THE PHOENIX RECYCLING PROJECT

A Characterization of Recyclable Materials in Residential Solid Wastes: Initial Results

EXECUTIVE SUMMARY

by

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May 25, 1988

ABSTRACT

A total of 846 Phoenix refuse pickups were collected from six sample census tracts which are representative of the socio-metric characteristics of Phoenix. Each refuse pickup was divided into target recyclables and non-recyclables which were measured by weight and volume. Overall, target recyclables in the Phoenix household refuse samples represented half the refuse by weight and two-thirds the refuse by volume. Early-week pickups tended to contain more recyclables in most census tracts. The volume of recyclables varied by census tract; the next report of this study will determine which specific recyclables create these overall differences in volume. The differences in discard by census tract and time-of-week of pickup, once understood, will be valuable in redesigning pickup routes and the efficient use of available equipment, personnel, and recycling facilities. Estimates of city-wide discard quantities were calculated.

THE PHOENIX RECYCLING PROJECT

Goal: A comprehensive study of recyclables in household refuse and variables which affect their collection in a curbside, mixed-recyclables, source separation program.

This report represents the first step of the project which identifies the basic parameters of the study, preliminary conclusions, and the direction of future analyses.

Sample Collection

Household refuse pickups--all of the refuse placed out in the City's standard 90-gallon bins for bi-weekly collection--were randomly sampled from within a set of six census tracts (Table 1a). These six tracts represent a wide range of median household income (from $7,883 to $31,186 in 1980), median age of residents (from 24.7 to 35.1 years in 1980), ethnicity (from 2.1 percent to 46.1 percent Hispanic), and household size (from 2.01 to 3.35 persons in 1985) (see Table 1a). This particular set of tracts was selected both to initially represent the diversity in the City of Phoenix and to be comparable to tracts studied over the last 14 years in the City of Tucson, Arizona. Tucson comparisons will be included in the next report. Note already the overall similarity of the sample refuse collected for this study in Phoenix and in Tucson (see Table 4).

Data Recording

The contents of each of 846 Phoenix sample pickups (Table 2) were divided into target recyclables and non-recyclables which were measured by weight in pounds and by "uncompacted" volume in gallons (Recyclables Analysis Procedure (RAP; see Table 3). The contents of 432 of these pickups (see Table 2) were further divided into 22 more detailed categories, 14 target recyclables, and 8 non-recyclables (Detailed Recyclables Analysis Procedure (DRAP; see Table 3, Appendix). These categories were defined in consultation with City of Phoenix Department of Public Works personnel and with Mr. Gene Gabrielli of The Ecology Companies, Incorporated. In addition, all potentially hazardous household wastes in the sample pickups were recorded using the Garbage Project's standard Hazardous Wastes Recording Procedure (Hz-RP).

Note the similarity between the socio-metric characteristics for Phoenix as a whole and the socio-metric characteristics calculated for refuse recorded from sample census tracts (see Table 1b).

Significance of Results

The purpose of this report is to establish preliminary parameters on the weight and volume of recyclables in sampled household refuse. These results are valuable because few studies have been conducted on the quantity of recylables actually <u>discarded</u> in household refuse. Those investigations

which have been completed either define only a few recyclables (such as just newspapers, aluminum, ferrous metal, and glass) or only record refuse from volunteer households. This study represents a contemporary appraisal of the quantity of the entire range of target recyclables discarded by a broad segment of the population of Phoenix.

Overall Quantities

The first results are the most general and the most significant. The standard measure of recyclables has been weight (the measure by which recyclables are sold). The good news is that the household refuse pickups sampled in Phoenix contained an average of 19.5 pounds of recyclable materials. This represents 50.3 percent of the average total weight of sampled pickups, which was 38.8 pounds (Table 4).

A volume measure of recyclables is important because the volume of refuse deposited in landfills determines how quickly the landfills will be filled. Nevertheless, since recyclables are rarely measured in this way, their contribution to the overall volume of household refuse has been open to speculation. By volume, target recyclable materials in sampled Phoenix household refuse represent an average of 38 out of 60 gallons. This means that theoretically 63.3 percent of the volume of household refuse can be recycled (Table 4).

Overall, target recyclables in Phoenix household refuse samples represent about half of household refuse by weight and two-thirds of household refuse by volume (Table 4).

Variability Tests

A great range of variability among refuse pickup samples is indicated by relatively high standard deviation statistics. There are two obvious potential sources of this variability. The first is differences among the income, ethnicity, family size, and other socio-metric characteristics of households in different census tracts. The second is time of refuse collection, either Monday/Tuesday (early-week, refuse discarded over a weekend) or Thursday/Friday (late-week, refuse discarded during the week).

The hypothesis that socio-metrics and collection period, together, account for significant amounts of variation in refuse characteristics was tested using analysis of variance. An F statistic was compared against F theoretical (at alpha = <.05, two-tailed). Any values which were greater than the theoretical F (higher than expected by chance 5 times in 100) were considered significant (see Table 7, significant scores are underlined).

Variability in Recyclables Due to Differences in the Time of Refuse Collection

The F tests as well as the tract averages broken down by early-week or late-week collections, indicate that there is a definite trend toward increased recyclables (by absolute weight and volume) in the early-week pickups (Tables 5, 6, and 7). This seems logical since the refuse is accumulated over the weekend. Sunday newspapers are larger than those on

weekdays. In addition, over weekends it seems logical that people would drink more beverages at home from cans and bottles, purchase big-ticket durables in large cardboard packages, and undertake more large-scale house cleanings, home repairs, and yard work. These activities would in turn lead to the discard of more textiles and boxes, more leaves and twigs, and more clean wood.

It is extremely interesting that the two tracts highest in Hispanic residents (Tract 1153--46.1 percent and 1162.03--23.4 percent) are the two major exceptions to this trend. Until a more detailed analysis of the recyclables breakdown is completed for the next report, it is hard to say what this pattern means. It is possible at present only to suggest that perhaps Hispanics spend more time at home than Anglos--weekend outings could be more often to the homes of other Hispanics. This hypothesis will be tested by determining what items create the weekend/weekday differences observable in neighborhoods high in Anglos and those high in Hispanics.

While absolute quantities varied, no significant differences in percent weight or volumes of recyclables were associated with time of collection.

Variability in Recyclables Due to Socio-Metric Differences between Census Tracts

The F tests, as well as the average quantities recorded by tract (Tables 5, 6, and 7), suggest that socio-metric differences at the census tract level have little significant

effect on variability in the weight of total recyclables discarded. The F test determined, however, that the volume of target recyclables was significantly associated with census tract. The early-week variability is low; the tract averages range only between 35 and 44 gallons. The late-week pickups, however, range from 24 gallons to double that figure, 48 gallons. The percent of weight for target recyclables was also significantly associated with tract designation. There was little late-week-variability, only 48 to 57 percent, but a great deal of early-week variation, from 46 to 66 percent.

One of the major goals in the on-going analyses for this study is to determine what changes in actual discards cause the differences observed in the overall weight and volume of recyclables. Understanding and exploiting this variability to minimize collection efforts must await the detailed analyses in the next report. It is possible, however, to anticipate useful results. Note that while the lowest income, highest percent Hispanic neighborhood has the lowest early-week absolute volume, it has the second highest late-week absolute volume. These kinds of differences, once understood, will be valuable in redesigning pickup routes and the efficient use of available equipment, personnel, and recycling facilities.

City-Wide Estimates of Discarded Recyclables

Completed statistical tests (see Tables 1b and 7) indicate that it is possible to roughly extrapolate from our samples to the quantities of recyclables discarded in household refuse at

the overall city-level (Table 8). "Minimum" and "maximum" figures were calculated to take the variances in the data into account. Thus, while actual discards may not exactly match "estimated" tons discarded per week, we have a 95 percent confidence level that actual discards will fall somewhere between our minimum and maximum figures.

It is essential to note in this process that households do not always place their containers out for pickup twice a week. In fact, a record compiled for our study indicates that on every pickup day some 27 percent of eligible households do not place their containers out with refuse. As a result, the city-wide estimates for this study include "no-discard" households.

The quantities of materials which we estimate to be discarded regularly by households in the City of Phoenix are staggering. The aluminum alone is currently worth (at 60 cents a pound) more than $122,500 each week (minimum: $81,700/maximum: $163,400)--a minimum of $6,372,000 per year! The newsprint discarded at $35 a ton would bring $1,647,900 in a year.

Current Analyses

There is a long road from estimates of actual discards to what the City of Phoenix can actually recover. It is the goal of this study to determine what is currently being discarded. To accomplish this objective, The Garbage Project will conduct

further hands-on refuse sorts in July and in November to further control for seasonal and socio-metric variability.

It is also a goal of this study to provide data which are useful in designing efficient collection systems. To meet this objective, the next report will quantify early-week and late-week differences by neighborhood in terms of the weight of specific constituents as well as overall weight and volume data. With such data, cost-effective collection systems can be designed to minimize hauler mileage and maximize recyclables collected.

It is a final goal of this study to determine whether patterns identified in Phoenix can be extrapolated to Tucson and visa versa. To achieve this objective, The Garbage Project will attempt to develop algorithms to predict the types and quantities of recyclables discarded in specific neighborhoods given information on income, ethnicity, and household size. These predictions will then be checked by hands-on sorts. Eventually, quantities of recyclables collected by the City can be compared to Garbage Project studies of discards to evaluate compliance to curbside recycling requests in various neighborhoods.

Ultimately, The Garbage Project hopes to provide reports worth more than their weight in gold toward exploiting the recyclable resources discarded daily in Phoenix household refuse.

Table 1a

General Characteristics of Cenus Tracts Sampled in Phoenix

Tract	Median Income	Median Age	Percent Hispanic	Persons per Household
		1980 Census Data		
1036.02	31,188	35.1	2.1	3.00
1162.03	20,500	29.1	23.4	2.79
1033.02	18,566	24.7	4.2	3.25
1090	14,312	24.9	10.3	2.27
1086	11,231	27.4	10.2	2.09
1153	7,883	26.1	46.1	3.48
		1985 Special Census Data[2]		
1162.03		29.9	26.3	2.36
1033.02		26.9	4.6	3.12
1090		26.0	11.1	2.27
1086		29.2	13.6	2.01
1153		25.5	54.0	3.35

[1]These figures are from the 1980 census.

[2]Income data were not available in the 1985 Special Census. Information on Phoenix census tract 1036.02 was also not available in the 1985 Special Census.

Table 1b

Comparison of Overall Census Tract Characteristics for Phoenix, Arizona with Characteristics Calculated from Refuse Sample Tracts

Type	Median Income($)	Median Age	Persons Per Household
Census Average[1]	17,419	28.9	2.74
Refuse Sample Average			
RAP	17,071	27.7	2.78
DRAP	17,274	27.8	2.78

Table 2

Number of Household Refuse Containers Sampled

	Monday/Tuesday Pickups		Thursday/Friday Pickups	
Tract	RAP	DRAP	RAP	DRAP
1033.02	76	38	75	35
1036.02	74	38	49	25
1086.00	75	38	74	37
1090.00	77	38	74	35
1153.00	72	34	52	27
1162.03	70	41	72	45
Subtotals	444	227	402	205

Total Sampled Containers: RAP = 846

DRAP = 432

RAP = Recyclables Analysis Procedure

DRAP = Detailed Recyclables Analysis Procedure

Table 3

RECYCLABLES

1. Aluminum (ALUM) - mainly cans and foil
2. Ferrous Metal (FERM) - includes tinned-steel cans
3. Other Metal (OTHM)
4. Corrugated Cardboard (CORC)
5. Newspapers (NEWS)
6. Packaging Paper (PACK) - includes paperboard boxes and paper grocery bags
7. Non-Packaging Paper (NPAC) - includes paper cups, plates, and stationary
8. Other Paper (OTHP) - includes books
9. Glossy Magazines (MAGS)
10. Glass (GLAS)
11. Plastic PET Containers (PETP) - 1, 2, and 3 liter plastic soft drink bottles and clear, rigid plastic bottles
12. Textiles (TEXT)
13. Leaves and Twigs (LEAF)
14. Clean Wood (WOOD)

NON-RECYCLABLES

15. Paper Towels and Tissues (TISP)
16. Foam (FOAM) - "styrofoam" containers and packaging materials
17. All Other Plastics (OTPL) - including HDPE milk jugs, PVC plastic bottles, jugs, and film wraps
18. Disposable Diapers (DIAP)
19. Food Debris (FOOD) - including both preparation debris, such as rinds, peels, tops, bones, and fat, as well as once-edible food "waste"
20. Grass, Lawn Trimmings (GRAS)
21. Rocks (ROCK)
22. Other (OTHR) -

Table 4

Sampled Phoenix Household Refuse

Overall Results

N = 846

	Target Recyclables	Total Refuse
Weight (pounds)	19.5 (17.2)*	38.8+
Percent Weight	50.3	100.0
Volume (gallons)	38 (28)*	60
Percent Volume	63.3	100.0

*(Standard Deviations)

+Note that this weight is the average for containers that hold refuse and does not average in those containers which are not placed out for collection.

Sampled Tucson Household Refuse

Overall Results

N = 628

	Target Recyclables	Total Refuse
Weight (pounds)	15.9	29.2
Percent Weight	54.4	100.0
Volume (gallons)	30	47
Percent Volume	64.1	100.0

Table 5

Weight Characteristics of
Phoenix Sample Refuse
by Census Tract

	Census Tract	1033.02	1036.02	1086	1090	1153	1162.03
			WEIGHT MEASURE (pounds) Mean (Standard Deviation)				
Monday/Tuesday Pickups	N	76	74	75	77	72	70
Recyclables		25.7(19.1)	25.7(20.3)	19.7(17.2)	21.5(15.5)	17.4(13.1)	22.1(19.2)
Non-Recyclables		23.2(25.0)	15.5(17.8)	18.7(23.9)	18.2(17.8)	22.9(27.0)	28.3(25.0)
Thursday/Friday Pickups	N	75	49	74	74	52	72
Recyclables		14.6(11.7)	14.6(12.9)	17.3(14.5)	13.6(15.4)	19.2(20.5)	20.2(19.7)
Non-Recyclables		17.0(21.3)	16.9(25.5)	16.7(20.5)	12.4(16.9)	23.2(22.0)	18.4(18.5)
			PERCENT WEIGHT				
Monday/Tuesday Pickups	N	76	74	75	77	72	70
Recyclables		57.2	66.6	56.0	55.9	46.8	47.6
Non-Recyclables		42.8	33.4	44.0	44.1	53.2	52.4
Thursday/Friday Pickups	N	75	49	74	74	52	72
Recyclables		55.9	57.0	56.4	56.4	48.2	55.7
Non-Recyclables		44.1	43.0	43.6	43.3	51.8	44.3

( ) = Standard Deviation

Table 6

Volume Characteristics of
Phoenix Sample Refuse
by Census Tract

	Census Tract	1033.02	1036.02	1086	1090	1153	1162.03
		VOLUME MEASURE (gallons) Mean (Standard Deviation)					
Monday/Tuesday Pickups	N	76	74	75	77	72	70
Recyclables		45(22)	46(28)	38(27)	44(26)	35(18)	41(25)
Non-Recyclables		26(17)	21(16)	24(24)	23(18)	23(16)	31(22)
Thursday/Friday Pickups	N	75	49	76	78	52	72
Recyclables		29(18)	33(24)	33(25)	24(20)	34(22)	48(52)
Non-Recyclables		19(18)	19(17)	19(18)	16(15)	21(13)	22(19)
		PERCENT VOLUME					
Monday/Tuesday Pickups	N	76	74	75	77	72	70
Recyclables		64.3	68.7	62.4	64.5	60.5	57.4
Non-Recyclables		35.7	31.3	37.6	35.5	39.5	42.6
Thursday/Friday Pickups	N	75	49	76	78	52	72
Recyclables		63.4	63.0	64.8	61.4	60.4	66.4
Non-Recyclables		36.6	37.0	35.2	38.6	39.6	33.6

( ) = Standard Deviation

Table 7

Tests of Association between
Recyclables, Census Tracts and Collection Time

Dependent Variable (DF)	Tract (5)		Time (1)	
	F Value	PR > F	F Value	PR > F+
Weight of Recyclables	1.07	0.3741	20.68	0.0001*
Volume of Recyclables	2.97	0.0116	15.95	0.0001
Percent Weight of Recyclables	6.01	0.0001	0.00	0.9557
Percent Volume of Recyclables	1.42	0.2142	0.08	0.7837

DF = Degrees of Freedom

+PR > F = Alpha level required to reject the hypothesis. Values less than or equal to 0.05 indicate significant F values.

*Results which are significant are underlined.

Table 8

Recyclables and Non-Recyclables Projections
for
Phoenix, Arizona
Households: 340,401 (1985 Special Census)

Type	Estimated Tons Per Week	Minimum Estimate	Maximum Estimate
RECYCLABLES/NON-RECYCLABLES ANALYSIS			
Weight of Recyclables	4,843.91 (18.79)*	4,544.35 (17.20)	5,143.46 (20.38)
Weight of Non-Recyclables	4,786.04 (11.00)	4,112.04 (10.15)	5,460.03 (11.95)
DETAILED RECYCLABLES/NON-RECYCLABLES ANALYSIS			
Recyclabes			
ALUM	102.12	68.08	136.16
FERR	428.90	296.15	561.66
OTHM	27.23	6.18	47.66
CORC	183.82	142.97	224.66
NEWS	905.47	639.95	1,170.98
PACK	551.45	496.98	605.91
NPAC	330.19	224.66	435.71
GLOS	142.97	47.87	228.07
OTHP	173.60	88.50	258.70
GLAS	830.37	673.99	966.74
PETP	27.23	13.62	40.85
TEXT	187.22	153.18	221.26
WOOD	316.57	156.58	476.56
LEAF	837.39	449.33	1,225.44
Non-Recyclables			
TISP	197.43	177.01	217.86
FOAM	30.64	17.02	44.25
OTPL	490.18	462.94	517.41
FOOD	1,045.03	898.66	1,191.40
GRAS	1,405.86	946.31	1,865.40
DIAP	306.36	132.76	479.96
ROCK	224.66	17.02	432.31
OTHR	956.53	677.40	1,239.66

*(Volume in millions of gallons)