MONTANA STATE UNIVERSITY

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.

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.

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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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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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.

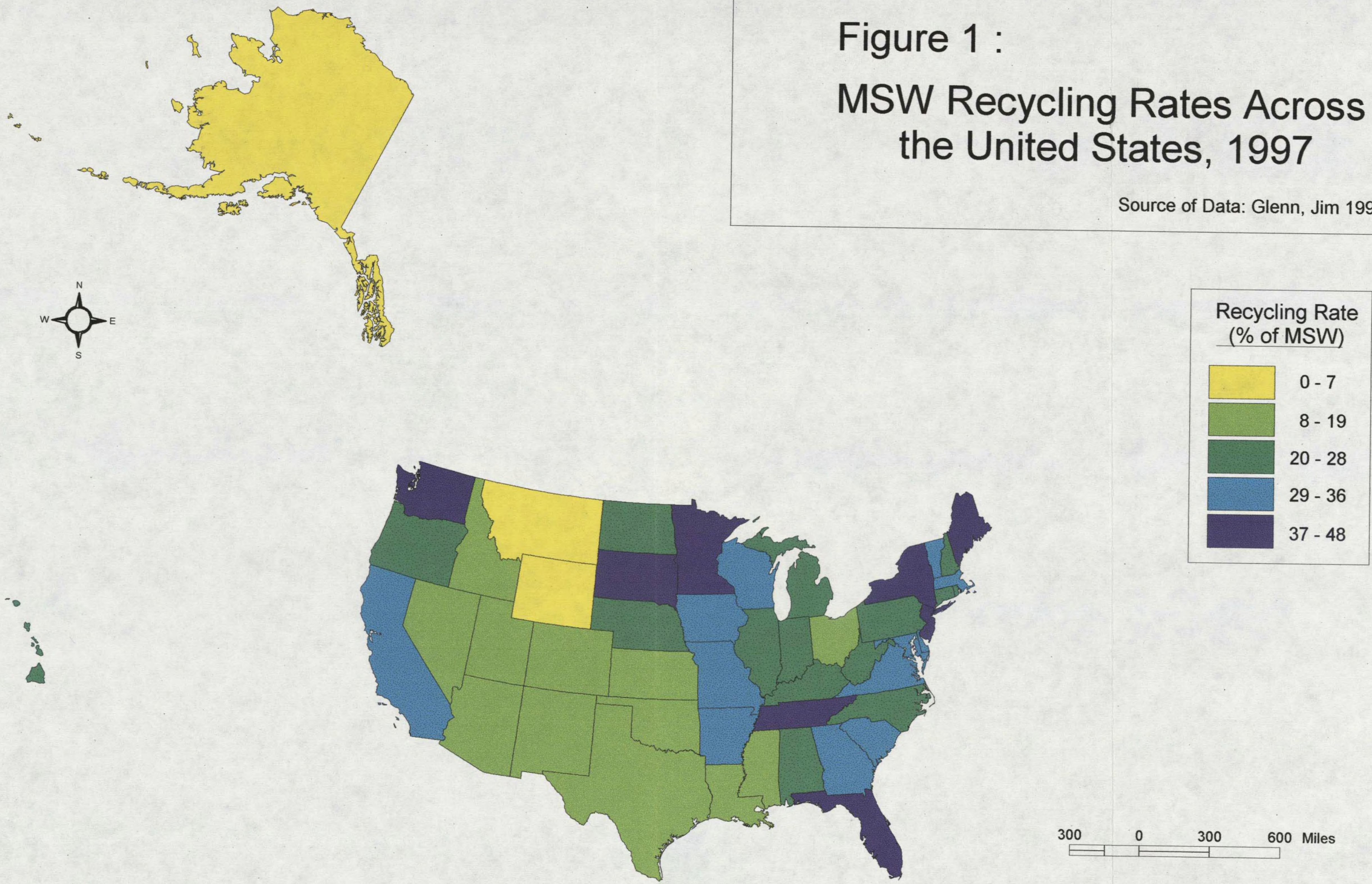


Figure 1 :

MSW Recycling Rates Across the United States, 1997

Source of Data: Glenn, Jim 1998, April

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 Arcveiw, 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.

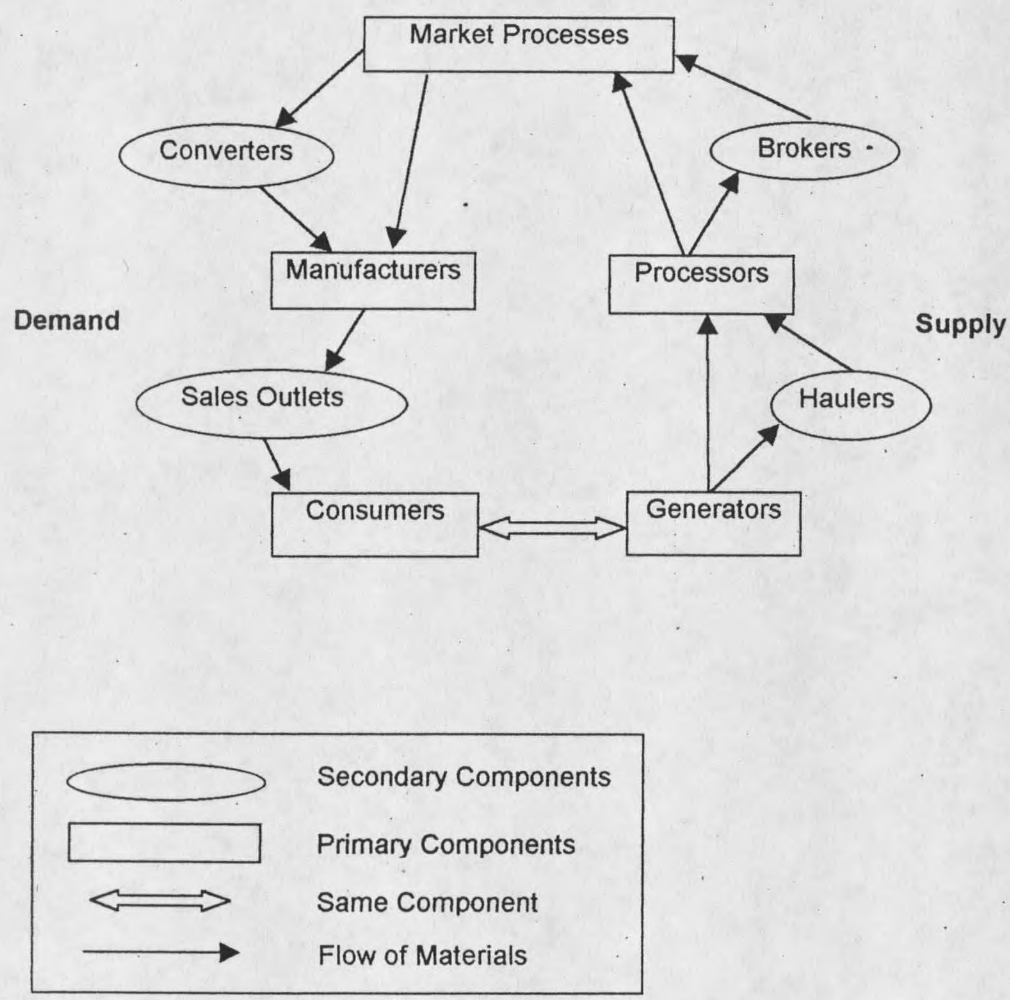
There are many definitions for "recycling". After reading many, it is apparent that there is a consensus that recycling encompasses many people at many stages of a process. One definition that seems to sum it all up in a concise manner is from a report by the Sound Resource Management Group, Inc. titled 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



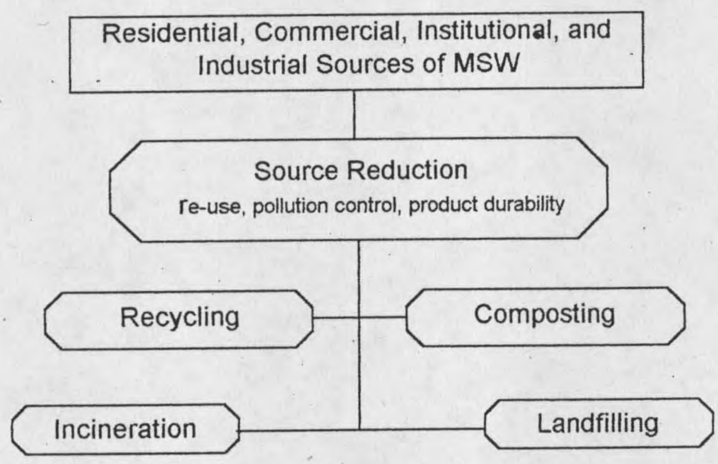
solid waste is through a technique called "Integrated Solid Waste Management". They have developed a hierarchy of options, or alternative methods of waste disposal, in order to most effectively meet the needs of local areas and the nation (United States Environmental Protection Agency 1995, xxvii). (Figure 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:

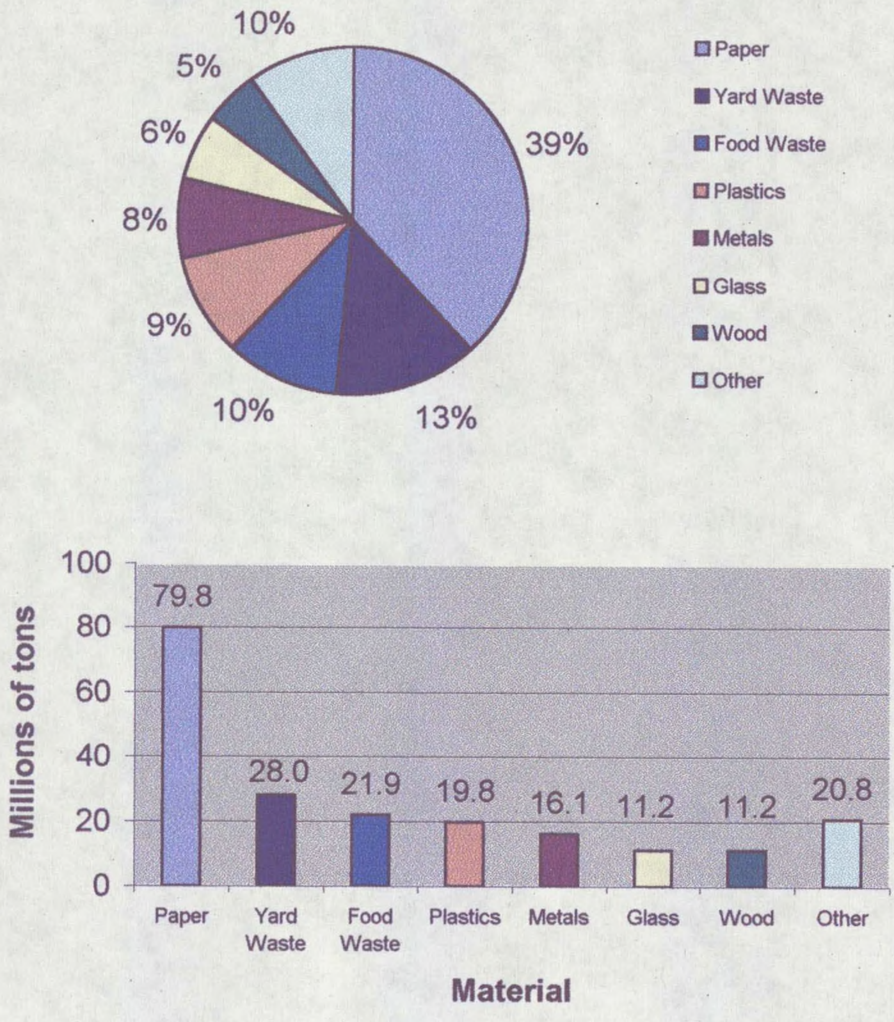
- A portion of an overall solid waste management system
- An industrial process which includes consumers, manufacturers, generators, and others in a continuous system
- Remanufacturing of useful products from waste materials that would otherwise go to a landfill or be incinerated
- A means to greater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

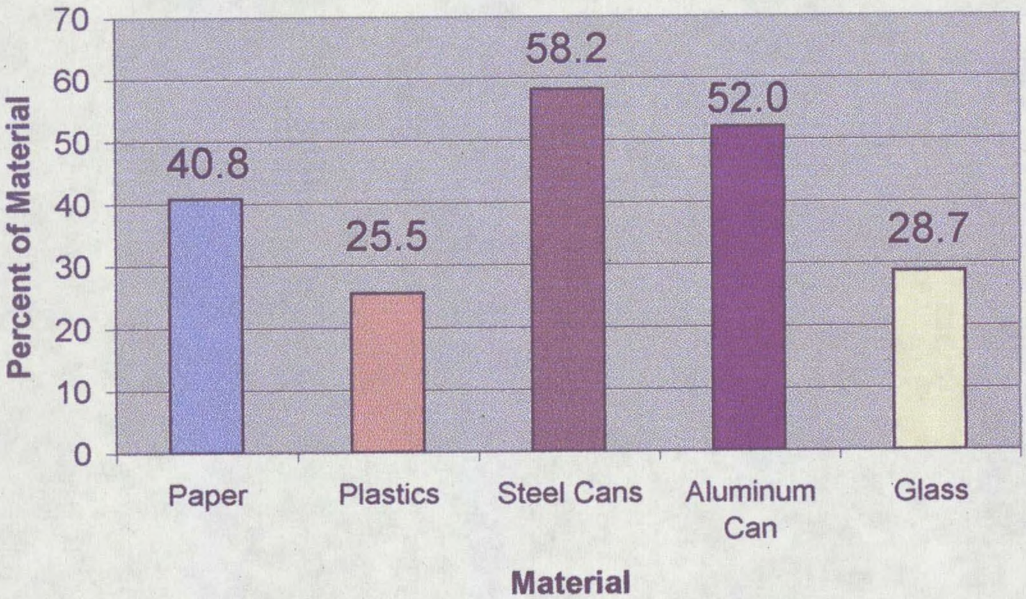
We all generate paper from copy and writing papers to napkins and toilet paper to newspaper, boxes, and much more. By far the material with the greatest generation rate is paper. Paper materials totaled 79.8 million tons, or 39 % of total U.S. MSW, in 1996 (See Figure 4). Records from 1992 show that 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 609% 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 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 it's 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) ArcVeiw.

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