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SOLID WASTE REDUCTION THROUGH RECYCLING
AN EXAMINATION OF PROGRAM DESIGN

by

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A thesis
presented to the University of Ottawa
in fulfillment of the
thesis requirement for the degree of
Masters of Arts
in
Geography

University of Ottawa
Ottawa, Ontario

Ottawa, Ontario, 1987

ISBN 0-315-46857-2

UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

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ACKNOWLEDGEMENTS

The production of this thesis was made possible, interesting and enjoyable through the support and care of a number of individuals. I thank Professor Barry Wellar, thesis director, for his supervision, his contributions, and our numerous discussions on the relevance of it all.

Professor Roger Needham and Dr. William Griggs (Canada Mortgage and Housing Corporation) also contributed to the thesis. Their interest, encouragement and enthusiasm for my topic are greatly appreciated. Thanks also to Professor Roger Roberge for his explanations of dummy variables and multiple regression analysis.

The number of people professionally involved in solid waste management and recycling is expanding rapidly and for obvious reasons. Some of the individuals who provided information, assistance, advice, ideas and feedback are Duncan Bury (City of Ottawa), Paul Taylor (Recycling Council of Ontario), Derek Stephenson (Resource Integration Systems Ltd.), Trish Ferrand (New Jersey Office of Recycling), and Jerry Powell (Resource Recycling), to mention a few.

Additional words of gratitude are given to fellow students – too numerous to name here – who helped create a special feeling of camaraderie in the department. Finally, I would like to thank my parents for their support throughout this endeavour and for keeping me in a style of life to which I would like to become accustomed.

ABSTRACT

Source separation of recyclable materials (paper, cardboard, glass, tin, aluminum, plastics and oil) for the purposes of recycling conserves energy, preserves natural resources, reduces litter, and extends the life of local landfills. Multi-material, curbside recycling programs which are properly designed can reduce the amount of municipal refuse going to landfill by 10 to 15 percent.

Public participation in recycling programs is crucial. Of special interest to this research is the difference in voluntary versus mandatory participation, examined in terms of the amount of solid waste recycled in communities which employ the one or the other approach. Consideration was also given, however, to the role of other recycling program factors: provision of a special in-house storage container; number of categories into which refuse must be sorted; degree of residential material preparation before collection; degree of promotion; collection frequency; size of program; and age of program.

To measure effectiveness, the quantity of recyclable materials diverted from the landfill -- per capita per day -- was selected as the dependent variable. Eight research hypotheses were formulated to test the significance of the different program design factors. A survey of 39 curbside recycling programs in Canada and the United States was conducted in order to compile the data with which to test the hypotheses.

On the basis of data and the analyses used to examine the programs, and in particular as a result of the multiple regression analysis, it was found that the more effective programs incorporate the following features:

(1) Participation is mandatory.

(2) Residents sort refuse into a relatively high number of categories.

(3) Program size is focused so that operation and responsibility is at a local level.

(4) Special storage containers are provided to each household.

RESUME

La séparation à la source de détritus recyclables tels que le papier, le carton, le verre, le fer-blanc, l'aluminium, le plastique et l'huile, permet non seulement de conserver l'énergie, mais aussi de préserver les ressources naturelles, de réduire le volume des déchets, et de prolonger l'utilisation des décharges publiques. Des programmes (au tri à la source) de recyclage biens conçus peuvent réduire de 10 à 15% la quantité de déchets voués au dépotoir.

La participation du public à ces programmes de recyclage est essentielle. La différence entre les programmes volontaires et imposés, mesurée en termes de quantité de déchets solides recyclés dans les communautés, est le sujet de cette recherche. D'autres facteurs, tels que l'utilisation d'un bac d'accumulation privé, le nombre de catégories définies de déchets recyclables, le degré de préparation des déchets avant leur ramassage, la quantité de publicité faite pour le programme, la fréquence du ramassage, la taille du programme et son ancienneté ont aussi été pris en considération.

Pour mesurer l'éfficacité du programme, la quantité de déchets détournés de la décharge publique -par personne et par jour- constituait la variable dépendante. L'importance des différents facteurs cités plus haut a été évaluée par l'intermédiaire de huit hypothèses de recherche. L'examen de trente neuf programmes de recyclage implantés au Canada et aux Etats-Unis a fourni les données nécessaires à l'éprouver des hypothèses.

Sur la base des données obtenues et des analyses utilisées pour l'examen des programmes, plus particulièrement l'analyse de régressions multiples, il a été établi que les programmes les plus efficaces étaient caractérisés par;

(1) Une participation obligatoire du public.

(2) Une séparation par les individus des déchets en un nombre relativement élevé de catégories.

(3) Une taille permettant une gestion assurée par des responsables locaux.

(4) Par la fourniture de bacs d'accumulation privés.

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Chapter 1

INTRODUCTION

1.1 Research Objectives

The primary objective of this research is to determine the type of source separation that is most successful in waste management programs that focus on solid waste diversion. Of particular interest in this regard is the issue of voluntary versus mandatory involvement of the public in the separation (at source) of recyclable materials. An associated concern is identification of other factors which affect the relative success of public involvement in multi-material, curbside pick-up programs implemented in Canada and the United States.

As a companion objective, the study seeks to draw lessons learned from previous experiences in other communities and apply them to both the design and implementation of recycling programs (based on source separation) in the Ottawa-Carleton region and elsewhere.

1.2 Research Hypotheses

The specification of variables and relationships underlying the research is derived from consultation with selected experts and practioners in the waste management field, and from the learned and popular literature on the subject.

As a consequence of those specifications, the quantity of materials diverted from the landfill site is taken as an appropriate measure of recycling program effectiveness, and is designated the dependent variable for the research hypotheses.

The eight independent variables, representing the various factors that influence the level of recycling effort, and derived in a similar manner, are as follows:

(1) participation (voluntary or mandatory)
(2) container provision (yes or no)
(3) number of sorted categories
(4) degree of preparation effort
(5) collection frequency
(6) degree of promotion
(7) program duration
(8) population served by the program

The relationships to be examined, and tested for, involve the extent to which the respective factors (independent variables) influence the effectiveness of recycling programs and hence the quantity of materials diverted from the landfill (dependent variable).

1.3 The Problem of Solid Waste Disposal

One of the most fundamental challenges confronting modern day cities is the problem of how to safely, effectively and efficiently dispose of increasing amounts of solid waste. Although no conurbation has escaped having to at least consider the problem, cities in Canada have not yet had to deal with the waste management problem as a

matter of urgent necessity, which is the case in Europe, Japan and in parts of the American megalopolis (Boston to Baltimore). The qualifier "yet" is used advisedly, however, because the evidence is becoming increasingly clear that even here the problem is reaching serious proportions, notwithstanding our relatively small population and large mass of geography that may be perceived to be readily capable of absorbing unlimited quantities of solid waste.

The current means of solid waste disposal in most urban areas, including that of Ottawa-Carleton, is the sanitary landfill. This solid waste management option has evolved from the open, pest-ridden dump to its present, more sophisticated form (see Section 1.4.5). In spite of its technical merit, however, the sanitary landfill has one particularly detracting characteristic: eventually it fills up. This is a problem for the following reasons:

(1) the supply of suitable land for new landfills is rapidly diminishing, especially near the larger cities;

(2) the social and political costs of selecting new disposal sites are high;

(3) as used landfill locations multiply throughout urban hinterlands, side effects that are harmful to the environment increase, spatially and numerically, and particularly in the form of contaminated groundwater.

In North America we appear to have endless expanses of vacant land on which to dispose our wastes. Such a perception is misleading, however, because of the urban nature of the problem. The sanitary landfill, as mentioned above, generally has a rural setting, the location of which is determined by a variety of factors such as public health and safety, the natural, social and cultural environments, and technical, financial and economic considerations (WASTEPLAN handout, 1986, Ottawa).

Facilities that can process or dispose of solid waste cannot, realistically, be located on distant or isolated margins of the Canadian Shield. That is, for reasons of transport cost, landfills are located as close to the sources of solid waste as possible. Consequently, we are left with the prospect of dotting our urban hinterlands with refuse-laden landfills that are, in effect, environmental time bombs.

Hence, and eventually, as metropolitan areas expand, dumps and landfills are overtaken and a worst-case scenario presents itself as a harsh reality: a Love Canal / Hyde Park situation emerges to haunt public health officials as well as political decision-makers, planners (urban, regional and rural), and the general public.[1]

What will the long term costs be if we continue to bury solid waste, which alternatively could be reused or recycled?, is a question which to date has received a great deal of attention in environmentally- and ecologically-oriented associations and journals (Friends of the Earth, Pollution Probe, Sierra Club; Journal of Environmental Systems, Resources and Conservation, Resource Recycling, Biocycle, Conservation and Recycling, Self-Reliance, etc.). That substantial effort notwithstanding, however, critical political decisions that are required have been successively and "successfully" put off because the crisis is not yet perceived as being directly upon us, even though lack of resolution of the problem will likely entail increasingly expensive or inconvenient landfill situations, higher energy costs, and diminishing natural resources.

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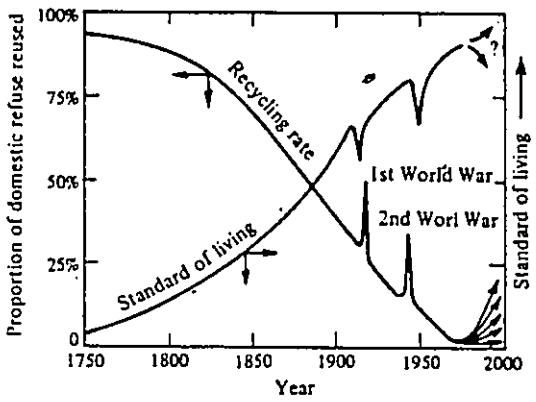
[1] The Niagara region of New York state has been the home of a large chemical industry for several decades. During the 1950s, the Love Canal was begun but never completed. A company by the name of Hooker Chemical acquired the large open trench and turned it into a regional chemical waste dump. Eventually, it was filled in and covered over. A community was established on top of it. Later on, as more and more residents became afflicted by a variety of illnesses, including cancer, a local and national outcry (and courtroom action against Hooker) resulted in the relocation of most of the community. The nearby area of Hyde Park was similarly contaminated.

The headlines and associated articles listed in Table 1 indicate the scope and magnitude of the disposal of solid waste as a public interest matter, and illustrate the difficulty of arriving at political determinations.

The growing solid waste disposal problem has been put into perspective by Wilson (1977, p.275). Figure 1, taken from his study, shows that the rate of recycling (of solid waste) is inversely proportional to our increasing standard of living. Wilson goes on to estimate that less than one percent (by mass) of our domestic waste is presently recycled. The problem of solid waste disposal is seemingly one of ever-increasing proportions.

Figure 1: Estimate of domestic waste recycled



(Source: Wilson, 1977, p.275)

Table 1: The Waste Disposal Problem and a Sampler of Associated Newspaper Articles (from The Ottawa Citizen)

Date	Headline	Issue
June 10 1985	600 angry residents rap Carlsbad Springs dump	"Not In My BackYard (NIMBY)
July 16 1985	Nepean residents suggest dumping Region over waste options	NIMBY
Aug. 25 1985	Tough decisions loom on garbage	Waste mgmt. master plan process
Sep. 27 1985	Region's proposed incinerators being studied for pollution	Air pollution
Sep. 30 1985	Cross-river option for garbage dump	"Put it in someone else's backyard"
Nov. 2 1985	The garbage explosion	The problem/landfills/ incinerators/recycling
Nov. 4 1985	The political perils of picking new dumps	Municipal inertia/ costs/NIMBY
Nov. 20 1985	Osgoode Council supports groups against dump sites	NIMBY
Nov. 26 1985	Residents condemn garbage dump plan for Shawville mine	NIMBY
Apr. 8 1985	Region pares down list of sites for garbage dumps, incinerators	Waste mgmt. master plan process
May 27 1985	Overbrook residents condemn incinerator plan	NIMBY
July 19 1985	Bulk of underground dumps health hazards	Water pollution
Sep. 19 1985	Water from the regional dump to be tested for pollution	Local concern re: contaminated river

1.4 Definition of Key Terms and Concepts

As in other fields of study, the vocabulary of this one is becoming increasingly eclectic with the result that awkward and occassionally erroneous cross-referencing occurs. The following subsections are included to briefly address some of the more important terms and concepts, the understanding of which is critical to an appreciation of the evolving nature of waste management principles and practices. A Glossary of Terms is provided in Appendix A.

1.4.1 Solid Waste Management and Land Use Planning from a Geographical Perspective

Solid waste management, in its broadest meaning, is the purposeful and systematic control of the generation, collection, transportation, storage, separation, processing, recycling, recovery and disposal of solid wastes (Vincent, 1981, p.69E). Land use planning necessarily overlaps with this definition of solid waste management since it is defined as that process "used by a locality to determine what courses of action are appropriate in shaping the built environment of facilities and land uses for the collective good" (Chapin and Kaiser, 1979, p.27).

Sanitary landfills, and solid waste processing and transfer facilities require space in or near urban areas. These facilities are conspicuous users of land and, because of their refuse-related character, are often cast as obnoxious users as well because they tend to offend our senses of sight, sound and smell. Hence, their location near human settlement is frequently controversial, and it is to this opposition that waste managers and regional planners must address themselves.

With respect to solid waste management facilities being accommodated by or respecting the built environment, the following policy, program and planning considerations indicate the nature of concerns to be addressed (modified from Hills, 1984, p.153):

(1) location, distribution and scale of industrial plants, parks and waste management facilities
(2) industrial infrastructure capacity
(3) planning control of site layout and construction of plant
(4) road network configurations
(5) routing requirements
(6) site identification/impact assessment for disposal technologies
(7) reconciliation of land use supply and demand relationships
(8) reclamation and utilization of disposal sites

Insofar as the above items are concerned, it is perhaps the seventh issue which presents the operational geographer and the land use planner with his greatest challenge. Because people are generally motivated out of self-interest (O'Riordan, 1976), a topic that is discussed further in Section 2.1.2, the geographer or the planner is faced with the difficult task of either:

a) serving as arbiter in arguments involving the "collective good"; or,
b) trying to provide a framework so that others – elected officials, regulatory bodies, citizens – often with different objectives, goals and different levels of expertise, can argue coherently and cogently about the relative merits of alternative waste management options.

1.4.2 Types of Solid Waste

Anything that anyone discards, before, during or after its use is referred to as WASTE. That which is known as SOLID WASTE, however, is more specifically defined as "those obsolete products discarded by domestic, commercial and municipal consumers which would normally be deposited at municipal refuse areas" (Vincent, 1981, p.43E). For the purposes of this study, this definition is adopted but under the term MUNICIPAL SOLID WASTE (or MSW), rather than just solid waste. An accepted synonym for solid waste is REFUSE.

DOMESTIC and RESIDENTIAL SOLID WASTE refer to the same thing, namely, that part of MSW that is generated within households. Source separation of recyclable materials, as will be defined shortly, is primarily but not exclusively concerned with this portion of the waste stream.

The proportion of MSW that is residential varies from 78.6% (Hickman, 1985, p.128) to 45% (Rhyner, 1976, p.30). The difference between these figures can be accounted for in a number of ways including the economic and socio-demographic differences that exist between or among urban areas.

Those wastes that require exceptional treatment are now referred to as SPECIAL WASTES. Such wastes include biomedical, nuclear, heavy industrial, and liquid and/or toxic matter. Although these substances have potentially profound environmental impacts and frequently are expensive and difficult to safely and effectively dispose of, they are outside the scope of this research.

1.4.3 The Composition of Solid Waste

Very few aggregations of material are as heterogeneous as MSW. Consequently, a number of studies have focused on the composition of solid waste in an attempt to identify the many different parts (Bird and Hale, 1979; Neissen, 1977; Clark and Brown, 1972).

The heterogeneity of MSW is a particularly important aspect of solid waste management and especially of recycling because not all components of MSW can be recycled. According to previous studies, the percentage of recyclable materials available varies from 18% (Hickman, 1985, Table 31, p.129) to 35% (MacLaren Engineers, 1985, table 7.1) to 60-70% (Bureau of Solid Waste Disposal, 1985b, p.50), depending on which items are targeted and which sources are referenced. A cursory examination of Table 2 might suggest that the higher percentages (those of the Bureau or MacLaren) would be more appropriate, but a caution is in order. That is, since much of the MSW material is frequently contaminated by or laminated with other substances (MacLaren Engineers, 1985, p.7-15), simple reference to its "as is" state can be misleading with respect to the amount or proportion which is readily recyclable

Enertask Consultants and Resource Integration Systems Ltd. (1979) estimated some recovery rates for five core materials that are often included in source separation programs. Table 3 lists these materials along with their estimated realizable recovery rates, and the percentage that the recoverable amounts represent of MSW.

The actual percentage of total MSW that is available for recovery can easily be deduced from these statistics. For example, if 41% of all newsprint can be recovered, and if newsprint represents 8.54% of the total MSW (from Table 2), it follows that 3.50% (41% of 8.54%) is the percentage of the newsprint component of MSW that can

Table 2: The Components of Municipal Solid Waste as a Percentage of Total Weight

Components	Percentages of total
Paper	36.45
kraft paper	9.11
newsprint	8.54
fine paper	6.00
other paper	12.80
Glass	6.61
beer containers	0.20
reuseable soft drink	0.28
non-reuseable	1.06
liquor and wine	1.43
containers - food	2.23
containers - other	0.34
flat and cullet	1.08
Ferrous metals	6.06
beer cans	0.04
soft drink cans	0.66
food cans	2.77
other	2.59
Non-ferrous metal	0.57
aluminum	0.52
other	0.05
Plastics	4.65
containers	0.87
sheet film other	3.78
Ceramics rubble	1.80
Lumber	4.18
Putrescible (organic matter)	27.59
Textiles, leather, rubber	4.26
Yard wastes, brush	6.09
Fines (sand, silt, etc.)	1.18
Petroleum/Chemical	0.56
	100.00

Source: Bird and Hale, 1979, p. 14.

be recovered. If 100% of each material could be recovered for recycling purposes,

Table 3: Estimated Recovery Rates

material	estimated realizable recovery rate (1)	percent of total MSW (2)	percent of total MSW realizably available (3)
newsprint	41 %	8.54 %	3.50 %
kraft *	41 %	9.11 %	3.74 %
fine paper	32 %	6.00 %	1.92 %
glass	29 %	6.61 %	1.92 %
metal cans	9 %	3.47 %	0.31 %
		33.73 %	11.39 %

* old corrugated cardboard

Source (1): Enertask Consultants and Resource Integration Systems Ltd., 1979, p. 4-12.
(2): From Table 2; Bird and Hale, 1979.
(3): Figures calculated as explained in text.

then that would represent 33.73% of the total. It is noted and emphasized that, due to the heterogeneity of MSW noted above, the column 3 calculation of 11.39% may be more representative of the percentage of MSW that is realizably available.

Table 4 contains refuse composition figures for countries in North America (Canada and the U.S.) and Europe, as well as for Japan. The figures clearly illustrate the variability of solid waste composition among the selected countries.

Canada and the United States have similar solid waste composition and generation (see next section) however, so it is therefore reasonable to compare and contrast source separation programs in these countries.

Table 4: A Summary of International Refuse Composition (percentages by weight)

Material	U.S.		CANADA		U.K.		JAPAN
	(1)	(2)	(1)	(3)	(1)	(4)	(1)
ash	0	0	5	0	30-40	20	19
paper	44	36	70	39	25-30	33	25
organics	27	17	10	34	10-15	20	37
metals	9	6	5	6	5-8	11	3
glass	9	8	5	7	5-8	11	3
misc.	12	33	5	15	5-10	7	13

Material	HOLLAND		FRANCE	GERMANY	SWEDEN
	(1)	(5)	(1)	(1)	(1)
ash	9	0	24	30	0
paper	45	22	30	19	55
organics	14	48	24	21	12
metals	5	3	4	5	6
glass	5	12	4	10	15
misc.	22	15	14	15	12

Sources:
(1) Neissen, 1977
(2) New Jersey Dept. of Environmental Protection, 1984
(3) Bird & Hale Ltd., 1979
(4) Smith, 1976
(5) Alter, 1980

1.4.4 The Generation of Solid Waste

During the literature review stage, solid waste generation statistics were collected from other studies, Canadian and American, so that a benchmark figure or index could be established. The general impression drawn from the literature review is that, over time, the generation of MSW is increasing. This premise is examined further and the index is derived in Appendix B. The estimated MSW generation figure for 1985 is 6.44 pounds per capita per day (2.96 kg).

According to Hare (1983), there are two ways of obtaining solid waste generation figures: the materials-collection method and the materials-generation method.

According to the materials collection method of deriving solid waste figures, data are gathered from municipal solid waste collection and/or disposal records, and the amount of recycled materials is added to that. Ideaaly, municipalities would have weigh scales at their landfill facilities, but this is not always the case. In Ontario for example, of roughly 1500 landfill facilities, only an estimated eight to ten have weigh scales (Ficzere, 1986, personal communication). As a consequence of this, the materials-collection method for determining solid waste generation is of questionable reliability.

With the materials-generation method, an annual estimate is made for the whole of MSW "according to production records in the entire country, for all consumer goods produced and for their associated packaging" (Hare, 1983, p.3.5). In addition, adjustments are made for imports and exports, and for the life of consumer products.

As reported by Hare, the U.S. figure for residential and commercial solid waste generation is 3.75 pounds per capita per day (pcd), which is considerably lower than the estimated index for 1985. The problem again may be one of definition with respect

to MSW. In his work, Hare makes reference to residential and commercial solid waste whereas, in another study, Glysson *et al.* (1972) are concerned with not only residential and commercial solid waste (4.29 pcd), but also solid waste from industrial, demolition and construction, institutional, sewage treatment plant, street and alley sweeping, tree and landscaping, park and beach, and catch-basin sources.

This second method of determining solid waste generation is inherently weak as well because of the lack of standardised definitions, the dangers of which, as demonstrated above, often result in conflicting figures. The reliability of data in this field is obviously highly questionable and a matter of concern to those attempting to do research on the topic, or to use available data to develop MSW programs.

In addition to the composition of solid waste varying widely, there can also be wide variation in the rate and amount of solid waste generation. This variability can be accounted for in several ways. First, there is the issue of reliable measurement and, second, there is the strong likelihood that even with 100% reliable measurement, the generation of solid waste will vary from one area to the next. To illustrate this point, attention is drawn to Table 5.

It is noted and emphasized that the generation and composition of solid waste may vary considerably from region to region according to size and location of each community, type of neighbourhood, time of year and climatic conditions (Kut and Hare, 1981, p.4). In particular, and as presented in Table 5, communities with a higher socio-economic status (Rockcliffe Park) usually have higher waste generation rates than those less well-off (Vanier).

Table 5: Solid Waste Generation Rates (residential and light commercial)

Place	Generation Rate (lbs/cap/day)	Descriptive Statistics	
Ottawa	2.32	Mean	2.32
Rockcliffe Park	3.00	Median	2.32
Vanier	1.94	Mode	2.32
Gloucester	2.16		
Cumberland	1.96	Range	1.06
Osgoode	2.32	Sum of	
Nepean	2.38	squares	0.81
Kanata	2.54	Variance	0.09
Region of Ottawa-Carleton	2.29		

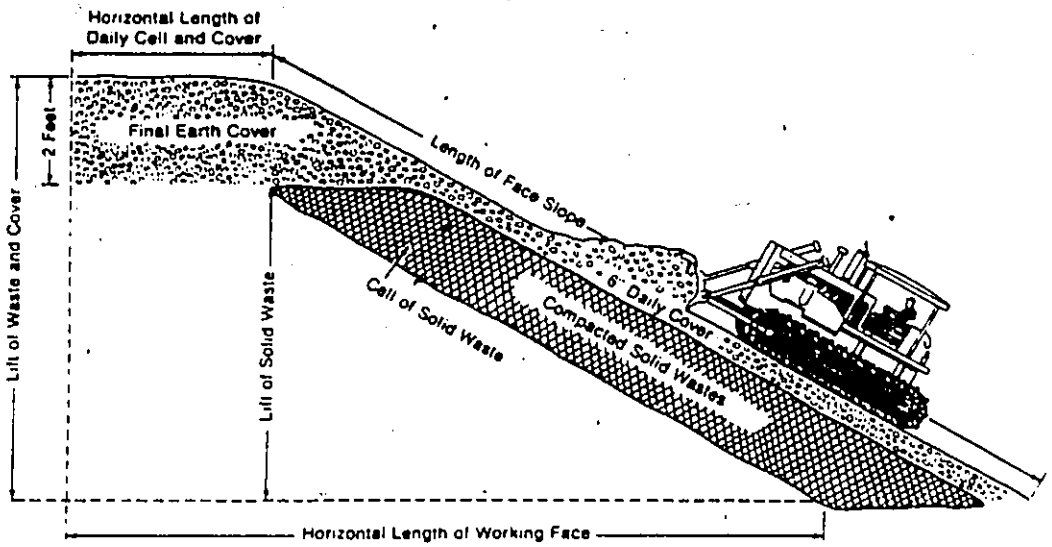
Source: MacLaren Engineers, 1985, table 3.2
Note: Descriptive statistics are added in.

1.4.5 Sanitary Landfill

The sanitary landfill is the primary solid waste management facility. Its design has evolved from the open, burning dump to a relatively sophisticated engineering operation. Present landfill methods involve the disposition of solid waste in compacted layers intermittently covered by an inert substance such as earth. Figure 2 depicts this process.

The problems associated with the sanitary landfill were noted in Section 1.3. From a technical perspective, it is possible to minimize dangers to public health and safety, and the environment, by concentrating and containing the disposed solid waste materials. This can be accomplished by sealing the bottom of the landfill and equiping it with a drainage system to filter out leachates. Furthermore, an impervious "umbrella" can be constructed so as to cover the site, thereby preventing the percolation of water through the landfill.

Figure 2: Sectional View Of A Sanitary Landfill



Source: Waste Management Branch, 1980.

Notwithstanding achievements in solid waste management engineering, however, sanitary landfill sites are becoming increasingly more difficult to establish near urban areas as evidenced by recent developments in the Ottawa area (The Ottawa Citizen, November 4, 1985, "The Political Perils of Picking New Dumps").

The Regional Municipality of Ottawa-Carleton is attempting to locate new solid waste processing and/or landfill facilities, but it is coming face to face with the "Not-In-My-Backyard" (NIMBY) syndrome. The flaw in the landfill option for waste disposal, as noted above, is that nearby residents are subjected to its offending odour and appearance, as well as the noise of large trucks rumbling to and from the site. In addition, and as illustrated by media items -- newspaper, radio, television -- citizens are also concerned about the potential contamination of water tables, and that adjacent homes will decrease in value. (Recall Table 1).

1.4.6 Recycling and Source Separation

The option of waste reduction through source separation is of particular significance to this thesis. Recycling has also been mentioned as a viable waste management concept. Both concepts have been practised for a long time, in one form or another. However, as illustrated in Figure 1 (Section 1.3) the rate of recycling of solid waste has decreased as our standard of living has increased, with the exception of crisis periods such as during the two world wars.

Source separation, or at-source segregation, brings solid waste management into everyone's home where the individual or family becomes the first (rather than the last) link in a waste material distribution network (Geller *et al.*, 1975, p.39). This system of waste reduction is also quite feasible in the work place, especially with respect to fine paper recovery. Source separation is decidedly labour-intensive as it requires that each household set aside distinct categories of waste, for example, glass, newspaper, and metal cans. Some source separation programs may also request (or require) that participants bundle or bag newspapers, rinse glass and metal containers, remove labels and/or flatten cans. Special containers are often provided wherever curbside collection is offered.

In communities where recyclables are not collected at the curb, individuals can often leave materials at depots or buy-back centers. Although source separation of recyclable materials is considered as more economical than mechanized resource recovery, it does place certain time and effort demands on the participant (Geller *et al.*, 1982, p.114).

To briefly elaborate this process, materials that are reused, such as bottles, are cleaned with caustic soda and water and then refilled. Beer bottles in Ontario have

made as many as 24 round-trips (Office on Energy Conservation, 1979, p.30). Such a closed loop system makes both ecological and economic sense. By requiring consumers to pay deposits of 5 or 10 cents on beverage containers they are induced – pecuniary motivation – to return the reusable container rather than dispose of it as litter or trash. (The pros and cons of deposit legislation are, obviously part of a much greater issue and are beyond the scope of this study.

Recycling, then, has quickly become a well-known word, and is synonymous with the idea of conservation. It is the activity of re-processing waste or scrap into a re-usable material or product. For instance, ground glass can be re-constituted as a bottle, or it can be used in road construction as "glassphalt". The objective of recycling, in brief, is to capture valuable materials from the waste stream before they end up in the local landfill.

In a discussion on recycling in Ontario, an official of the Municipal Waste Management Policy Section (Ontario) pointed out that a municipal waste diversion rate of between ten and fifteen percent is possible with a well-organised source separation program ("WASTEPLAN" Workshop, Ottawa, August 1986). That range coincides with the figure 11.39% in Table 3. The immediate target figure for the Regional Municipality of Ottawa-Carleton, as designated by MacLaren Engineers (1985) is 14%, rising to an anticipated 34% by the year 2001. The states of New Jersey and Massachusetts have set 25% as their five year targets for waste reduction through recycling (Bureau of Solid Waste Disposal, 1985b; Hertzberg, 1983b).

In Figure 3, the various waste management options are illustrated. They may be summarized as follows:

(1) Excessive or conspicuous production / consumption patterns can be reduced, such as by selective purchasing or reduction of "overpackaging". This first option requires a modification or rationalization of the production / consumption habits that are currently the "normal" practise in the factory and the home.

(2) Items such as bottles and containers can be cleaned and reused. Reuse occurs within the household, or, items are returned to the production / consumption function (usually as a result of deposit fee system).

(3) Selected materials claimed from waste are re-processed, re-worked and re-introduced to the production function as depicted in Figure 3.

(4) Materials can be burned for energy recovery (see next section).

(5) Waste can be deposited in landfill sites without any attempt at modifying the waste materials once they have been discarded by households.

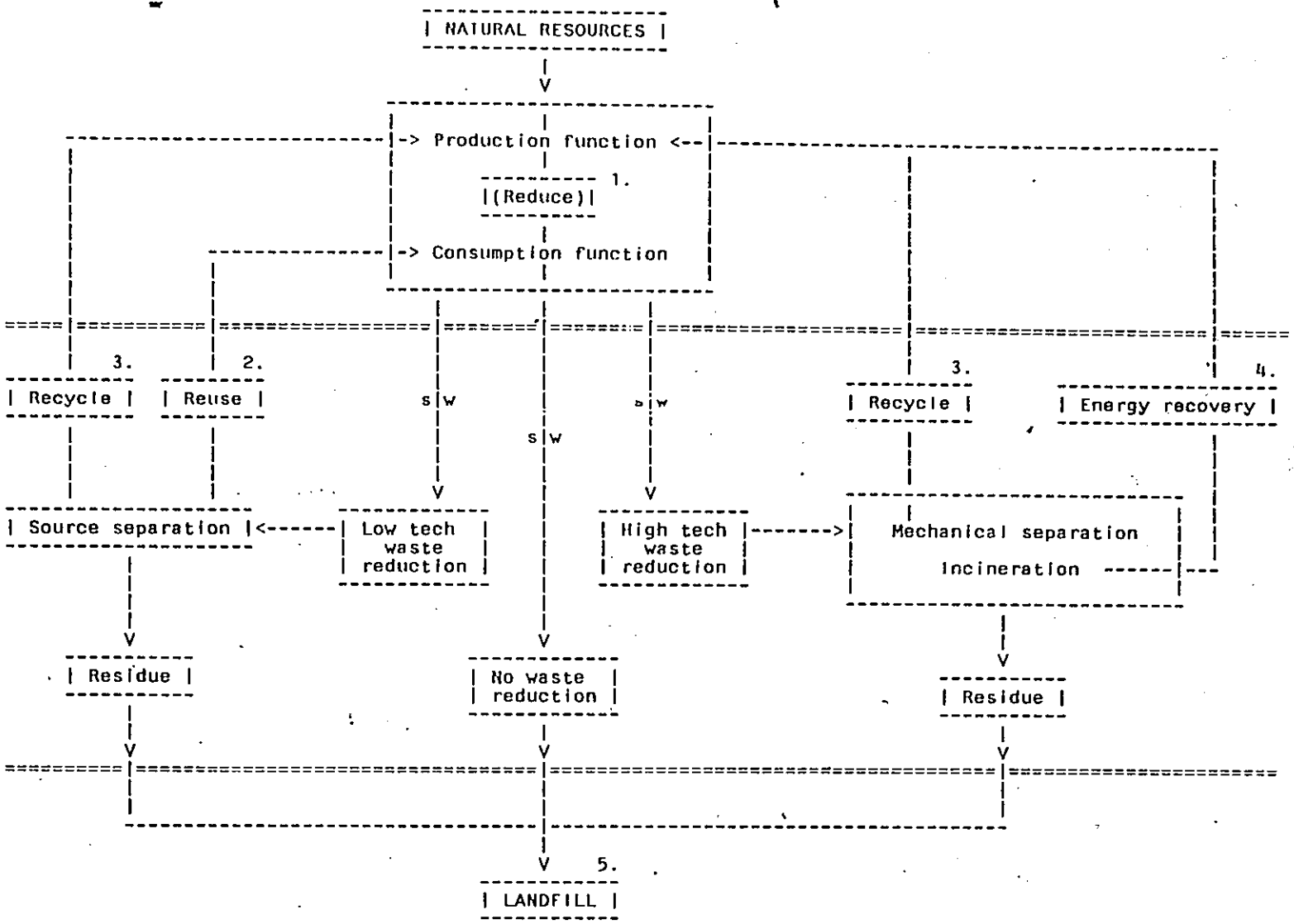


Figure 3: Waste Management Option Flows - Reduce, Reuse, Recycle, Energy Recovery and Landfill. (sw = solid waste)

Inevitably, however, and regardless of which recovery process is used, something in the form of residue must be disposed of via landfills. The challenge, then, since the waste disposal problem cannot be eliminated or avoided forever without incurring significant costs (Section 1.3), is to find that course of action which best extends landfill life according to political, economic, social, environmental, technological and aesthetic considerations. A detailed elaboration of the relationships between these broad considerations is provided by Wellar (1987) in his discussion of the elements, including landfills, which are negatively impacting upon rural areas in Canada and the U.S.

1.4.7 Other Waste Treatment Options

In addition to the sanitary landfill and source separation, there are other solid waste management options available. These processes, which are generally considered "high-tech", are characterized as highly mechanized, capital-intensive, and centralized.

A great deal of time, effort and money has been invested in the development of these processes. According to Harrison and Vesilund (1982), there were primarily three forces behind the enthusiasm for high-tech solid waste treatment facilities during the early 1970s:

(1) viable alternatives for refuse disposal were becoming fewer and more expensive;
(2) there were material and energy shortages;
(3) resource recovery was promoted by industry as a constructive and innovative alternative to solid waste disposal.

In addition to these three forces, the Resource Recovery Act of 1970 (U.S.) provided the risk capital for full-scale, high-tech resource recovery demonstration projects. As of 1980, it was estimated that 55% of the costs for high-tech facilities were subsi-

dized by one government program or another (Seldman and Knapp, 1980, p.15). Evidently, " the more cash there is available, the stronger the tendency to prefer capital-intensive to capital-saving technology" (Galtung, 1978, p.30).

This approach to handling MSW operates on the principle that the solid waste *mélange* can be mechanically sorted, and the valuable components (minerals, fibres, energy etc.) can be recovered at large, centralized processing facilities. One appeal of this approach lies in the fact that traditional collection services can continue as before. Less emphasis is placed on waste reduction because it is believed that the new technological fix will literally swallow municipal waste problems whole.

The following list (Table 6) is by no means exhaustive, but it does serve to demonstrate the extent to which the high-tech solid waste disposal venture has gone in seeking a technological solution to the solid waste problem.

Table 6: Illustrative High Tech Approaches to Solid Waste Reduction

- mechanized resource recovery facilities
  - dry
  - wet
- incineration with energy recovery
  - mass-burning modular facilities
  - mass-burning waterwall facilities
  - mass-burning refractory facilities
  - semi-suspension burning
- waste as a fuel
  - refuse-derived fuel (RDF)
- pyrolysis (gasification, destructive distillation)
- composting facilities
  - open air
  - in-vessel
- hydrapulping
- anaerobic digesters
- acid hydrolysis
- enzymatic hydrolysis
- wet oxidation

In a recent statement on resource recovery, Professor Bell of Purdue University reflects on reasons for the industry's lack of success despite the wide variety of technological solutions considered, and the large amounts of time, money and effort expended:

> *The resource recovery industry in the United States has suffered through a learning curve of over-estimated revenues, under-estimated costs, lack of public education concerning various technologies, reluctance of area residents to accept a facility, bad media publicity, failure of equipment suppliers to meet guaranteed performance of components, lack of adequate purchasers of energy and recovered materials, and the economy (Reilly, 1986, p.77).*

Evidently, then, high-tech waste management engineers still have numerous obstacles to overcome. From an operational perspective, a number of specific problems have plagued high-tech facilities, as reported by 39 U.S. plants which have experienced shutdowns. Some of the problems are listed below in Table 7.

Table 7: Reasons for High-Tech Plant Shutdowns

Reasons	Percent
equipment problems	21.5 %
retrofit/equipment installation	13.8 %
explosion	13.8 %
environmental problems	10.8 %
unfavourable economics	9.2 %
lack of markets	9.2 %
fire	7.7 %
legal problems	4.6 %
demonstration project completed	3.1 %
bad weather	3.1 %
plant never successfully went on-line	1.5 %
political problems	1.5 %
	99.8 %

Source: Reilly, 1986, p.79.

Of the high-tech processes mentioned, the most commonly adopted is that of incineration (Reilly, 1986). Its primary function is to reduce the volume of solid waste; in addition, it can be used to generate energy.

According to a study by Jacobs and Biswas (1972, p.81), incineration can reduce waste volumes by 60% to 85%, which suggests a high degree of solid waste reduction. In a more recent report, however, it was suggested that mass incineration of MSW is inherently very inefficient, primarily because of the ratio of non-combustibles (43%) to combustibles (57%) (Beattie, 1985, p.23).

Obviously, since divergent claims such as these are additionally subject to variations due to local solid waste composition figures, even the efficiency of incineration processes is still in question.

Further, and of critical health and environmental concern, is the effluence resulting from burned solid waste.

The federal Department of the Environment in Canada has initiated a National Incinerator Testing and Evaluation Program in order to assess the level of risk that incinerator emissions pose for urban populations (Environmental Protection Service, 1985). Notwithstanding the assurances of the agency, even if the risk levels should be found to be low, as well as any purported technological advances in this area, the general public will very likely remain just as skeptical as before (recall Table 1 and article entitled "Overbrook residents condemn incineration plan").

Finally, at a very practical level, setting technological and testing considerations aside, the incineration process suffers an abiding shortcoming. That is, and as made evident by media coverage of this topic, few if any residents living nearby are likely to willingly accept hundreds of 20-ton dump trucks rumbling to and from the site five days or more a week.

1.5 Summary

The purpose of this chapter is to introduce major elements and concerns of the thesis. The primary research objective of determining which type of source separation program is most successful has to be considered in the context of the overall problem of solid waste disposal. In addition, and as outlined above, due consideration must be given to the types, composition, and rates of generation of solid waste.

The sanitary landfill has been identified as an essential feature of solid waste management. Source separation and recycling procedures should not be considered as alternatives to it, however, since the unavoidable presence of non-recyclable proportion of MSW necessitates the continued presence of landfill disposal facilities (as illustrated in Figure 3).

The geographic implications of solid waste management are extensive, as highlighted in Sections 1.3 and 1.4.1. It should be restated in this summary that, in addition to an obvious environmental impact, solid waste disposal portends the inevitability of various social, political and aesthetic externalities. It goes without saying, therefore, that the locational and spatial relations aspects of solid waste disposal – production, transportation and treatment – must be addressed in a comprehensive land use planning context.

The theme of this inquiry is that labour-intensive efforts are preferable from an environmental and an economic point of view. The actual economic implications of recycling versus high-tech resource recovery have been discussed at length elsewhere (Bridgewater and Lidgren, 1981; Boston Gilbert Henry Associates Ltd., 1980; Pearce and Watson, 1977) and are not repeated here.

Finally, and in view of the problems and controversy surrounding garbage incineration and landfills, implementation of a community-based source separation program at this moment of enhanced local awareness of solid waste disposal problems (recall Table 1) could be aided and abetted by a much-needed groundswell of approval and support. Chapter 2 pursues this theme by focusing first on conservation and public participation and, second, on specific geographic and design factors that influence the effectiveness of source separation programs.

Chapter 2

LITERATURE REVIEW AND CONSULTATION WITH EXPERTS

2.1 Conservation and Public Participation

Source separation of recyclable materials is conservation practised in the home and, as such, community-based programs of this nature are highly dependent on support from the general public. Since this decentralization of responsibility could be perceived as being progressive – the spirit of community development and cooperation is encouraged at the grass-roots level – the proposed activity therefore falls within the purview of the public participation sphere.

However, notwithstanding that many citizens perceive public participation to be a worthwhile, if not esssential part of good government, that perception is not of itself sufficient to ensure public support and involvement in a cause, for two reasons. First, there are many causes competing for attention and, second, without special incentive provisions it is difficult to motivate "the occurrence of relatively inconvenient and/or time-consuming ... conservation strategies" (Geller *et al.*, 1982, p.23).

Hence, an understanding of this concept of public participation vis-a-vis conservation-related activities provides the larger context in which to set consideration of source separation program design and implementation. The first part of this chapter examines this concept by reviewing a variety of key issues such as the public good versus the social cost, the issue-attention cycle, and voluntary versus mandatory participa-

tion. Since additional factors (noted in Section 1.1) influence the effectiveness of community-based programs, they are considered in the second part of this chapter.

2.1.1 The Conserver Society Ethic

Conservation can be defined "as the management of the biosphere to yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" (Talbot, 1984, p. 136). In this context, the biosphere represents all resources that are both renewable and nonrenewable. In even simpler terms, conservation is the recognition of limits, and of increasing global interdependence in which more enlightened policies of resource management and use will help ensure long-term benefits (Galtung, 1978).

In opposition to the conservation ethic, or approach, is what has been referred to as the "twentieth century industrial dominant social paradigm", in which both resources and opportunities are considered infinite (Milbrath, 1984, p.8). Other characteristics of this paradigm include the development of capital-intensive technologies, conspicuous and mass consumption, and maximization of economic growth.

Table 8 highlights the differences between the two paradigms. Of particular note is the variance in basic philosophy. The conserver society ethic promotes the concept of doing more with less, while the consumer alternative does more with more. The conserver society's underlying theme is "the elimination, or at least substantial reduction of waste throughout the production-consumption continuity" (Valaskakis *et al.*, 1977, p. 19).

Table 8: A Comparison of the Consumer and Conserver Societies

	The Selective Conserver Society	Consumer Alternatives
	Efficiency Scenario	Status Quo
Thematic description	Doing more with less	Doing more with more
Goal	Seek maximization of well-being by minimizing waste, living in harmony with nature, and keeping options open for the future.	Seeking maximization of well-being without the constraints of conservation.
General objective	Efficiency	Growth
Specific objectives	Reduce waste without changing values.	Mixed laissez-faire
Principal strategies	Rental schemes, reform of inefficient consumption habits, tech. change, full cost-pricing public regulation.	Mixed laissez-faire
Population policy	Zero growth, excluding immigration	No definitive policy
Implications concerning growth in forward throughput	Controlled growth in forward throughput matched by growth in reverse throughput.	High growth in forward throughput and no recycling.
Possible impact on income distribution	Tendency toward egalitarian distribution.	Perpetuates income inequalities.
Impact on life-styles	Behaviour changes but not values.	Existing life-style.

Source: Valaskakis et al., 1977, p. 19.

With regard to the paradigms mentioned above and in accordance with the theories of Kuhn (1970), there is a growing consensus in the literature that we may be experiencing a paradigm shift from the consumer-oriented society to the conserver type (Milbrath, 1984; Seldman and Knapp, 1980; Castle, 1979; Shapiro, 1979; Hardin, 1979; Starrs, 1976). Seldman and Knapp (1980, p.15) are especially optimistic:

> *If the recycling paradigm fully emerges, solid waste management of the future will be implemented with inner city economics, job creation and community equity in mind, as well as environmentally safe and cost-efficient public service.*

However, as Hardin (1979. p.12) points out, for a conserver society (ie. recycling paradigm) to quickly – virtually at a crisis-response level – establish itself, energy and resources must become scarce and more expensive. Current trends indicate that oil and gas prices will remain low while supplies exceed demand (The Economist, Jan. 25, 1986, p.63; The Economist, May 24, 1986, p.66), and as developing nations in Asia, Africa and South America (with substantially cheaper labour) bring resource extraction industries on-stream, the price of natural resources is expected to drop even further (The Economist, May 3, 1986, p.90; The Economist, April 12, 1986, p.13). In light of these developments, the motivation to recycle goods due to their intrinsic value of a recycling philosophy weakens.

Regardless of the reasons given above, however, some recycling will occur, in part because the problems associated with the disposal of solid waste will not resolve themselves, and in part because waste difficulties are becoming increasingly common as an urban feature (Waste Age, 18(1), January 1987). Resolution of the problem is therefore being attempted, or at least considered, where many geographical concentrations of commercial or industrial activity occur.

Human settlements, as has been documented elsewhere, place tremendous demands on the natural environment (Miles, 1979; Harlick, 1974). Land use stress can

take many forms; however, few local land uses are as undesirable or socially stressful as the establishment of a landfill site or a waste incinerator. It follows, therefore, that the case for conservation should become stronger when it is considered that if people (as generators of solid waste) are part of the problem, then they should be a part of the solution.

Conservation in the urban environment requires significant and enduring amounts of public participation. Dasmann (1984, p.407) suggests that "the larger and more complex the metropolis, the less able is each individual to help himself". This image of the helpless individual appears to fly in the face of any program such as source separation which seeks to decentralize responsibility as a means towards possible solution. Seldmann and Knapp (1980. p.14) declare that source separation "requires individual participation and an understanding and overt acknowledgement of one's status as a citizen in a polity, a biological being in an interdependent environment". Individuals who do not, or are unable to participate (at any level) in community-related affairs may seek to justify their inaction by claiming "that technical adjustments will suffice" (O'Riordan, 1976, p. 21). This technological fix approach manifests itself in solid waste management as high-tech processes such as those listed in Section 1.4.7 (for example, incineration facilities). However, the increasing controversy surrounding such facilities indicates that, insofar as the challenge of urban conservation is concerned, the individual and the collective interest may be converging. The following section explores this theme further.

2.1.2 The "Tragedy of the Commons"

In the original essay, actually entitled "The Tragedy of the Commons", Hardin (1972) focuses on the moral implications of an over-exploited, communally-owned resource. In that case, a pasture is shared by a medieval cattle herder and his neighbours. Each herder has free access and equal rights to graze cattle on the commons. There is a point of equilibrium at which consumption of grass (by the cattle) equals production of grass. If one herder adds one cow, the balance is upset, but most of the benefits will accrue to him personally while most of the costs will be dispersed amongst all the herders. All the herders will conclude that if they do not add an extra cow someone else probably will. Therefore, everyone increases his herd so that, as a result, the commons becomes hopelessly overgrazed.

O'Riordan (1976, p.29) identifies two classic issues from the "Tragedy" story; 1) selfishness versus enlightened public spiritedness, and 2) short-sightedness versus an interest in the longer perspective. An optimist might claim that a group of humans sharing a limited resource, a commons, would necessarily opt for the course which would guarantee survival – mutually beneficial altruism. Quite clearly, the commons has a limited environmental carrying capacity. For Hardin, it is mankind's inability to recognize the finite nature of "spaceship earth" that constitutes the tragedy.

> *In a crowded world, tragedy is created whenever individual enterprisers, pursuing their own self-interest, degrade the world for everyone including themselves, as they do if they are allowed to throw unlimited wastes into the commons of air or water, or to catch fish without limit from the commons of the ocean (Hardin, 1979, p.14).*

The social and environmental costs in a society where people "are allowed to throw unlimited wastes into the commons" will invariably result in an enormous accumulation. The present "fouling of the nest" will eventually have personal repercussions. In the meantime,

> *consumers are never made aware of the ultimate consequences of their actions when they contribute to the waste stream, and there is no mechanism that provides them with a distinct incentive, other than perhaps a moral obligation, to adjust their consumption patterns in accordance with a less wasteful way of life (Boston Gilbert Henry Associates, 1980, p. 4).*

Several questions arise. Just how prevalent is this "moral obligation"? How enduring is it? And, even more importantly, How can there be obligation or commitment without a fundamental understanding of the greater issue at hand?

It might be assumed, in response to questions of this kind, that people who voluntarily participate in a program such as source separation probably do appreciate, in some way or another, the gravity of the solid waste problem. Unfortunately, however, the evidence available suggests that there is a discouraging lack of understanding of the need for a closed-loop system in which materials circulate and waste is minimized.

There is, in effect, a poorly developed sense of individual and collective responsibility towards environmental and resource development issues (Francis *et al.*, 1977). As a result, society's well-being is frequently measured by "economic indices which often count environmental degradation as positive gain" (Francis *et al.*, 1977, p.8; and see Starrs, 1976).

In the literature on eco-development, there is some concern that the conflict between individualistic and collective purpose leads to a corresponding incompatibility between community and environment (Chévalier and Burns, 1978, pp.8-9). In view of the phenomenon of solid waste and our current collection and disposal procedures, that concern is justified because "our present society reinforces a perception of unresponsibility. We don't accept responsibility not because we deliberately choose not to but because we don't even see it as ours " (Starrs, 1976, p.126). In other words, garbage which is disposed out of sight is subsequently out of mind.

What then is the essential difference between the individual good and the public good? De Laet (1972, p.122) comments as follows;

> *Society imposes constraints of many kinds on individual behaviour as it affects the common good. The individual voluntarily accepts certain codes of behaviour, based on an understanding of benefits and penalties to his physical, social and economic well-being. What we understand is what affects us directly, and we actively support measures that promote our direct interests. But what is not immediate and does not confront us directly, individually, and unequivocally, we tend to overlook and regulate responsibility elsewhere.*

If one were to accept the premise that "pollution is primarily a social problem" (De Laet, 1972, p.122), what role should the individual be expected to play? Hardin (1972, p.103) suggests that "a person will accept responsibility for a task only if there is some benefit to be gained", and O'Riordan (1976) believes that each person will pursue his or her own self-interest without concession, right up to the point of collapse. These Malthusian perspectives are countered by Leyhausen's (1971, p.109) claim that where population density is tolerable, "sacrifices made for a common cause will, one way or another, pay dividends to the individual and contribute to his own fulfillment" (1971, p. 109). In essence, if individuals are not prepared to bear the personal costs – time, effort, and inconvenience – of adopting environmentally-sensitive behaviour which respects the larger good, then the tragedy of the commons will become altogether too frequent.

2.1.3 The Issue-Attention Cycle

What was touched upon in the last section was the concept of public understanding or appreciation of a problem that affects the common good. The negative externalities of solid waste disposal (contamination of groundwater by leachates, methane gas build-ups, local opposition, etc.) have already been elaborated on and will not be reiterated here. Insofar as the issue-attention cycle is concerned, the "issue" is whether waste and environmental deterioration is a problem worth solving.

According to Downs (1972, pp.39-40), the issue-attention cycle has five stages:

(1) the pre-problem stage

(2) alarmed discovery and euphoric enthusiasm

(3) realization of the cost of significant progress

(4) gradual decline of intense public interest

(5) the post-problem stage.

In the pre-problem stage, the dilemma-to-be is in the process of developing. The disposal of solid waste is a case in point because of the time-lag factors which may be expressed by the following chain of events: materials accumulate at a site; rainwater percolates through the site; groundwater is contaminated; and, contamination is subsequently identified as a public health and safety issue.

The second stage of the issue-attention cycle is often manifested by a dramatic event in which the public becomes simultaneously aware of the problem and alarmed about it. Undoubtedly, "the media help to activate public interest and give the impression, at least, of aroused public opinion" (O'Riordan, 1976, p.255). In this sense, the media frequently sensationalizes and/or politicizes the issue during the course of providing the public with news about the event or matter.

Traditional public reaction during this stage, as suggested by Downs (1972, p.39), is that "every problem can be solved without any fundamental reordering of society itself". Such an attitude helps to maintain the status quo and the consumer-oriented paradigm (see previous section). De Laet (1972, p.132) reminds us that "all problems are not necessarily susceptible to merely technical attack".

In the third stage, the public begins to realize that the costs of solving the problem are unexpectedly high. This derives from the public and private focus on the technolgi-

cal fix, which may be expensive in its own right, but may also be perceived as expensive because the option of this route draws on funds used for other purposes, or requires that additional costs or taxes be imposed. This stage represents the peak of the issue-attention cycle; the optimism of stage two has been transformed into the realism of stage three.

A gradual decline of intense public interest marks the fourth stage. The costs are now seen as altogether too high, the difficulties too numerous. The public becomes discouraged or bored, attention wanes, and then another issue enters stage two and diverts interest to it (Downs, 1972, p. 40). The extent of the media's influence during this stage is uncertain; however, coverage of "the story" and public interest in it are more likely interrelated than not.

The post-problem stage finds the issue in a state of "prolonged limbo" (Downs, 1972, p.40). Every now and then public interest will become aroused, only to settle down to previous apathetic levels. Reasons for this can be attributed to saturation of the public conscience, administrative inertia, technological failures, lack of funds, lack of viable or "acceptable" solutions, or lack of public willingness to forego self-interest in order to advance the common good by contributing time, effort or money.

As suggested above and as documented in the literature, there is support for the general proposition that "participation is episodic and crisis oriented" (O'Riordan, 1976, p.253). In the absence of controversy and/or community activism, public interest in environmental issues quickly dissipates.

Is the disposal or processing of solid waste subject to the oscillations of the issue-attention cycle described above? There are two reasons why the solid waste issue should not fade from the public mind. First, solid waste is accumulated by every

household, every day, and garbage pick-up occurs on a weekly or even bi-weekly basis. This degree of regularity acts as a constant reminder of the solid waste phenomenon.

And, second, the solid waste disposal problem has reached such a degree of difficulty in many urban areas that proposed solutions to the problem hold real or perceived negative consequences for increasingly larger numbers of residents (Gilday, 1986). Hence, for reasons of its ever-present nature, and its capacity to create controversy and therefore headlines, one might expect the topic of solid waste disposal to achieve and maintain a relatively high profile.

From the literature reviewed, public concern for environmental issues has clearly moved from one stage of the issue-attention cycle to the next. Fifteen years ago, environmental problems were placed somewhere between stages two and three (Downs, 1972). Shortly thereafter, it was declared that this issue was in a definite state of decline, meaning stage 4 (Schatzow, 1977). However, and as suggested by Wellar (1982), environmental awareness or enthusiasm has tended to follow the ups and downs of economic growth and urban expansion. Therefore, given the recent economic resurgence of 1985-86, it is no surprise that the environment has again become a top concern for both Canadians and Americans as revealed in recent public polls (Matthews, 1987; Plaskin, 1986).

This discussion of the public interest brings us back to its episodic- and crisis-oriented nature. On the other hand, as negative externalities of the solid waste disposal problem spread, various groups will be adversely affected, perhaps resulting in the galvanization of community spirit and cooperation referred to briefly at the end of the last chapter. At this point then, in the early part of stage three of the issue-attention cycle, a program dependent on public support for success could be introduced and promoted as a viable alternative to other more expensive options.

2.1.4 Voluntary Source Separation

The concept of voluntary source separation is straightforward in principle. Residents are asked to separate, for example, newspapers, cans, and glass from their regular refuse. These recyclable materials are put aside or placed in special containers provided by the sponsoring organization. If the community has curbside collection, residents can participate in the program by placing materials at the curb on the assigned days of the week, if they so wish. In urban and rural areas that have depots, residents are invited to bring sorted recyclable items to those locations. A person participates according to his or her own inclination. Community officials may try to stimulate public interest in a local recycling program through promotional or educational strategies. Factors influencing the effectiveness of source separation programs are dealt with more thoroughly in Section 2.2.

2.1.4.1 Who Participates and Why

The success of a community-based program obviously depends on who participates and why. Environmentally-relevant behaviour manifests itself in selected portions of the population according to various socio-demographic and economic characteristics (Hickman, 1985; Milbrath, 1984; Turner, 1983; Belch, 1979; Cohen, 1979; Goodacre and Sher, 1979). The research conducted in this area (see previous references) attempts to determine the probability and spatial distribution of supportive behaviour from the general public.

From the literature, distinct character types have been observed to have a strong tendency towards socially and ecologically responsible behaviour. In other words, participation levels are relatively high for the kinds of individuals noted in Table 9.

Table 9: Character Types Having Socially and Ecologically Responsible Behaviour

(1) Well-educated (Milbrath, 1984; Tracy and Oskamp, 1983-84; Geller et al., 1982; Belch, 1979; Weigel, 1977; Arbuthnot, 1977)
(2) Relatively high in occupational status (Geller et al., 1982)
(3) High income earner (Hickman, 1985; Jacobs et al., 1984; Cohen, 1979; Weigel, 1977)
(4) Middle income earner (Milbrath, 1984)
(5) Younger (Belch, 1979)
(6) Older (Hickman, 1985; Milbrath, 1984)
(7) Increasing family size (Hickman, 1985)
(8) Socially liberal and open-minded (Geller et al., 1982; Belch, 1979)

As can be seen from the research findings noted in Table 9, some of the results contradict each other. For example, Hickman (1985) and Jacobs *et al.*, (1984) observed that participation in source separation programs was often higher in neighbourhoods with higher housing values. In contrast, Milbrath (1984) determined that those income earners in the lowest and highest brackets were more concerned about materialism than environmentalism.

With regard to age, Belch (1979) discovered that younger men and women should be targeted for social marketing procedures, that is, efforts to induce environmentally-sensitive behaviour, because they have a vested interest in the future. In more recent studies, Hickman (1985) and Milbrath (1984) found that concern for the environment increases with age.

It is not, however, the purpose of this section to attempt to reconcile the differences in past findings on age and income. Rather, the differences are mentioned to highlight the limits of attempting to generalize from various geographically-,

sociologically-, demographically-, or economically-specific samples to (other) populations.

Besides age and income, other characteristics, such as education, help provide an overall description of the kind of person who demonstrates some form of environmental concern and/or who might participate in a program such as source separation. Education, especially, appears to be a well-documented attribute of the ecologically cognizant and aware individual (Table 9).

As for the connection between attitude and behaviour, it has been examined at length (De Palma, 1983; Geller *et al.*, 1982; Humphrey *et al.*, 1978-77; Zimbardo and Ebbesen, 1970; White, 1966). The general impression gathered from a review of the literature is that pro-ecological attitudes do not always manifest themselves as pro-ecological behaviours. In other words, people can and do extol the merits of conservation without actually practising it. As Humphrey *et al.*, (1978-79, p.124) point out, being environmentally concerned does not necessarily help to reduce the problem of waste. Action is required.

To further understand the position of the individual, consideration might be given to Kantrowitz's (1985) five-stage decision-making pyramid, in which she attempts to draw the link between attitude and behaviour. This progression begins with awareness and is followed by interest, exploration, belief, and finally, action. Although the capacity for human decision-making is mostly psychological in nature, it is mentioned here because of its planning implications. An understanding of how and why an individual makes certain choices – to participate or not – might enable the researcher to identify or suggest various agents of change or approaches which could encourage that individual to willingly cooperate in a home-based conservation program.

2.1.4.2 Behavioural Modification Approaches

On the basis of materials examined to date, it appears that most of the research on voluntary participation in recycling or related conservation-oriented activities, has focused on the ways and means in which it can be stimulated (Pardini and Katzev, 1983-84; Macey and Brown, 1983; Luyben and Cummings, 1981-82; Luyben and Bailey, 1979; Geller *et al.*, 1978-79; Arbuthnot *et al.*, 1976-77; Reid 1976; Witmer and Geller, 1976). The major shortcoming of behavioural modification techniques, as reported in the literature, is that changes in behaviour are usually short-term and, thus, programs such as source separation which rely on public participation are eventually jeopardised as program novelty and/or interest declines (Arbuthnot *et al.*, 1976-77; Witmer and Geller, 1976).

Where cooperative behaviour is sought, a large degree of emphasis must be placed on publicity, information and education campaigns, and these all have varying effects (Schnelle *et al.*, 1980; Turner, 1983). According to Geller *et al.*, (1982, p.127), however, simple education and advertising procedures have been "relatively unsuccessful in encouraging participation" in recycling programs and they cite five sources in support of their claim.

Relatively inconvenient and /or time-consuming activities are usually abandoned by the general public fairly quickly. Therefore, more than just the correct information and guidelines are required. This has resulted in the concept of positive reinforcement in the form of prompts, rewards, prizes, raffles and contests. It is generally recognised that individuals have a stronger tendency towards participation whenever some kind of incentive is offered (Geller *et al.*, 1982, p.152; Humphrey *et al.*, 1978-79, p.111; Hall and Ackoff, 1972, p.358).

The duration of public participation and commitment, though, is still in question. In particular and because money is reputably such a powerful persuader, how effective are cash-rewards in stimulating participation? McClellend and Canter (1981, p.14) summarize as follows: Experimental research on the effects of positive reinforcement on conservation has "indicated that positive financial incentives can lead to some conservation, at least for a limited time (3 to 10 weeks). However, ... the effects have often faded over time; and many residents seem unaware of or uninterested in the monies available". Pardini and Katzev (1983-84, p.246) see the situation similarly yet in different terms:

> *Highly attractive external incentives will not be effective in promoting enduring changes in recycling because they bring such behaviour under the control of external inducements, rather than the individual's own conviction about the value of recycling.*

Commitment to recycle, based on intrinsic motivation, may be more effectual and lasting than participation for contingent rewards. On the other hand, some combination of intrinsic and extrinsic incentives may be what is called for, although this could have some unanticipated consequences. According to De Young (1984, p.42), extrinsic incentives such as cash rewards or tax breaks may actually reduce an individual's intrinsic desire to recycle rather than to support it. People should not become dependent on rewards to "do good".

Even if financial incentives did induce people to source separate recyclable items, how cost-effective would such a system be? According to Jacobs *et al.*, (1984, p.127), "procedures that facilitated the greatest levels of participation were not always cost-effective". How negative environmental externalities such as pollution or depletion of natural resources were determined in this instance, was not made clear. Even the social costs associated with source separation are matter-of-factly considered in economic terms (Clayton and Huie, 1973, p.9). The true cost of solid waste disposal may be much higher than expected.

In this case however, it does not make strict economic sense to pay individuals for recyclable items that may well be worth less than the payment. Perhaps full life-cycle costing (Francis *et al.*, 1977, p.2) would attach a more realistic social, economic and environmental value to wastefully produced and wastefully disposed goods. If such a costing process were established, the utility of source separation and public participation would become clearer. Municipal officials and waste managers might then decide that measures beyond behavioural modification and beyond voluntary participation are called for.

2.1.5 Mandatory Participation

In much of the literature on "the Conserver Society" (Dasmann, 1984; Milbrath, 1984; Hardin, 1979; Castle, 1979; Shapiro, 1979; Ritchie, *et al.*, 1979; O'Riordan, 1976), there is a growing sense of urgency with respect to the seriousness of our environmental deterioration. In the words of Castle (1979, p.19) "we have come within sight of the limits of our planet's capacity to sustain past rates of growth in human demand on finite resources". As a consequence of this, and because "the great majority of people do not have a strong urge to participate" (Milbrath, 1983, p.98), ordinances that make participation in community-based programs mandatory are now being considered throughout North America.

One study of U.S. cities with source separation recycling says that mandatory programs are not more effective than voluntary ones (SCS Engineers, 1974), while another study claims that they are (Cohen, 1978). States such as New Jersey which are heavily populated, highly industrialized and limited in size strongly support local cities that adopt mandatory recycling by-laws. The following two sections discuss this matter further.

2.1.5.1 The Element of Coercion

If, as has been suggested, "maladaptive human behaviour" is at the root of the current ecological crisis (Tracy and Oskamp, 1983-84), some element of coercion may be necessary in order to induce ecologically responsible behaviour. Freedom to act in the commons must be tempered by the virtue of necessity (B.F. Skinner, 1971).

In his book entitled The Ecological Transition, (1976, p.293) author John Bennett suggests that coercion is

> *required to ensure a reasonable degree of conformity to a conservationist or sustained yield policy. The word "coercion" has acquired an unpleasant connotation in a society preoccupied with individualistic freedom, and yet no human society has ever been able to exist without it. Coercion is a "bad" thing when it is imposed on top of permissive arrangements, but once institutionalized, resentment usually abates or disappears. The initially coerced conformity becomes an accepted routine of life; hence, human "adaptability" can facilitate the development of a system with greater respect for the environment along, of course, with the ability of humans to develop consensus.*

It would appear, however, that consensus is needed first on the gravity of the problems we all face before mutually beneficial coercion could be implemented. Unfortunately, what constitutes a problem or a necessity for one person or group, is not necessarily the same for another.

In an effort to reconcile differences – temporal, spatial, political, economic, social and environmental – compromises are frequently considered or required. For example, if smoke from a factory has a negative influence on nearby farms or residents, should the factory be re-located? To re-locate the factory may have a negative effect on its productivity. In cases such as this, the aim is often not to eliminate the smoke completely, but rather to secure the "optimal" amount of smoke pollution in order to a) reduce its negative influence on the surroundings and b) maximize the value of production (Coase, 1972, p.115).

In this example, the factory clearly has a vested interest in its own production process. The same could be said for a company which, from an environmental perspective, manufactures excessive packaging. The point made here is that it is not in the aforementioned plant's immediate or short-term interests to internalize the costs of these negative environmental externalities. However, since decisions made in the plants have the potential to negatively affect the public good, should not the companies be obligated to make "needed" adjustments to their production processes? Such a question has moral and philosophical implications beyond the scope of this thesis. It remains, however, that where public, private, individual or group participation is concerned, the idea of coercion or obligation is highly controversial.

Establishing the need for coercion, then, is the first problem.

The second problem is determining how people will react to it once implemented. Insofar as mandatory participation is concerned, the public is either for it, against it, or indifferent. The most vocal of the three groups would naturally be comprised of those who disliked intervention or regulation of any kind. An extreme expression of this sentiment comes from Skinner (1971, p.38); "Those who manipulate behaviour are said to be evil men, necessarily bent on exploitation. Control is clearly the opposite of freedom, and if freedom is good, control must be bad".

Legislated social change, such as mandatory participation, can often result in conflict (Sterngold and Kotler, 1979, p.195). Both Opperman (1979) and Turner (1983) agree that mandatory separation of recyclable items can lead to public resentment of compulsion, possibly resulting in non-participation or poor source separation (for example, contamination of categories).

One of the most important aspects of a community-based conservation program, as touched upon in previous sections, is the cultivation of appropriate behaviours. According to Macey and Brown (1983), that can be accomplished by offering incentives, or by the use of control. The objective is to make recycling, for example, a part of the individual's routine or habit. "Once the behaviour has been carried out with some frequency, the present findings suggest it is likely to continue" (Macey and Brown, 1983, p.138). Based on that premise, participation should be mandatory first (in order to entrench the behaviour) and then voluntary.

In effect, responsibility works well only when the decision-maker(s) and the person(s) affected by the decision are one and the same (Bennett, 1976, p.292). This situation has led some (namely Hardin) to conclude that, ultimately, "responsibility must be enforced for it can never be achieved by voluntary means" (O'Riordan, 1972, p.29). This rather Draconian point of view is countered by those who have more faith in mankind to "do the right thing". Bregha (1977, p. 120) in particular believes that "participation is an act of free will" and that "it can be promoted but it cannot be decreed". Leyhausen (1971), as quoted earlier (see Section 2.1.2) seems to concur with Bregha on this matter.

2.1.5.2 Legal-Regulatory Approaches

There are a number of reasons for implementing ordinances or by-laws which make source separation mandatory. First, public participation is a key ingredient in the success of source separation, and mandatory programs reportly have higher participation rates (Pettit, 1986, p.53). Second, and in contrast to the first, voluntary participation can be highly variable. Third, "the public believes that passing laws cures problems" (Pearson, 1977, p.229). And, fourth, making source separation mandatory

indicates to the local community that recycling is a priority issue, thereby drawing attention to and creating awareness of the solid waste disposal problem at hand.

However, following Wellar's problem appreciation triumvirate (1984), awareness of a problem frequently is not sufficient will lead to some action towards resolution of it. As a second step, people must be made to understand (the seriousness of) the problem and, third, they must be persuaded to act. Making something mandatory is, ultimately, very persuasive.

The first problem with mandatory recycling is the potential for a negative public reaction, as discussed above. The second associated problem is that of enforcement. In a 1978 survey of source separation collection programs in the United States, 61% of 51 communities responding to an ordinance enforcement question declared that the ordinance was enforced (Cohen, 1979, p.4). Strong enforcement could mean fines or dis-continuation of pick-up service of all refuse for those individuals refusing to comply. Weak enforcement could involve a phone call or a notice reminding householders to participate. There is no literature available on the cost-effectiveness of the one or the other type of enforcement. As mentioned above, other non-economic externalities would have to be considered in such an analysis.

2.2 Factors Influencing the Effectiveness of Source Separation Programs

At the outset of Chapter 1 it was stated that although the issue of voluntary versus mandatory source separation is a critical one, there are other factors that must be taken into account. In addition, these factors are all interrelated in ways which make it very difficult for the researcher to isolate and examine any specific factor. This second part of Chapter 2 explores selected aspects of this complex situation.

2.2.1 Identification and Explanation of Factors

There are three groups of factors that must be considered, each affecting the relative success or failure of community-based recycling. These are: community character; actual program design; and promotional considerations. The following three subsections discuss each of these groups of factors.

2.2.1.1 Community Characteristics

Community characteristics can be categorised and examined in various ways. For the purposes of this study the charcteristics of primary concern are;

- community type
- demographics
- community size
- geographical location
- local waste consciousness

Much of the importance attached to the socio-economic and demographic characteristics of a community comes from the literature on voluntary conservation behaviour (see Section 2.1.4). For example, those people who are married and have children, university education and higher incomes, may have a greater tendency towards participation in source separation programs (Taylor, 1986). In an impoverished or relatively less well-off area, residents likely would have preoccupations other than conservation, which may seem ironic because conservational practises such as reduce and reuse can save money.

Another significant factor is thought to be community size: the smaller the community the higher the participation (Oppermann, 1979, p.22). The concept of "small is beautiful" as developed by E.F. Schumacher (1973) is very much a part of the Conserver Society philosophy. Further, it has been suggested that smaller scale communities are needed within larger urban areas so that the individual has something with which to identify (Miles, 1979; Starrs, 1976). This proposition is further examined in forthcoming chapters.

As for the geographical location of the community in question, the importance of this characteristic lies in its proximity to the markets. By way of illustrating this point, high transportation costs from isolated communities can easily reduce typically narrow profit margins for private recycling enterprises, or increase the public cost of municipally-run endeavours. Further, plants that de-ink newspapers or recycle glass and tin are most often located in more densely-populated areas, that is, close to the sources of recyclable materials.

Overall public consciousness or concern about the problem of solid waste disposal will also affect residents' willingness to participate. For example, in the Region of Halton, in Southern Ontario, a pilot multi-material curbside pick-up program being run in Aldershot is achieving 96% participation (Taylor, 1986, personal communication). Aldershot is very close to both the old landfill site for the region and the proposed new landfill site. Consequently, residents are aware of the problem and what they can do to help alleviate it. Conversely, a community which is less directly affected by similar concerns is less likely to garner such widespread support for a recycling program.

2.2.1.2 Source Separation Program Design Factors

The second group of factors to consider in developing a community-based recycling program involve a multitude of program design elements. These are;

- type of program (curbside, depot, buy-back)
- curbside collection frequency
- fractions collected (multi-material, single-material)
- preparation requirements
- provision of special containers
- reliability of pickup service
- voluntary versus mandatory participation

There are basically three source separation program types:

1) Curbside collection offers the resident the greatest convenience by picking up recyclable items in the same way that regular refuse is collected.
2) Depot programs require individuals to bring recyclables to specific storage locations, which are often situated at shopping centers or other well-used places.
3) Buy-back facilities are similar to depots with the added incentive that individuals are paid for their sorted items.

State-of-the-art programs are those which combine all three types such as is done in Kitchener, Ontario.

Multi-material curbside programs have different collection frequencies. A pick-up service can be weekly, bi-weekly or monthly, and recyclable items can be collected separately from or simultaneously with regular refuse.

With regard to fractions collected, of the more than 200 source separation programs operated by communities in the U.S., almost all collect newspapers while approximately 20% of them collect glass, cans and other metals as well (Waste Age, 17(2), 1986, p.90). The materials that are sorted for recycling generally need to be cleaned; papers need to be bagged or bundled; cans sometimes have to be flattened and labels removed; and, all materials have to be stored until collection day.

It is noted and emphasized that separation programs which involve too much preparation or involve too many categories can cause non-compliance and/or costs in excess of benefits (Tichenor, 1976, p.24).

The evidence is becoming increasingly clear, on the other hand, that provision of special storage and set-out containers lends itself to increased participation and, as a result, increased diversion rates (Resource Integration Systems Ltd., 1983). That is, the container indicates to the resident that the program is a serious undertaking, it acts as a constant reminder, and participation becomes more convenient (Resource Integration Systems Ltd., 1982, p.114).

On collection day, in Kitchener, the regular presence or absence of a conspicuous bright blue container at the curb indicates to everyone who is participating and who is not. Peer pressure can be a very effective agent of social change (Middleton & Associates, 1975).

The importance of reliable and consistent collection service cannot be overstated. Programs that are disorganized or mismanaged will soon defeat themselves. As Macey and Brown (1983) suggest, for regular recycling behaviour to establish itself source separation must become a part of the individual's daily routine, and hence the need for a reliable and simple collection schedule.

The efficiency of a recycling program may depend on who operates it. The three basic types of operators are municipalities, private enterprises, and non-profit groups. No literature was found on the comparative virtues of each type, although one might speculate that a profit-motivated recycling system would be run as efficiently as possible. Undoubtedly, a successful program will attract higher participation levels (Taylor, 1986, personal communication).

Finally, voluntary and mandatory participation are also factors to be considered in designing a source separation program. The advantages and disadvantages of each have been presented at length so as to contrast their respective merits.

There is, however, a lack of research on the respective impacts on solid waste diversion of voluntary versus mandatory source separation (Hickman, 1985; Turner, 1983, p.89; Opperman, 1979, p.213). It is important to emphasize, again, that these two factors must be examined in consideration of a community's character (Section 2.2.1.1) and all the other program design factors noted in this section (Taylor, 1986; Reinfeldt and Tullock, 1982; Opperman, 1979).

2.2.1.3 Promotional Considerations

Public education and promotion are extremely important in creating the proper kind of environment in which community-based programs must be set. The two elements of primary concern with respect to promotion are;

- type
- frequency

The element of publicity is of growing significance in the recycling business. If we recall Kantrowitz's (1985) decision-making pyramid (Section 2.1.4.1) or Wellar's (1984) problem appreciation triumvirate (Section 2.1.5.2), public education and information programs are crucial as they stimulate awareness and interest in any given issue, and these are essential before appropriate source separation behaviours can be adapted. Effective publicity results in a social diffusion of ideas. Geller *et al.* (1982, p.203) believe that "programs need to be implemented with components that will lead consumers to evaluate their conservation efforts as successful and subsequently to tell others of the beneficial outcomes and methods for obtaining such outcomes". Such components would entail feedback mechanisms and good public relations.

After basic public education and information campaigns have been launched, usually just prior to program implementation, ongoing promotional efforts must be established. Jerry Powell, editor of Resource Recycling, observed that the three things needed most in getting a community-based program started are (1) promotion, (2) promotion, and (3) promotion (Stephenson, 1985).

Some means of publicity that have been used are presented in Table 10.

In Noord Brabant, Holland, researchers also found that newspapers had the greatest promotional impact, followed closely by the promotional effect of the container itself (Joosten, 1980, p.18).

After the recycling program has been implemented, the general public requires some kind of feedback as to the impact and relevance of its effort. Schnelle *et al.* (1980) found that newspaper feedback was effective in reducing a community's litter problems. Promotional efforts in the form of feedback, participation prompts, or program advertising should be run at least four times a year (Taylor, 1986, personal communication; Mackenzie, 1985; Seldman, 1983).

Table 10: Various Means Used for the Promotion of Recycling

1. - newspapers
2. - circulars
3. - announcements to/from civic groups
4. - radio spots
5. - posters
6. - school programs
7. - speeches
8. - letter from the mayor or government official
9. - TV spots
10. - calendar showing collection dates
11. - notices in utility bills
12. - contests
13. - buttons.

Note: Means are listed in decreasing order of importance according to Cohen (1979, p.81).

Another effective promotional tactic is the blockleader approach. Volunteers in Boulder, Colorado for example, are trained to knock on doors, explain the virtues of recycling, show how residents can participate and pass out literature. Ann Arbor, Michigan and Minneapolis, Minnesota have similar programs, although the prototype is in Boulder. Foot-in-the-door approaches – survey, personal appeal and then a letter – to prompt and/or reinforce participation have been shown to work but the effects are usually short term (Arbuthnot *et al.*, 1976-77, p.356). Therefore, program promotion and public awareness must be regularly attended to in order to maintain critical participation levels.

2.3 Summary

The purpose of this chapter is, first, to address a variety of concepts perceived as relevant to conservation and public participation and, second, to introduce an array of factors that should be considered in the evaluation of source separation programs.

As discussed above, the major obstacle to establishing conservation-related programs appears to be comprised of three components(Wellar, 1984):

1) making the general public aware of the problem at hand,
2) making the general public understand the significance of the consequences arising from the problem if it remains unresolved, and
3) persuading the general public to participate in the resolution of the problem.

Unfortunately, as noted in this chapter, apparently critical issues that may adversely affect everyone have a way of fading in and out of public focus. As a result, it is essential that planners and program implementers be cognizant of local issue-attention patterns. It would be decidedly advantageous to launch a community-based program at the "right time".

Conservation in the urban environment emerges as an attractive and sensible concept in view of the growing solid waste disposal problem. However, source separation of recyclable materials from the municipal refuse stream requires individual commitment, even though the benefits of such efforts accrue to society as a whole and not necessarily to each participating individual in a direct pay-back manner.

Therefore, getting people to participate in the resolution of a community-wide problem requires that 1) everyone accept some responsibility for it voluntarily; or, 2) laws be introduced legislating the behavioural change needed. The decision as to which

approach is more appropriate will naturally vary from community to community according to the extent or degree of the local solid waste disposal problem.

Of particular interest to this study is the issue of voluntary versus mandatory participation in source separation programs. From the literature reviewed and consultation with experts, there appears to be some question as to which type of participation is preferable in terms of program success. Further examination of this aspect is presented in the following chapters. However, and as indicated in Sections 1.1, 2.2 and elsewhere (Turner, 1983), various factors other than the type of participation must be taken into account in attempting to ascertain what influences the viability of source separation programs, and why.

Chapter 3

STATEMENT OF RESEARCH PROBLEM

3.1 General and Research Hypotheses

Depending on program design, local community characteristics and promotional efforts, the nature of a recycling initiative will, of itself, affect the amount of municipal refuse going to landfill. In other words, there is a relationship between the three factor groups above (first introduced in Section 2.2.1) and the success or failure of a recycling program. The research hypotheses which follow examine this general idea more closely. It is re-emphasized at the outset of the chapter that the primary objective of this research is to determine if there is a significant difference in the amount of MSW reduction arising from the implementation of voluntary versus mandatory source separation.

The research objective is indeed problematic. Therefore, for the reasons given above, and because of the differences in MSW diversion or reduction arising from a mandatory versus voluntary program, further differences in MSW diversion or reduction may also arise as a result of such participation level factors as container provision, number of sorted categories, preparation effort, collection frequency, promotion, program duration and program size.

Attempts to isolate factors in order to examine them and their effect on the dependent variable (diverson per capita per year) may lead to dubious if not spurious conclusions, given the interdependent nature of the factors. Analysis of the data is therefore

divided into two parts. First, each of the hypotheses presented in Sections 3.1.1 through 3.1.7 is examined with all other features or factors held constant. A summary of research hypotheses is presented at the end of this chapter in Table 11.

Second, in order to examine the combined influence of the independent variables on the dependent variable, stepwise multiple regression is utilized. This "search process" ranks the independent variables according to their contributions to the total variance (Yeates, 1974). More is said on this topic in Section 4.5.

As noted above, the variable used to measure the extent of a program's success is diversion, in per capita terms. The reported amounts of solid waste recycled are in tons. These figures are multiplied by 2000 for conversion to pounds, and then divided by the participating (source separating) population of each community.

It is appropriate to acknowledge at this point that at least three ways have been identified to measure program performance. That is, according to the literature, "program performance can be judged in three ways; participation achieved, waste quantities diverted, and collection productivity" (Heron, 1977, p.50). However, since participation and collection productivity are both difficult to measure and/or are unreliable in most cases, the diversion or capture rate is selected as the dependent variable for each hypothesis set forth in Sections 3.1.1 to 3.1.7.

3.1.1 Voluntary versus Mandatory Participation

Insofar as public participation in a source separation program is concerned, the first research hypothesis may be expressed as follows;

H1: Source separation programs with mandatory participation have higher diversion rates than voluntary programs.

This hypothesis is based on the premise that there is a positive relationship between participation and diversion rates (Cohen, 1979). Furthermore, research conducted by the New Jersey Office of Recycling has shown that rapid and dramatic increases in diversion rates can be achieved by applying a mandatory ordinance in a community where voluntary recycling is already established (Hertzberg, 1983c, p.18). However, consensus on this matter has not been achieved: "People do not respond if you have a mandatory program. Telling people that they must separate their garbage just wouldn't work" (Bernstein, 1986, p.14). With all other things being equal, the pertinent question is, Are mandatory source separation programs necessarily more effective than voluntary ones?

It is possible, obviously, that the quality of participation by those who voluntarily partake in source separation could be superior to that of those who are obligated to participate. In other words, on a per capita basis, the rate of diversion with voluntary source separation could be greater than the rate associated with a mandatory program of participation. Although an additional hypothesis could be formulated to examine this relationship, and it might lead to valuable findings, it is not pursued for two reasons. First, the quality of participation data is very suspect (Powell, 1986, personal communication) and, second, its measurement is not yet standardised.

3.1.2 Provision of Containers

It is now generally recognised that specially designed recycling containers help make source separation more convenient and, as a result, both participation and diversion rates improve (Resource Integration Systems Ltd., 1983; Geller *et al.*, 1983, p.151).

These containers tend to vary in size and shape, from place to place. One study suggests that because containers will often be stored in the wrong place (an inconvenient or relatively inaccessible spot), a more attractive container amenable to in-house or possibly in-kitchen use should be designed in order to foster still higher levels of participation (Jacobs *et al.*, 1984, p.130). This notion could be tested using control groups and differently designed containers; however, what is important to this study is the presence or absence of <u>any</u> type of container.

Of the total number of source separation programs surveyed (see next chapter), three-quarters indicated that a special container was not provided. The research hypothesis which examines this relationship is expressed as follows:

H2: Programs that include the use of special containers have higher diversion rates than those which do not.

This study provides an ideal opportunity to re-examine the significance of household collection containers and, in addition, to test the "normality" of the programs surveyed.

3.1.3 Number of Categories and Preparation Requirements

Convenience, as emphasized previously, is a critical ingredient in mustering and maintaining public support for any community-based program. It has been stated that "actual cooperation in a waste paper recovery program is inversely related to the personal effort required to participate in this kind of activity, even when attitudinal receptivity to such an environmental program is very favourable" (Humphrey *et al.*, 1978/79, p.122).

In empirical terms, then, What effect do convenience factors have on the rate of solid waste diversion? Turner (1983, p.123) noted in a related study that while it would have been desirable to do so, "it was not possible to assess whether fewer preparation and separation requirements for householders improved yields or participation rates". This section provides the research hypotheses that are subsequently tested to contribute to the body of empirical evidence about the importance of convenience to the success of source separation programs.

Two components of source separation that require individual effort are: 1) the number of categories or fractions into which waste must be sorted, and 2) the way that sorted materials must be prepared before they are collected. According to Tichenor (1976, p.21), "The decision as to what materials and how many categories of materials should be recycled must strike a balance between maximizing economic rewards and minimizing household problems". In other words, if participants are required to sort waste into more and more categories and employ more and more elaborate waste preparation routines, then that critical balance may not be achieved.

Hypothetically then, there is a preferred number of categories into which waste should be sorted with an preferred amount of preparation requirements. The research hypotheses therefore are:

H3: The fewer the number of sorted categories the higher the diversion rates.

H4: The lower the preparation effort the higher the diversion rates.

3.1.4 Collection Frequency

The frequency and timing of the collection of recyclables is another factor which is subject to variation from community to community. It has been suggested in this regard that recyclables should be picked up at the same time, or at least on the same day, as regular refuse (Jacobs *et al.*, 1984, p.127). That point of view is not examined in this study, however, since neither the pre-test questionnaire nor consultation with experts elicited the sense that the timing aspect of the collection process warranted such detailed examination. As a result, the frequency of collection for recyclables and regular refuse was surveyed in terms of once a week, every two weeks, every three weeks, or once a month.

Notwithstanding that participants do not necessarily set out recyclables for every collection, the question remains as to whether there is an optimal frequency at which such a service should be offered. The best system is purportedly once a week (same day as regular garbage collection) because that schedule is the easiest for the general public to remember (Taylor, 1985, personal communication; Heron, 1977). The research hypothesis which examines the matter of collection frequency therefore reads as follows:

H5: The more frequent the collection rate the higher the diversion rates.

3.1.5 Publicity and Promotion

There is a general understanding that promotion of source separation and recycling before, during and after implementation helps to enhance public participation (recall Section 2.2.1). Indeed, individuals cannot knowledgeablely participate in nor contribute to "the cause" unless they appreciate the essential who, what, where, when, why, and how behind it.

Publicity and promotion can vary in form and frequency. However, as Taylor (1985, personal communication) points out, this dimension of source separation is not always affordable, and as a result is often ignored. What is needed in order to understand the significance of this dimension, therefore, is some means of classifying the degree of publicity used by each program. A scale of varying intensity is used as the means of relating program success to level of promotional effort.

Turner notes that "reliable measure is not available for the output or effects of ... education programmes" (1983, p.132). Insofar as source separation is concerned, the best measure for the output or effects of promotional efforts is taken to be diversion rates. In research hypothesis terms, the significance of publicity and promotion to the success of waste separation programs is expressed as follows:

H6: Programs that have "more intensive" promotion have higher diversion rates.

3.1.6 Duration of the Program

The duration of a source separation program is obviously a measure of its success, all other things being equal. That is, a program that survives for a year is, *ceteris paribus*, more successful than a similar program that lasts only for a week, given of

course that the need or reason for the program remains. A well-established and successful program will naturally attract attention and support in the same way that a winning team seemingly has the most fans.

It has been observed that "participation in source separation tends to rise with lengthening programme duration" (Beattie, 1985, p.16; Goodacre and Sher, 1979, concur). On the other hand, however, another study found that cooperative behaviour actually deteriorates over time (Humphrey *et al.*, 1978/79, p.124). In view of the conflicting positions about the increase or decrease of participation rates over time, and the confirmed concerns about the reliability of the participation index, diversion figures are used to measure program success.

Based on the discussion above, the following research hypothesis is appropriate:

H7: As program duration increases diversion rates increase.

Program duration, as measured in this study, begins with implementation of a full program (and not just a pilot program), and runs through until the end of 1985.

3.1.7 Community Size

According to the literature community characteristics and especially the community's socio-economic and demographic make-up, significantly influence the success achieved by community-based conservation programs. Unfortunately, and regrettably, both for reasons of questionnaire design, and incomplete or vague responses to questions by respondents (Ackoff, 1953, pp.300-302), it is not possible to use the data collected to examine the relationship between community characteristics and program success in the communities that responded to the questionnaire.[2]

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[2] The two major constraints with regard to questionnaire design were 1) limited

Population statistics, on the other hand, are relatively easy for respondents to provide. With respect to recycling, it has been suggested that smaller communities are expected to have higher diversion rates (Opperman, 1979), which leads to the following research hypothesis:

H8: Smaller communities have higher diversion rates than larger ones.

3.2 Summary

Of the eight research hypotheses advanced above, five (H1, H2, H3, H4 and H5) are concerned specifically with the actual design of a source separation program, one (H7) examines the nature of program durability, another (H8) is concerned with community size, and one (H6) investigates the influence of publicity. The research hypotheses are listed as a set in Table 11.

A number of other factors that might influence the success of source separation programs were identified and discussed, but were not formulated as research hypotheses for two very compelling reasons. First, community characteristics such as socio-economic status, geographic location and local waste consciousness could not be subjected to testing as statistical hypotheses (due to the problem of measurement or data collection). Hence, the research hypotheses involving those features were foregone. As a caveat it is additionally noted that these community characteristcs are not pursued in this study in part because they would have placed an undue burden on repondents (given all the other data demands), and also because the complexity of the domain warrants separate study in its own right.

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resources and 2) the desire not to over-tax respondents with data requests.

Table 11: Summary of Research Hypotheses

H1:	Source separation programs with mandatory participation have higher diversion rates than voluntary programs.
H2:	Programs that provide special recycling containers have higher rates of diversion than those which do not.
H3:	The fewer the number of sorted categories the higher the diversion rates.
H4:	The lower the preparation effort the higher the diversion rates.
H5:	The more frequent the collection rate the higher the diversion rates.
H6:	Programs that have more intense promotion have higher diversion rates.
H7:	As program duration increases diversion rates increase.
H8:	Smaller communities have higher diversion rates than larger ones.

Similarly, although reliability of pick-up service is regarded as an important factor in program success, it is not included as a research hypothesis candidate because of measurement difficulties.

Second, the focus of this study is on program design and, therefore, although the factors mentioned above are significant enough to influence the effectiveness of source separation programs, they are considered to be outside the scope of this research.

Finally, a potential problem in any at-home source separation program is quite simply the lack of space for accommodating refuse containers within residential units. In one survey Humphrey *et al.*, (1978/79, p.115) "found that as living space decreased, reluctance to sort garbage increased".

To paraphrase their finding, with less space to store recyclable items until collection, the less willing are residents to participate. While such a premise is untestable in the context of this research, there may well be circumstances (for example, where multiple-unit structures are involved) that warrant giving serious consideration to storage space as a factor in the design of in-house recycling containers.

Chapter 4

RESEARCH DESIGN

4.1 Identification and Location of Source Separation Programs

Source separation recycling programs normally offer one, or two, or a combination of all three of the following services:

- curbside pickup,
- drop-off depots, and
- buy-back centers.

Depending on the scope of the program, residents are asked to separate anywhere from one to six or more recyclable items. For the purposes of this research, as discussed in Chapters 1 and 2, programs included in the source separation survey offer at least curbside collection and are multi-material (more than one category sorted) in nature. Further, programs surveyed are in urban rather than rural or regional municipalities. Finally, the data for each program are for 1985, which required that each program had to have run throughout all of that year. Obviously, program duration involves an accounting of years before 1985, wherever necessary.

Establishing the North American population of multi-material, curbside collection recycling programs proved difficult. Various experts and state or provincial recycling associations were contacted by telephone or mail in order to locate all source separation programs in Canada and the United States that met the criteria listed above. Although the literature indicates that there are now over 200 separate collection pro-

grams in the U.S., only 20% of these can be classified as multi-material and curbside (Waste Age, 17(2), 1986, p.90).

In an even more recent study, published after the analysis of responses was initiated, 43 programs were identified in 28 states (Pettit, 1986). Part of the problem in compiling a complete inventory of candidate programs is that of knowing about such programs in the first instance. By way of illustration, even though a program such as that in Boscobel, Wisconsin is reputably quite successful (Pettit, 1986, p.53), one requires a contact name or address in order to initiate a data search. Hence, although questionnaires were mailed to 37 U.S. programs, since they were identified during the data collection phase of the study, Pettit's list does add another 28 recycling programs to the universe of programs in the U.S. which could be included in a subsequent inquiry.

In Canada, there are reportedly 91 curbside programs of which an undetermined number are multi-material (Recycling Council of Ontario handout, 1986). Inquiries directed to the Recycling Council of British Columbia resulted in only one program (Saanich) being identified out of 17 potential or claimed recycling programs. Reasons for the differences between actual and estimated or claimed programs could be attributed to the fleeting nature of recycling programs. However, mis-information, mis-directed communication, or simply dis-interest in responding to the inquiry could also account for a less-than-complete inventory.

The identification of numerous candidate programs in Ontario occurred late in the data collection phase. The Ministry of the Environment (MOE) reported 53 operating curbside programs as of December 31, 1985. However, many of these can be disqualified because they do not meet all the criteria outlined at the beginning of this section. Since 14 programs began sometime during 1985 and another 17 are not mulit-material

in nature, there are conceivably 22 eligible programs in Ontario.[3] Of these, 59% or 13 programs are included in the survey.

In the province of Quebec, correspondence with the *regroupment des récupérateurs à la source* revealed seven source separation programs, two of which met the criteria of this study. The 1985 data for only one of these, Ancienne-Lorette, could be secured.

All qualifying programs that could be identified and located were examined in terms of whether they met the criteria noted at the beginning of this chapter (multi-material, curbside pick-up, full 1985 operation and located in an urban municipality).

It is acknowledged in closing this section that the population of recycling programs is much larger than 53 (37 U.S. programs, 13 from Ontario, two from Quebec and one from British Columbia) since the National Solid Waste Management Association's (NSWMA) recent survey included various other programs (Pettit, 1986). However, upon realizing after a great deal of investigation that there is no definitive list of recycling programs in the U.S. or Canada, an operational decision was made. That is, the decision was made to proceed with the surveying of all programs initially identified (37 U.S. plus five Canadian). The alternative of then continuing the search for data on more programs arose when their hitherto unknown existence became apparent (eleven Canadian). Every effort was made to include as many multi-material curbside programs in the survey as possible. In Appendix C, the names and addresses of all the programs that were surveyed are presented.

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[3] The word "conceivably" is used because an undetermined number of programs reported on having curbside collection of newspapers plus depots for glass containers and metal cans. In the absence of that distinction being made, 22 is assumed as the base number.

4.2 Development of Questionnaire

Due to the geographical dispersion of the programs in question, the mailed questionnaire was considered to be the most cost-effective means of obtaining the needed data. Further, so as to minimize the burden on respondents, the questionnaire was designed to be as direct as possible, focusing primarily on program design and performance, community characteristics, promotional activities, and other qualitative aspects.

The questionnaire was pre-tested in sequence by three qualified individuals. The first draft was substantially modified after review by the Director of the Recycling Council of Ontario (Taylor, 1986, personal communication). A second draft was submitted to the Waste Management Co-ordinator of the City of Ottawa and various recommendations were subsequently adopted (Bury, 1986, personal communication). Third, the Wasteplan Manager from the Regional Municipality of Ottawa-Carleton received a draft for her perusal and further adjustments were made (Poirier, 1986, personal communication). A cover letter was also pre-tested with the latter two individuals. It is presented in Appendix D along with the questionnaire.

Part of the questionnaire concerns landfill facilities for an obvious reason. An important and practical concern of the research is to examine the effectiveness of source separation programs in terms of landfill life extension.

In other words, given a projected landfill life, a community's MSW generation rate and the amount of solid waste diverted fro the landfill by means of recycling, a key question arises: What would be the implications for the remaining life of the landfill site? However, and unfortunately, in terms of pursuing that question, only three of the 31 questionnaire responses provided landfill capacity figures. The vast majority of pro-

grams reported landfill life in terms of years remaining (always approximated). As a consequence, diversion of recycled material (pounds per capita per year) rather than remaining landfill life became the dependent variable with which to test the various factors that influence the effectiveness of source separation programs.

As mentioned previously, there is considerable interest in the type of community involved in a successful (or unsuccessful) recycling campaign. For example, other studies have considered the average value of houses or average family incomes as indicators of socio-economic status (Chamard, 1984). The following question was therefore included in the source separation survey: "In general socio-economic terms, how would you describe your community?"

However, as the questionnaire was sent to program operators (public, private, and non-profit), such information would not necessarily have been readily available. The question as phrased does beg rather subjective responses and, as a result, a research hypothesis involving commmunity characteristics not pursued.

At the bottom of the first page of the questionnaire, a matrix was presented so that respondents could tabulate various data through time. Responses that utilized the matrix in the intended way revealed interesting performance patterns, generally all progressing from one year to the next. The purpose of this time-series matrix was to secure a general understanding of each program's past performance.

The question, "How much municipal solid waste is disposed in your landfill?" was based on the expectation that most communities have weigh scales. This, unfortunately, is not the case. However, of the 39 programs included in the analysis stage, MSW data for 34 was made available either through their responses or from other sources.

The question pertaining to landfill disposal fees was included in the questionnaire in order to discover whether a specific economic cost was incurred by each community. Two problems arose. First, of the ten communities included in this survey and that of the NSWMA, only two disposal fees coincided, which indicates that the data are unreliable. Second, although respondents were requested to report their disposal fees in dollars per ton, many did not.

On the second page of the questionnaire, a series of questions are posed in order to elicit insights, not readily reducible to "hard data", with which to complement the quantitative aspects of the questionnaire. Such questions were included so as to help establish a broader understanding of the solid waste disposal issue as it affects different communitites throughout North America.

4.3 Assumptions and Limitations

Insofar as the research design of this study is concerned, a number of simplifications, assumptions and limitations need to be made explicit.

It is appropriate to begin this section of qualification at a general level by re-noting and re-acknowledging that the issues under consideration are environmental, social, political, economical, and geographical in nature (Section 1.3). Clearly, only a selected few of the issues that influence the effectiveness of a source separation program are embodied in the research hyptheses. However, from a scientific inquiry point of view, such simplification is acceptable and necessary, especially with regard to the initial development of models that attempt to represent a complex reality.

Second, with regard to assumptions, it is assumed that economic parameters such as market conditions and cost performance are of no concern in the operation of a successful source separation program. Such an assumption eliminates a critical dimension that, in the recycling field, so often determines the fate of these programs. Generally speaking, "recycling is justified only if the revenues generated, together with the 'avoided disposal costs' a community would otherwise pay, are at least as great as the cost of collection, processing and marketing" (Pettit, 1986). In the absence of costs not being met by revenues, programs often receive subsidies.

In the short run, subsidization of recycling programs may appear unsustainable; however, conventional garbage collection and landfilling procedures are always publicly supported through municipal funding or direct residential charging. At a Wasteplan workshop (Ottawa, 1985), the following point was made: When options are evaluated do we expect them to make a profit, break-even, or reduce current (or future) waste management costs? Such a decision should consider other costs in addition to economic ones.

The free market fluctuation of commodity prices, according to the laws of supply and demand, can wreak havoc on recycling operations. Where the margin between being in the black or in the red is narrow, a drop in the price of newsprint, for example, can close a program down altogether, as was the case in the City of Ottawa in 1981. Consequently, recycling programs in Ontario at least are being brought on-stream gradually so as not to oversaturate this part of the market (Taylor, 1986, personal communication). To reiterate, even though the economic aspect of recycling is of vital significance in the operation of a source separation program, it is considered to be outside the scope of this research.

A final assumption made concerns the generation of solid waste. That is, it is assumed that the industrial/commercial sector will support recycling as a worthwhile activity. In fact, the concept of recycling of beverage containers, for example, is not necessarily in the industry's best interest since (1) virgin materials are still abundant and relatively cheap and (2) that particular production infrastructure (recall Figure 3 in Section 1.4.6) is already well-established. Only government intervention in the form of rules and regulations is likely to produce any sort of industrial metomorphosis or shift towards the recycling paradigm discussed in Section 2.1.1.

For the purposes of this study, the problem of solid waste disposal is taken as a given even though waste reduction measures can be effectively applied at the point of generation (within the production/consumption function depicted in Figure 3).

Third, with regard to acknowledged limitations, one of the major limitations of this study, and others in this field, is the lack of confidence in the reliability of data. According to Powell (1986, personal communication), editor of Resource Recycling, there are primarily three problems with data on source separation programs:

(1) In many cases source separation data simply do not exist;

(2) If the data do exist they are often measured differently from program to program;

(3) In the absence of data, some operators may fabricate statistics in order to make their programs look more successful than they really are.

The prevalence of data unreliability in this field suggests that much work remains to be done. Various agencies and councils in Ontario, for example, are currently moving in that direction.

Finally, there is an inherent representativeness limitation in the study due to research design. That is, the status of all recycling programs is represented by just those programs for which responses were received. In point of fact, then, coverage and any findings are biased towards the situations of respondents.

Further, since responses are more likely to flow from successful as opposed to unsuccessful programs, the coverage and findings would tend to be biased towards good news rather than bad news situations. While this "tilt" in the data base poses statistical problems, it remains that the responses which were received covered a wide range of programs.

As the study progresses through the analysis stage, the assumptions and limitations presented in this section warrant being borne in mind by the reader.

4.4 Data Collection and Organization

The questionnaire was applied according to a multi-wave, follow-up procedure. That is, potential respondents were given roughly two to three weeks to return the source separation survey questionnaire. A post-card reminder was then sent to those who had not responded. One to two weeks later, a second questionnaire was sent out to those organizations that still had not responded. Ideally, a telephone call would then have been made to those still not responding and this was done in two cases. Unfortunately, the cost of using the telephone to prompt responses from more than just a couple of American organizations was beyond the resources available. In the case of Ontario where the cost of long-distance calls is less, all the necessary telephone contacts were made.

Of 42 questionnaires sent in the main batch, 15 were returned without any prompting. The post-card reminder yielded six more responses, including one which had not received the questionnaire and another claiming to have returned a completed form. With the mailing of the second questionnaire, there were nine more responses. One questionnaire sent to Fresno CA yielded six responses of which four met the criteria listed in Section 4.1. Two telephone calls to the United States resulted in two more responses. Programs that were not multi-material and curbside in nature, and had not run throughout 1985 were disqualified. This eliminated five of the original 42.

Subsequent to sending out the main batch of questionnaires, a number of qualifying programs were located in Ontario (nine) and Quebec (two). By means of other studies (Chamard, 1984), a government-commissioned survey (Recycling Council of Ontario, 1986), and numerous telephone calls (within Ontario), all the required data were secured. The final response rate from all organizations receiving the source separation survey was 76.2%.

Due to the importance of the data base to this and subsequent research studies, and to the public at large, an extra measure of attention is given to this part of the study. In particular, to preserve the data in a disaggregated state, a tabular format is used to ensure correspondence between each community and the data provided regarding the various factors and diversion characteristics. The data for all programs included in the survey (as well as three programs that met all the criteria except a twelve month run through 1985) are presented in Appendix E.

With respect to the data, three levels of measurement are used; nominal, ordinal, and ratio. Table 12 lists the factors (the independent variables) and the dependent variable (*) according to the scale of measurement employed. A brief descriptor is included under the CHARACTERISTIC subtitle.

Table 12: Measurement of Variables

SCALE	VARIABLE	CHARACTERISTIC
nominal	type of program	voluntary or mandatory
	provision of containers	yes or no
ordinal	preparation requirements	minimum to maximum effort required
	promotion / publicity	least intense to most intense
ratio	categories	number
	collection frequency	weekly, bi-weekly..
	duration of program	number in months
	population served	number
	diversion *	number

As is apparent from Table 12, the nominal and ratio scales of measurement are straightforward. Qualitative descriptions such as male-female, black-white, or yes-no can be represented numerically by the numbers 0 and 1. In this case, voluntary participation is 0 and mandatory is 1.

Those variables measured according to a ratio scale "consist of measures for which there are equal intervals between each discrete measurement" (Yeates, 1974, p.8) The five variables listed under the ratio scale in Table 12 can all be accounted for, one by one. In other words, one could count the number of categories to be sorted as one would count recycled bottles. Also, a program that is 24 months old is exactly twice as old as one that is 12 months old. Such is the nature of a ratio scale of measurement.

Finally, the ordinal scale of measurement arises from the process of rank-ordering. A movie, for instance, could be evaluated as excellent, good, average, or poor. A

numerical sequence of 1-2-3-4 could be applied in this case. However, the intervals between the ranks are not equal. For this study, two variables required ordinal scaling. Both of these – preparation requirements and promotion – were ranked, respectively, according to 1-2-3-4-5 and 1-2-3-4 scales. For these two variables the better end of each scale is least preparation requirements and most intense promotion. Further, the ranking is relative.

It is acknowledged that the ranking of these two variables is fraught with difficulty; however, because of their reported influence on the dependent variable, they are included in the analysis despite the subjective nature of their assigned values.

During the ranking process, five categories for residential preparation requirements emerged. These are listed as follows, beginning with perceived least effort through to perceived most effort.[4] In this arrangement, there is an accumulation of tasks; for example, category 4 includes all the preceding categories as well.

(1) Place unseparated items in any container, clean and dry.

(2) Separate from each other newspapers, cans and glass; tie or bundle newspapers; rinse cans and glass; remove lids from glass bottles and jars.

(3) Separate glass according to colour; place recyclable oil in sealable container; flatten and tie cardboard.

(4) Remove labels from cans.

(5) Flatten cans; remove plastic bits from glass.

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4 The word "perceived" is chosen advisedly since there is no known work in this field relating to a ranking process of this nature.

Promotion was treated similarly. Each category includes most of the items under it.

(1) General information provided; recycling instructions and collection schedules.

(2) Flyers, school lectures, public service announcements, periodic newsletters, utility bill inserts.

(3) Bi-monthly newsletter, monthly news release to radio or local paper, major publicity events (picnics, fairs), presentations to local groups, associations or classes.

(4) Block-leader program (door-to-door promotion/enforcement), poster contests, displays; certificates of participation, fines for non-participation.

The ordinal scale of measurement, as described above, is obviously more complicated and more subject to errors of omission or commission, or differences in interpretation on the part of the respondents, than are either the nominal or ratio scales of measurement. However, it was decided to include the ordinal scale for two reasons. First, and as Stevens (1946) points out, "Any particular scale ... may be objected to on the grounds of bias, low precision, restricted generality, and other factors, but ... no scale used by mortals is perfectly free of their taint" (p.680). And, second, it was expected that questions requiring use of the ordinal scale would provide respondents with an opportunity to report on aspects of their programs that could not be examined by measures limited to the other two scales.

The data to be analyzed are presented in Table 9. Under the heading "PLACE" are those communities which have multi-material, curbside recycling programs that ran for all 12 months in 1985. The programs in the table are organized according to program type and whether a container is provided or not. As can be seen in the table, there are four groups. Descriptive statistics for each group are presented in Chapter 5.

Table 13: Source Separation Survey - 1985

OBS	PLACE	CAT	CF	PRE	PUB	AGE	POP	SERV	DIV	DPC
					T=m C=n					
1	St. Cloud	3	4	2	1	34	44300	37655	346	18
2	Saanich	4	3	5	3	60	86000	85140	1700	40
3	Islip	6	1	2	2	38	300000	150000	10400	139
4	Longmeadow	2	1	1	1	72	16000	16000	1243	155
5	Hamburg	4	1	1	4	37	10500	10500	936	178
6	Montclair	3	2	2	2	120	38321	38321	3627	189
7	West Orange	3	3	4	2	24	39500	39500	6735	341
8	Woodbury	6	1	5	4	60	10353	10353	2935	567
					T=m C=y					
9	West Berlin	6	1	1	2	51	5300	4664	1455	624
					T=v C=n					
10	Reedley	4	1	1	1	12	11000	11000	59	11
11	Sanger	4	1	1	1	24	12500	12500	87	14
12	Athens	4	2	3	2	20	20000	20000	161	16
13	Halton Hills	3	1	1	1	51	35190	35190	442	25
14	Oshawa	5	1	2	1	127	118438	118438	1809	31
15	Welland	3	2	2	2	144	45448	36358	751	41
16	Kingsburg	4	1	1	1	36	5500	5500	128	47
17	Dundas	3	1	3	1	88	19586	16648	417	50
18	Milton	3	1	1	1	51	28067	28067	722	52
19	Thorold	3	2	2	2	72	15412	10788	304	56
20	Richmond Hill	5	1	4	1	120	37778	28334	879	62
21	Ann Arbor	4	4	5	4	84	107316	60097	2128	71
22	Burlington	5	1	1	1	51	114853	114853	4277	75
23	San Joaquin	4	1	1	1	36	2000	2000	80	80
24	Oakville	3	1	1	1	51	76720	76720	3097	81
25	Oceanside	4	1	2	1	24	76698	24543	1015	83
26	Davis	4	1	3	3	132	40000	40000	3000	150
27	Boulder	6	4	2	4	101	132500	123225	10500	170
28	El Cerrito	5	1	2	1	84	22731	22731	2686	236
29	Pelham	3	1	2	2	72	11104	7754	982	253
30	Linwood	6	2	4	2	28	6476	6476	865	267
					T=v C=y					
31	Austin	3	1	3	4	36	457000	219360	3500	32
32	Santa Monica	5	2	3	4	36	88314	87431	1655	38
33	Grimsby	4	1	2	2	60	15797	13743	334	49
34	An.-Lorette	4	1	4	3	31	13000	13000	345	53
35	Fonthill	4	1	2	2	15	7500	7200	400	111
36	Kitchener	3	1	2	3	15	142000	92300	6000	130
37	Sunnyvale	5	1	2	3	31	106618	63971	4200	131
38	Palo Alto	6	1	4	3	56	56500	45200	6956	308
39	Burbank	3	2	2	2	27	84625	42312	7200	340

'T' is program type - 'v' is voluntary & 'm' is mandatory

'C' is container provision - 'y' is yes & 'n' is no

'CAT' is the number of categories sorted

'CF' is collection frequency (every week, every two weeks, etc.)

'PRE' is prep. ation requirements (scaled 1 to 5 from least preparation to most

'PUB' is publicity or promotion (scaled 1 to 4 from least intensive to most)

'AGE' is in months, for program duration to the end of 1985

'POP' is each community's total population

'SERV' is the population actually served by the curbside program

'DIV' is diversion measured in tons

'DPC' is diversion per capita per year in pounds

4.5 Selection of Statistical Tests

As stated at the beginning of Chapter 3, analysis of data is divided into two parts. The first part examines the binomial relationship between each of the eight independent variables and the dependent variable. The second part examines the combined influence of the eight independent variables on the dependent variable.

In the first part, various statistical tests are employed according to the scale of measurement used for each variable. For example, both hypotheses 1 and 2 involve nominally measured data. A program is either voluntary or mandatory, and special containers are either provided or not. The Point Biserial Coefficient is the appropriate measure of correlation for nominal data (Shaw and Wheeler, 1985, pp.158-159). This measure is designed to examine a binomial relationship between one dichotomous variable and one continuous variable. The dependent variable falls into this latter category.

From Table 12 in Section 4.4, a second grouping of independent variables is shown; that is, variables which are measured on the ordinal scale. Both preparation requirements and promotion are ranked on scales ranging from "least" to "most". Two non-parametric correlation techniques, Spearman's rank-correlation coefficient and Kendall's tau, are applied in order to test hypotheses 4 and 6. In these applications the dependent variable is regarded as ordinally scaled. A correction factor has been adopted for calculation of the Spearman coefficient because of the large number of tied values occurring in these groups.

For the explanatory (or independent) variables that are measured on a continuous scale, Pearson's product-moment correlation coefficient is used. This coefficient measures covariance which, in words to the same effect, describes the co-variation of two

variables together (Shaw and Wheeler, 1985, p.152). This test is applied to hypotheses 3, 5, 7 and 8.

The two independent variables that are less concerned with program design are program durability and community size. Their respective relationships with the dependent variable can best be illustrated in scatter diagrams. These are presented in the next chapter along with a discussion of the findings. Table 14 summarizes the statistical techniques and matches them with the research hypotheses stated in Chapter 3.

In the second part of the statistical analysis, stepwise multiple regression is used in order to determine how much of the total variance in the model can be explained according to various combinations of independent variables. This analytical procedure also ranks the explanatory variables according to their contributions to the total variance. The stepwise multiple regression technique creates a sequence of regression equations by involving one independent variable, then two, three, and so on. The coefficient of determination (R-square) changes (improves) with each new inclusion. This forward inclusion process begins with those explanatory variables that contribute the most to the total variance. The rate of improvement of explanation diminishes as the independent variables that contribute the least to the total variance are added, latterly, to the regression model. Small increases in the R-square value reflect either the multicollinearity of the newly added independent variables (Shaw and Wheeler, 1985, p.241), or the insignificance of that particular variable.

The two independent variables measured on a nominal scale (program type and container provision) are included in this part of the statistical analysis by their inclusion as "dummy" variables. With respect to the ordinal variables, their utility lies in discussing them in terms of an "as X increases, how does Y change?" relationship

Table 14: Summary of Statistical Hypotheses and Statistical Tests

Variable	Statistical Hypothesis	Statistical Test
H1	Program type (T) (mandatory vs. voluntary) does correlate with diversion rate.	- Point Biserial Coeff. - Two-sample t-test
H2	Container provision (C) (yes or no) does correlate with diversion rate.	- Point Biserial Coeff. - Two-sample t-test
H3	The no. of sorted categories (CAT) does correlate wth diversion rate.	- Pearson's product-moment correlation coeff.
H4	The degree of preparation effort (PRE) does correlate with diversion rate.	- Spearman's rank-corr. coeff.(with correction factor) - Kendall's Tau B correlation coeff.
H5	Collection frequency (CF) does correlate with diversion rate.	- Pearson's product-moment corr. coeff.
H6	The degree of promotion (PUB) does correlate with diversion rate.	- Spearman's rank-corr. coeff.(with correction factor) - Kendall's Tau B correlation coeff.
H7	Program duration (AGE) does correlate with diversion rate.	- Pearson's product-moment corr. (simple linear regression)
H8	Community size (SERV) does correlate with diversion rate.	- Pearson's product-moment corr. (simple linear regression) - distance decay models

Note: Application of the statistical tests was greatly facilitated by use of an IBM software package called Statistical Analysis Systems (SAS). Reference to different SAS programs are made in Chapter 5, particularly in Section 5.2.

(Walizer and Weinir, 1977, p.77). Therefore, while the ordinal data are included in the

multiple regression analysis their contribution is appropriately constrained.

4.6 Summary

The research design of this study, as outlined in this chapter, is not without its operational weaknesses. First, determination of the universe or population of source separation programs in North America was not achieved. Random sampling of the population was therefore not possible.

Second, due to the geographical dispersion of the programs surveyed, a mailed questionnaire was the least expensive data collection technique available. Had more funds been available, it may have been possible to improve upon the 76.2% response rate that was achieved, thereby yielding a more representative sample. (It is noted that the 76.2% rate is regarded as "respectable" according to the work of Nachmias and Nachmias, 1985).

Third, and despite having conducted a pre-test among selected experts, but with all the advantages that hindsight conveys, some questions included in the questionnaire could have been omitted, others should have been modified, and several pertinent questions should have been added. A number of these question problems are addressed in Chapters 5 and 6.

Fourth, the initial research focus was on voluntary versus mandatory participation. Investigations conducted at the beginning of the study revealed various other factors that also influence the effectiveness of source separation programs. Eight of these factors are embodied in the hypotheses of Chapter 3; however, various other factors could not be accommodated. In particular, economic parameters were set aside. This

assumption separated the research design from the abiding reality that economic/ financial considerations frequently determine whether a recycling initiative is even launched much less successfully implemented.

And fifth, the use of three different scales of measurement – nominal, ordinal, and ratio – does introduce a degree of statistical uncertainty insofar as the multiple regression analysis is concerned.

As demonstrated in the subsequent chapter, however, none of the weaknesses is sufficient to invalidate the analyses which follow. Further, by specifying and understanding the weaknesses and shortcomings, two positive purposes are served. First, other researchers who pursue similar prospective projects have been alerted to the problems and pitfalls that affected this undertaking. Second, explicit recognition of the shortcomings in research design should temper not only the findings and conclusions of this study, and what readers might attempt to draw from the work, but should also serve to guide others who consider employing a similar research design in their efforts (Ackoff, 1953).

Chapter 5

RESEARCH FINDINGS AND DISCUSSION

In this chapter the eight research hypotheses are statistically tested and bivariate relationships are examined (Section 5.1). Selected descriptive statistics preface the respective tests in order to establish a general understanding of each independent variable. Then the multivariate analyses are presented (Section 5.2). Sections 3.1 and 4.5 provided the rationale underlying the techniques of analysis employed in this chapter.

5.1 Bivariate Analyses

5.1.1 Voluntary Versus Mandatory Participation

The research sample includes, in total, 39 source separation recycling programs. Of these, the majority (76.9%)are based upon voluntary participation. The other 23.1% have ordinances or by-laws that make participation mandatory. These proportions are similar to those found by Cohen (1979). Table 15 contains frequency and percentage distributions, as well as the mean, the median, the maximum, and the minimum figures of diversion of MSW in pounds per capita per year (the dependent variable, DPC) for each group.

As shown in Table 15, both the mean and the median DPC rates are higher (250.1 pcy versus 101.9 pcy, 178.0 pcy versus 66.5 pcy) for mandatory programs. However, statistical procedures are required to determine if inferences can be made from the research sample to the population (Walizer and Wienir, 1978, pp. 252-257).

Table 15: Summary of voluntary and mandatory source separation in terms of MSW recycled in pounds per capita per year (pcy)

Program type	f	%	Mean	Median	Max	Min
vol.	30	76.9	101.9 pcy	66.5 pcy	340 pcy	11 pcy
mand.	9	23.1	250.1 "	178.0 "	624 pcy	18 "
total	39	100.0	136.1 "	80.0 "		

The first research hypothesis is:

H1: Source separation programs with mandatory participation have higher diversion rates than voluntary programs.

The statistical testing of H1 proceeds as follows:

1) The null hypothesis (Ho) is that program type – voluntary or mandatory – is not correlated with DPC.
2) The test statistic is the Point Biserial Coefficient Test (from Shaw and Wheeler, 1985, pp.158-159). It is used here because one of the variables is dichotomous (nominal) and one is continuous (ratio). R can be used to produce a t statistic with which to test the Ho.
3) Level of significance equals 0.05; this is a two tailed test; degrees of freedom (df) = 39-1 = 38.
4) The critical region in which Ho can be rejected is defined as $t \leq -2.04$ or $t \geq 2.04$.
5) R=0.44, therefore t=2.98.
6) Reject Ho because t falls into the critical region.

On the basis of the test noted above it is therefore reasonable to conclude that there is a correlation between program type and per capita diversion; namely, programs with mandatory participation divert more solid waste per capita than do voluntary programs.

Another approach in analysing H1 is with a Two-Sample t-test in which the mean of one group (voluntary participation) is compared with the mean of another group (mandatory participation). Whether these means are significantly different is the question under consideration, as follows:

1) Ho: mean(v) = mean(m), H1: mean(v) $\neq$ mean(m)
2) Test statistics; two-sample t-test and F ratio, both produced using IBM SAS program PROC TTEST.
3) Group variances assumed equal; significance level = 0.05; df = 39-1 = 38 for t-test, and 9-1 = 8 and 30-1 = 29 for F-ratio.
4) Critical region; $t \leq -2.04$ or $t \geq 2.04$, and $F > 3.08$
5) t=3.01 and F=5.61
6) Ho is rejected for both test statistics.

This second test supports the first. Nevertheless, any suggestion that a mandatory program of source separation is necessarily more effective than a voluntary one would be an over-statement at this stage because everything else influencing the effectiveness of a recycling program has been assumed as constant or set aside. Furthermore, the difference in group sizes is substantial and may have biased the tests towards the smaller groups which may have "happened" to have relatively high DPC figures. However, to suggest on the other hand that the mean of DPC of the mandatory programs would be significantly different if that group was twice as large is unwarranted.

The point biserial coefficient test and the two-sample t-test indicate that, all other things being assumed equal, the probability of making a type I error (rejecting Ho when it is in fact true) is 0.05. In summary, and on the basis of the two statistical tests of H1, it is therefore concluded that source separation programs with mandatory participation divert more solid waste from the local landfill than do voluntary-based programs.

5.1.2 Provision of Containers

From the research sample of 39 programs it can be seen that 25.6% of them provided special recycling containers for each household served. The other 74.4% did not. Although it is generally perceived that provision of recycling containers is a critical element in any source separation program (see Section 2.2.1.2), proportional figures indicating how many programs provide them and how many do not, could not be found in the literature. Table 16, which summarizes the data collected on container provision, therefore takes on added significance as perhaps one of the few if not the first actual account of this recycling feature.

Table 16: Summary of the influence of container provision in terms of MSW recycled in pounds per capita per year (pcy)

Provision of container	f	%	Mean	Median	Max	Min
yes	10	25.6	181.1 pcy	120.5 pcy	624 pcy	32 pcy
no	29	74.4	114.1 "	75.0 "	567 "	11 "
total	39	100.0	136.1 "	80.0 "		

The second research hypothesis maintains the following;

H2: Programs that provide special recycling containers have higher rates of diversion than those which do not.

As with the first hypothesis, observation of the means and medians indicates that they are supportive of H2. The statistical tests that follow seek to ascertain whether these group means are a reflection of the population or not. Since the characteristics of the two variables under consideration are very similar to those for H1, the same tests can be applied. There are, however, two relationships to be tested here:

Whether there is any correlation between the two data sets; and,

Whether the the means of each group (voluntary and mandatory) are significantly different.

The statistical testing is as follows:

1) H'o; no correlation between provision of containers and DPC. H''o; mean(y) = mean(n), H2'': mean(y) $\neq$ mean(n)
2) Test statistics; the Point biserial coefficient, the two-sample t-test, and the F ratio.
3) Group variances assumed equal; significance level = 0.05; df = 39-1 = 38 for t-test, and 10-1 = 9 and 29-1 = 28 for F ratio.
4) Critical region; $t \leq 2.04$ or $t \geq 2.04$, $F > 2.86$
5) r =0.19, therefore t'= 1.18; t''= -1.16 and F = 2.41
6) Both H'o and H''o are not rejected because all test values fail to fall into their respective regions of rejection.

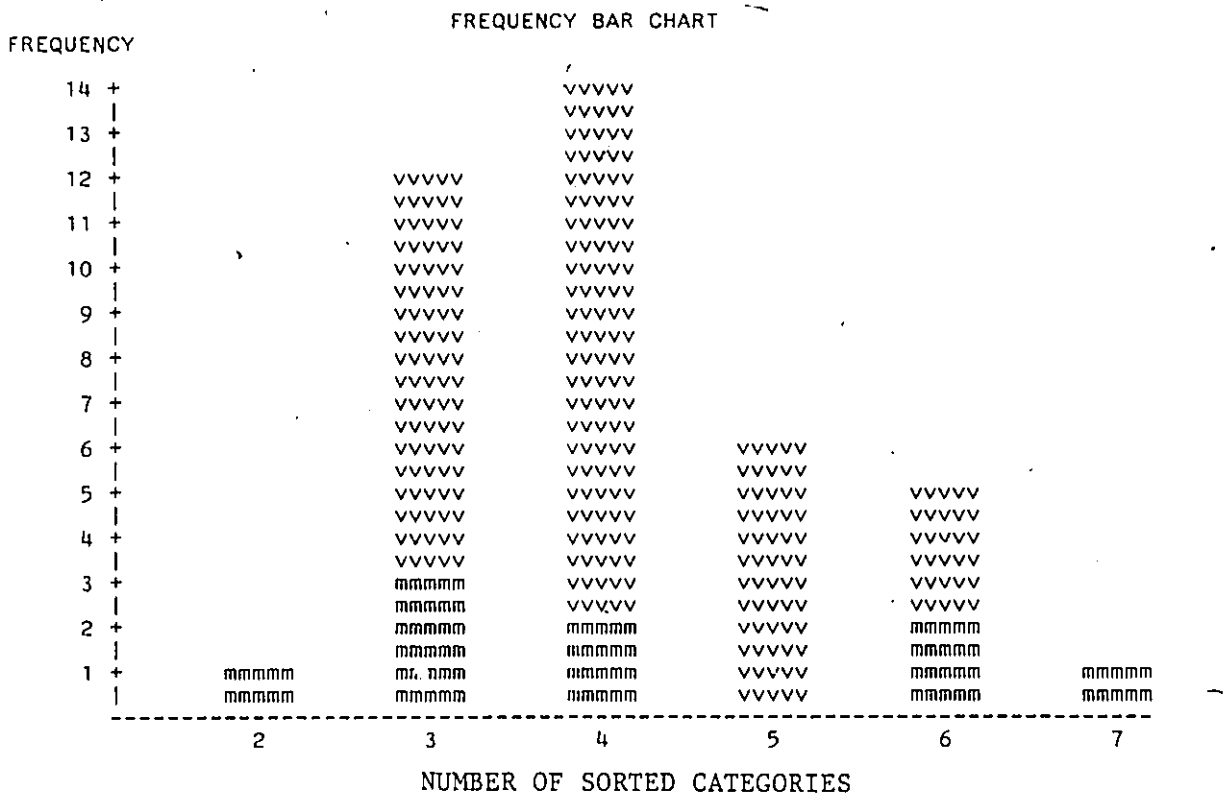
The second test supports the first. It is noted that H2 is tested with all other things being equal. Differing group sizes may have affected the analyses; however, based on

the the data collected and the tests, it appears that provision of a special container does not necessarily mean *(ceteris paribus)* that DPC increases.

5.1.3 Number of Categories

Source separation programs tend to vary in their ambition, as indicated by the number of categories into which residents are asked to sort refuse. The survey found that the range of categories is from 2 to 7. The distribution of these categories in all 39 programs is illustrated in Figure 4.

Figure 4: Number of Categories – Frequencies



In the interest of taking full advantage of the data base, a differentiation is made between those programs that are voluntary and those that are mandatory. Overall, most programs (66.7%) ask residents to sort their refuse into 3 or 4 categories. The third research hypothesis is:

H3: The fewer the number of sorted categories the higher the diversion rates.

By way of elaboration, since sorting into fewer categories is relatively more simple and convenient than sorting into many, it would appear to follow that diversion rates are higher in communities where residents are asked to sort fewer categories. Therefore, according to H3, as the number of categories increases the dependent variable should show a decrease,

Pearson's Product-Moment Correlation Coefficient (r) can be used because both the number of categories and DPC are measured on ratio scales and the statistical test is formulated as:

1) Ho: There is no correlation between the number of categories and DPC.
2) Test statistic is Pearson's r which can be converted into a t. Also, r-square is the coefficient of determination which has various interpretations (see below).
3) Level of significance = 0.05, two-tailed test, df = 39-1 = 38
4) Critical region; $t \leq -2.04$ or $t \geq 2.04$
5) r = 0.436, therefore t = 2.96; r-square = 0.19
6) Reject Ho because t falls in the critical region.

According to the test above, the correlation between the number of categories and DPC is significant at the 0.05 level. Of considerable importance is the finding that the correlation is in the opposite direction of that which was hypothesized. That is to say,

DPC evidently will increase as residents sort more categories (all other things being equal).

The question which then arises concerns the importance of convenience. The difference in effort required to sort 6 categories versus 3 is apparently not sufficient to discourage participation. Since it is possible that other factors such as provision of containers or preparation requirements influence this variable, it is re-considered in the section on multivariate analysis.

Pearson's r can be manipulated to show the proportion of the variation in one set of data that is associated with another. The computed r-square has a value of 0.19. According to Walizer and Wienir(1975, p.387), this value indicates that the strength of association between the two variables is "moderately weak". Furthermore, because the coefficient of nondetermination ($1-r^2$) is 0.81, this means that 81% of the variance in DPC cannot be predicted by or determined by the number of categories (Roscoe, 1969, p.80). Therefore, even though a significant correlation has been shown to exist (Ho rejected), there is insufficient evidence in this bivariate analysis to establish a causal relationship between the number of categories and DPC.

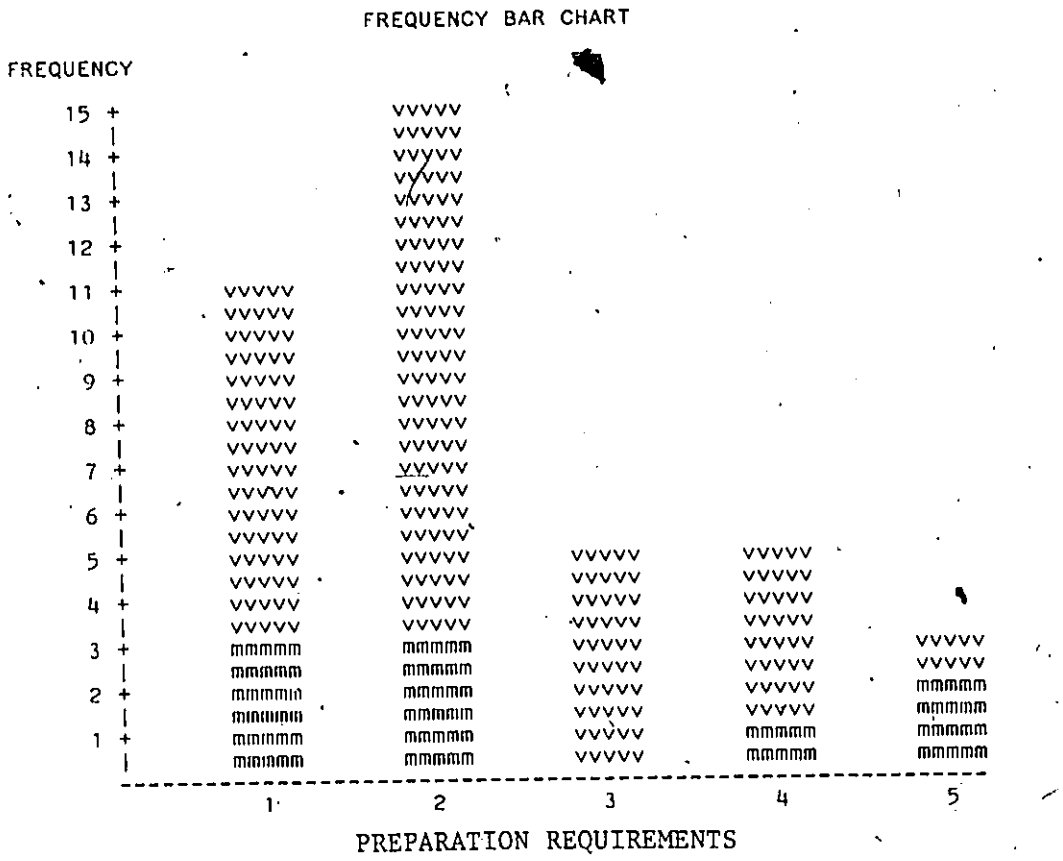
5.1.4 Preparation Requirements

Another factor to be examined is the amount of preparation that residents are required or asked to do with recyclable materials before they are picked up. This independent variable is ordinally measured from least effort to most effort on a scale from 1 to 5. The fourth research hypothesis is;

H4: The lower the preparation effort the higher the diversion rates.

Figure 5 illustrates the distribution of the varying degrees of preparation from program to program. Two thirds of the programs (columns 1 and 2) are based on low-effort levels of preparation.

Figure 5: Preparation Requirements – Frequencies



Testing of this hypothesis might appear to call for Spearman's Rank Correlation Coefficient test, r, due to the ordinal nature of the independent variable, and by means of considering the dependent variable to be ordinal in this case. However, since "r is not appropriate with table data in which numerous cases are distributed among ordinal variables with only a few values, Kendall's tau is preferable for such data" (Watson

and McGaw, 1980, p.219). Following Watson and McGaw, therefore, Kendall's tau test is applied, as is Spearman's Coefficient via the use of a correction factor to compensate for the high number of tied values (Blalock, 1972; Siegel, 1956, pp.206-210):

1) Ho: There is no correlation between preparation requirements and DPC.
2) Test statistic; Spearman's r (with correction factor) and Kendall's tau. The former can be converted into a t value, the latter a standard score (z).
3) Level of significance = 0.05, two tailed test, df = 39-1 = 38. The critical region; $t \leq -2.04$ or $t \geq 2.04$, and $z \leq -1.96$ or $z \geq 1.96$
5) r = -0.07, therefore t = -0.43; tau = 0.10, therefore z = 0.90
6) Ho cannot be rejected in both tests.

The second test supports the first. From the evidence, there is no correlation between preparation requirements and DPC. In other words, programs that require higher degrees of preparation of recyclable materials do not necessarily have lower diversion levels.

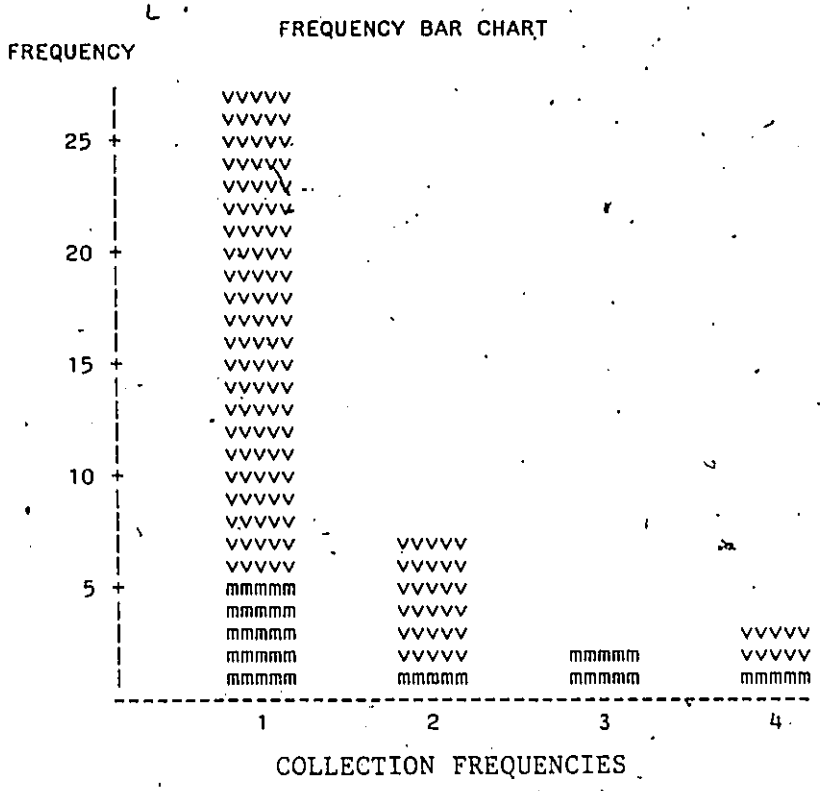
5.1.5 Collection Frequency

The best frequency for the collection of recyclable items is generally believed to be once a week (see Section 3.1.4). Of the 39 programs surveyed the majority (69.2%) have weekly collection systems. Figure 6 presents the distribution of collection frequencies for all the programs.

The fifth research hypothesis is:

H5: The more frequent the collection rate the higher the diversion rate.

Figure 6: Occurrence of Collection Frequencies



As both the independent and the dependent variables are ratio in nature, Pearson's r can be used in the same manner as with H3:

1) Ho: There is no correlation between the frequency of collection of recyclable materials and DPC.
2) Test statistic; Pearson's r which can be converted to a t value. The coefficient of determination (r-square) can be interpreted as well (see below).
3) Level of significance = 0.05, two-tailed test, df = 39-1 = 38.
4) The critical region; $t \leq -2.04$ or $t \geq 2.04$
5) R = -0.05, therefore t = -0.31; and r-square = 0.0025
6) Ho cannot be rejected

There is no evidence to suggest that a correlation exists between collection frequency and DPC. Moreover, the corresponding coefficient of determination (0.0025) is extremely small. Therefore, the variance in DPC must be explained by factors other than or in addition to the collection frequency.

5.1.6 Publicity and Promotion

The importance of promotion in stimulating participation is widely advanced as a critical element in all source separation programs. However, promotion can take many forms and is applied in varying degrees from program to program. In order to measure the influence of promotion on the quantity of materials that are recycled per capita per program, this independent variable has been measured on an ordinal scale ranging from 1 to 4 where 1 is the least intensive promotion and 4 is the most intensive. The distribution of these promotional efforts, as revealed by the survey, is graphically displayed in Figure 7. The majority of programs (69.2%) tend towards the lower parts of the scale.

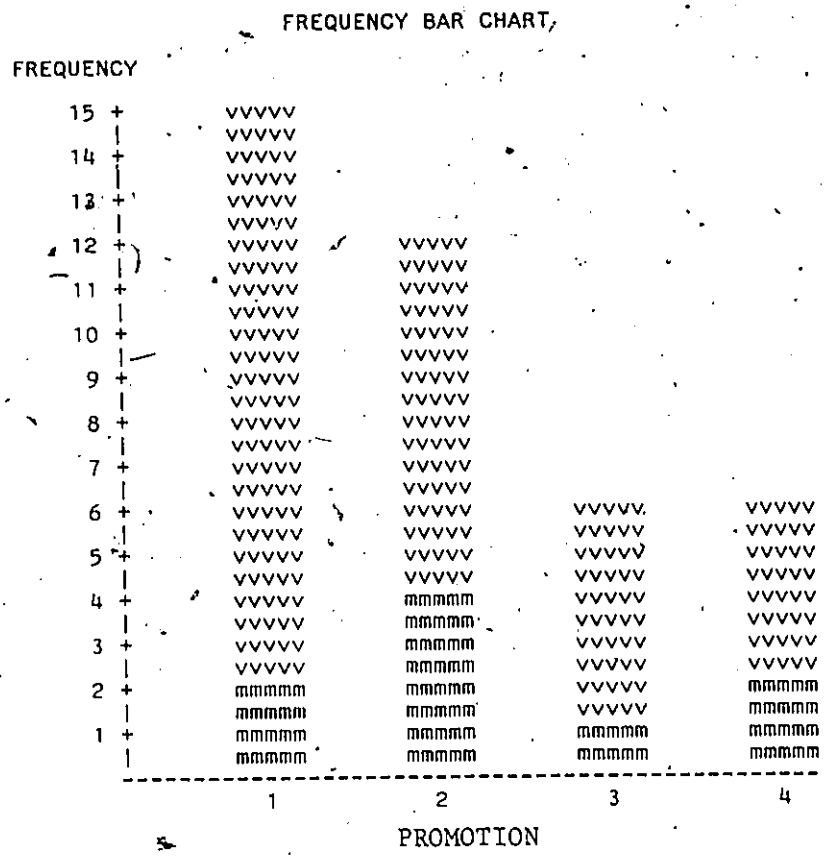
The sixth research hypothesis is:

H6: Programs that have more intense promotion have higher diversion rates.

The relationship between promotion and DPC can be treated similarly to that between preparation requirements and DPC:

1) Ho: There is no correlation between the intensity of promotion and DPC.
2) Test statistics: Spearman's r with a correctional factor because of the large number of tied values; followed by Kendall's tau. T and z conversions will be used to test the significance of the proposed relationship.
3) Level of significance = 0.05, two-tailed test, df = 39-1 = 38
4) Critical region, $t \leq -2.04$ or $t \geq 2.04$, and $z \leq -1.96$ or $z \geq 1.96$

Figure 7: Publicity and Promotion -- Frequencies



5) r = 0.33, therefore t = 2.13; tau = 0.22, therefore z = 1 97

6) Reject Ho in both cases.

From the two tests, it is apparent that there is a correlation between intensity of promction and DPC. That is, as intensity increases in form and degree, DPC evidently increases as well. The caution that must be explicitedly noted is that all other things have been assumed equal and, therefore, the reality of the situation might be other than that proposed. The section on multivariate analysis attempts to deal with possible shortcomings in the bivariate approach to examining this program characteristic.

5.1.7 Program Duration

The seventh hypothesis is concerned with the age of source separation programs. Of considerable interest to elected officals, waste managers, community planners and the public is the progress that a program exhibits over time. There are varying expectations in the field of recycling, as discussed in Section 3.1.6. The research hypothesis to be tested is:

H7: As program duration increases diversion rates increase.

In order to fully emphasize the dispersion of the data, a time series scattergram is presented in Figure 8. Again, to take full advantage of the data collected, the symbols are graphed to differentiate between voluntary and mandatory programs. As depicted along the x-axis, programs range in age from 12 months in the case of Reedley, CA to 144 months in Welland, ONT. The mean age of programs surveyed is almost 57 months. The median is 51. The dependent variable, DPC, is graphed along the y-axis. The two most successful programs, with the highest DPC values, are clearly West Berlin and Woodbury, New Jersey.

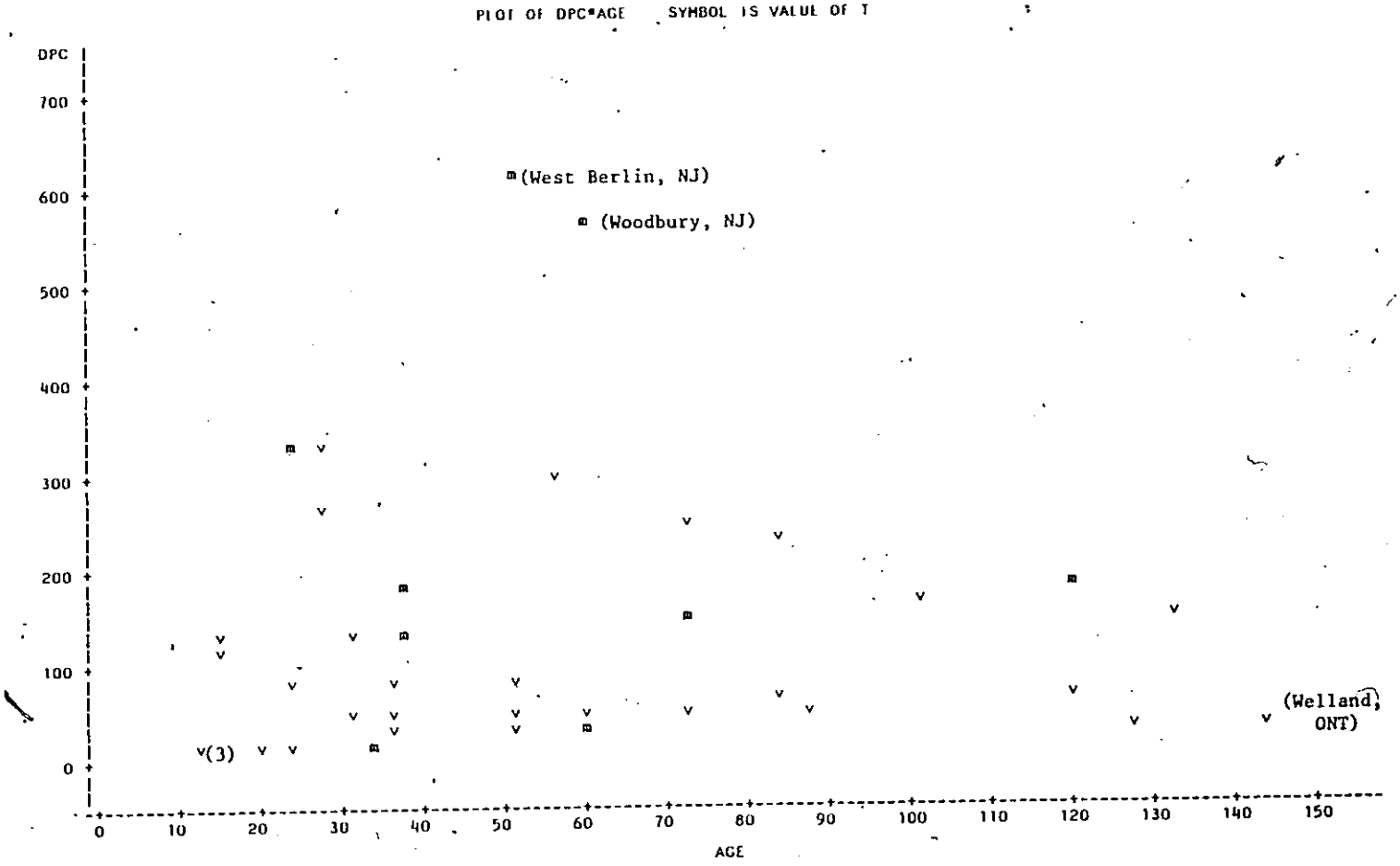


Figure 8 Distribution of Programs According to Program Duration and Diversion Per Capita Per Year

Note:
2 obs. hidden

v = voluntary participation
m = mandatory participation

For the purposes of statistical analysis it is noted that both variables are measured on the ratio scale. Pearson's correlation coefficient is appropriate to test H7:

1) Ho: There is no correlation between program duration and DPC.
2) The test statistic is t.
3) Level of significance = 0.05; df = 39-2 = 37.
4) Region of rejection of Ho is, $t \leq -2.04$ and $t \geq 2.04$.
5) r=-0.02, therefore t= -0.12
6) Retain Ho because the calculated t fails to fall into the rejection region.

On the basis of the statistical test, and visual interpretation of the scattergram, no apparent relationship exists between the age of a source separation program and its degree of success. As discussed previously (Section 3.1) "success" in this study is measured by reference to per capita diversion figures in order to accommodate the different-sized communities involved in the survey. If participation in a source separation program did increase with time then, *ceteris paribus*, DPC figures would increase as well.

Returning to the interpretation of the statistical test of H7, the coefficient of determination, r-square, is extremely small at 0.0004. Consequently, the proportion of variation in DPC as predicted by program age is virtually nil. A predicted line of regression runs horizontally along the mean value for DPC (136 pounds per person) with a very slight decline as program age increases. Therefore, the suggested association between these two variables as hypothesized in H7 is rejected, according to the data and test used.

As a final note on the relationship between program duration and diversion rate, an attempt was made in the source separation survey to gather data from each pro-

gram through time. It might have proved revealing, for example, to ascertain the successes of West Berlin and Woodbury as they evolved. Was there a jump in DPC when participation became mandatory?, is a question that can only be answered from program to program. Unfortunately, program data gathered were too weak or incomplete to pursue this matter, and as a resultthis potentially valuable line of inquiry must be left to another study.

5.1.8 Community Size

Are smaller scale source separation programs easier to implement and operate than larger ones? The eighth hypothesis examines this line of inquiry:

H8: Smaller communities have higher diversion rates than larger ones.

The independent variable is the number of people actually served by the program.

As with the previous section, a scattergram is presented in order to illustrate the dispersion of data (Figure 9). The size of each community (population served by the program) is plotted against the dependent variable, DPC. The graph symbols, m and v, are for mandatory and voluntary participation, respectively. Visual inspection of the graph suggests that there may be some form of inverse correlation. That is, as values on the x-axis increase, y values seemingly decrease. There is, however, a cluster of values at the lower end of each axis which may indicate non-correlation of the two variables in question.

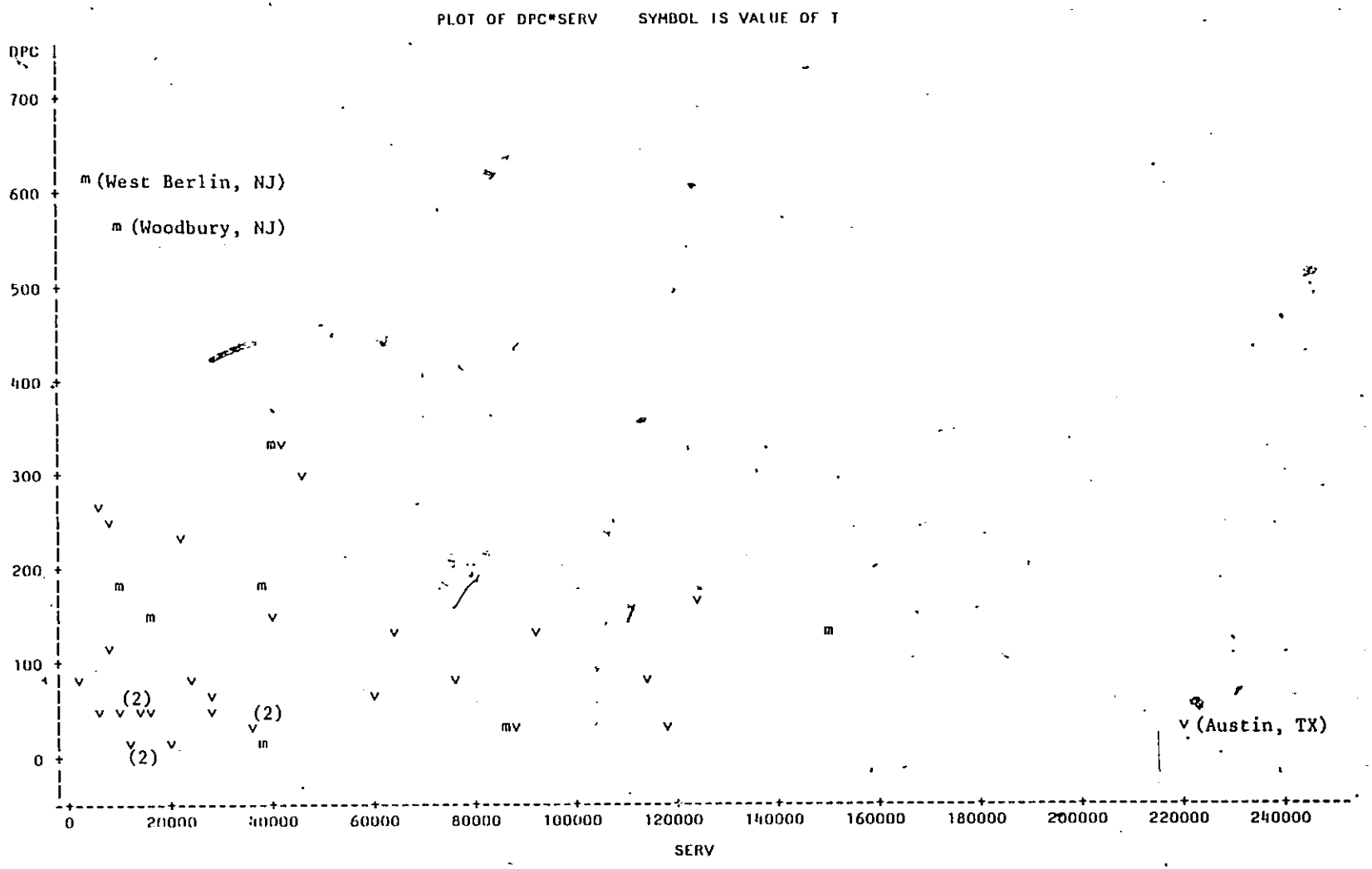


Figure 9 Distribution of Programs According to Program Size and Diversion Per Capita Per Year

Note:
3 obs. hidden

v = voluntary participation
m = mandatory participation

Since both variables are ratio, Pearson's r is applicable to test H8:

1) Ho: There is no correlation between community size and DPC.
2) The test statistic is t.
3) Level of significance = 0.05; df = 39-2 = 37
4) Region of rejection of Ho is, $t \leq -2.04$ and $t \geq 2.04$
5) r= -0.21, therefore t= -1.31
6) Retain Ho because t fails to fall within the critical region.

The test indicates that there is no correlation between community size and DPC. This finding could be considered surprising given the seeming appearance of a pattern in the graphed data in Figure 9. Anticipating that a non-linear relationship might exist in the form of a distance decay model (from Taylor, 1975), five distance decay functions were employed. In each case, the data were transformed and then linear regression lines were fitted. The test runs were accomplished by using an IBM SAS program called PROC REG (SAS Institute Inc., 1985). An r-square value for each fitted line was produced; however, these values were all (extremely) insignificant, ranging from 0.013 to 0.022. Therefore, although it might appear from a visual inspection that a power curve ($y=ax^{-b}$) might be fitted to the data graphed in Figure 9, such an expectation was not borne out.

5.2 Multivariate Analysis

As demonstrated by the bivariate analyses carried out in the first part of this chapter, the dependent variable, per capita diversion of MSW, is influenced by more than just one independent variable. For example, from Section 5.1.3, even though the correlation between the number of categories and DPC is statistically significant, the coeffi-

cient of non-determination still indicates that 81% of the variance in DPC cannot be predicted or explained by that variable alone. In order to attempt to account for a greater proportion of the variance in DPC, multiple regression is employed. The relative importance of the different variables is determined by means of stepwise multiple regression.

It is noted and emphasized that the actual prediction or estimation of DPC (from a knowledge of the independent variables) is of secondary importance. The primary concern is to ascertain the strength of the regression model. Further, the amount of variation in DPC not accounted for by the eight factors is of particular importance in this study. The multiple correlation coefficient (also known as the coefficient of multiple determination) is employed for its contribution to that end.

Finally, in multivariate analysis, the possibility of multicollinearity arises. That is, if the correlation between certain independent variables is unexpectedly high, the behaviour of the regression model will be spuriously affected. In such a case, the two correlating aariables could be combined to form one variable.

The data in question were tested using the SAS PROC CORR procedure. The highest correlation coefficient between independent variables is -0.52 (PUB and PRE). This in itself is unexpected because, according to the literature and consultation with experts, one would expect a positive correlation at the very least. That is, as programs ask more and more of their residents (in the way of preparation requirements), it would seem to follow that more promotion and publicity should become necessary.

Any incidence of multicollinearity may indicate that the regression model is over-specified. In other words, "more parameters are postulated than are needed to express the data, or the data are not adequate to estimate the model set down" (Draper and

Smith, 1981, p.258). To simplify the model, a parameter or variable – PRE for example – could be dropped, as is done in the following section.

5.2.1 Multiple Regression

This section is organized as follows: 1) all the independent variables are regressed against the dependent variable (DPC) for all 39 observations; and then, 2) stepwise multiple regression is used to rank the independent variables.

The two IBM SAS programs used to regress the data are PROC REG and PROC STEPWISE. In all cases, a multiple correlation coefficient, r-square, is derived. Furthermore, an F value and a probability-greater-than-F value are produced with which to test the significance of r-square. This latter statistic, in particular, serves to indicate the probability that the r-square value did not occur by chance.

The two nominal or categorical variables, program type and container provision, can be included in the regression model as dummy or indicator variables. As mentioned above, one of the parameters could be dropped, and is – PRE – because of its relatively high correlation with PUB and because of its singular statistical insignificance (see Section 5.1.4). Further, the variable AGE is not a factor in the actual design of a source separation program. SERV, however, is of interest in seeking to distinguish between small programs and large programs. Therefore, even though no correlation was found between community size and DPC (see Section 5.1.8), SERV is retained in the model to observe how it "behaves".

Thus, two multiple regression models are tested: 1) all independent variables, and 2) all independent variables less PRE and AGE.

In the case of multiple regression, there is a null hypothesis (Ho) that the regression model does not explain the dependent variable's behaviour. The first regression model tested uses SAS PROC REG, and the results are presented in Table 17.

Table 17: Summary of Overall Multiple Regression Procedure – All Variables Included

Source of variation	Degrees of freedom	Sum of squares	F ratio	Prob>F
MODEL	8	393954	3.914	0.0029
ERROR	30	377467		
TOTAL	38	771421	R-square =	0.5107

In this case, Ho is rejected at the 0.05 significance level because the statistic under the heading Prob>F (in Table 17) is less than 0.05 (after Shaw and Wheeler, 1985, pp.238-239). Therefore, the regression model incorporating all of the independent variables is a valid expression of the dependent variable's behaviour. It has been supposed, however, on *a priori* grounds, that all the variables are of equal importance.

The PROC REG program derives a t-statistic for each parameter estimate. From these figures, statistical significance or insignificance can be detected. Those variables that are greatly insignificant are PRE, CF, PUB, and AGE. The next section ranks all variables in degree of importance. From this analysis, the four variables above should be ranked as being least influential.

From the PROC REG program, parameter estimates are derived. These can be used to produce the "fitted equation" with which the dependent variable could theoretically be determined.

Equation 1

$$DPC = -105.3 + 46.0(CAT) - 16.3(CF) + 3.4(PRE) + 15.0(PUB) + 0.4(AGE) - 0.001(SERV) + 162.3(T) + 82.7(C)$$

Although the entire regression model is significant at the 0.05 level, certain variables, that is PRE, CF, PUB, and AGE, are not.

Of particular interest is the sign of each parameter estimate. For example, as CF increases from 1 to 4, a larger and larger value is negated from the equation. In other words, the less frequently that recycled materials are picked up, the less materials there will be to pick up. With another variable, say PUB, a higher value is added to DPC as promotion increases in intensity from 1 to a maximum of 4 (recall Section 4.4 for the ranking of PUB and PRE). The PRE variable is not behaving as expected. If is the least influential variable of the eight as will be indicated in the next section. It can therefore be removed from the model without serious consequence.

To close discussion of Equation 1, consider the two "dummy" variables, T and C, and note what happens to DPC (in the fitted equation above) as T is voluntary (0) or mandatory (1), and C is 'yes container' (1) or 'no container' (0). Because these two variables are binomial, they act as simple "switches" in the equation. In other words, the parameter estimate of each is either added in or not, according to a) the nature of participation and b) container status. A mandatory program that provides a container adds 250 pounds per capita per year to the dependent variable.

The second regression model, less the variables PRE and AGE, is summarized in Table 18.

Table 18: Summary of Multiple Regression Procedure – All variables less PRE and AGE

Source of variation	Degrees of freedom	Sum of squares	F-ratio	Prob>F
MODEL	6	385493	5.327	0.0007
ERROR	32	375009		
TOTAL	38	771421	R-square =	0.4997

The parameter estimates are different for some of the variables as can be seen in the following fitted equation:

Equation 2

$$DPC = -81.1 + 45.6(CAT) - 15.3(CF) + 19.5(PUB) - 0.001(SERV) + 157(T) + 66.1(C)$$

Again, the signs are all as expected (see Section 5.1, binomial hypotheses). The r-square value above is negligibly less than that for the eight-variable model. The F-ratio is larger, however, which indicates that this six-variable model is possibly more powerful than the other model (according to Draper and Smith, 1981). The stepwise multiple regression procedure in the next section seeks to derive the "best" model by eliminating insignificant factors.

Finally, in both regression model cases, an r-square of 0.5107 or 0.4997 indicates that a moderately strong association exists (Walizer and Wienir, 1975, p.388). However, a substantial proportion, 47.46% ($1-r^2$), of the variance in DPC must be explained by factors other than the eight included in the regression model.

Two influences on the success of source separation programs not accounted for in the model are the economic conditions (markets, financing, etc.) and the prevailing

socio-economic characteristics of the population in any specific area. These of course will vary in a spatial and temporal sense. The exclusion of these two factors from the research design has already been commented upon; however, they are mentioned again in deference to their potentially large contribution to explaining the variance in the dependent variable, DPC.

5.2.2 Stepwise Multiple Regression

The stepwise multiple regression technique introduces each variable, individually, into the regression model in order of its contribution to the total variance, from the largest to the smallest. This searching process effectively rank-orders the variables according to their importance to the regression model. At each stage, "the overall regression is checked for significance, the improvement in the r-square value is noted, and the partial F-values for *both variables now in the equation* are examined" (Draper and Smith, 1981, p.308).

The purpose of this analysis is to develop a regression model that best expresses any explanation residing in the data. In fact, the model presented in the last section -- incorporating all the variables -- should be simplified because of certain low partial F-values. The full results of the SAS PROC STEPWISE program are presented in Appendix E. All eight variables are entered and each of the different models (one-variable, two-variable, and so on to eight-variable) are tested.

The best model found is a four-variable model using T, CAT, SERV, and C (with an r-square value of 0.4849). The fitted equation is as follows;

Equation 3

$$DPC = -91.1 + 50.9(CAT) - 0.001(SERV) + 160.4(T) + 89.7(C)$$

For any other variable entered into this model, the corresponding partial F-value is extremely low (see Appendix E where the partial F-values are those listed below the F-value for the whole model). Moreover, for each variable added to the model after C, the r-square increments are very small. The four least influential factors involved in this stepwise regression analysis are AGE, PUB, CF, and PRE (as suggested in the last section). They are statistically inconsequential in the determination of DPC.

The four influential variables present in the fitted equation above are, in order of their importance, T, CAT, SERV, and C. From the data collected and the analyses used, a program that has mandatory participation (T=1) recycles 160.4 pounds per capita per year more than a voluntary program. Therefore, from a let's-recycle-as-much-as-possible perspective, a program with mandatory participation is evidently much more successful than a voluntary one.

The number of categories that residents are asked to sort is also of consequence. From the evidence examined, it appears that individuals do not object to sorting more materials for recycling. The incremental factor is 50.9 pounds per category per capita per year. As discussed earlier, the inconvenience of sorting more categories does not seem to be a negative force.

At the beginning of Section 5.2.1 it was suggested that although SERV is uncorrelated with DPC (all other things being equal), it should be included in the regression analysis for purposes of completeness. As demonstrated, however, the size of a source separation program (population served by the program) is the third most influential variable. The parameter estimate has a negative sign as well, indicating that as the number of people served by a program increases the per capita diversion of recycled materials decreases. In other words, "small is not only beautiful", but it is more effective.

Finally, the provision of a container is ranked fourth. Like T, C is a binary variable. The effect of 0 or 1 being present in the fitted equation is obvious. With the addition of a special recycling container (C=1), a recycling program can gain 89.7 pounds of recycled materials per capita per year. The provision of a container is therefore a positive addition to any source separation program.

5.3 Summary

Two methods of data analysis are employed in this chapter. The first involves binomial relationships and the second, multinomial. As was stressed throughout Section 5.1, examination of the various binomial relationships was conducted with the following crucial caveat: All other variables were assumed as constant and non-problematic. Such a condition severly and obviously limits the generalizations to be drawn.

It is noteworthy that several variables found to be statistically insignificant in a bivariate analysis were significant under multivariate analysis. In particular, both C (provision of containers) and SERV (the size of the program) became statistically significant (at the 95% confidence level) in all of the regression models. On the other hand, although PUB (publicity and promotion) was found to be correlated with DPC under bivariate analysis, it became insignificant under multivariate analysis.

The section on bivariate analysis was a useful contribution to the study in its own right, and because it broke the full (eight-variable) research model into its basic parts. In this latter regard, by way of illustration of the bivariate to multivariate progression of the analyses, when the negative parameter estimates appeared during the multiple regression analysis (for CF and SERV), a basis already existed for understanding why.

That is, it was possible to refer to Table 11, Summary of Research Hypotheses, in which inverse relationships are hypothesized between CF and DPC, and between SERV and DPC, and obtain an interpretation of why that occurred.

The importance of the multiple regression analysis, on the other hand, is that inter-variable relationships are accommodated. Such an approach provides for a better appreciation of reality than does one wherein a factor (independent variable) is "isolated" and all other factors are held constant. This is evident in the change in the parameter estimates from Equation 1 to Equation 2.

The stepwise multiple regression procedure was particularly useful. The model that best expresses the data was derived and insignificant variables were eliminated. Equation 3 includes only 4 of the original eight variables; however, these are all statistically significant. The r-square value of 0.4849 should be recalled and emphasized, however, because it indicates that roughly 50% of the variance in the dependent variable must be explained by factors other than those in the model presented in this study.

Chapter 6

CONCLUSIONS

Source separation programs are appearing with increasing regularity, but as a rule they are not implemented without difficulty. Hence, and particularly where situations are unfavourable to introducing such a program, it is advantageous to pool the experiences of recyclists across the continent so that the design and implementation of new programs can benefit from the successes and learn from the mistakes made elsewhere. To this end, Chapter 6 is divided into two parts: the first deals with the findings and implications, and the second deals with suggested further research.

6.1 Policy and Program Implications

On the basis of data and the analyses used to examine the status of 39 source separation programs in Canada and the U.S., and in particular as a result of the multiple regression analyses, the four most influential factors in the design of (successful) source separation programs are, in order of importance:

- program type (voluntary versus mandatory);
- number of categories into which refuse is sorted;
- size of the program (population of residents served); and
- provision of container (yes or no).

The four factors that are statistically insignificant are:

- program duration;

- promotion;
- collection frequency; and
- preparation requirements.

The four recommendations which follow represent the design initiatives which are deemed most likely to increase the per capita diversion of recycled materials.

RECOMMENDATION 1

Participation in a source separation program should be mandatory. Statistically significant evidence was found to support the claim that programs with compulsory participation recycle more materials. There are, admittedly concerns in legislating participation – enforcement, noncompliance, and possible reduction in positive community spirit. However, where the problems of solid waste disposal are most acute, and where community cooperation is essential to a program's success, then mandatory as opposed to voluntary participation is the preferred route. It must be immediately noted and emphasized, as part of this recommendation, that compulsory participation is a necessary but not sufficient condition for program success. That is, compulsory participation must be supported by other design considerations.

RECOMMENDATION 2

Insofar as the matter of convenience is concerned, that is, the time and effort required of residents to sort refuse into categories, it does not appear to be a constraining factor. In other words, since residential compliance is not adversely affected as the number of categories increases, then the larger the number of categories handled by operators the greater the diversion rate.

It is recommended, therefore, that some source separation programs be designed to incorporate as many categories as possible. It is important to realize, however, that other factors interact with this variable. Residents being asked to sort refuse into five or six categories will most likely expect or insist upon more frequent collection service, simple preparation requirements, and a special recycling container (see Recommendation 4).

RECOMMENDATION 3

Programs with a small-area focus are more successful than those involving large (geographic and administrative) areas. As discussed previously, the decentralization of responsibilities is not without its costs or problems – logistical, communications, overall organization – just as centralized efforts of an on-going nature in large urban areas, or within regional jurisdictions, also have costs or problems to be addressed.

Given, however, that both the top-down and bottom-up approaches involve costs and benefits, it is recommended that the responsibility for source separation programs be as localized as conditions permit. Within the Regional Municipality of Ottawa-Carleton, for example, the three cities of Ottawa, Nepean and Gloucester should each be directly responsible for recycling activities in their respective areas as part of a regional recycling program.

RECOMMENDATION 4

Finally, the provision of a container is a positive addition to any source separation program. This is generally accepted as a"common sense" idea. On the evidence, however, that is according to the data collected and the outcomes of the (regression) analysis, the provision of a container is,indeed, a statistically significant factor in the success of a source separation program. Simply put, the convenience and promotion characteristics of containers encourage and stimulate participation.

It is therefore recommended that any organization, company or municipality seriously interested in multi-material curbside recycling provide each resident with a special storage container.

6.2 Suggested Further Research

Two of the independent variables, promotion and preparation requirements, were found to have little or no bearing on the success of source separation programs. Since this finding is contrary to suggestions in the literature, and perhaps to intuition or common sense expectations as well, grounds exist for suggesting that a different research design might lead to a different outcome. Several suggestions follow to indicate the nature of such a research design.

In this study, promotion and preparation requirements were transformed from qualitative survey responses to ordinal scales of measurement. The rankings were based on the distribution of responses. For example, for promotion, there were four distinct categories; for preparation requirements there were five categories. The quality of the responses was obviously critical to the classification process. A preponderance of vaguely worded responses would have blurred the distinction between categories.

Each of these two factors would be better represented in the regression model if a quantitative index could be used. For promotion, expenditures could be adopted as long as that variable could be standardized to account for varying community sizes. There are, however, some problems associated with this proposal. Some of the best promotion is "free", that is, no funds are expended, yet very effective. Of special importance are block leader programs. Communities intent on getting a "bigger bang

for their buck" may not necessarily be investing in the best form of promotion. More research in this area is clearly needed.

Other factors not included in the research design are reliability of pickup service (possibly public operator versus private), geographic location of the community (proximity to markets), local waste consciousness / awareness, financial / funding arrangements, storage space in the home (or the lack thereof), and the socio-economic characteristics of the communities in question (recall Section 2.1.4.1). Ideally, in the above regard, consideration of those features are relevant to the formulation of a model that accommodates *all* factors that have any influence on the success of a recycling program.

As indicated in Section 4.3, the interest and influence of the private sector – which is to say, industry as a whole – on waste generation was not within the purview of the present study. There is, nevertheless, a great need for investigation in the area of industrial waste reduction, since roughly half of the waste disposed in our landfills has a non-residential source (recall Section 1.4.2).

Finally, of critical interest to researchers, and to policy-makers and the public as well, is the nature of the dependent variable, that is, how to define and measure a program's success.

As noted earlier, program success has tended to be based on the percentage of total municipal solid waste recycled. By working at a less aggregate level, the examination of program success in this study involved the manipulation of data at a per capita level. The finding was that the rate of generation of MSW on a per capita basis varied tremendously from community to community, which prompted concerns about data reliability.

It was therefore decided to remove MSW generation (as a factor in determining the dependent variable) from the analyses by using the actual diversion figures as they were of primary concern. To standardize the figure, tonnages were multiplied by 2000 for pounds and then divided by the number of participants served by the program. To speak in terms of pounds (or a metric equivalent) per capita per year, or per month, is perhaps more "real" and understandable to participants than accumulated percentages, and suggests a topic for further research: that is, to determine if and by how much the regression model(s) would change if the dependent variable (diversion per capita per year) were replaced by a variable measuring the percentage of municipal solid waste diverted through recycling.

Appendix A

GLOSSARY OF TERMS

Buy-back Center: Additional incentive to source separate is sometimes provided to residents in the form of a buy-back center. Recyclable items are actually purchased from participating individuals or groups, usually for a nominal amount.

Incineration: A volume of solid waste can be substantially reduced if it is burned. The heat generated by the process is energy that can be recovered (Energy-from-waste – EFW). The ash or residue left over from incineration then goes to landfill.

Municipal Solid Waste: Any material used or unused that is discarded as garbage, trash, litter or refuse by residential, commercial or industrial generators is known as municipal solid waste (MSW) or refuse. "Special wastes" are excluded from this category.

Municipal Solid Waste Stream: From the point of discard of the product or package, MSW follows a path which eventually leads to its final disposal. Along that path, MSW can be handled or processed in any number of ways, particularly in regards to (volume) reduction.

Recycling: "Waste" material that has been reprocessed, re-worked and re-introduced as a useable product, has been effectively recycled. Reclamation of a commodity from MSW through either low-tech or high-tech means is known as recyclng.

Recycling Depot: A depot is an unmanned collection point, open all the time, where source separated recyclable items can be deposited. Such items usually include glass bottles and jars, tin cans and newspapers and may include waste oil.

Reduce: The best way to reduce waste is to reduce consumption. This can be accomplished through selective purchasing or by rejecting overpackaged goods.

Resource Recovery: Capital-intensive extraction or separation of a commodity from the MSW stream is referred to as resource recovery. Mechanized composting and energy recovery are two examples of this approach to waste reduction.

Sanitary Landfill: A sanitary landfill is where municipal refuse is deposited under controlled conditions. Solid waste is compacted in layers and covered at regular intervals by an inert matter such as earth.

Source Separation: Recyclable items such as glass, tin cans and newspaper are separated from the MSW stream by each resident and are then collected separately, often by specially designed vehicles. A multi-material curbside recycling program is dependent on realiable and continuous source separation.

Special Wastes: Wastes that are biomedical, nuclear, heavy industrial, liquid (sewage), hazardous or toxic require special disposal procedures. These kinds of wastes are not disposed in municipal landfills.

Transfer Station: In large cities, the landfill site(s) is (are) often located relatively far away. To reduce transportation costs, municipal refuse is off-loaded at transfer stations (possibly within the city limits) by regular compactor trucks; then the refuse is compacted further and re-loaded on to much larger trucks for the trip to the landfill. Transfer stations often accommodate recycling or resource recovery facilities.

Appendix B

DERIVATION OF MUNICIPAL SOLID WASTE PER CAPITA GENERATION INDEX

Is the per capita generation of MSW increasing with time? An attempt can be made to answer this important question because of the availability of time series data collected and produced during this study. In particular, from their responses to the survey, a number of communities provided MSW figures for 1985. Per capita generation of MSW was calculated and these figures are presented in Table 15. The mean and the median are listed there as well. Further, a variety of per capita generation figures have been presented, over time, in the literature. These are presented in Table 16 along with their sources.

From Table 15, it is observed that the mean is notably larger than the median. According to the literature, the median is a "resistant statistical measure" whereas the mean is subject to deterioration in the presence of extreme values (Kolata, 1979; Mosteller and Rourke, 1973). Therefore, in the derivation of an MSW per capita generation index, the median will be used. As a final note to Table 15, some of the PCD figures are projections (OBS 18, 20, 21 and 23). Consequently, the index derived for 1986 is based, to a certain degree, on conjecture.

Linear regression is used to calculate a least-squares line which summarizes the distribution of per capita generation of MSW in accordance with the alteration by year (from Watson and McGaw, 1980, p.165). The test statistic for the significance of the

regression model is F (the variance ratio). The SAS PROC GLM program derives an r-square value as well which indicates what percent of the observed variation is "explained" by variation in the independent variable.

In Table 16, some of the years have more than one estimation for PCD. In these cases, the average per capita generation figures were calculated (for those years). This reduces the number of points from 23 to 14. (The 14 values which were regressed are those listed under PCD in Table 18).

The results of the regression analysis are presented in Table 17. The probability of an F-ratio greater than 10.92 is less than one percent. In other words, the regression model is significant at the 99% confidence level. An r-square value of 0.4765 indicates that a moderately strong association exists in the regression model (Walizer and Wienir, 1975). From the equation (or regression model) produced, a prediction of PCD in any given year can be made.

Table 18 presents the actual regression predictions and residuals of PCD. These data are graphed in Figure 10 where "A" represents the 14 values mentioned above and "P" represents the predicted values. The r-square of 0.4765 describes the line of best fit (all the P points connected).

From this analysis it would appear that per capita generation of MSW is indeed increasing through time, according to the literature and the data collected in this survey.

Table 19: Municipal Solid Waste Generation Figures

Calculated from Source Separation Survey Data for those communities who provided MSW figures.

OBS	PLACE	COUNTRY	PCD
1	Saanich	CAN	1.19
2	Hamburg	USA	1.23
3	Islip	USA	1.58
4	Pelham	CAN	1.63
5	Halton Hills	CAN	1.66
6	Milton	CAN	1.83
7	Oshawa	CAN	1.85
8	Burlington	CAN	1.98
9	Oakville	CAN	2.01
10	Dundas	CAN	2.08
11	Longmeadow	USA	2.13
12	Grimsby	CAN	2.42
13	Austin	USA	2.54
14	Kitchener	CAN	2.65
15	West Berlin	USA	2.79
16	El Cerrito	USA	2.96
17	Woodbury	USA	3.54
18	Ann Arbor	USA	4.30
19	Linwood	USA	4.42
20	Burbank	USA	4.66
21	Montclair	USA	4.76
22	Athens	USA	4.85
23	Davis	USA	4.93
24	Santa Monica	USA	5.27
25	Boulder	USA	7.14
26	Sunnyvale	USA	7.62
27	Palo Alto	USA	8.43
28	San Joaquim	USA	10.47
29	Reedley	USA	11.66
30	Sanger	USA	11.67
31	Kingsburg	USA	11.76

the mean	4.45
the median	3.54

Table 20: Municipal Solid Waste Generation - assorted references

(PCD = Pounds per Capita per Day)

	YEAR	PCD		
1	1962	3.83	(Glysson et al., 1972)	U.S.
2	1965	4.79	(Clark & Brown, 1972)	Canada
3	1966	4.93	(Jacobs & Biswas, 1972)	Canada
4	1967	5.53	(Clark & Brown. 1972)	Canada
5	1968	5.30	(Baum et al., 1973)	U.S.
6	1968	8.19	(Glysson et al., 1972)	U.S.
7	1968	5.16	(National Center for Resource Recovery, 1974)	U.S.
8	1968	3.00	(Black, 1968)	U.S.
9	1968	5.20	(Rhyner, 1976)	U.S.
10	1968	5.00	(Niessen, 1977)	U.S.
11	1969	5.74	(Clark & Brown, 1972)	Canada
12	1970	4.05	(Institute for Solid Wastes, 1970)	U.S.
13	1970	4.30	(H.J. Porter & Associates, 1982)	Canada
14	1973	5.32	(Hagerty et al., 1973)	U.S.
15	1975	4.39	(Goddard, 1975)	U.S.
16	1976	6.17	(Ontario Waste Management Advisory board, 1976)	Canada
17	1977	6.50	(Niessen, 1977)	U.S.
18	1980	8.00	(Baum et al., 1973)	U.S.
19	1980	4.85	(Hare, 1983)	Canada
20	1980	4.30	(Flockton, 1971)	Canada
21	1985	8.33	(Niessen, 1977)	U.S.
22	1985	3.54	(Sinclair, 1986)	U.S. & Canada
23	1986	6.58	(Jacobs & Biswas, 1972)	Canada

Table 21: Summary of Statistical Tests (using the median from Table 15)

Source of variation	Degrees of freedom	Sum of squares	F-Ratio	Prob>F
model	1	4.417	10.92	0.006
error	12	4.853		
total	13	9.271	R-square = 0.4765	

Equation: PCD = -150.2153 + 0.0789(YEAR)

Table 22: Regression Predictions and Residuals of PCD

OBS	YEAR	PCD	PREDICTION	RESIDUAL
1	1962	3.83	4.50	-0.67
2	1965	4.79	4.74	0.05
3	1966	4.93	4.82	0.11
4	1967	5.53	4.90	0.63
5	1968	5.31	4.98	0.34
6	1969	5.74	5.05	0.69
7	1970	4.18	5.13	-0.95
8	1973	5.32	5.37	-0.05
9	1975	4.39	5.53	-1.13
10	1976	6.17	5.61	0.57
11	1977	6.50	5.69	0.82
12	1980	5.72	5.92	-0.20
13	1985	5.94	6.32	-0.38
14	1986	6.58	6.39	0.19

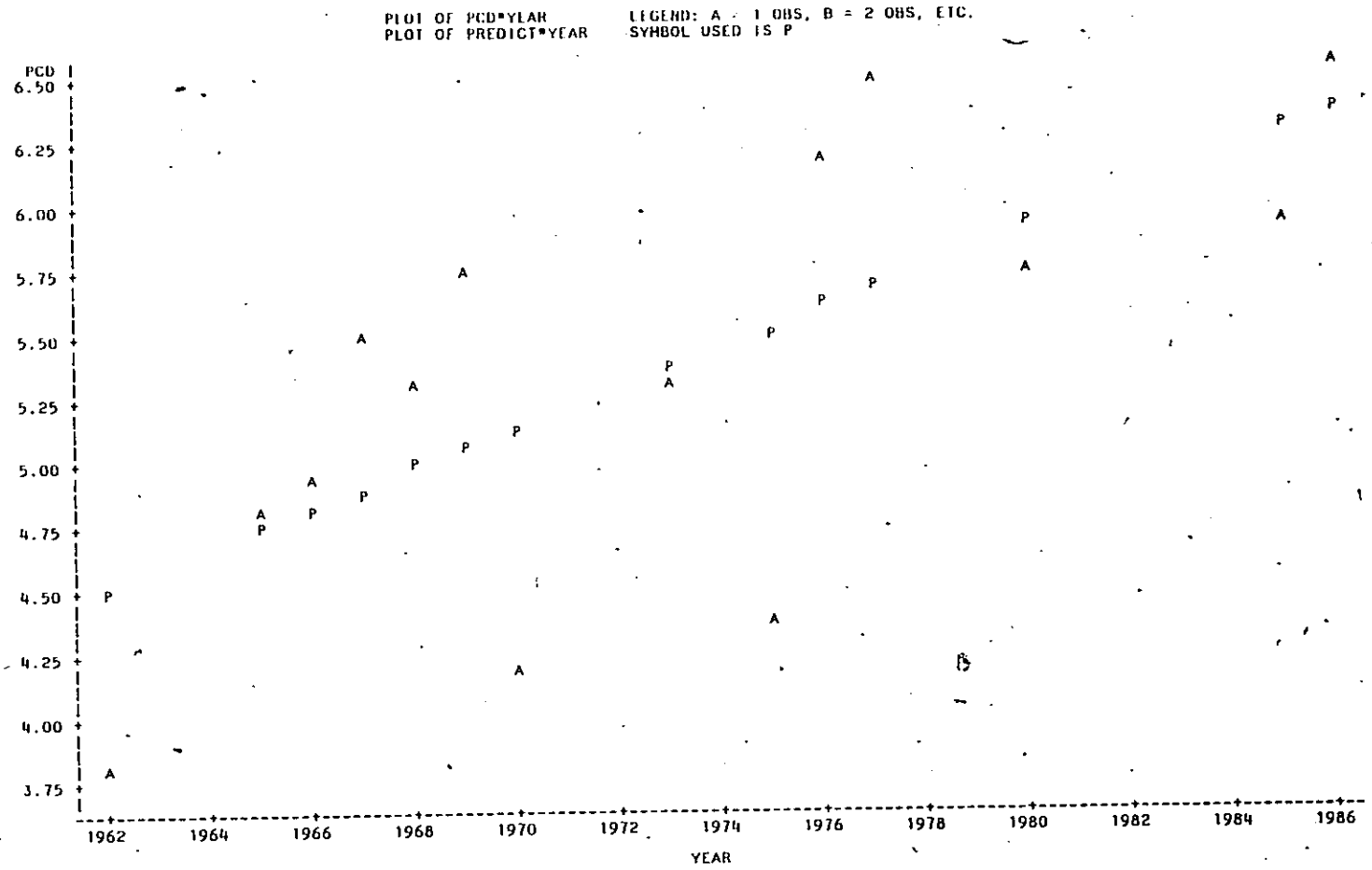


Figure 10 Distribution of Municipal Solid Waste generation figures (per capita per day) found in the literature, and the predicted line of best fit.

Appendix C

IDENTIFICATION OF SOURCE SEPARATION PROGRAMS

CANADA
Gregg Scott
Vancouver Island Recycling Society
No.3 - 50 Montreal Street
Saanich, BC V8V 1Y5

George & Gwen Discepolo
Halton's Recycling Resources
P.O.Box 1174, Station B
Burlington, Ontario L7P 3S9

(have programs in Burlington, Oakville and Milton)

Norman Bagshaw
Third Sector (Recycling)
Town of Dundas, Ontario

Nyle Ludolph
Total Recycling System Ltd.
Box 10
Kitchener, Ontario N2G 3W9

Region of Halton, Public Works
Box 7000, 1151 Bronte Rd.
Oakville, Ontario L6J 6E1

(run program in Halton Hills)

Glenda Gies
Durham Recycling Center Inc.
77 Wilson Rd. South
Oshawa, Ontario L1H 6E9

(new program in nearby Ajax began 09/1985)

Frank Marsh (chairman)
Richmond Hill Recycling Corp.
% 459 Gamble Rd. RR No.1
Richmond Hill, Ontario L4C 4X7

Brian McMullan
Niagara Recycling
486 Webber Road
Welland, Ontario L3B 5N8

(has programs in Pelham, Thorold, Fonthill, Grimsby and Welland)

Andre Paradis, president
Recyclage Quebec

615 rue Montmartre
Quebec, Quebec G1N 1B3

UNITED STATES

Kate Krebs
Arcata Recycling Center
1380 9th Street
Arcata, CA 95521

(Program did not have multi-material curbside pickup at the time of the survey)

Joy Hamilton
City of Burbank
275 E. Olive Avenue
Burbank, CA 91502

Richard Gertman
Davis Waste Removal Com. Inc.
P.O. Box 496
Davis, CA 95617

Joel Witherell
Community Services Department
E.C.ology Recycling
10890 San Pablo Avenue
El Cerrito, CA 94530

Rick Anthony
Fresno County
4499 E. Kings Canyon Road
Fresno, CA 93702

(6 questionnaires filled out; Reedley, Sanger, San Joaquim and Kingsburg qualified as multi-material and curbside)

Dana Armstrong
City of Palo Alto Recycling
P.O. Box 10250
Palo Alto, CA 94303

Jean Zanco
Oceanside Disposal
P.O. Box 2169
Oceanside, CA 92054

Richard Gertman
City of San Jose
810 N. First Street
San Jose, CA 95110

(program began 05/1985)

Deborah Baine
City of Santa Monica
1685 Main Street
Santa Monica, CA 90401

Joe Garbarino
Marin County Recycling and

(no response)

Resource Recovery Association
P.O. Box 3511
San Raphael, CA 94901

Stu Clark
Redwood Empire Waste Management Co.
P.O. Box 697
Santa Rosa, CA 95402

(no response)

Pat Miller
City of Sunnydale
P.O. Box 60607
Sunnyvale, CA 94088

Peter Lombardo
President, Trash-Away
31 Christian Lane
New Britain, CONN 06051

(no response)

Bob Becket
Director, Public Works Department
Town of East Lyme
P.O. Drawer 519
Niantic, CONN 06357

(no response)

Pete Grogan
Eco Cycle
P.O. Box 4193
Boulder, CO 80306

Arlene Miller
Chairperson, Longmeadow Recycling Program
68 E. Greenwich Road
Longmeadow, MASS 01106

Wayne Attridge
P.O. Box 98
Marblehead, MASS 01945

(no response)

Virginia Cole
268 Highland Road
Andover, MASS 49504

(program did not have multi-material, curbside pickup at the time of the survey)

Jim Frey
The Ecology Center of Ann Arbor
417 Detroit Street
Ann Arbor, MI 48104

R/U Collection Station
Oxford Food Centre
817 Oxford, SW
Grand Rapids, MI 49504

(no response)

John Dolentz
Director of Public Works and
City Engineer
St. Cloud, MINNESOTA 56301

Mike McGee
Township of Berlin
Department of Public Works
Bate Avenue
West Berlin, NJ 08091

Douglas Crum, Eugene Reilly
West Orange Department of
Waste Management
25 Mt. Pleasant Place
West Orange, NJ 07052

Julie Grillo
R.D. 1, Box 123
Glen Gardner, NJ 08826

(no response)

Wallace Blazier, Molly Adams
Borough Hall
360 Elkwood Avenue
New Providence, NJ 07974

(no response)

Lori Scozzafava
Morris Company Planning
Board
Courthouse
Morristown, NJ 07960

(program began during 1985)

Ed Jablonowski
East Brunswick Township
Recycling Coordinator
1 Civic Center Drive
E. Brunswick, NJ 08816

(Program did not have multi-material pickup at the time of the survey)

Donald Sanderson
City of Woodbury
33 Delaware Street
Woodbury, NJ 08096

Jean Clark
Montclair Recycling
219 N. Fullerton Avenue
Montclair, NJ 07042

George Jones
Assistant Supervisor, Linwood
Streets Dept.
500 Hamilton Avenue
Linwood, NJ 08221

Jim Agnesino
Public Works Director
Monroe Township Dept. of Public Works
Box 171, R.D. 2 Glassboro Rd.
Williamstown, NJ 08094

(no response)

Gerry Knoll
Public Works Director
Village of Hamburg, NY

Elizabeth Gallagher
Assistant to the Commissioner of Environmental Control
Town of Islip, 401 Main Street,
Islip, NY 11751

Thomas O'Grady
Program Manager
Athens County Litter Control
Athens City-County Health Dept.
278 West Union Street
Athens, OHIO 45701

Steven R. Shannon
Recycle Center Manager
Barberton Health Dept.
571 West Tuscarawas Avenue
Barberton, OHIO 44203

(Program began 05/1985)

Ed Drubek
West Linn City Hall
4900 Portland Avenue
West Linn, OR 97068

(no response)

Beth Brown
City of Austin Public Works
P.O. Box 1088
Austin, TX 78767

Appendix D

THE COVER LETTER AND THE PROGRAM QUESTIONNAIRE

UNIVERSITÉ D'OTTAWA UNIVERSITY OF OTTAWA
OTTAWA ONTARIO
CANADA

April 18, 1986

Dear

I am a graduate student at the University of Ottawa and am presently conducting research into source separation and recycling. This survey is entirely of my own undertaking and my research is being supervised by Dr. Barry Wellar. The information which I collect with the accompanying questionnaire will help form the basis of my Master's thesis, and for this reason your cooperation would be greatly appreciated.

The purpose of this study is to compare voluntary and mandatory programs of source separation of solid waste in terms of their respective implications on the life of landfill facilities. There are other factors which affect public participation as well. These factors can be grouped as follows: program design, community character, and publicity. Because all these factors will be carefully considered, it is important that you respond to as many (if not all) of the questions as possible.

I should add that your program was selected because of its (reputed) state-of-the-art status, and the likelihood that you do have a record of the data which I seek. This is not an extensive continent-wide survey as it involves, at most, 30 source separation programs. Therefore, I would stress again the value of your completing this questionnaire.

Finally, I realize that I am asking a great deal, especially with regard to the landfill and waste flow statistics. I can only thank you in advance for your time and effort. If you would like a summary of the completed study, please so indicate on the questionnaire.

Sincerely yours,

Barry S. Wellar
Professor and Director
of thesis

Robert G. Sinclair
Master's Candidate

Géographie
Faculté des arts

165 Waller
K1N 6N5

Geography
Faculty of Arts

SOURCE SEPARATION SURVEY

Town or city name: _____ Population: _____

In general socio-economic terms, how would you describe your community? (eg. suburban with light commercial: manufacturing center, etc.) _____

When did your multi-material curbside collection program begin? _____

Approximately what percent of the population is served by the program? (Or, how many households are served?) _____

Is your source separation program voluntary or mandatory? _____

If you switched from voluntary to mandatory, or vice versa, please specify the nature and date of the switch. _____

Who operates the program (private, public...)? _____

What recyclable materials are collected? _____ _____

_____ _____

Please specify the way (if any) the materials have to be prepared before they are collected: _____

Do you provide special containers for the set-out of recyclable materials? _____

How often are the recyclable materials collected? _____

How often is regular refuse collected? _____

What is the total remaining capacity of your landfill facility or facilities (Please indicate how many landfills, if more than one, and specify if volume or weight) ? _____

Please indicate whether the landfill is for local and/or regional use: _____

If you have maintained a file dealing with the questions below, please enter the data in the appropriate boxes for as many years as possible. For the first two questions, please specify the units of measure; that is, volume or weight by month or year (preferably, tons/year).

YEARS / QUESTION				
How much recyclable material is collected ?				
How much M.S.W. is disposed in your landfill facility? *				
Of those people served by the program, what percent participate?				
What are your landfill disposal fees, in dollars per ton?				

* M.S.W. equals municipal solid waste (residential plus commercial wastes)

TURN OVER

Why does your community have a source separation program? In other words, what is the primary motivation for having the program at all?

How is your program funded? (Government assistance, landfill diversion credits, revenues from the sale of recyclable materials, a collection fee per household...etc.)

Please provide materials about your program, and/or briefly describe what you do, how often, etc., to maintain, promote, and/or enforce participation.

What, if anything, would you change about your program if you had the opportunity?

How do you measure participation rates? (Please provide documentation if the space provided is insufficient for your reply).

Do you employ waste reduction methods other than source separation? (If yes, please name and briefly describe the method).

Appendix E

THE RAW DATA

The data in this Appendix were compiled throughout 1986. Most of the data were collected via the "Source Separation Survey"; programs reported on by other means are indicated with an asterisk.

The data for Islip, NY were found in Hertzberg (1983a), and Chamard (1984). A telephone call to Ms. Elizabeth Gallagher, Assistant to the Commissioner of Environmental Control, brought the figures up-to-date. Woodbury, NJ data were secured from an unpublished document forwarded by Trish Ferrand of the State of New Jersey Office of Recycling. In addition, a telephone call to Donald Sanderson, Public Works Official, resulted in more up-to-date data for Woodbury.

In the latter part of 1985, a "Description of Active Recycling Projects as of December 31, 1985" was brought to this writer's attention by Ann Simpson of Energy Pathways of Ottawa. Approximately 71 recycling programs in Ontario were surveyed by the Recycling Council of Ontario for the Ministry of the Environment. An attempt was made to identify all the eligible programs, however, many of these Ontario programs could not be included in this study for reasons already discussed (Section 4.4).

Some categories are marked with "n.a." or "–", which simply means that either the data were not available, no response was made, or no response to the question was asked for. In the latter case, some questions were ruled out after the questionnaire had already been sent out. This decision was based on the quality of responses received for those same questions (recall Section 4.2).

In the tables that follow short forms (abbreviations and acronyms) have been used liberally in order to accommodate all the data in as small a space as possible; hence, some of the information is somewhat truncated. The following list is intended to assist the reader in relating short forms to their associated complete words or terms:

agr	-	agriculture	pcy	-	pounds per capita per year
al	-	aluminum	PET	-	polyethylene teraphthalate
c	-	cans	plas, pl	-	plastic
cl	-	clear glass	PR	-	public relations
co	-	coloured glass	priv	-	private
comm	-	commercial	PSA	-	public service announcement
conta	-	containers	reg	-	regional
corp	-	corporation	res	-	residential
cy, cu.yd	-	cubic yards	r.s.w.	-	residential solid waste
est	-	estimated	sep	-	separate
fer	-	ferrous	sub	-	suburban
fndtn	-	foundation	sum	-	summer

g	-	glass
groc	-	grocery
h	-	houses
ind	-	industry
l	-	loose
ldfll	-	landfill
m	-	month
mand	-	mandatory
manu	-	manufacturing
mun	-	municipal
n	-	newspaper
non res	-	non-residential
occ	-	old corrugated cardboard
t	-	tin
trsh	-	trash
T	-	ton (imperial)
tx	-	tax
uni	-	university
v	-	very
vol	-	voluntary
w/	-	with
w	-	waste
win	-	winter
y, yr	-	year
?	-	unknown
*	-	data not collected via survey

Program (town)	Population	Socio-economic status	When did program begin?	% of pop. served	vol. or mand.	private or public	Materials collected	Material preparation	special contain-ers ?	Frequency of collection	
										recyclables	regular
Dundas, ONT *	19,586	--	09/1978	85%	vol.	--	n, g, c	clean & sep. remove lids and labels	no	weekly	--
Kitchener ONT	142,000	suburban comm. lt& heavy ind.	09/83	65%	vol.	private	g,c,n, oil, appliances	sep. & clean + labels on, & not flat n-bag/bundle	yes	weekly	weekly
Oshawa, ONT *	118,438	--	06/1976	100%	vol.	non-profit	n, g, c OCC, fine paper	clean & sep. g - lids etc removed	no	weekly	--
Richmond Hill, ONT *	37,778	--	01/1975	75%	vol.	private	n, g, c, OCC, fine paper	n-bundle c-labels off & flattened	no	weekly	--
Welland, ONT *	45,448	--	01/1974	80%	vol.	non-profit	n, g, cans	n-tied/bagged remove lids from g.	no	every second week	--
Fonthill, ONT	7,500	sub-res w/ lt. comm.	09/1984	96%	vol.	non-profit	n,g,c & plastics--temporarly	"	yes	weekly	weekly
Thorold, ONT *	15,412	--	01/1980	70%	vol.	non-profit	n, g, c	"	no	weekly	--
Pelham, ONT *	11,104	--	01/1980	70%	vol.	non-profit	n, g, c	"	no	weekly	--
Grimsby, ONT *	15,797	--	01/1980	87%	vol.	non-profit	n, g, c	"	yes	weekly	--
Oakville, ONT *	76,760	--	08/1980	100%	vol.	private	n, g, c	n - bundled g & c clean and sep.	no	weekly	weekly
Burlington ONT *	114,853	--	08/1980	100%	vol.	private	n, g, c, OCC, fine paper	"	no	weekly	weekly
Milton, ONT *	28,067	--	08/1980	100%	vol.	private	n, g, c	"	no	weekly	weekly
Halton Hills, ONT*	35,190	--	08/1980	100%	vol.	public	n, g, c	"	no	weekly	weekly

Program (town)	LANDFILL no.	LANDFILL remaining capacity	LANDFILL use	How much recyclable material is collected? Year 1	Year 2	Year 3	Year 4	How much M.S.W. is disposed in your landfill(s)? Year 1	Year 2	Year 3	Year 4
Dundas, ONT	--	--	--			1985 417 T/y				1985 7016 T	
Kitchener, ONT	1	20 yrs	regional	1983 3000 T/y	1984 6000 T/y	1985 6000 T/y		1983 41,000 T/y Res.S.W.	1984 41,500 T/y Res.S.W.	1985 42,000 T/y Res.S.W	1985 62,685 T/y
Oshawa, ONT	--	--	--			1985 1809 T/y				1985 38177 T	
Richmond Hill ONT	--	--	--			1985 879 T				n.a.	
Welland, ONT	--	--	--			1985 751 T/y		n.a.			
Fonthill, ONT	--	--	--		1984 250 T/y	1985 400 T/y		n.a.			
Thorold, ONT	--	--	--			1985 304 T/y		n.a.			
Pelham, ONT	1	"nearly full"	reg.			1985 982 T/y				1985 2554 T	
Grimsby, ONT	1		reg.			1985 334 T/y				1985 6637 T	
The following four communities share the same Halton Region landfill.											
Oakville, ONT	1	"on	reg.			1985 3097 T/y				1985 24945 T	
Burlington,ONT	1	extended	reg.			1985 4277 T/y				1985 37845 T	
Milton, ONT	1	time"	reg.			1985 722 T/y				1985 8745 T	
Halton Hills ONT	1		reg.			1985 442 T/y				1985 10218 T	

Program (town)	What are your landfill disposal fees, in dollars per year ? Year 1	Year 2	Year 3	Year 4	Partici-pation 1985	Promotion	How is your program funded?
Dundas, ONT	--				--	card calendar/schedule, local newspaper ads.	--
Kitchener, ONT	1983 CDN $6.00 /T	1984 $8.75/T	1985 $11.75/T		80-85%	annual newsletter, school presentations, lots of media coverage, blue box PR	landfill div. credit, Prov. govt. assistance, revenues from sales.
Oshawa, ONT	--				--	general info. hydro bill insert, block leader program being developed (?).	--
Richmond Hill, ONT	--				--	truck ads, "word-of-mouth"	--
Welland, ONT	--				--	bi-annual flyer; ads in local paper; recycling info.	
Fonthill, ONT	1984 $70/load	1985 $70/load			85 %	bi-annual flyer, ads in local paper. Blue box PR.	govt. assistance, landfill div. credits + revenue from the sale of recyclables
Thorold, ONT	--				--	"	(All operated together) Government assistance landfill diversion credits, + the sale of recyclable materials.
Pelham, ONT	--				--	"	
Grimsby, ONT	--				--	Same as above plus blue box.	
Oakville, ONT *	--				--	The Region of Halton is responsible for PR.	sale of recyclable materials, fee for service from mun., + waste diversion credit
Burlington ONT *	--				--	General awareness levels maintained.	"
Milton, * ONT	--				--	"Program already well-established".	"
Halton * Hills, ONT	--				--		"

Program (town)	Population	Socio-economic status	When did program begin?	% of pop. served	vol. or mand.	private or public	Materials collected	Material preparation	special containers ?	Frequency of collection: recyclables	Frequency of collection: regular
Ancienne-Lorette, QUEBEC	13,000	--	05/1982	100%	vol.	--	n, g, c (al.+ t)	n-bundle g-color sep. c-flattened	yes	weekly	--
Saanich, BRITISH COLUMBIA	86,000	sub. w lt. comm+retail	1980 1985	99%	mand.	non-profit	g,n,tin cans	n-tied bundle g-metal off c-clean, flat labels off	5000 h yes	every three weeks	bi-weekly (win) weekly (sum)

Programs in the UNITED STATES (organized according to states, in alphabetical order where possible).

Burbank, CA	84,625	suburban light comm. heavy manu.	09/1982	50%	vol.	private	g,n,c	separated & cleaned	yes	every second week	weekly
Davis, CA	40,000	uni.town sub. w/ lt. comm.	1974	100%	vol.	private	g,n,al,OCC	mater.must be placed in sep paper bags	no	weekly	weekly
El Cerrito CA	22,731	middle - upper class	1978	100%	vol.	public	n,g,al,fer. OCC , wine bottles	--	no	weekly	weekly
Kingsburg, Fresno Co. CA	5,500	farm commun +agr.relat-ed ind.	1982	100%	vol.	private	g,n,al,OCC	clean & dry	no	every fourth week	weekly
Reedley, Fresno Co. CA	11,000	"	1984	100%	vol.	public	g,n,al,OCC	clean & dry	no	every fourth week	weekly
Sanger, Fresno Co. CA	12,500	"	1983	100%	vol.	public city	g,n,al,OCC	clean & dry	no	every fourth week	weekly
San Joaquin Fresno Co. CA	2,000	"	1982	100%	vol.	city	g,n,al,OCC	clean & dry	no	weekly	weekly
Oceanside CA	76,698	tourist & light manu.	1983	32%	vol.	private	g,n,c(t,al)	al-bagged n-tied/bag	no	weekly	weekly
Palo Alto, CA	56,500	sub.w/comm computer, high-tech industry	04/1980	80%	vol.	private	n,g,OCC,c oil,scrap	n-bundled g-no metal c-no labels OCC-flat	yes (burlap bag)	weekly	weekly

Program (town)	LANDFILL no.	LANDFILL remaining capacity	LANDFILL use	How much recyclable material is collected? Year 1	Year 2	Year 3	Year 4	How much M.S.W. is disposed in your landfill(s)? Year 1	Year 2	Year 3	Year 4
Ancienne-Lorette, QUE	--	--	--	1983 315 T/y		1985 345 T/y		1983 5816 T/y		1985 3600 T/y	
Saanich, BC	1	a few yrs left	reg.		1984 750 T/y	1985 1700 T/y			1984 16,000 T	1985 17,000T/y	
Programs in the UNITED STATES (organized according to states, in alphabetical order).											
Burbank, CA	1	5 million tons (80 yrs)	local	1985-86 7200 T/y				1985-86 65,000 T/y			
Davis, CA	--	--	regional	250 T/mo 3000 T/y				3000 T/mo 36,000 T/y			
El Cerrito, CA	1	1989 3 yrs.	reg.			1984/85 2,918 T/y	1985/86 2,686 T/y			1985 9600 T/y	
The following three communities all share the same Southeast Regional Landfill and are therefore treated as a group.											
Kingsburg, CA	1	2 yrs.	reg.	1981-82 46 T	1983 139 T	1984 132 T	1985 128 T	1981-82 13,297 T	1983 16,907 T	1984 17,434 T	1985 16,103 T
Reedley, CA	"	"	"		1983 36 T	1984 52 T	1985 59 T	1981-82 26,587 T	1983 33,805 T	1984 34,859 T	1985 32,197 T
Sanger, CA	"	"	"	1981-82 33.5 T	1983 59 T	1984 103 T	1985 87 T	1981-82 30,211 T	1983 38,413 T	1984 39,611 T	1985 36,585 T
(Fresno County)				79.5 T	234 T	287 T	274 T	70,095 T	89,125 T	91,904 T	84,885 T
San Joaquin CA	1	25-30 yrs	reg.	1981-82 20 T	1983 30 T	1984 80 T		1981-82 12,000 T	1983 14,500 T	1984 12,410 T	1985 15,500 T
Oceanside, CA	1	1.5 yr (max)	regional			1985 996 T ---->1015 T/y +240 cu.yd of tin		--			
Palo Alto, CA	1	6-7 yrs	local	1982-83 5700 T	1983-84 6175 T	1984-85 6956 T		1982-83 1295661 cy	1983-84 1389262 cy	1984-85 1614662 cy	

Program (town)	What are your landfill disposal fees, in dollars per year ? Year 1	Year 2	Year 3	Year 4	Participant 1985	Promotion	How is your program funded?
Ancienne-Lorette, QUE	--				--	monthly paper ads to highlight progress; phone survey mailed reminders, recycling info. posters:stores/schools	--
Saanich, BC	$8.50/T (Cdn)				70%	bimonthly newsletters, monthly radio press releases calendar/schedules, local TV & paper highlight program...	mun. grant each year + sale of recyclable materials.
Programs in the UNITED STATES (organized according to states, in alphabetical order where possible).							
Burbank, CA	$6.50/T				45%	utility bill inserts, annual PR every 100th refuse bill paid for that month.	revenues from the sale of recyclables
Davis, CA	$4.00/T				75%	lots of media attention, prochures, poster displays throughout the city, bumper stickers, presentations ...	garbage rates, sale of materials.
El Cerrito CA	$10.00 /T				60%	annual newsletter, PR in tri-annual city prochure	revenues and volume surcharge
The following three communities all share the same Southeast Regional Landfill.							
Kingsburg CA	1981-82 $2.50 per ton	1983 $3.50 per ton	1984 $4.00/T	1985 $4.50/T	n.a.	no set type or frequency of PR, brochures, ads in local newspapers, schedules distributed.	sale of recyclable materials
Reedley, CA	"	"	"	"	n.a.		"
Sanger, CA	"	"	"	"	n.a.		"
San Joaquin CA				1985 $2.50 /T	n.a.		"
Oceanside, CA	1985 $6.90/T				11%	no PR at this time	--
Palo Alto CA	$14pcy non.res. $8pcy res				70%	utility bill inserts, paid ads in papers, garbage awareness month, citizen's committee-feedback on PR, letter from the Mayor...	city refuse disposal fund; operating deficit covered by municipality.

Program (town)	Population	Community type	When did program begin?	% of pop. served	vol. or mand.	private or public	Materials collected	Material preparation	special contain-ers ?	Frequency of collection	
										recyclables	regular
San Jose, CA	700,000	light manu.	05/1985	10.7%	vol.	private	g,n,c(t,al)	can labels and bottle	yes	weekly	weekly
Santa Monica, CA	88,314	urban-res. lt. comm. & very light industry	01/1982	99%	vol.	public	g,n,c(al+t) motor oil	g&c-cleaned n-bag/bundled oil-sealed container	yes	every second week	twice a week
Sunnyvale CA	106,618	c ectronic & defense ind.	05/1982	60%	vol.	public	n,g,c, PET, oil	c-burlap bag g- " " n-bag or tied	yes burlap bag	weekly	weekly
Boulder / Longmont CO	87,500 45,000	uni.town light manu.	B 07/1976 L 04/1984	B 90% L 100%	vol.	non-profit group	scrap metal n,g,al,oil, OCC	g-remove lids n-tied/bagged OCC - flat	no	every fourth	weekly
Longmeadow MASS	16,000	totally res (sub.)	1979	100%	mand.	private	n, OCC	n-paper bag or in marked can	no	weekly	weekly
Ann Arbor MICHIGAN	107,316	uni.town urban w/lt. commercial	1978	56%	vol.	non-profit	g,n,c,OCC	n& OCC-bundle g-sep.bycolor c-flat&labels removed	no-pilot coming up	every fourth week	weekly
St. Cloud MIN	44,300	metro. heavy manu.	02/1983	85%	mand.	public	n, g, al.	clean & sep. n-bundled g.&al.-bag or	no	every four weeks	weekly
Linwood, NJ	6,476	sub. w/lt. commercial	8/82	100%	vol.	public	g,n,al,oil white goods cast iron	n-bundled or groc.bag g-colour sep.	no	every second week	weekly
Montclair NJ	38,321	suburban residential	n-1975 g-1980	100%	mand.	public	g, n, al.	n-bundled/bag g&al-mixed & put in conta.	no	every second week	twice a week
Morristown NJ	16,615	sub. light commercial	04/1985	---	vol.	public	g,n,al, white goods & leaves	--	no	every fourth week	twice weekly
West Berlin NJ	5,300	sub. light comm. & light ind.	vol. 9/80-6/81 mand. 6/81-->	88%	mand.	public	n,g,c(t,al) OCC, leaves & brush	"minimal"	yes 5 gallon bucket	weekly	weekly

Program (town)	LANDFILL no.	LANDFILL remaining capacity	LANDFILL use	How much recyclable material is collected? Year 1	Year 2	Year 3	Year 4	How much M.S.W. is disposed in your landfill(s)? Year 1	Year 2	Year 3	Year 4
San Jose, CA	2	1. 30 yr 2. new	local			1985 3139 T/y	1986 3139 T/y			1985 547,000---->620,000 T/y	1986 T/y
Santa Monica CA	1	30 yrs	reg.	1982 1276 T	1982 1361 T	1984 1429 T	1985 1655 T	1982 75,780 T	1983 81,571 T	1984 82,224 T	1985 83,300 T
Sunnyvale, CA	?	30% r.s.w 30% ind.w <9 yrs>	local			1984/85 4,200 T/y				1984/85 144,000 T/y	
Boulder	1	6-9 month	local	1982 9,200 T/y	1983 10,800T/y	1984 13,250T/y	1985 10,500T/y			1985 162,060 T	
Longmont CO	1	1-2 yrs									
Longmeadow, MA	1	10 yrs	reg.	1983(vol) 671 T	1984 800 T	1985(mand) 1243 T	1986(6m) 635 T	1983 5,500 T	1984 5400 T	1985 5000 T	1986(6m) 5000 T
Ann Arbor, MI	1	approx. 15 years	local and reg.	1983 1500 T	1984 1800 T	1985 2128 T	1986(est) 2500 T		1984 81,000 T	1985 82,000 T	1986(est) 83,000 T
St. Cloud, MIN	--	--	--	1983 436 T/y	1984 389 T/y	1985 346 T/y		--			
Linwood, NJ	9	1/1/85 882,799 T	local and regional	1982 1375 T/y	1983 691 T/y	1984 909 T/y	1985 864 T/y	1982 4280 T/y	1983 4266 T/y	1984 4157 T/y	1985 4363 T/y
Montclair, NJ	1	. yr	reg.	1982 3015 T	1983 3963 T	1984 3442 T	1985 3627 T	1982 28,704 T	1983 28,012 T	1984 29,387 T	1985 29,688 T
Morristown, NJ	1	? yrs	reg.			1985 183.72 T				1985 16,433cuyd	
West Berlin NJ	1	3-5 yrs	reg.	1982 876 T/y	1983 871 T/y	1984 827 T/y	1985 1455 T/y	1982 7962cu.yd	1983 7980cu.yd	1984 8451cu.yd	1985 8085cu.yd

Program (town)	What are your landfill disposal fees, in dollars per year ? Year 1	Year 2	Year 3	Year 4	Participation 1985	Promotion	How is your program funded?
San Jose, CA	1985 $12.00 /T	1986 $8.03/T			50%		sale of materials-40% of cost govt. assistance, landfill diversion rebates.
Santa Monica, CA	1982 $3.08/T	1983 $3.38/T	1984 $3.87/T	1985 $3.91/T	35%	block leaders, PSA's, poster contests & displays, truck ads, TV messages, calendars	refuse fund;collection charge per household + start-up grant from state.
Sunnyvale, CA	0 (city owned)				--	newcomers package - recycle information.	solid waste surcharge
Boulder & Longmont CO	$8.00/T				30-35% 25%	block leader program - 800 volunteers "innovation diffusion techniques"	revenue from sales,local govt ldfll surcharge tx,tx on trsh users,general fund membershp priv.donors,corp/fndtn suppt.
Longmeadow MA	1983 $6.75/T	1984 $6.75/T	1985 $14.00/T	1986(6m) $26.50/T	90%	calendar/schedule, recycling instructions.	funded from town budget. revenues go into this fund.
Ann Arbor MI	1983 $12/T	1984 $12/T	1989 $12/T	1986(est) increase pending	50%	block coordinator program, flyers, prochures, reminders PSA's, limited paid ads, presentations to groups.	40%-revenues from sales 60%-contract w/ the city of Ann Arbor
St. Cloud MIN	--	--			--	next to no PR at this time.	revenue from the sale of recyclable items. Collection fees. Collection fees.
Linwood, NJ	1982 $8.16 /T	1983 $11.16 /T	1984 $23.49 /T	1985 $27.54 /T	27%	mail-outs-keep res.'s up to date on program's progress. calendar/schedules, info.	equipment grants, revenue from sales, ldfll.div.credit
Montclair, NJ	1982 $6.42 /T	1983 $6.42 /T	1984 $10.89 /T	1985 $16.35 /T	80%	annual flyer, weekly paper reminders, refuse was inspected & res.'s notified.	revenues from sales.NJ recycling tonnage grant program.
Morristown NJ	$4.9852 per cu. yd. (6.49cuyd/T)	--->$32.35 per ton			25%		municipal funding
West Berlin NJ	1982 $3.27/c.y	1983 $3.27/c.y	1984 $3.27/c.y	1985 $10.00/cy	90%	bimonthly newsletters + periodic notices to res.'s Minor enforcement...	revenue from sales

Program (town)	Population	Socio-economic status	When did program begin?	% of pop. served	vol. or mand.	private or public	Materials collected	Material preparation	special contain-ers ?	Frequency of collection: recyclables	Frequency of collection: regular
West Orange NJ	39,500	sub. w/ lt. comm.	1983	100 %	mand..	public	n,g,leaves	n-tied or so g-color sep. metal removed	no	every third week	twice weekly
Woodbury, * NJ	10,353	--	01/1981	99%	mand.	public	g,n,c(al+t) yard waste, OCC	n-bun.or non plastic bags g-colour sep. &remove non-g	no	weekly	weekly
Hamburg, NY	10,500	sub. light commer.	11/1981	100%	mand.	private	n,g,c, oil OCC	place in sep. containers	no (for oil only)	weekly	weekly
Islip, NY *	300,000	sub. w/ lt. commercial	10/1981	50%	mand.	public	n,g,c(t,al OCC,plastic beverage containers	n-bun/bagged g,c,pl-clean metal/labels removed	no	weekly	weekly
Athens, OH	12,500-20,000	Uni.town w/ v.lt. comm. or manu.	04/1984	100%	vol.	public	g-color sep al., n	sep.g-co/cl n-bundled/dry	no	every second week	weekly
Barberton, OH	29,721	urban, former ind. centre	05/1985	20%	vol.	non-profit corp.	n,g,al.can & foil	jars/cans rinsed	yes (clear plastic bags)	every second week	weekly
Austin, TX	457,000	large sub. area, light manu, htech	1982 as pilot	48%	vol.	public	g,n,c	n-bag/bundle g- color sep. c-clean/mix	yes	once per week	twice per week

Program (town)	LANDFILL no.	LANDFILL remaining capacity	LANDFILL use	How much recyclable material is collected? Year 1	Year 2	Year 3	Year 4	How much M.S.W. is disposed in your landfill(s)? Year 1	Year 2	Year 3	Year 4
West Orange, NJ	1	will close in 1987	reg.	1982 5235 T/y	1983 9144 T/y	1984 7019 T/y	1985 6735 T/y	--			
Woodbury, NJ	1	1986	reg.		1984 4121 T/y	1985 3751 T/y			1984 3352 T/y	1985 2935 T/y	
Hamburg, NY	?	?	reg.	948 T/y	936 T/y			8100 cu.yd	8400 cu.yd	9300 cu.yd	
Islip, NY	?	?	?	1983 19,240 T		1985 10,400 T		1983 93,854 T		1985 86,667 T	
Athens, OHIO	1	4 yr.	reg.		1984 161 T/y	1985 n.a.			1984 315 cu.yd/day	1985 1600 cu.yd/day	
Barberton, OH	1	2 yrs	reg.	300 T/y				14300 T/y cu.yd/day		cu.yd/day	
Austin, TX	1	8,783,400 cu. yd. (20 yr)	local & reg.	1982 50 T/y	1983 900 T/y	1984 2,300 T/y	1985 3,500 T/y	1982 118,000 T/y	1983 174,000 T/y	1984 187,000 T/y	1985 208,000 T/y

Program (town)	What are your landfill disposal fees, in dollars per year ? Year 1	Year 2	Year 3	Year 4	Participation 1985	Promotion	How is your program funded?
West Orange NJ	$14.28 pcy				50-60 %	yearly schedules, flyers, school lectures, garbage inspected-court summons	township taxes, sale of recyclables, garbage rebate, state tonnage grant
Woodbury, NJ *	1981 $18.28/T				85-95%	fines for non-part., various PR items available for any group- audio, slides ...	govt. assistance and sale of recyclables
Hamburg, NY	1982 $2.00/T	1983 $2.50/T	1984 $2.50/T	1985/86 $4.20/T	99%	case by case enforcement of ordinance. Warnings, phone calls...	initial start-up grant revenue from sales
Islip, NY	$10.00/T				30%	$250 fine for non-participation	
Athens, OH	$.60/cy	$.60/cy	$1/cy.Loos $1.5/cy Compacted	$1.5/cy.L $2/cy.Com	20%	paper ads, PSA's, "some" special events, "some" classroom education.	state grant + tax on litter stream ind.'s. Sale of recyclable materials.
Barberton, OH	$7.00/T				35%		state grants + sale of recyclables
Austin, TX	1985 $8-11.00				35%	block leader program, flyers presentations, media blitz..	collection fee

Appendix F

SAS PROC STEPWISE PROGRAM

SAS

MAXIMUM R-SQUARE IMPROVEMENT FOR DEPENDENT VARIABLE PCD

STEP 1 VARIABLE T ENTERED R SQUARE = 0.19660569 C(P) = 14.25634731

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	151665.84700855	151665.84700855	9.05	0.0047
ERROR	37	619755.58888889	16750.15105105		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	102.10000000				
T	148.01111111	49.18807033	151665.84700855	9.05	0.0047

BOUNDS ON CONDITION NUMBER: 1

THE ABOVE MODEL IS THE BEST 1 VARIABLE MODEL FOUND.

STEP 2 VARIABLE CAT ENTERED R SQUARE = 0.34980803 C(P) = 6.86346592

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	269849.41229161	134924.70614580	9.68	0.0004
ERROR	36	501572.02360583	13932.55621127		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-102.35630545				
CAT	50.27614068	17.26230521	118183.56528306	8.48	0.0061
T	145.77661597	44.86723703	147078.05588978	10.56	0.0025

BOUNDS ON CONDITION NUMBER: 1.000292, 4.00117

THE ABOVE MODEL IS THE BEST 2 VARIABLE MODEL FOUND.

STEP 3 VARIABLE SERV ENTERED R SQUARE = 0.41278714 C(P) = 5.00219741

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	318432.85113810	106144.28371270	8.20	0.0003
ERROR	35	452988.58475933	12942.53099312		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-84.93607827				
CAT	54.59645629	16.78645407	136908.43005028	10.58	0.0025
SERV	-0.00075749	0.00039097	48583.43884650	3.75	0.0608
T	143.59924234	43.25836879	142620.91977487	11.02	0.0021

BOUNDS ON CONDITION NUMBER: 1.018525, 9.11326

THE ABOVE MODEL IS THE BEST 3 VARIABLE MODEL FOUND.

STEP 4 VARIABLE C ENTERED R SQUARE = 0.48493766 C(P) = 2.5786272

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	374091.30878588	93522.82719647	8.00	0.0001
ERROR	34	397330.12711156	11686.18020916		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-91.14285563				
CAT	50.91070133	16.04007607	117727.49183706	10.07	0.0032
SERV	-0.00088128	0.00037581	64262.06384862	5.50	0.0250
T	160.38418042	41.81855407	171892.77101861	14.71	0.0005
C	89.71188300	41.10746335	55658.45764778	4.76	0.0361

BOUNDS ON CONDITION NUMBER: 1.075232, 16.73275

THE ABOVE MODEL IS THE BEST 4 VARIABLE MODEL FOUND.

STEP 5 VARIABLE AGE ENTERED R SQUARE = 0.49821197 C(P) = 3.76477564

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	384331.39204616	76866.27840923	6.55	0.0002
ERROR	33	387090.04385128	11730.00132883		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-119.59142264				
CAT	50.21079674	16.08757134	114264.49785935	9.74	0.0037
AGE	0.50346347	0.53884673	10240.08326028	0.87	0.3569
SERV	-0.00093032	0.00038016	70247.61174931	5.99	0.0199
T	164.33041956	42.10923591	178640.22921444	15.23	0.0004
C	105.64061556	44.57354793	65887.87477809	5.62	0.0238

BOUNDS ON CONDITION NUMBER: 1.259476, 27.8938

THE ABOVE MODEL IS THE BEST 5 VARIABLE MODEL FOUND.

STEP 6 VARIABLE PUB ENTERED R SQUARE = 0.50314578 C(P) = 5.46228238

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	388137.43726590	64689.57287765	5.40	0.0006
ERROR	32	383283.99863153	11977.62495724		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-124.54830180				
CAT	48.09859070	16.68273282	99563.69935893	8.31	0.0070
AGE	0.45733068	0.55062042	8262.79107619	0.69	0.4124
PUB	11.27315806	19.99834146	3806.04521975	0.32	0.5769
SERV	-0.00099287	0.00039986	73849.73431457	6.17	0.0185
T	158.22091203	43.90996959	155514.97142802	12.98	0.0011
C	94.06293244	49.50328931	43245.37065731	3.61	0.0665

BOUNDS ON CONDITION NUMBER: 1.521356, 45.44084

THE ABOVE MODEL IS THE BEST 6 VARIABLE MODEL FOUND.

STEP 7 VARIABLE CF ENTERED R SQUARE = 0.51012015 C(P) = 7.03468150

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	393517.61775214	56216.80253602	4.61	0.0013
ERROR	31	377903.81814530	12190.44574662		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-105.37358876				
CAT	46.46266750	17.00948430	90958.97803796	7.46	0.0103
CF	-15.01383991	22.59972483	5380.18048624	0.44	0.5114
AGE	0.45076464	0.55557856	8024.69073013	0.66	0.4234
PUB	16.89747366	21.87953010	7270.88308287	0.60	0.4458
SERV	-0.00097117	0.00040471	70196.78625455	5.76	0.0226
T	161.67532587	44.60248689	160172.85897235	13.14	0.0010
C	82.80235633	52.73920246	30049.54231792	2.47	0.1266

BOUNDS ON CONDITION NUMBER: 1.758069, 65.71926

THE ABOVE MODEL IS THE BEST 7 VARIABLE MODEL FOUND.

STEP 8 VARIABLE PRE ENTERED R SQUARE = 0.51068582 C(P) = 9.00000000

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	393953.98893490	49244.24861686	3.91	0.0029
ERROR	30	377467.44696253	12582.24823208		
TOTAL	38	771421.43589744			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	-105.34397514				
CAT	45.95157851	17.49723288	86780.14556686	6.90	0.0135
CF	-16.33199543	24.02629385	5813.84139169	0.46	0.5019
AGE	0.43468989	0.57099803	7292.02437278	0.58	0.4524
PRE	3.44150922	18.47991761	436.37118277	0.03	0.8535
PUB	15.02630545	24.39374438	4774.25638063	0.38	0.5425
SERV	-0.00095411	0.00042125	64546.09464390	5.13	0.0309
T	162.34498878	45.45603705	160491.81306384	12.76	0.0012
C	82.69083930	53.58336832	29964.91347941	2.38	0.1333

BOUNDS ON CONDITION NUMBER: 2.11728, 93.056

THE ABOVE MODEL IS THE BEST 8 VARIABLE MODEL FOUND.

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