal financial support stopped and state programs thinned. Around the state "private buy-back centers, both for-profit and non-profit, opened in many Montana towns" (MDHES 1994, p20). Then Subtitle D Landfill Requirements were passed by the EPA. It was feared that the wide open spaces of Montana would become an attractive alternative for out-of-state disposal needs. In 1989 a moratorium was placed on the importation of waste (MDHES 1994). The moratorium was overruled by court action and legalities are still under debate.

Renewed support led to the authorization of waste management facility fees which were applied toward the expansion of the Montana State Solid Waste Management Program. In 1991, The Integrated Waste Management Act (IWMA) was passed in to shift the SWM Program toward a more balanced approach between management of waste

and conservation of resources. The Act established a waste reduction goal of 25% by 1996. It also adopted an integrated waste management policy which must be based on the following order of priority: 1) Source reduction; 2) Reuse; 3) Recycling; 4) Composting; 5) Landfill disposal or incineration (MDHES 1994). State agencies, universities, and the legislature were directed to begin a procurement program for products made from post-consumer materials "if the use is technologically practical and reasonably cost-effective" (Montana Codes Annotated 75-10-806). The same agencies were directed to prepare and implement source reduction and recycling plans. Recycling was for the first time a higher priority than landfilling for Montana.

The IWMA also required a state solid waste management plan to be prepared by MDHES. Such a plan was adopted on July 15, 1994, designed to be a guide not requirements and will be updated every five years. Recommendations for further development of MSW recycling called for increased education, increased purchases of recycled products, expanded collection facilities, a concentrated effort for support of one or two materials (unspecified at this time), variable garbage rates which reward recyclers, tax or equipment incentives for industry, and the development of grant and loan programs. Another result of the IWMA was The 1995 Montana Guide for Buying Recycled Products published by MDHES with funds provided by the EPA (MDHES 1994).

The State of Montana took a position to include MSW recycling in its overall solid waste management practices in 1991 and provided direction for increasing the recycling infrastructure by 1994. In fact, recycling was already practiced across the state by private businesses and had been for some time. An assessment of recycling practices in

1991 claimed that "Montana has a surprisingly strong recycling collection and processing network ... however, it is still in its infancy when it comes to integrated solid waste management" (Lightle 1991, p146).

Study State Legislative Profiles

Due to Montana's late entry into the public arena of MSW recycling, it was and still is in a position to learn from other states. A strong private and grassroots infrastructure for recycling supports further development. This allows Montana to utilize the best approaches toward building its recycling infrastructure to achieve whichever goals are determined most desirable for the health and welfare of residents.

In order to determine whether MSW recycling is currently viable in Montana, the policies and social pressures are examined for each study state. This examination reveals the level of interest and the most effective policies towards MSW recycling for states with similar population and regional characteristics. The interest and policies of Montana are then assessed to determine their ability to produce a viable MSW recycling system for the state. Table 10 lists some of the pertinent policies of each of the study states.

Landfill pressures are often reported as the main force behind MSW recycling and for some states it is the most critical issue. But, correlation by regression analysis for recycling rates and landfill data show that there is no significant correlation between recycling rate and either the number of landfill facilities or the expected lifetime of landfill capacity (Appendix D). Lack of correlation implies that nationally there must be significant other forces at work. There does appear to be some trend, although slight,

Table 10 : Pertinent Government Policies of the Study States

State	Goals (%)	Goal Deadline	Post-consumer		Structural Mandate	Tax incentive	Business Reporting	Tax/Surcharge Funding	Legislative Appropriation
			Landfill Bans	Procurement					
Alaska	10	1996							
Idaho	25	1995				X			
Minnesota	50/35	1996	X		X			X	
Montana	25	1996		X		X			X
Nevada	25	1995			X	X		X	
New Mexico	50	2000				X	X		
North Dakota	40	2000							X
South Dakota	50	2001	X	X				X	
Wyoming	25	2005		X					X

within the study states as the following will discuss.

The landfill capacity, by the number of years remaining, for the study states include some of the highest in the nation, yet vary considerably (Glenn 1998 April). (See Table 9, p96). They range from 10 (Minnesota and South Dakota) years to 100 (Wyoming) years. (Alaska and Idaho did not report remaining capacity). Both Minnesota and South Dakota aggressively approach MSW recycling, while Wyoming does not seem to be greatly threatened by landfill closures in the near future. The remaining study states do not directly fit the model, although their recycling rates and remaining capacities vary between those of the states already discussed. There is between 20 and 75 years of capacity for New Mexico (20), North Dakota (40), and Nevada (75). Montana also fits between the outer parameters of the model with approximately 20 years of remaining landfill capacity. This evident limit to landfiling is not reflected in its' MSW recycling rate of only 5%.

Another measure of landfill pressure is the cost per ton of disposal. There does not appear to be a trend between recycling rate and the cost of landfill disposal for the study states. Minnesota (\$50) and Alaska (\$80) have high fees while Wyoming has the lowest fee at only \$10 per ton. The remaining states have disposal fees between \$21.5 and \$35, about average for the nation. Montana (\$35) actually has the highest rate in this group, but, again its' recycling rate does not correlate to this level of disposal cost.

Landfill pressures likely influenced the timing of study state entry into the MSW recycling arena and may play a part in a state's approach to recycling, although it does not appear to be directly related to MSW recycling achievements as measured by the recycling rate of a state.

All study states have established a recycling or combination waste reduction and recycling goal. Each state has also published a recycling directory which commonly lists the locations of recycling facilities where households can drop off separated materials. Some directories also list manufacturers which utilize recovered materials, and the products which they produce. Many of the study states have only produced one issue of the directory, and thus many are three and five years old.

Minnesota has been publicly involved in directing its' recycling system towards success almost since the beginning of the national movement for MSW recycling. Even prior to state involvement, as early as the mid 1980's, the region surrounding Minneapolis-St. Paul had began building a MSW recycling infrastructure. In 1989, the state passed legislation which placed requirements on counties for meeting certain recycling goals. It should be noted that the state did not mandate recycling by the generators themselves, but began to provide a state-wide recycling service.

In 1993 the recycling goals for counties were raised to 35% (from 25%) for Greater Minnesota and 50%(from 35%) for the Metropolitan Area, to be achieved by 1996. Counties were directed to meet goals by providing certain minimum services. All counties had to provide at least one convenient recycling center, as well as recycling promotion and education. Additionally, cities with over 5,000 residents were required to provide drop-off or curbside services, the exact requirements were based on population size. Counties were also required to provide implementation reports. Many counties decided to require businesses to recycle in order to meet the state mandated recycling goals. The Minnesota Office of Environmental Assistance was the primary source for

technical assistance from the start and continues to develop new assistance programs (Minnesota Office of Environmental Assistance 1996).

Loan and grant programs were developed to assist recycling endeavors and as incentives for businesses which produce recycled products. In 1989, Minnesota also imposed a garbage collection tax of 6% to provide for direct assistance to all counties. The tax was later altered to become a 9.75% fee directed at MSW haulers. Through this method, the state raised \$23,400,000 in 1997 for recycling activities (Glenn 1990 April ; ---- 1998 May).

Minnesota has implemented two other policies in an effort to promote recycling. First, it has banned telephone books from landfills (in addition to tires, yard trimmings, motor oil, appliances, mercury, vehicle batteries, fluids, and filters). Second, it instituted source reduction credits to be applied toward recycling rates for counties. Certain programs and activities directed at source reduction and composting allow counties to earn these credits which help them to achieve their goals.

The recycling achievements of South Dakota are just as impressive as those in Minnesota with both states reporting a 42% recycling rate for 1997. Yet, South Dakota has a population and tax base more similar to Montana than to Minnesota, and therefore may be more comparable to Montana.

South Dakota actually approaches MSW recycling in a few of the same ways as Minnesota but not all. They are the only two states with landfill bans on materials of interest to this study. South Dakota goes beyond Minnesota and any other state in the nation by banning "office and computer paper, newsprint, corrugated and paperboard;

glass, plastic, steel, and aluminum containers" (Glenn 1998-May, p49). (These bans are in addition to tires, yard trimmings, motor oil, appliances, mercury, vehicle batteries, fluids, and filters). The state also has a 50% recycling and waste reduction goal for 2001.

A state and local government preference for recycled content materials has also been established in South Dakota. The percentage of recycled content is not specified, nor is post-consumer. Furthermore, it is a preference rather than a mandate, and it is qualified by only being a preference if it is more cost effective to purchase the recycled material (Barton 1998). A qualifier such as this defeats the attempt to support post-consumer products. In this situation, there is no example for the public to follow, demand will never increase, and therefore the price of these products will not fall, or the product will not even be provided.

South Dakota has had a recycling coordinator since 1992 when legislation for waste reduction and recycling was established. As with many other states, the priority is waste diversion in any form, not just recycling. According to Deborah Barton, Executive Director of South Dakotas' Department of Environment and Natural Resources, there are no "formal programs" but a great deal of local initiative which direct the recycling system in South Dakota (Personal Correspondence). "Some areas have 100% government owned and operated centers and other areas have elected to use privately owned and operated centers which contract with local governments to collect, process and market recyclables" (Barton 1998). Local governments are taking responsibility to insure MSW recycling availability for residents. Their efforts are supported by state policies.

South Dakota utilizes both a \$1.00 per ton surcharge on disposal, as well as a tax

on tires to support recycling programs. In 1997, \$1,300,000 was raised with these two methods. The funds are used to provide grants and loans for waste minimization, recycling, and economic development through the Solid Waste Management Program. At least half of the money is earmarked specifically for recycling projects. The Department of Natural Resources and the South Dakota Solid Waste Management Association have promoted waste reduction through education and technical assistance as well (Glenn 1998 May ; South Dakota Government website).

Nevada obtains nearly as much funding as South Dakota and also requires county recycling provisions. Funding is provided by a tax on tires which brought in approximately \$1,100,000 for in 1997. This money is used for recycling initiatives including administrative and educational costs, and for providing grants to rural areas, non-profit organizations, and the University of Nevada (Glenn 1998 May ; Sturtevant and Crossley 1997).

Requirements for counties in Nevada to provide certain recycling opportunities were developed in 1991 and later amended. Specific requirements are determined by the population within the county. As of 1995, counties with less than 25,000 people are exempt. Those with populations between 25,000 and 100,000 must provide recycling centers if none are present, while counties with more than 100,000 people must provide curbside services to residents. Since 1993, Nevada has also collected annual tonnage reports for recycling on a county level. Though, they still have problems with data collection which falls within proprietary rights. In an attempt to resolve these data gaps, the state passed legislation which requires all recycling centers to report the number of

tons processed for each material (Sturtevant and Crossley 1997).

Additional funding for the state was received through a grant from the EPA Jobs-Through-Recycling program. Nevada matched the amount received by the grant. With these funds, the state hired a Recycling & Economic Development Advocate to assist "small-scale entrepreneurship and encourage" businesses to relocate to Nevada (Sturtevant and Crossley 1997, p15). The Nevada Division of Environmental Protection is also required to submit annual reports to the Legislative Counsel Bureau on recycling, waste reduction, and market development activities.

One incentive aimed at increasing recovered material market development is a tax abatement plan offered to businesses for the purpose of purchasing and upgrading equipment for processing and remanufacturing processes. The tax abatement receives 5% of the 7% total tax on purchases of this sort (Nevada Commission on Economic Development (NCED) 1998).

All of the recycling and waste reduction funding for Nevada has developed out of a response to the intent of the state to meet its' MSW management goals. In 1991, the state established a goal of 25%, called a "diversion goal", which includes waste reduction and re-use. The deadline for this goal was 1995 and they reported only 15% for their recycling rate in 1997. The remaining quantity that is diverted was not reported and likely is unclear due to the difficulty with measuring source reduction.

Even with all of this apparent interest in recycling in Nevada, the state was criticized in the 1998 Recycling Market Development Report (NCED 1998). The report pointed out that limitations with the incentives and the lack of motivation to reach the

recycling goal indicates to industry that Nevada does not take recycling as a serious endeavor. Without the assurance of public devotion to recycling, steady volume, legislative commitment, and incentives for the support of recycling, potential re-manufacturers do not and will not want to relocate or invest capital to retrofit their businesses. Some of the blame for these shortcomings are related to the structure of garbage franchise agreements in Nevada which, reportedly, adversely effect the willingness of counties to promote recycling because they gain no benefits from doing so. The franchise agreements also discourage third party recycling.

New Mexico also appears to be actively involved in directing MSW management, including recycling, within its' borders. The state began taking control of solid waste management in the early 1970's in a response to problems associated with litter. Solid Waste Management Regulations were adopted in 1989 and The Solid Waste Act of 1990 assigned the New Mexico Health and Environment Department responsibility for creating a cooperative effort "to develop and implement ... a comprehensive solid waste management plan" and to assure the protection of the environment through this process (The New Mexico Environment Department (NMED) 1997, p12).

The 1990 Act requires, among others, annual reports on the progress of management programs, including recycling, numbers on the volumes of material handled and evaluation of markets for recovered materials. The act also established a policy for state purchasing agents to establish guidelines and purchase products with recycled content, "when technically and economically feasible" (NMED 1997, p15). This policy was later clarified to become a mandate for 5% procurement of recycled products. New

Mexico was actually the first of the study states with minimum content laws of this nature.

New Mexico offers a tax credit on recycling equipment to encourage MSW recycling. The state has also established a 50% recycling goal with a deadline in the year 2000. It also provided \$250,000 in waste reduction grants during 1997. Although, New Mexico does not report any funding for recycling programs in 1997 (NMED 1997 ; Glenn 1998 May).

Similarly, neither Alaska nor Idaho reported funding designated specifically for MSW recycling. In addition, the remaining study states, (Wyoming, Montana, and North Dakota), reported the lowest levels of funding for 1997 which appears to be reflected in each state's level of involvement (Glenn 1998 May). Yet, non-profit organizations, local and grassroots initiative often supplement state support and can successfully enhance recycling endeavors.

Alaska has recognized that efforts aimed at bringing landfills into compliance in remote areas are greatly challenged. Alaska is really working to capture industrial waste since, in Anchorage, 80% of all waste going to landfills is industrial, and only 20% is household. (O'Connell 1998). The Green Star Program was developed in Anchorage for this purpose. The program recognizes business efforts to maintain standards of waste prevention.

According to Kim O'Connell, the author of "Northern Exposure : Solid Waste Developments in Alaska", all recovered materials are hauled to Washington for processing as there are no processing facilities in the state. There is a recycling center operating in Anchorage where household materials are collected. Smaller communities are also

attempting to develop ways to recycle. Assistance often comes from Alaskans for Litter Prevention and Recycling, an organization based in Anchorage, working with issues of economic feasibility. Among other activities, the organization "coordinates the back-hauling of waste and recyclables [mostly aluminum] to the Lower 48" (O'Connell 1998, p37).

The state shows support for recycling markets through a 5% procurement preference for recycled content within state agencies. In addition, Alaska has set a goal of 10% for waste reduction and recycling, but failed to meet the goal in 1996, as targeted. (O'Connell 1998). Through the end of 1997, the state had managed to recycle an estimated 7% of MSW. This represents the third lowest recycling rate in the U.S., but more than either Montana or Wyoming (Glenn 1998 May). Again, the additional amount of waste reduction is difficult to measure and was not reported. Had this amount been measured, the state may have been able to claim that it had reached its target goal, a reward for all of those striving to improve waste reduction and recycling.

Idaho established a recycling goal of 25% with a target date of 1995, but the state reported only a 10% recycling rate in 1996. Idaho has also established tax breaks similar to those of other states. There is also a tax reduction on the purchase of machinery which allows manufacturers to use recovered materials to produce new products. In 1995, Idaho applied for and received a grant from the EPA's Jobs Through Recycling Program. The funds are used for market development for glass and cardboard, as well as organics. In 1997 and 1998 the state sponsored additional analyses, workshops, and support aimed toward industry development (EPA on-line 1998, State Profiles).

Wyoming has a 25% recycling goal with a deadline in 2005 (Glenn 1998 May). Currently, the recycling rate is only 5% of the MSW generated. Programs in Wyoming were funded through legislative appropriation in the amount of \$48,000 in 1997. Montana has also enacted legislative appropriation for roughly the same amount, (\$50,000).

According to the Wyoming Recycles Website (1998), there are no standard data collection methods or formal programs, but there is the intent to enhance recycling activities within the state and the region. "Since 1991 about \$140,000 has been awarded to 49 different community recycling programs" with \$20,000 from the state and additional monies coming from private funding (Gentry-Hogle 1998). The state has also received a grant through the EPA Jobs-Through-Recycling program which covers the cost of three Recycling Economic Development Advocates. The Wyoming Governor's Committee on Recycling also offers grants to cities, counties, and non-profit organizations for MSW recycling activities.

North Dakota has established a recycling goal of 40% with a deadline 2000. In 1997 the state reported a recycling rate of 21%. In addition to bans on vehicle batteries and motor oil, North Dakota has a landfill ban on white goods which may have influenced the development of a steel recycling infrastructure throughout the state.

North Dakota reported the lowest funding of all the study states in 1997 at \$45,000, although this is just slightly lower than funding in Montana and Wyoming. North Dakota's recycling funds are obtained through general legislative appropriation. The state uses part of the allocation to employ a recycling coordinator and also publishes a recycling directory.

In summary, each of the study states has incorporated MSW recycling into their overall waste management plan. The extent of state involvement varies from mandated directives, to recommendations supported by financial and technical support, to the provision of a goal, and education. The study states do not utilize all of the available methods of recycling promotion. In addition, not all policies are directly applicable to each state due to the individual characteristics. Montana can gain from the experience of these other states though. Many states have tested their policies over a long period and continue to adjust policies and reestablish goals, and intentions as their situation changes.

The study states have approached the management of MSW recycling by utilizing several methods of direction for local waste management. In some cases, like Minnesota and Nevada, mandated directives have created a statewide structure of recycling accessibility for residents. Throughout the rest of the study states, state authorities have provided recommendations or guidelines but has not mandated procedures.

All study states have established goals for the amount of MSW which they intend to divert from landfills. But, many deadlines have passed without consequence for failing to meet or even come close to the goals. Procurement preferences are also a common method by which states assert support for recycling and market development for recovered MSW materials. The preferences require very low percentages of recycled content and are often qualified by statements which work against the intent of the preference. Preferences are also just that, preferences not mandates, and will not generally be followed due to initial inconvenience of researching purchases. New Mexico is the only study state which has mandated a specific level of required purchases for recycled

products. Another common policy is that of tax breaks for machinery to be used for processing or manufacturing recycled products. Again, it does not appear that the incentives are strong enough to serve their intended purpose, that of enticing new entries into the recycling industry or investment into expanded operations.

Grants and loans are other methods by which states can assist recycling efforts and have some authority in planning and directing the activities which would be most helpful in their states. Unfortunately, such programs have not generally been available to individuals or private businesses, except in South Dakota. Montana restricts these benefits to government entities and non-profit organizations. Yet, the recycling structure in Montana is built on private business.

It is very difficult to determine from this limited review of policy issues which policies are the most effective for a state such as Montana, but the State can learn from the examples. A structured mandate program such as that seen in Minnesota is effective for a large population base, but does not seem to be as effective in more sparsely inhabited areas, such as Nevada. In Montana such a program would be very difficult to institute. In addition, counties in Montana which would likely be included in mandated recycling center or drop-off facility accessibility, (those with higher populations), already have private facilities.

South Dakota has taken a large step to emphasize its' desire to keep certain recyclable materials out of landfills by placing bans on targeted materials. For this state, this method is obviously effective. Again, it would be difficult to establish such a ban in Montana, and may even cause adverse effects on existing recycling programs without the

proper alternatives to disposal in place.

As discussed above, goals, procurement preferences, and tax incentives are valid methods of showing an intent to support MSW recycling, especially when combined with appropriate assistance and directives. Yet, weak language, low standards, and small benefit from incentives cannot accomplish the intended outcome on their own. In fact, such an approach sets a bad example for the public when there is such a small effort by officials to meet the set goals or stand by their preferences. In Nevada, small tax breaks have not proven to be effective in demonstrating to industry that there is a legitimate concern for MSW recycling, or that the legislation or community will support them if they risk moving to the state.

The state of Montana has taken a positive step toward promoting recycling by establishing the intention of integrated solid waste management, a goal for the percentage of recycling desired, tax incentives, and a full-time waste management and recycling coordinator. In addition, the state has mandated procurement as well as waste reduction and recycling for state agencies, universities, and legislative bodies. Unfortunately, the recycling goal was not met by the targeted deadline and there was no consequence nor even a reassessment at that time. As with many of the study states, this reflects poorly on the state and does not set an example of serious intent for residents or for potential manufacturers.

The state does better to show a serious intent to promote recycling through the recycled product procurement mandate. The legislation was qualified somewhat to avoid extreme demands, but the verbiage of the mandate still remains strong. In addition,

support was provided in the form of a market development task force which met in 1992 and 1993. The task force helped establish accessible vendors for supplies and assisted with waste reduction and recycling planning. Unfortunately, the task force did not establish a precedent for high post-consumer content and therefore Montana still considers 30% post-consumer content in paper to be adequate. Numbers on the success of this mandate are currently being collected by the Department of Environmental Quality.

Tax incentives provided by the state of Montana come in two forms: 1.) 10% tax deduction is provided for businesses who buy recycled products, and 2.) tax credit on "depreciable property that is used (a) to collect and process reclaimable material or (b) to manufacture products from reclaimable material ..." (DEQ 1999, Waste Reduction Incentives for Montanans). Since 1996, the amount of credit begins with 25% on \$250,000 invested, and falls to 15% and then to 5%, not to exceed a million dollars. Both of these tax incentives are reasonably strong incentives for purchasing products and equipment which promote recycling.

The performance of Montana to direct its institutions, municipalities, and citizens toward achieving a viable MSW recycling system is on the right track. The state appears to be in a better policy position than many of the study states whose policies are weak, unimpressive, and ineffective. Several recommendations could improve the effectiveness of MSW recycling in Montana.

A reassessment of the status and goals of recycling is definitely in order. In fact, the IWMA requires that the solid waste management plan is updated every five years. Currently, data collection for this purpose is underway. With this reassessment, the

recycling goal could be lowered to a more realistic level, one which can be achieved through serious intent. Recycling goals specific to paper, plastic, and glass could also be developed in hopes of focusing efforts on effective support. Striving for a realistic goal may inspire those working towards it. Reaching that goal will then be a reward, one which will be announced throughout the state, meaning free promotion and education for MSW recycling. Increased enthusiasm about recycling will follow. The situation can then be reassessed, and a higher, but realistic, goal established.

Tax incentives for recycling equipment and especially for manufacturing facilities should be increased and grants should be made available to private businesses. Montana has a strong private infrastructure for the collection and processing of MSW materials already in place. Such enterprises should be rewarded and allowed to flourish. Neither the state nor municipalities need to duplicate existing services if the market is supplying them. Private services should be utilized to expand MSW recycling. Increasing funding for expansion through tax breaks, and especially accessibility to grants, will allow the state to have some control, through application procedures, to direct growth in the most appropriate manner.

The post-consumer content of certain products should be specified in the procurement mandate. As the following section on end-users will discuss in detail, aluminum, steel, and glass are commonly made of post-consumer materials. According to the Department of Environmental Quality, State institutions are currently buying paper with approximately 30% post-consumer material. Fifty and one hundred percent post-consumer paper products are also readily accessible for most uses. When bought in large

quantities, the per unit cost can be very close to that of non post-consumer products. As the demand increases, the cost will fall. A central supply store for state procurement could more effectively acquire reasonable contracts for paper supplies. Currently, post-consumer plastic products are not as readily accessible, but are being produced. This is an emerging industry and requires the support of consumers in order to become fully established. Again, increased demand will make products more accessible and will reduce costs. In addition, procurement mandates should be extended to all municipalities.

Financial and technical support will also have to be provided as will terms for exemptions.

From the study state analysis, it appears that additional or alternate funding to legislative appropriation would benefit recycling activities. Taxes on problem-causing materials such as tires, or on landfill disposal itself, are two of the most common methods. Charging those who landfill and thus rewarding those who recycle and reduce seems the most logical method to obtain funds for recycling activities and to reduce landfill activities.

Standardized monitoring of recycling activities should also be considered.

Tracking data would assist in documenting that the state is succeeding in its goal. But, due to the large involvement of private facilities, obtaining accurate data would be difficult due to proprietary rights, and forcing this issue would be an infringement likely not welcomed by industry. Funds to support this type of monitoring would also have to be in place prior to a mandate. One solution to explore could be to incorporate data reporting into requirements for obtaining grants.

All of these suggestions would improve the viability of recycling MSW in Montana by : increasing the awareness of the intention to support recycling ; setting an example for

residents to follow ; and displaying a serious intent to assist the development of the MSW recycling system. Most of the suggestions would not greatly impact the finances of the state or the residents, but would represent the desire to reduce the states' dependence on landfills.

END-USER CHARACTERISTICS AND LOCATION RELATIVE TO SOURCE AREAS

Introduction to End-users

Quite often the discussion of recycling stops at suppliers, and associated costs for local communities. It is important to recognize that manufacturing is a vital part of the recycling system. Characteristics of manufacturing, such as location, capacities, and raw materials specifications can greatly affect the ability of suppliers to operate and the costs under which they operate. In addition, many of the benefits received by recycling MSW materials are realized in the manufacturing phase of the recycling system. These benefits contribute to the development of the industrial infrastructure for recycling and therefore can directly impact costs at a local, regional, and national levels. By understanding the needs and desires of manufacturers, for each type of recovered material, we can customize the many local programs and individual preferences to support and fit into the national recycling industry.

Suppliers, including collectors, processors, and brokers, from all regions must seek a market for recovered materials. The market, or end-user is not interested in waste, but in a feedstock for production (United States Environmental Protection Agency 1995).

End-users including mills, foundries, factories, refineries, and plants, use many manufacturing methods, operate a variety of equipment, and produce a vast array of products. The key for industry is "whether they can obtain clean and reliable supplies, at a low enough cost, without sacrificing the quality or the price that their customers have

come to expect" (Arrandale 1991, p44). This is where directed buying power helps to show industry that consumers are willing to support more post-consumer content such as discussed in previous sections on materials and policies. Often, utilizing recovered materials requires large capital investments, initially, in specialized equipment. The long-term benefits of installing such equipment must outweigh the short-term costs for this type of investment. For private industry, this consideration is usually a reflection of the potential to increase the profit margin in the long-term.

Coincident with national events leading to increased MSW recycling and monitoring efforts in the U.S. during the late 1980's, manufacturing regions and districts were mapped by Fisher (Fisher 1989 In Souza 1990, p355). Figure 26 was adapted from Fisher's data to show the states without a major manufacturing region or smaller district in the contiguous United states. Based on this map, seven of the nine study states show no manufacturing district, (Alaska is not included in the Fisher study). The only state in 1989, with a definable manufacturing area was Minnesota. In effect, Montana was completely surrounded by states who lack manufacturing regions when the initial attempts at MSW recycling on a public scale were begun. No other state was so completely isolated. Fishers' study also did not consider manufacturing regions in Canada, which could serve as neighboring market regions for Montana. This indicates that Montana must overcome a lack of manufacturing before recycling operations could function on even ground with the rest of the country.

Capacities for recovered feedstock have increased in the targeted industries, (plastic, aluminum, steel, glass, paper), due to the benefits gained through energy and cost



300 0 300 600 Miles



Study State

Alaska and Hawaii
Not Included in Fisher Study

Figure 26 :
States without Manufacturing Regions
or Districts, 1989

Source : Modified from Fisher in Souza, Anthony R. de 1990, p.355

reductions associated with greater efficiencies of operation as well as gaining a reputation for supporting environmental conservation. Yet, recovered MSW material capacities still vary considerably by industry. Manufacturing of recovered materials is typically a portion of a larger production which developed on a virgin raw materials base. Therefore, the location of industrial facilities has historically been driven by factors other than supply of recovered MSW materials. Only in a few instances has recovered scrap been developed as a primary source of raw material for production. In effect, the location of industry has been oriented towards sources of virgin raw materials, inexpensive energy for fuel, consumer markets, cheap labor, or production associations within an industry (Miller 1977). The current industrial distribution that has developed out of these locational factors affect the costs accrued by a source area of recovered materials by impacting transportation costs of to market. Simply, longer distances increase transportation costs, thereby reducing financial benefits of marketing the materials. In an attempt to test the viability of the MSW recycling system in Montana, the relationship of the state (as a source area) and its' potential end-users (industry) are assessed.

The potential availability of markets for recovered MSW materials were examined to determine the impact of costs associated with industrial capacities, manufacturing benefits of using recovered materials, and transportation in the study states, and subsequently in Montana. In the following sections, a profile of each of the target material industries is developed. Each includes general information about required specifications for recovered materials, the processes involved in remanufacturing recovered materials, benefits derived by the industry through utilizing recovered materials versus virgin

materials, and the historical outlook of the industry towards recovered MSW materials. In addition, the current distribution of industrial facilities for targeted MSW materials in the United States were mapped. The distribution data were obtained from The Glass Packaging Institute, American Plastics Council, and yellow page searches through Excite and GTE on the Internet.

Paper

Wood, cotton, hemp, and other fibrous materials are virgin stock for paper, though, wood has been the main virgin resource used for paper making in the U.S. since the mid 1850's. Wood pulping technology was developed as a response to a shortage of rags, which were the main source of fiber for paper manufacturers prior to that time. Large forests across North America were an ideal source of unlimited fiber. Early wood pulping mills were located close to the vast forests. Mills in Canada and the U.S. now contribute 77% of the global pulp production (Conservatree 1998). At the same time, The Canadian Pulp & Paper Association claims to import recovered paper from the United States, almost 2 million tons per year, to meet mill capacities. Canada also exports 75 % of their recycled paper products, most of which is shipped right back to the U.S. (The Canadian Pulp and Paper Association, 1998).

The desire to reduce landfill pressures by utilizing MSW materials has promoted technology for recycling in the paper industry. Recall that waste paper is largest portion of MSW, thus paper is the most significant strain on landfill space. Once sorted by grade, according to specifications, paper made from recovered materials must go through a series

of processes to remove contaminants and create a useable pulp from which to make the paper product. These processes are usually carried out by de-inking mills, or pulp mills which have invested the necessary capital towards equipment for this purpose.

De-inking of wastepaper has been practiced since the early 1800's, but de-inking capacity really began to expand in the early 1990's due to overwhelming desire and support from individuals to utilize recovered papers. The paper industry was reluctant to invest the necessary capital into new equipment for the purpose of recycling recovered paper. The reason for the reluctance was that they were unsure that the necessary volumes of recovered papers would be consistently supplied and that the specifications for high grade papers would be met. Wood pulp is readily available. In addition, the industry was concerned that recycling was just a fad and the demand for recycled products would not withstand time. But, the industry did make the investments in the mid 1990's with support and commitment from the public. Yet, complications with the overwhelming types of contaminants resulted in the closure of many plants soon after opening. Many of those which withstood the initial challenges are reportedly running below capacity due to a relaxed consumer position, as was feared (Conservatree 1998).

The de-inking process consists of a series of mixing, filtering, and washing techniques. Water, heat, and chemicals are applied to recovered paper to separate ink and other contaminants from the fibers. Large non-paper contaminants such as staples and paper clips are removed through filtering. Additional washing removes smaller contaminants such as ink particles (Cross Pointe Paper Corporation 1993).

Two main technologies are utilized to remove ink, a 'washing system' and

flotation cell technology which is a newer technology allowing ink droplets to float off the mixture. The two technologies react very differently to clay which is found as a coating on magazines. Clay reduces effectiveness with the washing system, but flotation cell technology is enhanced by a certain amount of clay. Therefore, it is crucial to industry that specifications for papers are adhered to for the specific end-user (Sound Resource Management Group Inc. 1996). It is also important to source areas to supply a high quality raw material because the quality directly affects the price paid by industry for the recovered materials. The clean pulp is spun to remove additional lightweight contaminants, and then spread to dry in a sheet which is then used to make paper products.

Often the pulp mixture is also bleached to brighten fibers. Bleaching with chlorine can cause a multitude of environmental problems. (For additional discussion on consequences of chlorine bleaching see the web site for Treecycle located at www.treecycle.com on the Internet.) Bleached products are considered to be the consumers choice by industry, although many consumers are not aware that unbleached paper products are available to those who request them. With greater demand, these products will become more accessible in every store.

Paper fibers do break down through use and remanufacturing, so paper cannot be indefinitely reused. Virgin stock is required to maintain the current output of paper products. Yet, paper fibers can be reused many times, and it is beneficial to do so, not only from the viewpoint of MSW management. When de-inking printing and writing papers, as much as 20 - 30% of the original scrap ends up as a non-useable sludge of ink,

stickies, and fine, worn fibers. This sludge still requires disposal. In contrast, it is estimated that only 50% of virgin wood contains the cellulose fiber that can be made into paper (Kinsella 1996).

Manufacturers gain benefits when recycling recovered paper in the form of energy and water savings, as well as a reduction in pollution, and thus remediation costs.

"According to the U.S. Environmental Protection Agency, one ton of pulp made from deinked fiber requires 60 percent less energy to manufacture than one ton of pulp made from virgin wood fiber...Producing one ton of deinked fiber also takes much less water - about 7000 fewer gallons - than producing a ton of virgin fiber. In addition, the recycled paper production process generates far less air pollution and chemical waste than virgin-pulp production" (Cross Pointe Paper Corporation 1993). These benefits are gained not only by the manufacturers of recovered materials, but by communities near the facility, as well as the entire nation. Source areas which have resident end-users also benefit from low transportation costs associated with delivering recovered materials to market.

Recovered paper is exported in large volumes to end-users in South America, Mexico, Canada and Asian markets. Economic and market conditions in these areas are subject to constant fluctuations. Due to this large demand from outside of the United States, and lack of demand domestically, the recycling system for paper is not sustainable on a national scale. The reliance of the American paper recycling system upon these end-users places the nation at the mercy of constantly changing conditions.

Two examples of this reliance are well illustrated by recent market conditions in Germany and in Asia. In the early 1990's, Germany established an aggressive, mandated

recovery program. As a result, recovery of paper quickly out paced the established markets for recycling paper, forcing manufacturers to export large quantities of cheap recovered paper. Subsequently, the price paid for recovered paper around the world, including the U.S., dropped. In addition, countries with end-users which had formerly purchased primarily from the U.S., began to buy from the German competition, reducing the ability of the U.S. to export its recovered paper (Franklin Associates Ltd. 1994). U.S. manufacturers attempted to increase domestic capacities for utilizing recovered paper, but as discussed previously, were not able to establish a reliable domestic infrastructure due to lack of demand for recycled paper products.

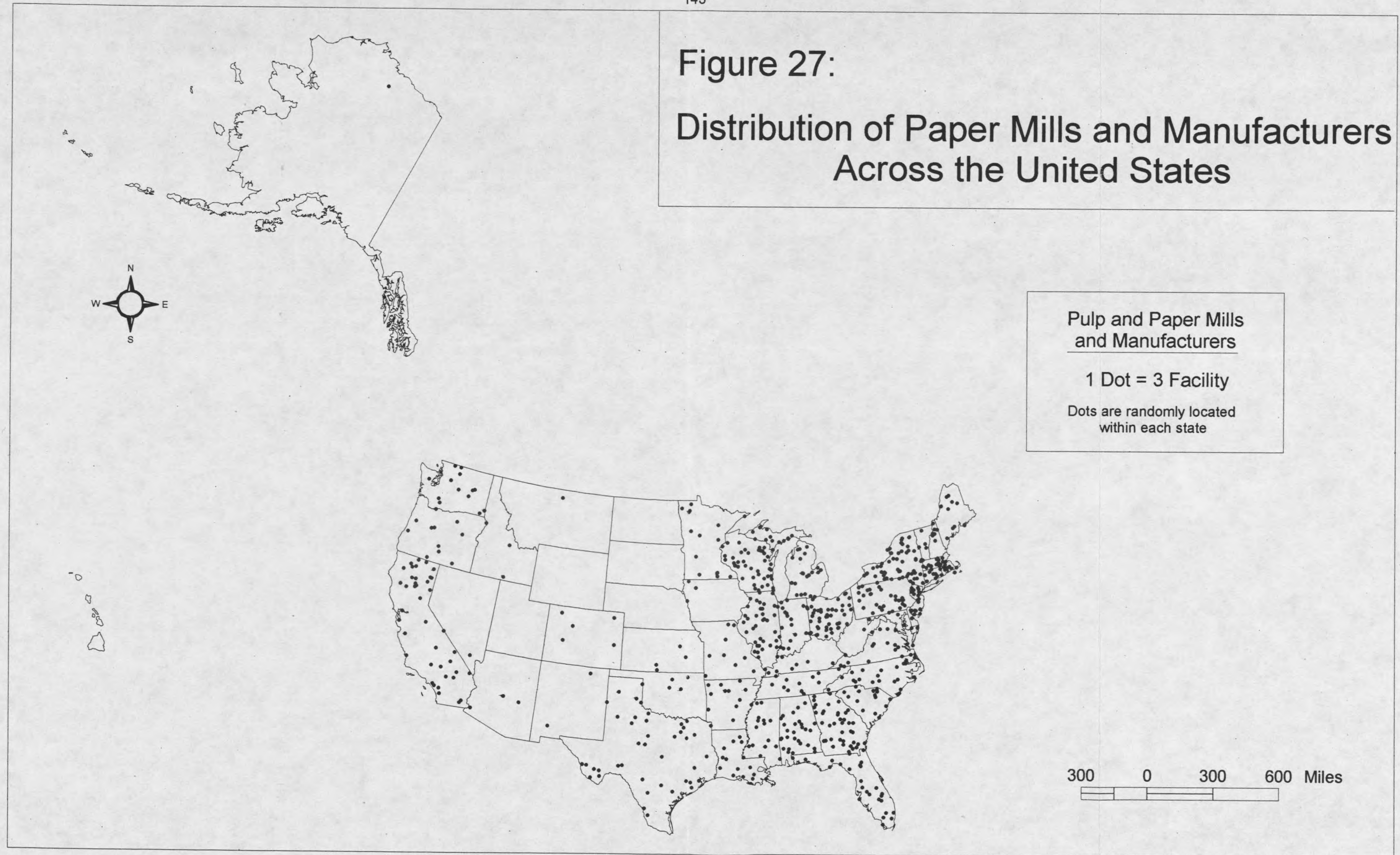
By 1997, the U.S. paper recycling system was still not domestically sustainable, and relied heavily upon the post-consumer manufacturing practices of other countries. During this year, bad debts, bankruptcy, and generally low economic activity caused the devaluation of currencies throughout Asian countries. In turn, demand for recovered paper imports were reduced dramatically in these countries. The United States, once again, had a glut of recovered paper and was forced to reduce exports and domestic recovery of MSW (Cesar 1998). Although U.S. consumers purchase millions of tons of paper every year, we do not request and demand high quality post-consumer products. Therefore domestic manufacturers have not been able to develop the necessary capacities for recycling paper in this country. Until the U.S. supports post-consumer paper products, recycling of MSW will not be sustainable. Community efforts to collect and process MSW recyclables are currently dependent upon exports and will be hampered or even be curtailed with each turn of world events.

Domestic paper mills and manufacturers are primarily located in the eastern United States (See Figure 27). The west coast also contains significant paper making capacities, with sparse facilities in the interior west and Alaska. Also note that only a portion of the facilities mapped currently accept post-consumer paper for remanufacturing. The American Forest and Paper Association claims that the majority of paper manufacturing facilities are equipped to use recovered paper, but the association was not able to elaborate on this subject. Therefore, the facilities located on Figure 27 may be viewed as potential end-users.

Minnesota has 43 facilities, about average for the United States. It is also the only study state with greater than 7 facilities within its' borders. Idaho, New Mexico, and Alaska have from 7 to 5 paper mills and manufacturers, respectively. Montana matches Nevada with 2, while North and South Dakota have only 1 each. Wyoming is the only state in the U.S. without a single paper manufacturer, or, a paper, pulp, or paperboard mill (GTE 1999). The distribution of facilities across the United States generally reflects the distribution of forests. A correlation also exists with the distribution of higher density populations, or rather, consumer markets.

Only one of the facilities located in Montana utilizes recovered paper as a raw material for production. Smurfit Stone Container, located in Frenchtown, produces approximately 2,000 tons of linerboard per day. About 26% of the pulp for that production is made up of old corrugated cardboard. According to Lisa Phillips, Environmental Engineer for Smurfit Stone Container, all recovered cardboard from Montana is readily converted to linerboard. Additional recovered materials are regularly

Figure 27:
Distribution of Paper Mills and Manufacturers
Across the United States



purchased from as far away as Chicago. The finished linerboard is shipped to box plants across the U.S. to be assembled, along with corrugated filler, into cardboard boxes (Phillips 1999).

In summary, the national paper industry is a willing yet tentative player in MSW recycling systems. The industry relies on consumers to direct the course of their involvement in producing recycled paper products. Due to the lack of national demand for products with high post-consumer content, the industry has turned to international markets to utilize the available equipment capacities. As a result, industry and source areas which supply recovered raw material to industry are reliant on constantly changing world conditions. National paper recycling systems are not currently sustainable within the United States.

Montana is heavily reliant upon the national paper recycling industry. Although there are two paper facilities in the state, Stone Container is the only end-user for post-consumer materials. Accepted material is limited to old corrugated cardboard. The rest of the post-consumer paper collected across Montana must be shipped to out-of-state markets. Due to the relatively small volume of material generated (due to low population), Montana is not a primary source of raw material for the paper industry. In addition, since the state has very limited resident end-users, there is no loyalty by industry to accommodate supplies from Montana. The state does not have the necessary bargaining power to maintain long-term contracts with markets for recovered paper. Thus, Montana's paper recovery system must be very flexible in order to respond to short-term needs of industry.

The location of end-user markets relative to Montana also directly effects the costs of operating a paper recycling system in Montana. Cardboard and paperboard are delivered to Stone Container in Frenchtown, Montana. The location of this facility is near high population centers where materials are generated at the highest volumes. Therefore, transportation costs do not significantly cut into the profit gained by selling these materials to the facility. Furthermore, the benefits of utilizing recovered materials versus virgin materials which are gained by Stone Container are transferred to the surrounding communities through lower product prices, a clean environment, jobs, and reduced resource consumption.

On the other hand, the operating costs of all other paper products recovered in Montana are adversely affected by the location of markets outside of the state. Montana does not directly benefit from manufacturing efficiencies realized through using these recovered materials, although there is still a national benefit. Therefore, when calculating costs, it is difficult to incorporate manufacturing benefits into the equation. Long distances to market increase the total cost since shipping expenses rise with the number of miles.

The viability of recycling paper products in Montana is directly linked to the national system. Until end-user markets locate within the state, which rely primarily on the local recovered materials, a viable system will not exist.

Plastics

Crude oil is the primary virgin material used to make plastic products. The oil is refined, producing liquefied gases, which are further processed into organic chemicals such as ethylene, propylene, benzene, and paraxylene (Sound Resource Management Group Inc. 1996). These materials are "polymerized" in conjunction with certain additives to produce plastics with a variety of characteristics. The plastic is then formed or molded to the specific product.

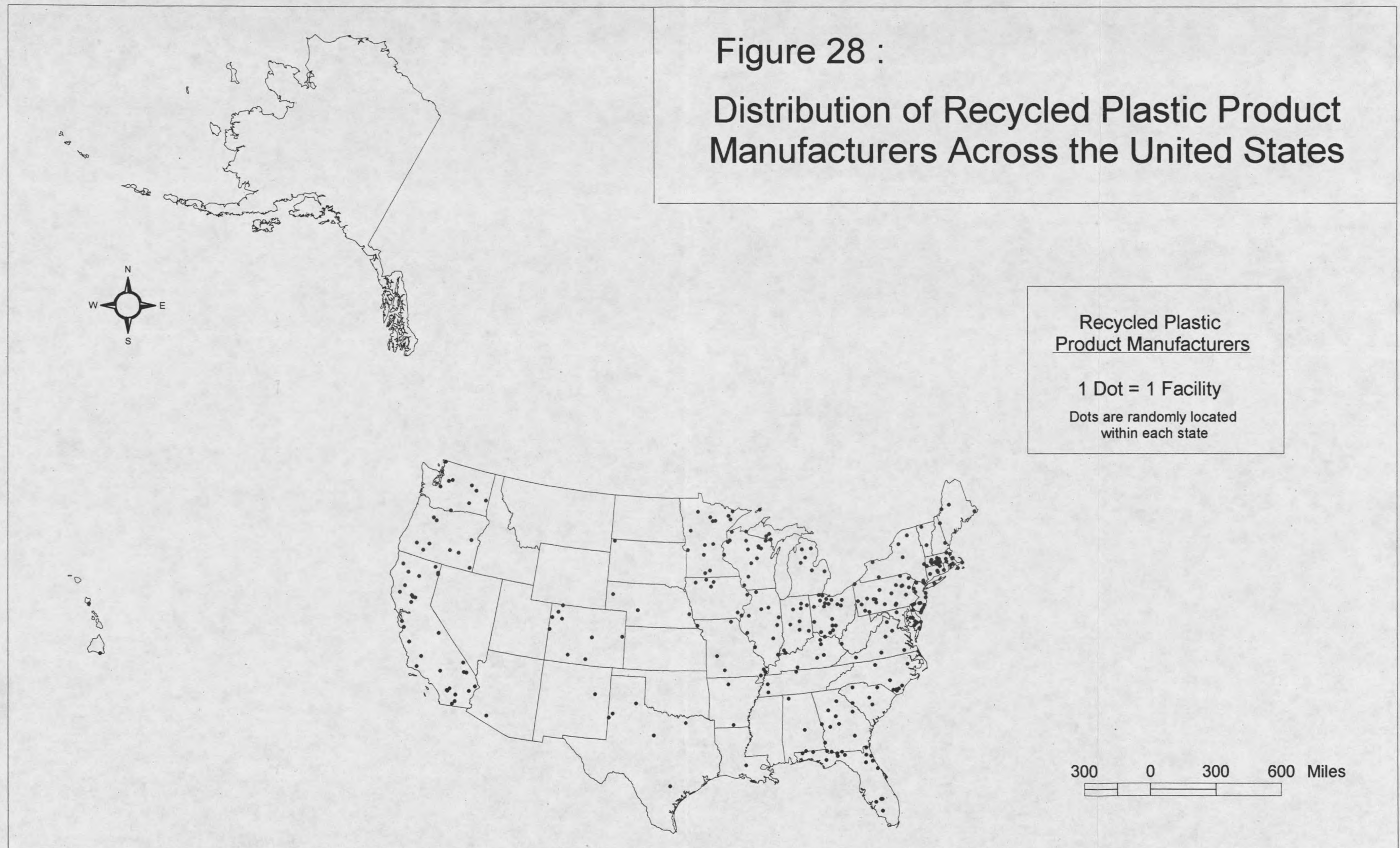
Plastic cannot always be recycled. Some plastic products are cured into permanent shapes which can not be remelted. Many other plastics can be recycled but each resin type must be processed separately to maintain consistent characteristics of the recovered plastic. This is somewhat difficult, but essential to the remanufacturing process. Post-industrial plastic has been recycled for years due to quantities of consistent resin produced by industry. Post-consumer plastic recycling is a fairly recent phenomenon, primarily driven by MSW concerns rather than by industry. As mentioned in the materials section of this thesis, plastic technologies are constantly evolving and therefore may lead to the development of new products which incorporate the recycling of MSW plastic. Yet, the current infrastructure is not well developed, and while supply increases, demand is not strong. An effective way to increase demand is to seek out recycled materials when purchasing. The American Plastics Council produces the Recycled Plastics Products Source Book (1998) which lists both the available products and manufacturers whom produce them.

Recycling of post-consumer polyethylene terephthalate (PET) and high density polyethylene (HDPE) products usually requires grinding, remelting, and pelletizing of the recovered material. Fabricators then form the resin back into new products, such as containers. Fiber industries can also utilize recovered PET for applications in carpet, clothing, plastic lumber, and equipment. HDPE applications include film and vehicle parts, among others (Sound Resource Management Group Inc. 1996 ; Franklin & Associates Ltd. 1994).

Too much contamination in the form of foreign resin causes the resin produced from the pellets to lose it's "intrinsic viscosity" requiring costly depolymerization prior to use (Sound Resource Management Group Inc. 1996, p134). The intrinsic viscosity of plastic is also broken down after repeated recycling of the material. Large energy and resource savings can be realized by the recycling of plastic. But, quality control limits the MSW recycling potential to a few, high-volume types of plastic. Furthermore, repeated recycling of plastic greatly reduces the savings realized due to the cost of repolymerization (Sound Resource Management Group Inc. 1996 ; Franklin & Associates Ltd. 1994).

Manufacturers of recycled plastic products in the United States are mapped on Figure 28 (American Plastics Council 1998). Again, the greatest number of facilities are found in eastern states and along the west coast. Large industry and consumer markets have directed the growth of plastic recyclers. There is a noticeable lack of recycled plastic manufacturers in the western interior, with the exception of Colorado and Nebraska. The Study States have a total of 16 recycled plastic manufacturers. Fourteen are found in Minnesota, with the remaining two in South Dakota and New Mexico.

Figure 28 :
Distribution of Recycled Plastic Product
Manufacturers Across the United States



Again, Montana is dependent upon markets for recovered plastic materials which are far from the state. Montana also lacks any benefits realized during the manufacturing phase of recycling plastic. The result is an increase in total cost applied to source area operations above what costs would be if end-users were located within the state.

Since the infrastructure of the plastic industry is still emerging, and new products being developed rapidly, there is ample opportunity for Montana to develop a niche of its' own within the industry. A product developed for irrigation or fencing, for instance, could contribute to the region and sustain the recycling of MSW plastic within the state. Montana has much to offer in the way of labor and a high quality environment as incentives to investment in the area.

Glass

Glass containers are originally made out of sand (silica oxide at 70%), soda ash (sodium carbonate - 15%), and lime (calcium carbonate-12%), and 3% other materials (Sound Resource Management Group Inc. 1996). This mixture is melted under high temperatures and then cooled and refined to remove "crystalline materials and gas bubbles" (Sound Resource Management Group Inc. 1996, p115). The melt is then formed into containers.

Recovered glass cullet is added directly to a glass mix of virgin materials for remanufacturing. The recovered material tends to melt at lower temperatures which increases the efficiency of the furnace. "The glass container industry used 80% of the glass recycled in 1996 as a raw material in making glass containers. Secondary markets...used

the remainder of the glass recycled in 1996" (Miller 1997 September, p87 - 88). The Glass Packaging Institute explains that because "using recycled glass reduces energy consumption, raw materials use, and wear and tear on machinery, ensuring a steady supply of recycled glass, or cullet, has become crucial to the industry success" (Glass Packaging Institute 1998, Recycling Homepage). In-house recycling of cullet has always taken place for this reason. Greater operating efficiencies have also led to reduced amounts of in-house scrap cullet available for recovery. The recycled content of U.S.- produced bottles is estimated to be 27% (Miller 1997 September).

Large quantities of cullet can be substituted for virgin material in a batch of mix. But again, contaminants are a big issue with recycling post-consumer materials. Any number of foreign objects in the cullet can ruin a batch of glass mix. Virgin materials are used to maintain the chemistry of the mix and thus the melting characteristics. The characteristics of the batch are especially sensitive to glass of a foreign color (Sound Resource Management Group Inc. 1996).

The major colors of glass containers processed in the U.S. are: clear (flint), brown (amber), and green (emerald). A batch of glass mixed to produce clear containers is tolerant of only 5% other colors. Likewise, both brown and green can only tolerate about 10% foreign color in the batch. (Sound Resource Management Group Inc. 1996 ; Miller 1997 September). Manufacturers in the U.S. produce primarily brown and secondarily clear containers, while green is usually imported. As a result, there is usually an abundance of recovered green containers which cannot be utilized. Often collection programs do not include green glass for this reason.

The Glass Packaging Institute maintains a database of cullet processors for the United States and Canada. (1998) These facilities are mapped in Figure 29. Due to the nature of glass production, there is a limited number of facilities in the United States. These facilities utilize as much recovered material as possible through a well established infrastructure.

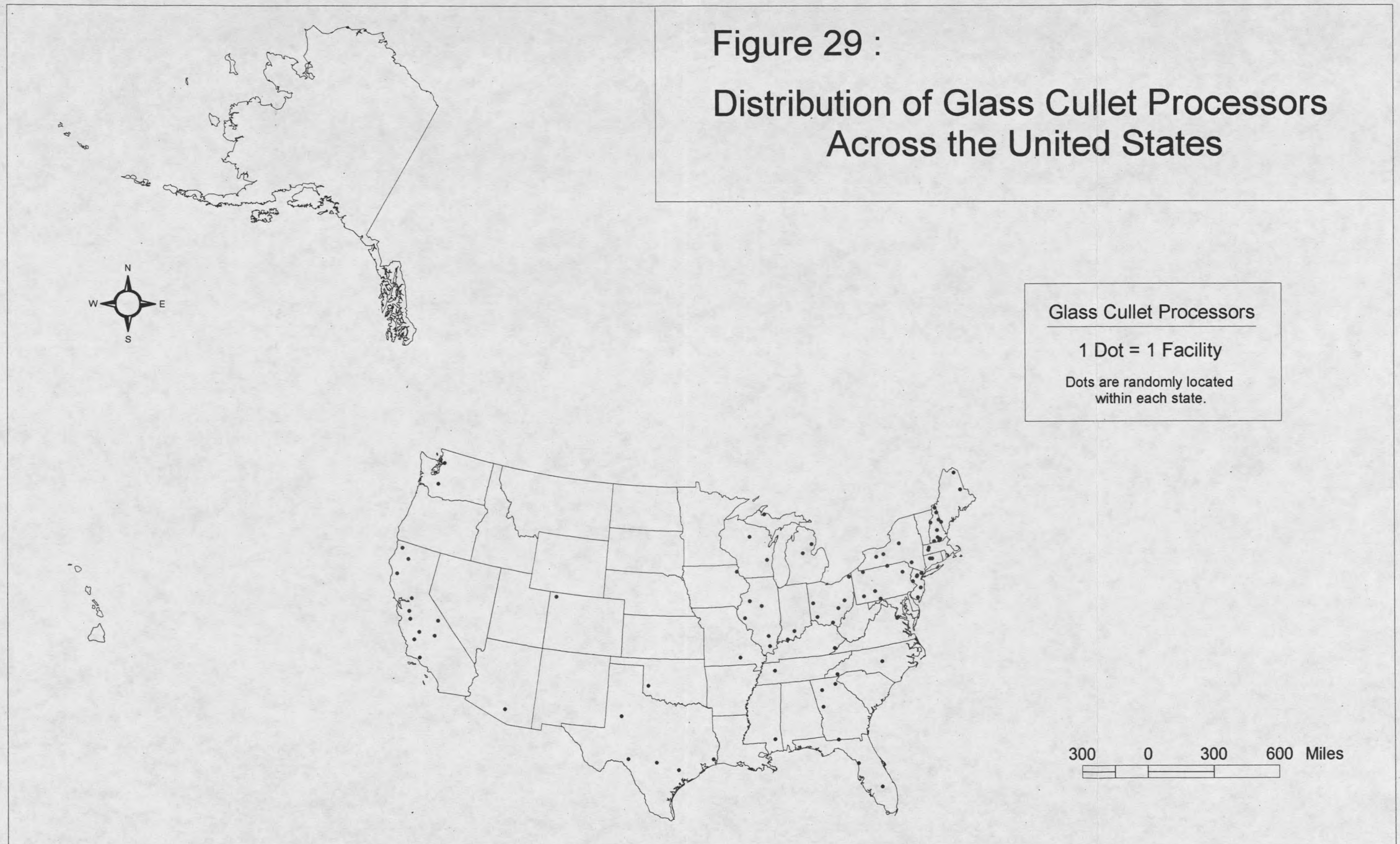
Montana is not located near an existing glass facility nor does the state have a large enough population to create demand for its own facility, or to supply a manufacturing facility. Therefore, secondary markets must be created within the state to utilize recovered glass. Secondary markets include facilities which utilize recovered glass without remanufacturing. At least two secondary glass end-users are located in the state. Both utilize glass in roadbed mixtures rather than remanufacturing it into glass packaging. Each market is relatively small and utilizes materials from local generators. Additional local glass end-users can be developed, and must be if Montana intends to recycle glass.

Steel

The steel industry supports a huge infrastructure for the recovery of ferrous metal scrap, including steel cans, due to the costs of mining and refining of virgin materials. Scrap reduces the time which a furnace is required to operate and therefore reduces fuel consumption. In addition, steel does not lose its strength or qualities with remanufacturing processes so scrap can be used over and over again.

Most steel contains elements and alloys which must either be removed or sorted according to consistent characteristics. This allows the manufacturer to utilize the existing

Figure 29 :
Distribution of Glass Cullet Processors
Across the United States



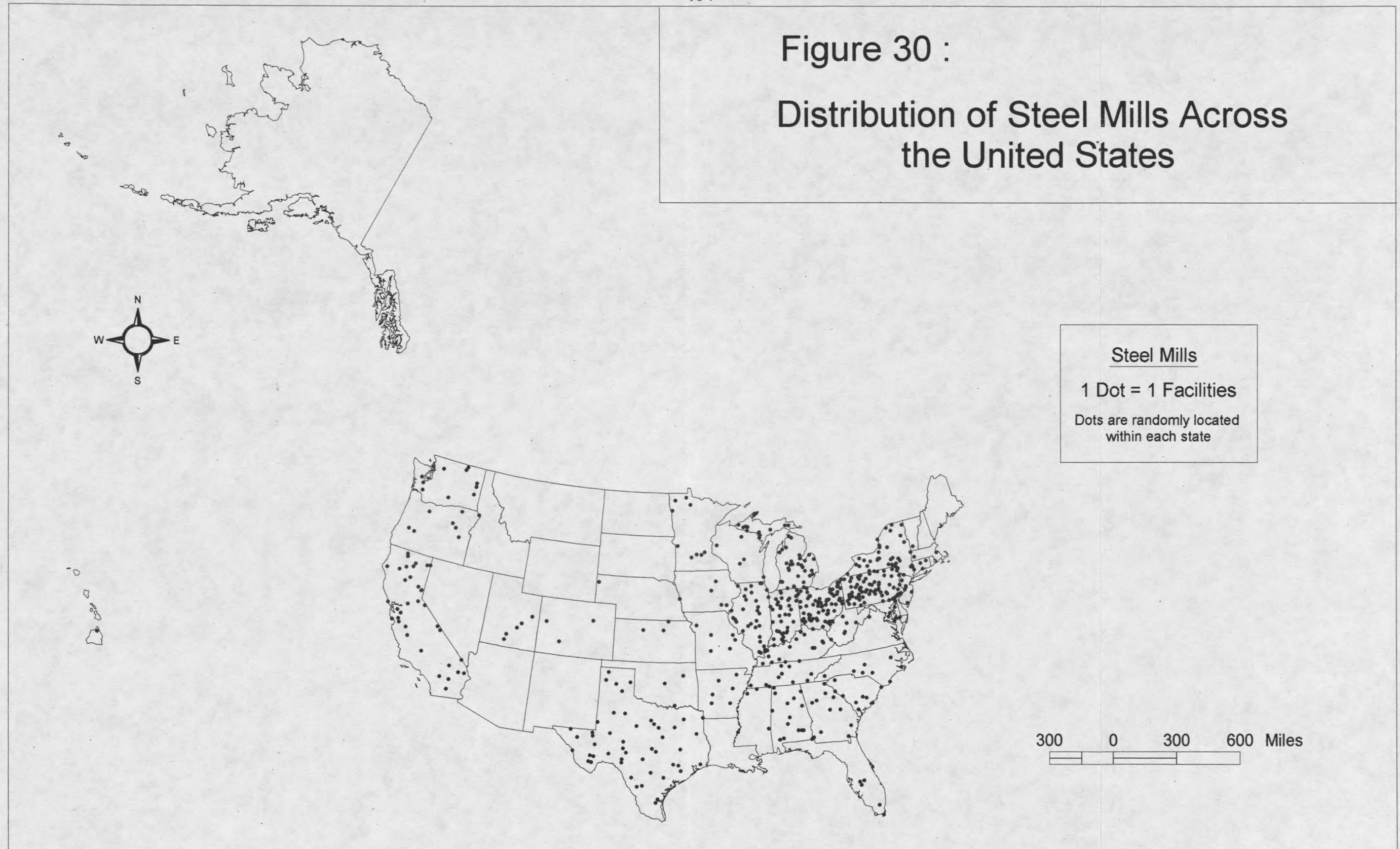
alloy characteristics in similar applications to the original product. Detinning plants remove the tin coating on steel cans, as discussed previously in the materials section. Steel mills and foundries utilize the recovered scrap in production. "Foundries use scrap as a raw material in making castings and molds for industrial users" (Miller 1998, p71). While steel mills produce new steel for use in a variety of products. Steel mills are the major end-users for post-consumer steel cans.

There are two main methods of making steel. These are the basic oxygen furnace (BOF) and the electric arc furnace (EAF). Each furnace produces a different kind of product and is capable of using scrap steel in different capacities.

The BOF produces steel used "for flat-rolled products, such as can, appliance and automotive sheet, and...studs for steel framing" (Crawford 1998, p47). This process uses from 25 - 28% steel scrap. "Steel cans provide less than 10% of this scrap" (Miller 1998, p70). The EAF produces steel "for long or heavy shapes, products such as I-beams, plate, channel, rebar, wire, and nails" (Crawford 1998, p47). The EAF is capable of using 100% steel scrap. Electric arc furnaces are generally smaller than basic oxygen furnaces but outnumber the BOF. EAF's are expected to increase across the U.S. and acquire an equal share of steel making capacity in the not-so-distant future (Crawford 1998).

Since steel mills utilize most recovered steel cans, they are mapped in Figure 30. Steel mills are clustered in the northeast and Great Lakes region as a result of historical dependence on coal and iron ore deposits. Substantial numbers of steel mills also exist across the South and on the west coast. Along with the increases in scrap steel, the dependence on virgin raw materials and fuel requirements were reduced. Major consumer

Figure 30 :

Distribution of Steel Mills Across
the United States

markets began to play a larger role in the location of steel facilities across the nation. Historical sites still dominate the landscape due to the large capital invested in facilities and the industrial links of those sites. These sites are also located near large consumer populations (Miller 1977).

Nine steel mills are located in Minnesota. Throughout the rest of the study states no steel mills are recorded. Montana is the home of many foundries and at least five manufacturers of steel products. Post-consumer steel cans are not currently utilized by these facilities. As a result, Montana faces a similar situation for post-consumer steel cans as it does for most materials. Until facilities are developed within the state which will utilize post-consumer materials in the production process the state must ship those materials over long distances and forego the benefits realized when local manufacturers utilize recovered materials.

Yet, the infrastructure for recovering scrap steel is much stronger than any already discussed. Montana also has a strong network for recovering white goods and other scrap metals. Although these materials were not the focus of this study they are relevant in that steel cans are supported through the overall network which handles all scrap metals. Contracts between Montanas' processors and markets for such materials have existed for a long time and are built upon strong foundations. These historic ties give steel cans an advantage over paper, glass, and plastic.

Aluminum

The procedure required to produce virgin aluminum products begins with the

mining of bauxite, which is then processed to produce alumina, which in-turn is melted and formed into blocks or sheets for production. Energy requirements can be reduced by up to 75% when using recovered aluminum in place of virgin materials (Crawford 1998). Some estimates claim that 95% less energy is used when making a can from recycled aluminum instead of virgin materials (Arrandale 1991).

Huge savings in energy, and reductions in associated emissions, gained through the aluminum recycling process have led a concerted effort by industry to develop a dependable infrastructure designed for procuring scrap. "Recycling of aluminum cans, then, is not likely to be constrained by lack of capacity either in secondary smelters where recycled aluminum beverage cans are processed into ingot or can sheet rolling mills..." (Sound Resource Management Group Inc. 1994, p46). There is a high capacity to absorb virtually all recovered aluminum.

Aluminum manufacturers want to maintain a pure quality in recovered aluminum to maintain melting temperatures and characteristics. Processors must first flatten, bale, or shred the recovered aluminum. Then the scrap is put through a chemical decontamination process to free the aluminum of foreign compounds. The scrap is then formed into ingots, or slabs, for use in production.

Secondary smelters and can sheet companies are the primary market for recovered aluminum beverage cans (Miller 1997 October). Recovered scrap ingots can be directly substituted for virgin materials in the production of can sheet. Still, it is not uncommon to add pure virgin aluminum to purify the batch, or maintain quality characteristics. And thus, it is estimated that 51 - 55% of aluminum cans are made of recycled content (Miller

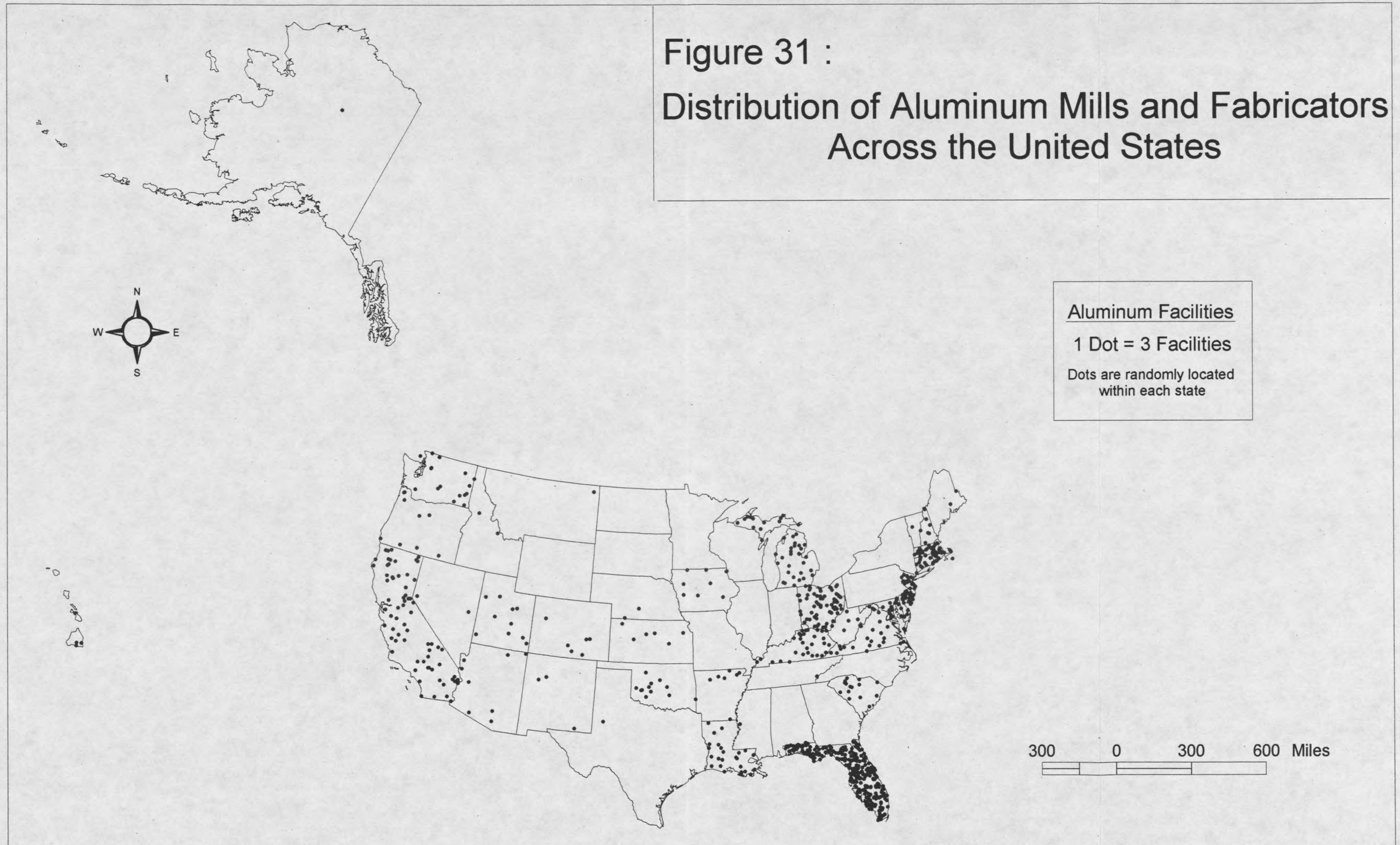
1997 October ; United States Department of the Interior 1993). Recovered aluminum is also sent to "non-integrated fabricators" who cast aluminum products, or smelters who make can sheet, foil, wire, and extruded products. Aluminum scrap is also exported, primarily to Japan, Mexico, and Canada (Franklin Associates Ltd. 1994).

Aluminum facilities are distributed across the United States as shown in Figure 31. Cheap power and large consumer markets usually determine the location of can sheet mills as well as aluminum reduction facilities. Facilities are often oriented to available Bauxite supplies as well. A large number of aluminum facilities are located in Florida which is likely due the importation of bauxite from areas of the West Indies, Brazil, and West Africa.

The U.S. infrastructure for aluminum includes at least one facility in every study state with the exception of two, South Dakota and Wyoming. North Dakota and Minnesota report only one facility each, while Montana has 3 and Alaska has 4. New Mexico, Nevada, and Idaho report between 6 and 9 facilities.

The three aluminum facilities which exist in Montana do not currently accept post-consumer materials. Two of the facilities are fabricators of specialized products. The third facility is the Columbia Falls Aluminum Company. This facility was established in the 1950's to take advantage of low cost hydropower from nearby Hungry Horse Dam. The company uses alumina to produce pure aluminum in the form of ingots, and aluminum alloys in the form of slabs (sheet ingot). Sixty different alloys are produced in eight sizes. Unfortunately, the facility uses very little recovered material and no MSW aluminum because of the specialized equipment required to process recovered materials (Payne

Figure 31 :
Distribution of Aluminum Mills and Fabricators
Across the United States



1999).

According to Tom Payne, Technical and Customer Service Manager, the Columbia Falls Aluminum Company facility is moving toward expanding operations to become a supplier for can sheet mills. Inquiries have been made and some testing is underway. This expansion requires new equipment to process scrap, for the removal of impurities, and to provide the capabilities of producing larger ingots preferred by can sheet mills. There is potential for recovered MSW to become a greater portion of the feedstock for the Columbia Falls facility with these new capabilities in operation. Though, according to Mr. Payne, recovered aluminum is considered "not readily available" in Montana due to the total population, Northern Idaho and Calgary are being considered as possible sources for recovered post-consumer aluminum.

The potential for Montana to have an end-user for recovered aluminum cans is on the horizon, and every effort should be made to ensure that this happens. Although, the development of aluminum end-users are really not a major concern for the state. There are several reasons. Aluminum is not a major component of MSW. This non-ferrous metal has historically been collected and recycled due to its' value in the remanufacturing process. There is no need for Montana to further develop this infrastructure. In addition, the transportation costs for delivering aluminum to end-users is often paid by industry rather than by the source area. This is not generally the case with other materials. Benefits from utilizing recovered aluminum are so great that they have been recognized for a long time and there are national and international in scope. There is not a significant disadvantage to Montana's recycling system as a result of its location relative to end-users

for aluminum.

End-user Summary

A number of benefits can be gained by end-users when utilizing recovered materials as well as by nearby communities. Reduced pollution and energy consumption are two of the most readily identifiable advantages. Nationally, we can all claim the benefits of increased resource conservation. It is more difficult to assess and apply manufacturing benefits from recycling to a local situation when they are national in scope. Manufacturing benefits are indirect benefits for local programs and are often not given credit. Still, benefits do exist and should be accounted for when figuring the costs associated with MSW recycling.

Within the study states, there are no states which have all five types of end-user facilities. Glass cullet processors are non-existent within all study states, and Wyoming has none of the targeted end-user facilities. In fact, there are a minimal number of facilities located in the interior west and Alaska, when compared to the rest of the nation. As discussed, this makes it especially difficult for the study states to claim a benefit from the manufacturing phase of recycling. Excluding Minnesota, there are 30 aluminum facilities, 24 paper facilities, 0 steel mills, and 2 recycled plastics manufacturers operating within the study states. Minnesota contributes an additional 14 plastic manufacturers, 9 steel mills, 1 aluminum facility, and 43 paper mills/manufacturers to the total. California alone can top all of these totals. In addition, it should be pointed out that not all of the facilities mapped will except recovered materials.

The implications of the existing distribution of targeted industries go beyond the lack of direct benefits from remanufacturing. Transportation costs for any material increase with distance. Due to the scarce numbers of industrial facilities in the interior west and Alaska, and lack of many facilities in the study states, local MSW recycling is additionally challenged. This obstacle can be generally visualized when comparing U.S. recycling rates (Figure 3) with the facility maps (Figures 27 - 31). Several exceptions do stand out. North Dakota, and South Dakota all exhibit higher than typical recycling rates as compared to the number of facilities residing within their boundaries.

In fact, the end-user maps do not show the whole picture. Appendix E lists the Principle Industries for the study states. Manufacturing is listed as one of the principle industries of five of the nine study states including: Nevada, North Dakota, Idaho, South Dakota, and Minnesota. Nevada's principle manufactured goods include plastics, North Dakota includes fabricated metal, Idaho includes fabricated and primary metals, South Dakota includes machinery and electrical products, and Minnesota includes metal and paper products.

The exceptions also may be partially explained by two topics previously discussed. These are the relative location of population clusters to other, more densely populated states, with a higher number of facilities, (Source Area section), and public policies and attitudes toward MSW recycling in general (Public Policy Section).

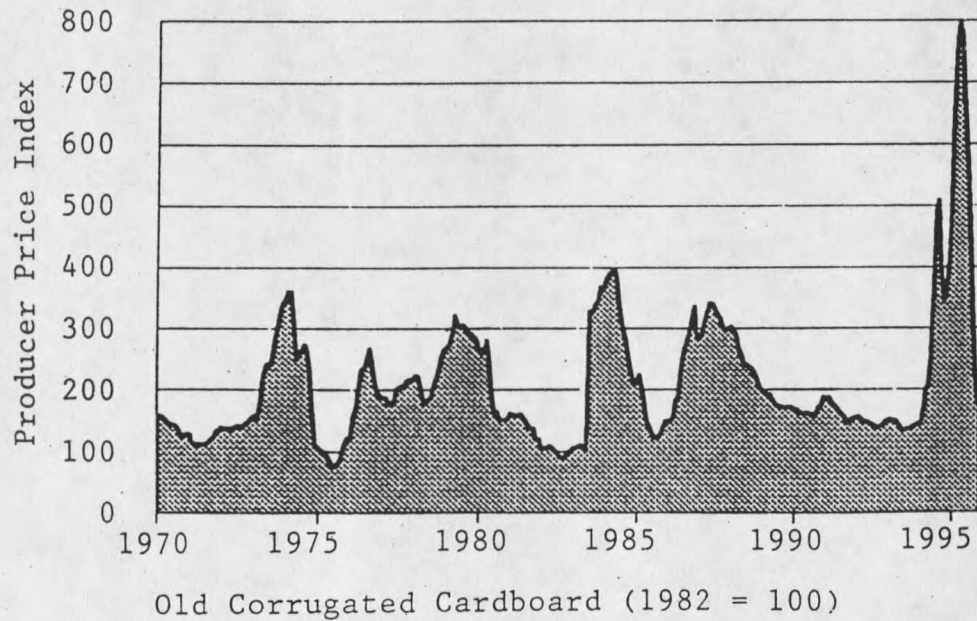
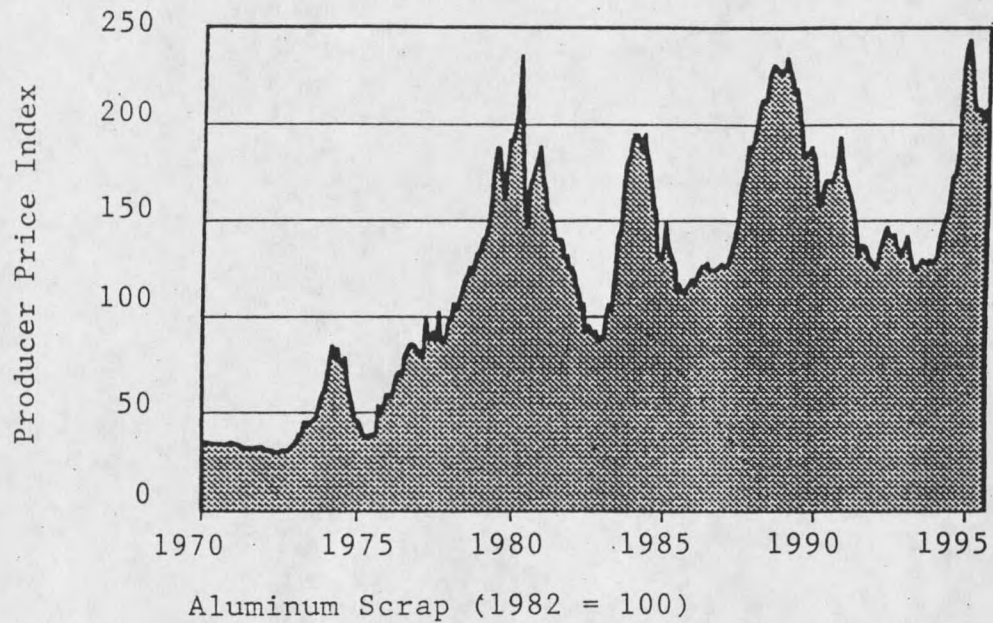
The market prices offered for recovered materials also affect the ability of a state to increase its recycling rate. In order to achieve recycling, the source area must transfer the recovered materials to the end-user. This transaction between buyer, or end-user, and

seller is based on market prices. Price is dependent on material specifications and quality, competing virgin material prices, national and world economic trends, and capacity, or demand, within a region. Therefore, prices vary from the national averages on a regional basis.

Private and public processors need to meet a bottom line in operating costs, nationwide. Private organizations must earn a profit, while public entities attempt to at least offset collection costs with revenue earned from material sales. Though there have been periods of high revenue, recycling has not proven to be a profitable business for suppliers of recovered material, and revenues do not always cover the costs of collection and processing. Market prices for recovered materials have historically displayed a volatile nature, rising and falling in an unpredictable manner. An example of this behavior was provided by graphs produced by Frank Ackerman in his book titled Why Do We Recycle ? (1997, p72 - 73). The graphs, shown in Figure 32, are based on Bureau of Labor Statistics and track the producer price index for several scrap materials from 1970 to mid-1995. A price index is not a direct chart of prices, but represents the fluctuation in price around a datum of 100, which in this case was arbitrarily chosen as the 1982 value of prices.

The regional fluctuation of market prices is also somewhat unpredictable and has a direct effect on the costs associated with individual programs in an area. Market prices are often used to determine whether a program is economically feasible or not. As has been discussed, many factors contribute to recycling achievements. Regional market prices can provide an additional indication of the viability of recycling certain materials in

Figure 32 : Market Price Trends for Old
Corrugated Cardboard and Aluminum



Source : Adapted from Bureau of Labor Statistics In
Ackerman, Frank 1997, pp.72 - 73.

states such as Montana.

An excellent source for current recovered material market prices can be found in Waste Age's Recycling Times which produces "The Markets Page" (Ridgley 1995-1998). This report lists current prices paid by end-users as reported by sources contacted on a bi-monthly basis. The prices are broken down by material and region (seven in all). Montana is located in the West Central region according to this layout. To assess the viability of targeted materials in Montana, trends of recent market prices for recovered materials are required. Graphs of prices paid by end-users were created utilizing figures reported on "The Markets Page" from December of 1995 through March of 1998. Also included are national averages, calculated from regional data, to provide a standard of comparison. The west central and national trends are shown for paper, glass, plastic, steel cans, and aluminum in Figures 33-37.

Aluminum scrap market prices are significantly higher than any of the other materials. This is in large part due to the historic involvement of the aluminum industry to build and maintain an infrastructure for recycling aluminum scrap, including soft drink containers. As noted, huge energy savings gained by the recycling of recovered aluminum versus virgin materials has made aluminum a valuable commodity. A steady demand for aluminum products maintains a capacity to use all available scrap. There is strong competition between virgin and recovered material suppliers, as well as international markets. All of these factors create a demand for recovered aluminum and "tend to create a floor price for [used beverage cans] below which domestic integrated aluminum producers and can sheet manufacturers will not let prices fall for fear of losing too much

Figure 33 : Market Price Trends for Aluminum

(Prices Paid by End-Users)

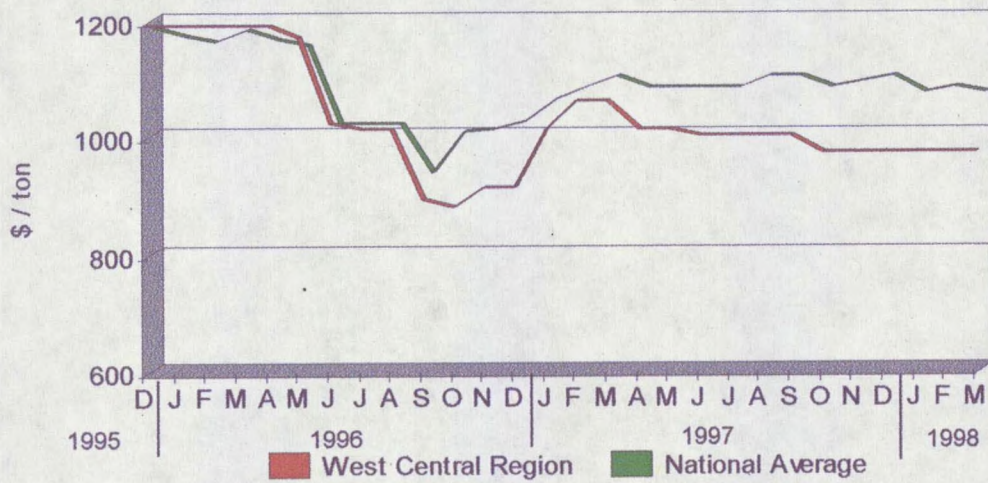
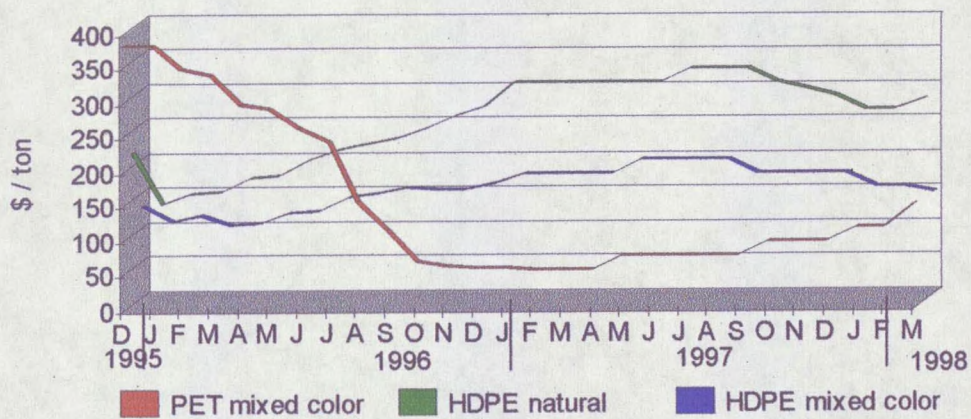
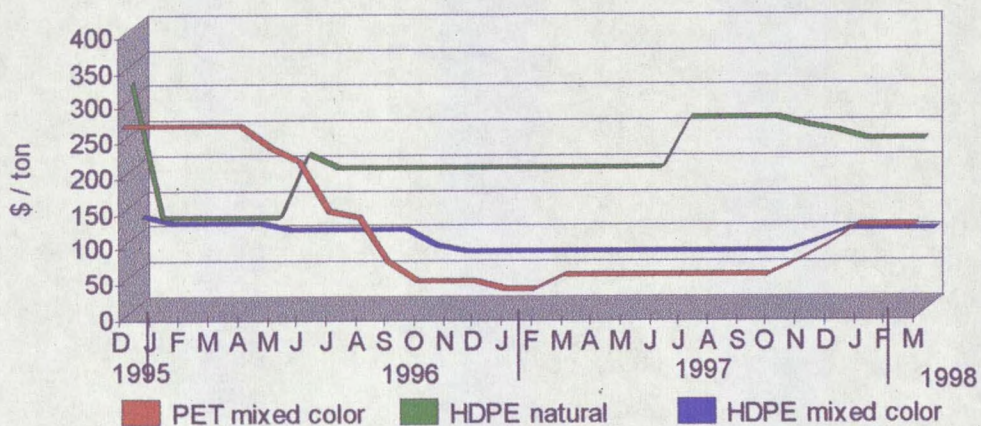
**Aluminum Scrap Trends**Source : Ridgley, Heidi. *Waste Age 1995 - 1998.*

Figure 34 : Market Price Trends for Plastic
(Prices Paid by End-Users)



National Price Trends

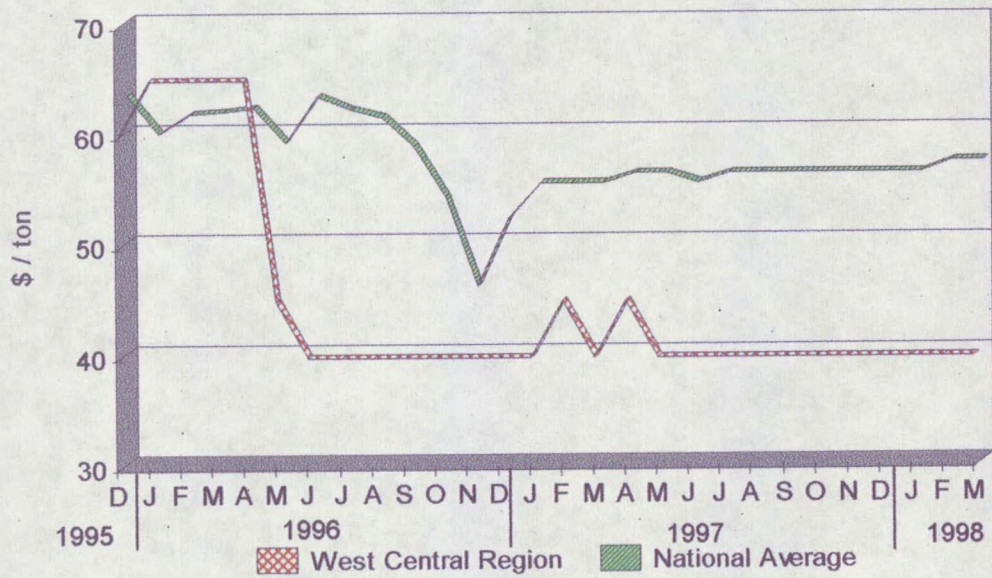


West Central Region Price Trends

Source : Ridgley, Heidi. *Waste Age* 1995 - 1998.

Figure 35 : Market Price Trends for Steel

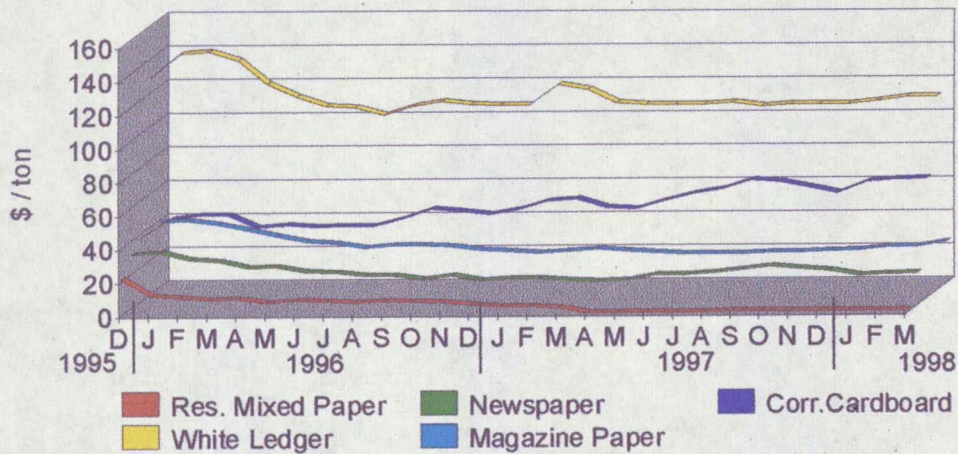
(Prices Paid by End-Users)



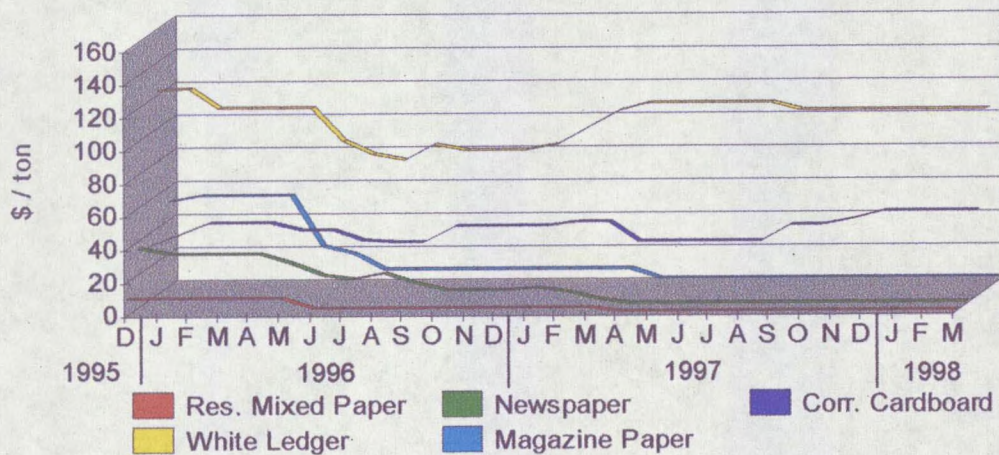
Steel Scrap Trends

Source : Ridgley, Heidi. Waste Age 1995 - 1998.

Figure 36 : Market Price Trends for Paper
(Prices Paid by End-Users)



National Price Trends

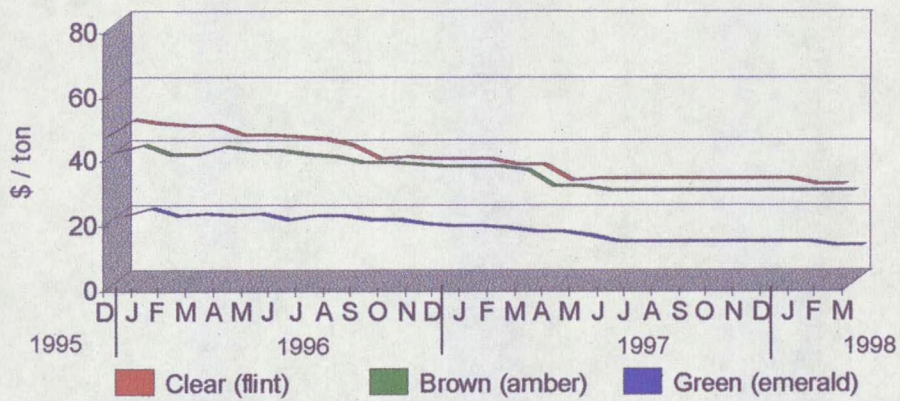


West Central Price Trends

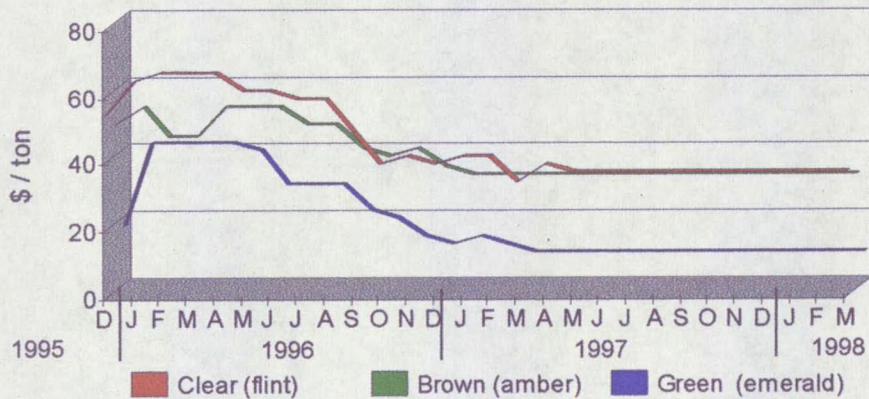
Source : Ridgley, Heidi. *Waste Age* 1995 - 1998.

Figure 37 : Market Price Trends for Glass

(Prices Paid by End-Users)



National Price Trends



West Central Region Price Trends

Source : Ridgley, Heidi. *Waste Age* 1995 - 1998.

control over [used beverage cans] supplies" (Sound Resource Management Group 1994, p28).

Plastic is said to be the newest growing sector of recycling due to increased uses of plastic containers, increased recovery technologies, and increased product designs made of recycled plastic materials. Yet, the field is still emerging and virgin suppliers are aggressively seeking to retain and enlarge current markets. Reduced prices in PET have been contributed to a worldwide increase in facilities supplying virgin PET which created a low price for virgin resin. Once all facilities were on-line, prices rebounded somewhat.

The recent trend in market prices for steel show what appears to be an unusually long depression in the market. This is a reflection of national economic trends during this period. Paper products have traditionally maintained a much lower price than metals, yet are similar to steel prices during this period. There is still a wide variation among paper grades with white ledger bringing the best prices. Corrugated cardboard has maintained a slight edge over mixed paper, magazines, and newspaper. The three papers of lowest price continued to decline nationally between 1995 and 1998. Recovered glass is also of comparable price during this period, but shows general decline. The persistent low price of green glass is a reflection of the lack of green bottle manufacturing capacity as previously discussed.

Generally the west central region reflect national trends in pricing but seems to fall in price ahead of a decline in the national average, and the prices for this region rise behind the national increase. In a few instances, the west central prices have surpassed the national average, but not for long. The price appears to dive even faster at the turndown

which inevitably follows. The west central variation from the national average is likely influenced by the lack of end-user capacity and thus lack of consumer demand in the region.

The recycling system is dynamic in nature, continuously adjusting to demand by changing price and supply. Suppliers must adjust accordingly, reducing supply when market prices are low, and increasing supply when the price is high. It is extremely difficult, or really impossible, to predict the future of market prices on either a short- or long-term basis. In addition, generators are extremely slow to adjust to supply and demand of recovered materials. Due to the regional location of Montana, prices paid for recovered materials are generally lower than the national average and there is little room to adjust costs.

CONCLUSIONS

My purpose for presenting this thesis is to provide individuals, private businesses, and public officials with an informative report about the health of Montana's municipal solid waste (MSW) recycling system. Furthermore, this report tested the hypothesis that a MSW recycling system is viable in Montana, as well as provided the reader with the knowledge necessary to embark on activities which will most effectively increase the viability of recycling certain MSW materials.

The components which comprise a MSW recycling system are the generators of waste materials, manufacturers or end-users, and consumers of products with post-consumer content. Generators and consumers are the same people acting in different capacities. Both components exhibit the same demographic, political, and locational characteristics and thus are not treated separately in this thesis. They are referred to as the source area throughout the text.

The relationship between components consists of market transactions based on economic principles of supply and demand. The balance of costs and benefits attributed to a particular place determine whether or not a recycling system is viable. The interaction between components take place in the national economic and political environment surrounding waste management and industrial practices. Yet, it has been shown that population distribution, public policy, private choices, material specifications, end-user capacities, and accessibility to markets for recovered materials, are all variables which can

affect the benefits and costs of recycling MSW in a particular place. An assessment of the existing solid waste, demographic, political, and locational characteristics specific to Montana reveal a clearer picture of the current viability MSW recycling in Montana and provides a focus for future recycling efforts.

A series of analyses were conducted to determine the costs and benefits accrued by Montana during the process of recycling post-consumer paper, glass, plastic, steel cans, and aluminum cans. Two questionnaires were developed to collect current data on MSW management practices, and recycling in particular, throughout the state. The first questionnaire was directed toward County Sanitarians while the second was directed toward private businesses which collect and process recovered MSW materials. The particular effects of source area characteristics including population, political approaches, and location upon Montana's MSW recycling system were assessed by comparative analysis between a select number of study states. Seven were chosen based on their population and land area similarities to Montana. One additional state with relatively high population was chosen for contrast. In addition, the effect of end-user distribution relative to a source area was assessed through mapping end-users in the United States and regional market analysis for recovered materials. The findings of each analysis revealed which of Montana's characteristics contribute benefits and which contribute costs to the MSW recycling system.

Although public opinion claims that the low density of Montana creates a unique and often insurmountable cost for operating a recycling system, this study found this assumption to be false. According to questionnaires, an infrastructure for collection and

processing of MSW materials for recycling currently exists and has developed substantially in Montana over the past 10 - 15 years. As can be seen from a comparison of Figure 11 (Recycling Centers, Rural, and Curbside Services) and Figure 15 (Geographic Boundaries of Services Areas of Private Businesses) most of the population of Montana has access to recycling services. The bulk of the services are centers where residents can drop-off their materials and most are located near major population centers. The services are provided by both public and private entities.

Regression analysis of average density versus recycling rate was conducted for all fifty U.S. states and for the eight study states of similar population level. No significant correlation was found to exist between these two phenomena. The impact of both average density and the percentage of rural population of the study states were assessed along with recycling rates through a discussion of comparisons. This method also revealed that these characteristics for the source area do not appear to have a significant impact on the resulting recycling rates for a state. Montana has the third lowest average density in the United States and just over 50% of its population is rural. But, these demographic characteristics do not explain why it has the lowest recycling rate in the nation.

Through analysis of states with similar population characteristics to Montana it was found that the clustering of population centers does generally promote higher recycling rates. The location of these population centers relative to neighboring states of higher populations (and thus greater commerce) also promotes higher statewide recycling rates.

Population centers are generally located along a northwest to southeast axis in

western Montana, and surrounding Billings, located in Yellowstone County. Recycling services are generally available near these areas. Additional services are available in counties along U.S. highway 2 in the north, and along the eastern border.

The majority of population centers of Montana are oriented toward the west and Idaho. Idaho itself does not have a substantially larger population base than of Montana. In fact, it is a study state for this thesis due to its similar population size. Likewise, North Dakota and Wyoming also do not have populations which promote high commerce for Montana. Therefore, where the clustering of Montana's population assists recycling, the location of these clusters is near states that have low populations and thus less commerce.

Additional analysis was conducted to determine the impact of Montana's physical location upon its MSW recycling system. Results of the questionnaires show that recovered materials are generally collected and sent to several processing centers within the state and then for the most part, shipped to out-of-state markets. County sanitarians reported that within three counties there were established markets for recovered materials. Stone Container utilizes recovered cardboard in Missoula county, United Materials utilizes recovered glass in Cascade County, and Flathead County has an unidentified market. The questionnaires revealed a similar finding to that of the population distribution section; neighboring states do not contribute substantially to the recycling rate in Montana. Although neighboring states and Canada provide some commerce for recovered materials, Montana ships most materials to larger urban centers along the west coast, to Utah, Colorado, and as far as Tennessee, and Illinois.

Potential markets for recovered materials (potential end-users) were mapped

across the United States to determine the extent which the physical location of source areas relative to their markets had upon the recycling rate of a state. It was found that Montana and many of the study states do not have markets for most materials within their borders. In fact, the entire region in which Montana is located has scarce numbers of industrial facilities for the materials of interest to this thesis.

There are three direct impacts which effect the MSW recycling system in Montana as a result of the current end-user distribution in the United States. First, transportation costs for shipping recovered materials to market are higher for this region than for any other due to the distance materials must be shipped. Also, due to low end-user capacity in the region, supply of recovered materials outweighs demand and therefore market prices for recovered materials are generally low. Finally, Montana does not directly receive the benefits, of jobs and industrial efficiencies, associated with manufacturing products with recovered materials versus virgin materials which are realized by industry and neighboring communities. Although, there are national benefits of water, energy, and resource conservation when utilizing recovered materials instead of virgin materials for manufacturing, these benefits are difficult to incorporate into health and welfare considerations and financial analyses for recycling in the state.

Viable, as defined for this study, is comprised of three elements. First, a recycling system is viable if it is "capable of working, functioning, or developing adequately". Secondly, a recycling system is viable if it is "capable of existence and development as an independent unit". And lastly, a recycling system must have "a reasonable chance of succeeding" to be viable. (Merriam-Webster 1989) Based on this definition, the MSW

recycling system of Montana comprised of those materials evaluated in this study, is not currently viable. Primarily this is due to the second element of the definition. Recycling is a system lacking a complete infrastructure in Montana, therefore it is not an independent unit. Particularly end-users, a pivotal point of all recycling, are lacking (except for cardboard and some glass). You might conclude from this that we should not recycle in Montana. This is not the conclusion I have made. One reason is that lack of end-users within the state is not an obstacle unique to Montana. This can be overcome, to benefit not only the MSW recycling system but also the economic well being of the State. In addition, it can easily be argued that the first and third element of viability for Montana's recycling system have been met although not entirely within the state. Montana has a sufficient collection and processing infrastructure in place. Portions of the municipal solid waste have been recycled privately since the early 1970s. The MSW recycling system for Montana is capable of working, functioning, and developing adequately. In addition, the system has a reasonable chance of succeeding, or continuing to operate. The terms 'adequately' and 'succeeding' are subjective terms which require a basis from which to judge them. This basis is found in the goals and intentions of the people of Montana toward MSW recycling.

Montana has only twenty years of current landfill capacity. Waste management is an issue in Montana and will become more so as the population grows and the current landfills close. Costs associated with building and maintaining landfills are already very high. The State has taken a position to support MSW recycling as a management alternative that makes more sense than landfilling or incineration. This has been done by

setting a waste reduction and recycling goal, implementing procurement mandates for state institutions, tax credits for business purchases, tax deductions for recycling equipment purchases, employing a waste reduction and recycling coordinator, and awarding grants to public and non-profit institutions.

The largest category of MSW generated in Montana is paper, according to the C MSW RQ (Figure 8). Each of the remaining materials under study comprise less than 10% of total MSW. The purpose of recycling paper is not so much conserving resources, wood or other fibers, as it is diversion of materials from landfills. This is in contrast to aluminum, steel, and plastic for example. As has been shown, the use of recovered materials versus virgin materials for aluminum, steel, and plastic conserves large quantities of energy, and resources but contributes far less to landfill diversion. Glass exhibits a combination of low benefits from recycling in terms of resource conservation values, low recovered market prices, and relatively low diversion potential. Glass still accounts for a greater percentage of MSW than steel, plastic, or aluminum.

For the recycling system in Montana to be adequate or to succeed, it must provide substantial landfill diversion by recycling paper. Responses from questionnaires indicate that cardboard, newspaper, and aluminum are the most commonly processed materials. This service reduces landfill disposal for part of the largest component of municipal solid waste and helps to support collection and processing operations by providing valuable returns on aluminum sales.

Recycling is a valid use for solid waste management funds. By diverting funds from landfill services to build an infrastructure to increase the potential for recycling in the

future, we are investing in economic as well as social well being. To some extent, Montana is already capable of claiming the benefit of diversion of MSW from landfills and incineration. Additionally, individuals, private business, and public entities already claim benefits from reduced disposal costs and from having created reputations for environmental consideration. A more efficient MSW recycling system also would provide jobs from manufacturing located within the state. In turn, manufacturing with recovered materials versus virgin materials would provide efficiencies for industry which would transfer benefits to the state.

Several recommendations for achieving a more efficient MSW recycling system in Montana were presented at the end of the section titled "Political and Social Effects on MSW Recycling" (pp129 - 132). Generally, the recommendations included reassessing the recycling goal, expanding procurement requirements, strengthening the existing incentives for recovered material market development, directing State efforts toward education and market development while supporting the existing private collection and processing businesses through accessibility to grants. Paper is the most important recovered material upon which to focus. Methods of building the infrastructures for recycling plastic, and glass (through secondary markets) should also be explored. Municipalities, individuals, and private businesses must be informed of the State position, opportunities that it provides, and must be educated as to how they can effectively contribute.

The desire to recycle is not enough, and as has been shown, taking post-consumer materials to the recycling center does not in itself accomplish recycling. In order to

increase the efficiency, and the viability, of MSW recycling in Montana, public and private (including individuals) support is required. The most significant obstacle to overcome is the lack of end-user markets within the state, with those for recovered paper being most important consideration for Montana. Post-consumer product development is the most effective way to contribute to the state's recycling system. In the short term, purchases for products with high post-consumer content will strengthen demand and increase prices paid for recovered materials on both a national and regional basis. Higher profits will help sustain local collection and processing facilities. Industries for paper and plastic currently have the least developed infrastructures for utilizing recovered materials and are therefore most flexible to the demand of consumers. The development of recycling infrastructures in these industries will also serve to divert materials from disposal.

Demand for post-consumer products also represents a serious intention on the part of Montanans to support a MSW recycling system. It is not enough that State agencies follow procurement guidelines and claim to be working toward the achievement of a recycling goal. Individuals, private businesses, and municipalities must all work towards the same goals. Potential resident end-users must realize that Montanans will do their best to support local post-consumer products. As the population increases, the power of product demand will also expand and further stimulate industrial growth.

This thesis has provided a base upon which to build a more efficient MSW recycling system in Montana. This state has a complex arrangement of recycling system components operated under a variety of private, public, individual, and community perspectives. The conclusions have led to broad recommendations focused on

overcoming the major obstacles to a sustainable MSW recycling system. Much remains to be done. Specific plans for implementing the recommendations need to be developed and many additional topics should be studied. These include issues such as: how does marketing power correlate to population growth? Is the cost of landfilling a direct incentive to recycle? How do the impacts of timber, mining, and tourism compare to impacts of manufacturing? What are available pollution control technologies for potential resident end-users? How much is the potential job growth with resident manufacturing? Or, topics could include those more specific to local product development. For instance, is Montana's principle industry, agriculture, a significant potential market for new post-consumer plastic products such as irrigation pipe, horse troughs, etc.? Or, what is the feasibility of establishing a local box-making facility to purchase post-consumer linerboard from Stone Container and supply shipping boxes to businesses across the region? These are just a few of the topics revealed during this study but which remained outside of the working parameters of this thesis.

In conclusion, Montana's existing MSW recycling system does not meet all the criteria of a viable recycling system. Yet, the existing infrastructure does exhibit qualities which meet the remaining two criteria of a viable system. The difficulty that Montana experiences is explained most by its location relative to end-users, a reflection of low population and thus low product demand. This phenomenon is not unique to Montana but is key to developing a viable recycling system through directed planning techniques which support the existing infrastructure and develop local markets for recovered materials.

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APPENDICES

APPENDIX A
RECYCLING CONTACTS AND RESOURCES

CONTACTS

Contacts in Montana

City of Bozeman

Roger Sicz, Street and Sanitation Superintendent
406-582-3200

Headwaters Cooperative Recycling

Kathy Jackson - Manager
406-431-1247 cell # 406-225-3967

Jefferson County Solid Waste District

Sherrel Siegmund
406-225-4128

P.O. Box H; Boulder, MT 59632

Keep Montana Clean & Beautiful, Inc

Peggy Likens, Program Manager
406-443-6242

P.O. Box 5925; Helena, MT 59604

Montana Department of Environmental Quality

406-444-4400 main office

Peggy Nelson, State Recycling Coordinator

406-444-1430; pnelson@mt.gov

P.O. Box 200901; Helena, MT 59620

Pat Crowley, Solid Waste Management

406-444-5294; fcrowley@mt.gov

Located: Metcalf Building ; Helena, MT

MSU Extension Service, Solid Waste Program

Lara Dando, Training Coordinator

406-994-3451

MSU; Bozeman, MT 59717

Michael Vogel

Pacific Steel and Recycling

Brett Ewer

406-727-6222

1401 3rd St. NW; Great Falls, MT

Recycle Now

Doug Stewart

406-721-1120

P.O. Box 8449; Missoula, MT 59807

CONTACTS - ContinuedContacts for Other States

Blue Earth County, Environmental Services Department

Jean Lundquist

507-389-8381 507-389-8431 fax

Gov't Center; 410 S. Fifth St.; P.O. Box 3566;

Mankato, MN 56002-3566

Scott Fichtner

Idaho Division of Environmental Quality

Jean Robinson, Clerical Specialist

208-236-6160 208-236-6168 fax

224 S. Arthur Ave.; Pocatello, ID 83204

Idaho Regional Environmental Quality

Katie Sewell, Chief, Planning, Prevention and Outreach Bureau

Barry N. Burnell, E.H.S.; Acting Watershed Protection Supervisor

208-334-0550 208-373-0287 fax

1410 N. Hilton St.; Boise, ID 83706-1255

Nebraska State, DAS Material Division

Steven Danahy, Recycling Coordinator

402-471-2431 402-471-2089 fax

P.O. Box 94847; Lincoln, NE 68509-4847

Located : 301 Centennial Mall S.; Lincoln, NE 68509

Nebraska State Recycling Association

Kay Stevens, Executive Director

402-444-4188 402-444-3953

1941 S. 42nd St.; Suite 512; Omaha, NE 68105-2945

Nevada Bureau of Waste Management, Division of Environmental Protection

Susan Sturtevant, Recycling Coordinator

702-687-4670

333 W. Nye Ln.; Room 138; Carson City, NV 89706-0851

Lew Dodgion, Administrator- Div. Of Env. Protection

New Mexico Solid Waste Bureau

Cathy L. Tyson, State Recycling & HHW Coordinator

505-827-2883

1190 S. Saint Francis Dr.; Santa Fe, NM 87505

North Dakota Department of Health, Environmental Health Section

Robert Tubbs-Avalon, Recycling Coordinator

701-328-5266 701-328-5200 fax

P.O. Box 5520; Bismarck, ND 58506-5520

Martin Schock

CONTACTS - Continued

South Dakota Department of Environment and Natural Resources

David Templeton, Mid-Continent Recycling Association

605-773-6498 605-7736035 fax

523 E. Capital; Pierre, SD 57501

Wasteline, Inc.

Deborah A. Barton, Executive Director

605-394-6747 605-394-2497 fax 605-348-9461 msg

e-mail Wasteline6@AOL.com

P.O. Box 3471; Rapid City, SD 57709-3471

Wyoming Department of Environmental Quality;

Solid and Hazardous Waste Division

Dianna Gentry-Hogle - State Recycling Coordinator -

307-332-6924 307-332-7726 fax

e-mail dhogle@missc.state.wy.us Website

250 Lincoln St.; Lander, WY 82520

David Finley, Administrator- Dept. Of Env. Quality

No Response

Alaska Solid Waste Program, Department of Environmental Conservation

Heather Stockard, Program Manager

907-465-5150 907-465-5164 fax

e-mail hstockar@environ.state.ak.us

website www.state.ak.us/dec

410 Willoughby Ave., Suite 105; Juneau, AK 99801-1795

Minnesota Office of Environmental Assistance

Christopher Cloutier, Market Development Specialist

612-215-0234 612-215-0246

520 Lafayette Rd.; St. Paul, MN 55155

Recommended by Jean Lundquist

New Mexico Environmental Department

505-722-4160

306 S. 5th St.; Gallup, NM 87301

South Dakota Solid Waste Management Association

P.O. Box 957; Rapid City, SD 57709-0957

Recommended by David Templeton

Wyoming Tire Recyclers

Jan Winsborough, President

307-235-0133 307-266-6027 fax 307-261-3901 msg

6925 Cactus Ln.; P.O. Box 1400; Casper, WY 82602

INTERNET RESOURCES

State Recycling

Address

Colorado Recycles
New Mexico
Wyoming Recycles
Alaska

www.colorado-recycles.org/index.htm
www.nmrc.web-site.org/nmrc.htm/
www.trib.com/WYOMING/RECYCLE/
www.state.ak.us/dec

Markets and Industrial Associations

Glass Packaging Institute
American Plastics Council
National Association of Manufacturers
Warren Paper Manufacturers
Institute of Scrap Recycling Industries, Inc.
American Metal Market
Steel Recycling Institute
American Forest & Paper Association
Canadian Pulp and Paper Association
Chicago Board of Trade Recyclables Exchange
Global Recycling Network (GRN)
Recyclers World

www.gpi.org
www.plasticsresource.com
www.nam.org/
<http://www.warren-idea-exchange.com>
www.isri.org
www.amm.com/
www.recycle-steel.org
www.afandpa.org/index.html
www.open.doors.cppa.ca/
<http://cbot-recycle.com>
<http://grn.com/>
www.recycle.net/recycle

Recycling and Environment Information

EPA
US Environmental Hotline-EPA
-Recycling Locations by Zip Code
Montana
Treecycle - Bozeman, MT
-On-line post-consumer paper orders and info.
Waste Age and Recycling Times Publications
- Pricing and issues
Conservatree
Bozeman Daily Chronicle
Recycling Insights
-recycling products, newsletter, discussion

www.epa.gov
www.1800cleanup.org/text/main.htm
"...text/states/montana.mt.htm"
<http://www.treecycle.com/info.html>
www.wasteage.com
www.conservatree.com
www.gomontana.com/
www.Recycling-Insights.com

INTERNET RESOURCES - Continued

Ecoweb Factoids	http://ecosys.drdr.virginia.edu/factoids.html
-factoids on materials, energy use, %age recycled, etc.	
-publications and organizations	
Earth Systems, Inc.	Earthsystems.org
-Environmental Info at a cost \$	
EnviroSense	http://es.epa.gov/index.html
1-800-67-SWICH	
Nat'l Solid Waste Info Clearinghouse	
Internet Environmental Resources	http://www.muohio.edu/~zoocwis/zoo_121b/eco/env.htmlx

Searches

Greenlink	http://ccar-greenlink.org/documents/state_contacts/montana.html
-Directory of State Environment, Health, & Safety Agencies by State	
Yellow pages	www.excite.com
National Phone Numbers	www.switchboard.com
	www.clearinghouse.net/
GTE Yellow Pages	http://Yp2.superpages.com/
FindSVP	www.findsvp.com/search.html
-Worldwide Research, Advisory, and Business Intelligence Services Market and Industry Reports (at a \$)	

Geographic Information Systems and Mapping

Maps of Montana	http://nris.msl.mt.gov/gis/mtmaps.html
Montana Maps	http://ansa.ucdavis.edu/ABT181/s97proj/jonesd/sources.html
MT Nat'l Resource Info System	http://nris.msl.mt.gov/
MT Dept. Of Commerce	http://com.mt.gov/index.htm
Demographic Info	http://www.census.gov/
Demographics	http://cbasc.org/english/english/english/manitoba/links/demo1.html
-Canadian & US population, publications (monthly)	
GIS/Cartography Starting Points	http://www.iko.unit.no/gis/gisen.html
Additional GIS Resources	www.cecer.army.mil/grass/GRASS.main.html
	www.cast.uark.edu/main.html

APPENDIX B

THE COUNTY MUNICIPAL SOLID WASTE STREAM /
RECYCLING QUESTIONNAIRE

_____ County Municipal Solid Waste Stream/Recycling Questionnaire

Filled out by: _____ Date: _____

1. What is the total weight of municipal solid waste (MSW), or garbage, generated in your county? _____ tons
2. In your opinion, what percentage of the total weight of the solid waste stream generated within your county would fall into each of the following categories?

_____ % Plastics	_____ % Construction Waste/Wood	_____ % Paper and Paperboard
_____ % Aluminum	_____ % Ferrous Metals	_____ % Rubber and Leather
_____ % Glass	_____ % Food Scraps	_____ % Yard Trimmings
_____ % Textiles	_____ % Other _____	

3. How many licensed solid waste disposal facilities in your county have _____ opened or _____ closed during 1997?

4. What kind of municipal solid waste disposal facilities are located within your county?

5. What is the average landfill gate fee for disposal of a load of household municipal solid waste (MSW)? _____ \$ per ton

6. What is the average landfill gate fee (if different from above) for a load of:

Plastic _____ \$ per ton	Newspaper _____ \$ per ton	Tires _____ \$ per ton
Glass _____ \$ per ton	Ferrous Metal _____ \$ per ton	Cardboard _____ \$ per ton
Aluminum _____ \$ per ton		

7. Is there a surcharge in addition to the tipping fee? If so please list the surcharge

for county MSW. _____ \$ per ton
for out-of-county MSW. _____ \$ per ton

8. Are there any public composting facilities in the county? Yes ____ No ____ If yes, please do not include composting data in any questions which refer to recycling.

9. Do you believe that recycling of household solid waste is economically feasible in your county?
Yes ____ No ____

For the purposes of this questionnaire a material recovery facility (MRF) is defined as: an established recycling facility which utilizes crushing, bailing, shredding, or other compaction equipment to prepare materials for market. Unstaffed drop-off facilities are not included.

9. How many MRFs are located within the county? _____

10. Please supply the names of companies operating MRFs in your county? _____

For the purposes of this questionnaire a **recycling center** is defined as: an established location at which household MSW materials can be brought by the public or private hauler for the purpose of recycling those materials. It can include both staffed and unstaffed drop-off facilities as well as MRFs.

11. How many recycling centers are located within the county? _____

12. Is the rural population of your county specifically served by recycling centers? In other words are there recycling centers located outside of the urban portion of your county?

Yes _____ No _____ Additional comments _____

13. How many curbside or "blue bag" recycling programs are active in your county? _____

14. Do any groups (ie. Boy Scouts) collect materials for recycling? _____ Yes _____ No If so, Which materials? _____

15. Which household waste materials are collected by recycling centers or programs in your county, not including the above groups?(Place X)

Glass:

_____ Brown _____ Clear _____ Green _____ Yellow _____ Other

Plastic:

_____ PET (#1) HDPE (#2): _____ Clear _____ Colored

Paper:

_____ Newspaper _____ Corrugated Cardboard _____ White Paper

_____ Paperboard _____ Magazine/gloss paper _____ Phone Books

Metals:

_____ Aluminum _____ Steel Cans

Other materials: _____

16. What percentage, by weight, of the total waste stream of the county is recycled?
 Actual _____ % or Estimate _____ %

17. Does the county license MRFs? Yes _____ No _____

18. Does the county require MRFs to submit reports on the tons of materials processed?
 Yes _____ No _____

19. Has your county established any recycling goals for the county? Yes _____ No _____ Unknown _____

20. How much money has your county budgeted for recycling? in 1997 \$ _____ 1998\$ _____

21. Do any organizations in your county take advantage of any grants or subsidies to fund recycling activities? Yes _____ No _____

22. If Yes to the above question, please list the source and/or dollar amounts provided.

23. Are there established markets for secondary (recycled) materials located within your county? Yes _____ No _____

24. If yes to the above question, please list the industry(ies) and type of post-consumer waste utilized (ie. JTL Gravel Group/glass). _____

25. What percentage, by weight, of recycled materials processed in your county are exported out of the county to market? _____ %

26. Does the above answer include those materials collected from other counties? Yes _____ No _____

27. Where do the exported materials go? (Specific or generally by region) _____

28. What percentage, by weight, of the entire exports fall into which category?

_____ %Aluminum	_____ %Steel cans	_____ %Other scrap metals
_____ %HDPE	_____ %PET	_____ %Other Plastics
_____ %Office Paper	_____ %Newspaper	_____ %Cardboard (Corrugated)
_____ %Mag./Junk mail	_____ %Paper Board	_____ %Glass
_____ %Other _____		

29. What percentage of the tons of recyclable material exports are shipped by each of the following modes of transportation?

_____ Truck (back-haul rates)	_____ Truck (Direct rates).	_____ Water
_____ Railroad	_____ Air	_____ Other _____

30. Please list two persons which you feel are the most knowledgeable about recycling in your county ("Myself" is acceptable as one). How may I contact them?

APPENDIX C

THE MUNICIPAL SOLID WASTE STREAM RECYCLING
QUESTIONNAIRE FOR PRIVATE BUSINESS

199
Municipal Solid Waste Stream Recycling Questionnaire
For Private Business

Filled out by: _____ Company: _____

Date: _____

1. How long has your organization been in business in Montana? _____

2. What are the primary operations of this business? (Circle all that apply)

municipal solid waste collection _____

industrial solid waste collection _____

landfill operations _____

processing municipal solid waste for recovered material sales to end users _____

processing industrial solid waste for recovered material sales to end users _____

production of consumer product(s) from recovered waste materials _____

compost services _____

other: (please explain) _____

3. On the line to the right of each activity circled in question number 2, show the importance of the activity as a percent of total operations. All circled activities should equal 100%.

4. What are the geographic boundaries of your typical service area (ie. Counties or cities served by this facility)? _____

For the purposes of this study municipal solid waste recyclables include any of the following post-consumer materials: aluminum cans, steel (tin) cans, plastic food and drink containers, papers of all grades, and glass containers.

5. How long has municipal solid waste recycling been a part of your business? _____

6. Which municipal solid waste recyclables does your business collect, process, or recycle?
(Place an X next to all that apply)

Glass:

Brown _____ Clear _____ Green _____ Yellow _____ Other _____

Plastic:

PET (#1) _____ HDPE (#2): Clear _____ Colored _____

Paper:

Newspaper _____ Corrugated Cardboard _____ White Paper _____

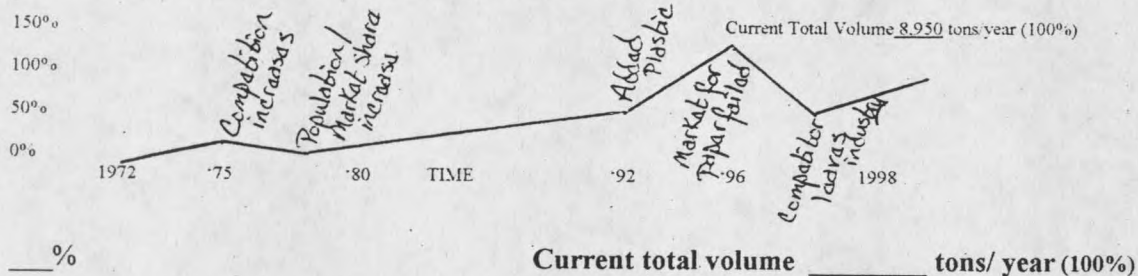
Paperboard _____ Magazine/gloss paper _____ Phone Books _____

Metals:

Aluminum _____ Steel Cans _____

Other Materials: (Explain) _____

7. Graph the approximate change in the volume of municipal solid waste recyclables handled by your organization from the time mentioned in question number 5 until the present. Also please explain each point at which the slope of the line changes. For Example:



50%

0%

19__

Time

1998

8. Where are the recyclable materials shipped when they leave your site to market (Specifically or generally by region)? _____

9. Currently, how many local competitors do you have in the household municipal solid waste recycling business? _____

10. How many local competitors are you aware of that have left the recycling market in:
1998? _____ 1997 - 1996? _____ 1995 - 1990? _____

11. Are you optimistic about the future of recycling household municipal solid waste materials in your locale? Yes _____ No _____ Explain _____

12. Which municipal solid waste materials do you feel are the most economically viable materials for recycling in your locale? _____

13. Which municipal solid waste materials do you feel are the least economically viable material for recycling in your locale? _____

Additional Comments: _____

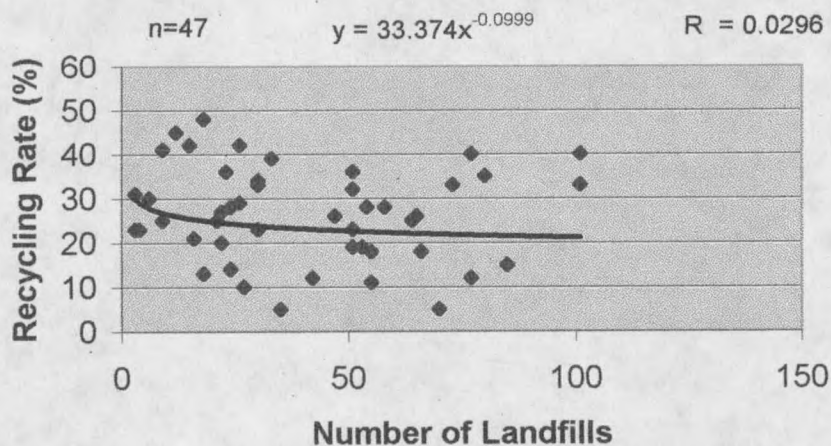
Additional pages are welcome.

Thank you for your assistance.

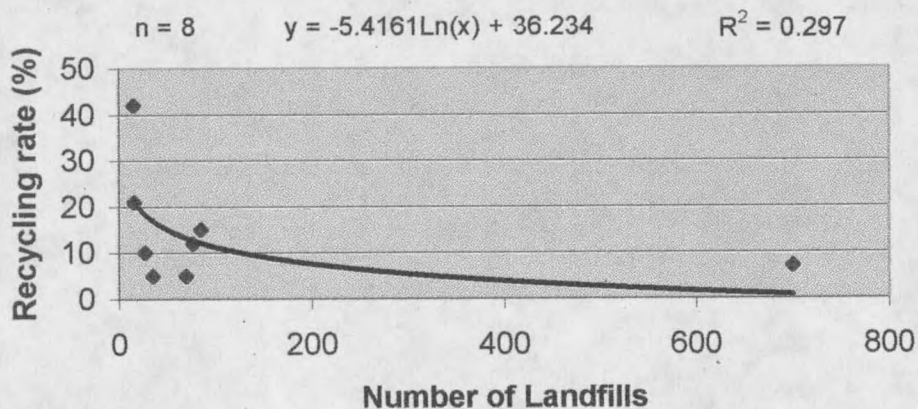
APPENDIX D

LANDFILL CAPACITY REGRESSION ANALYSES

Regression Analyses of the Number of Landfills versus Recycling Rate for a State



National Correlation



Study State Correlation (Except Minnesota)

Explanation :

y = trendline equation

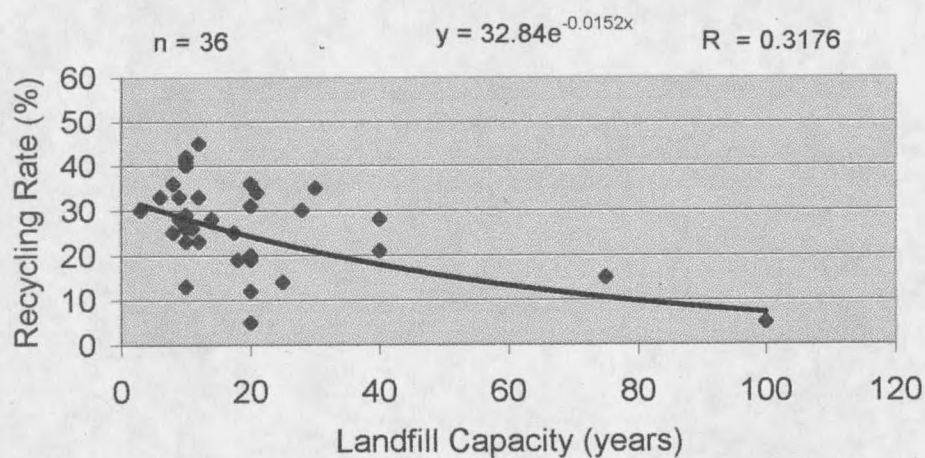
n = number of data points (states)

Source : Glenn, Jim 1998 April and May.

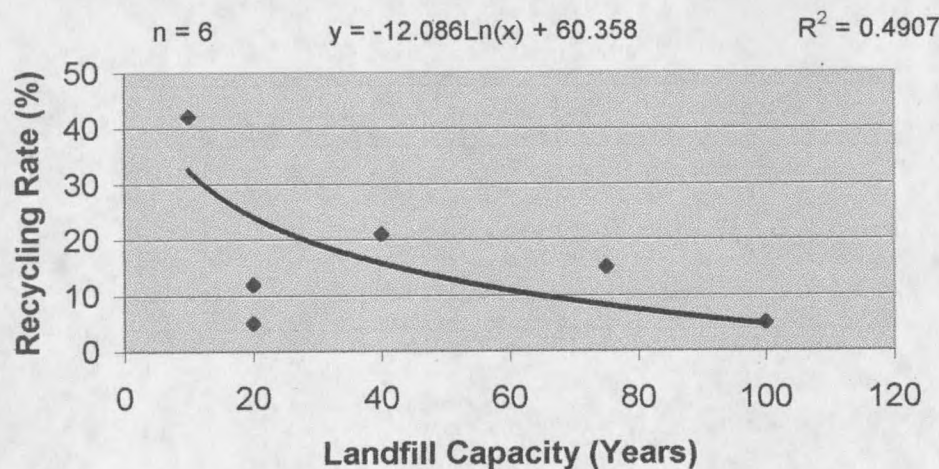
R = regression coefficient

(1 indicates direct relationship)

Regression Analyses of the Expected Lifetime of Landfills versus Recycling Rate for a State



National Correlation



Study State Correlation (Except Minnesota)

Note : No landfill lifetime data available for Alaska and Idaho.

Explanation :

y = trendline equation

n = number of data points (states)

Source : Glenn, Jim 1998 April and May.

R = regression coefficient

(1 indicates direct relationship)

APPENDIX E

PRINCIPLE INDUSTRIES AND MANUFACTURED GOODS
OF THE STUDY STATES

PRINCIPLE INDUSTRIES AND MANUFACTURED GOODS OF THE STUDY STATES

Source : KILL Reference Corporation 1997:

	<u>Principle Industries</u>	<u>Principle Manufactured Goods</u>
Alaska	petroleum tourism fishing mining forestry transportation aerospace	fish products lumber & pulp furs
Idaho	agriculture manufacturing tourism lumber mining electronics	processed foods lumber & wood products chemical products primary metals fabricated metal products machinery electronic components computer equipment
Minnesota	agribusiness forest products mining manufacturing tourism	food products fabricated metal products chemical & paper products industrial machinery electric & electronic equipment computers printing & publishing scientific & medical instruments forest products
Montana	agriculture timber mining tourism oil & gas	food products wood & paper products primary metals printing & publishing petroleum & coal products

	<u>Principle Industries</u>	<u>Principle Manufactured Goods</u>
Nevada	gaming tourism mining manufacturing government retailing warehousing trucking	food products plastics chemical aerospace products lawn & garden irrigation equipment seismic & machinery-monitoring devices
New Mexico	government services trade	food products apparel printing machinery lumber electronics transportation equipment semi-conductors
North Dakota	agriculture mining tourism manufacturing telecommunications energy food processing	farm equipment processed foods fabricated metal high technology electronics
South Dakota	agriculture services manufacturing	food & kindred products machinery electric & electronic equipment
Wyoming	mineral extraction oil natural gas tourism & recreation agriculture	refined petroleum wood, stone, clay products foods electronic devices sporting apparel aircraft

MONTANA STATE UNIVERSITY - BOZEMAN



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