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Optimizing recycling in all of New York City's neighborhoods: Using GIS to develop the REAP index for improved recycling education, awareness, and participation

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Abstract

New York City's recycling program began in 1988 with scattered pilot programs to collect a restricted number of recyclable categories. Over time, the program was made more uniform in its implementation, was expanded citywide, and targeted more types of recyclables. Although Department of Sanitation surveys have shown that residents in all areas of the city have understood the requirements of the recycling program, recycling diversion rates vary substantially throughout the city's neighborhoods, ranging from 9 to 31% per district, while city-wide the diversion rate averages only about 20%.

This paper explores the possible reasons for the disparity of recycling participation rates amongst neighborhoods, using recycling data collected by the city and federal census information to characterize the city's neighborhoods and show variation in recycling participation rates, demographics, socio-economic indicators, and other metrics. Four variables were found to be strongly correlated with low diversion rates: percentage of persons below poverty level; percentage of households headed by a single female with children; percentage of adults without a high school diploma; and percentage of minority population.

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A weighted linear model is used to calculate a one-number descriptive measure, called the recycling education, awareness, and participation (REAP) index, which relates recycling behavior for each of New York City's 59 sanitation districts with demographic and socio-economic variables that might "predict" recycling rates. This REAP index can then be used to help inform decision- and policy-making about strategies for increasing recycling education, awareness, and participation, help target particular communities for assistance, and prioritize resources. The effects of rapid program changes and substandard residential recycling environments are also discussed as possible influences on recycling participation rates, as well as other attitudinal, physical, and knowledge-based factors that may be indirectly associated with low socio-economic status communities.

Keywords: Recycling; Diversion rates; Recycling participation; Geographic information systems (GIS); Weighted linear index model; New York City; Solid waste management; Solid waste policy; Disparities

1. Who recycles in New York City?

The residents of New York City generate approximately 13,000 t of solid waste per day, much of it recyclable (Maantay, 2001). Despite some drastic reductions and confusing changes in New York City's recycling program, the New York City Department of Sanitation has for the past few years provided weekly pickups of recyclables in all neighborhoods (New York City Department of Sanitation, 2001). However, recycling rates vary widely among the 59 sanitation districts in New York City, from a low of 9% to a high of 31% of the total waste generated (New York City Department of Sanitation, 2001).

This study seeks to determine which demographic or socio-economic variables might help "explain" this disparity in recycling rates, and to develop a one-number descriptive index for each of New York City's 59 sanitation districts that takes into account current recycling behavior and variables that currently "predict" recycling behavior. This recycling education, awareness, and participation (REAP) index can then be used to help inform decision- and policy-making about strategies for increasing recycling education, awareness, and participation; help target particular communities for assistance; and prioritize resources.

This analysis uses ArcGIS by Environmental Systems Research Institute (ESRI), a computerized mapping and spatial analysis software, and publicly available data sets from the New York City Department of Sanitation (NYC DOS) and the Department of City Planning (NYC DCP). Geographic information systems (GIS) have become an important means of visualizing and exploring data that is spatial in nature, to more effectively examine and predict the impacts of current or future actions on the environment, human health, and the economy (Maantay, 2002). The study's objective is to better understand the reasons for low recycling participation rates in order to address potential strategies for remediation.

New York City's sanitation districts are coterminous with its 59 community districts (CDs), which were created to represent cohesive neighborhood geographic units having a certain amount of internal consistency and homogeneity. Among districts, however, the demographic and socio-economic characteristics have a wide range (see Table 1). For instance, the minority population in New York's community districts ranges from a low of 10% to a high of 99%, and the percentage of adults without a high school diploma

Table 1
Descriptive statistics of New York City community districts' diversion rates and socio-demographic variables

Variable	Minimum	Maximum	Range	Mean	Median	S.D.
Adults without H.S. diploma (%)	4.67	56.60	51.93	29.32	28.97	13.15
Persons below poverty level (%)	4.90	45.67	40.77	22.38	19.58	11.73
Female head w/children (%)	1.17	28.13	26.96	11.72	9.15	8.02
Minority population (%)	10.89	99.31	88.42	65.61	65.59	27.22
Diversion rates (%)	9.17	31.10	21.93	20.78	22.32	6.20

ranges from 4 to 56% (New York City Department of City Planning, 2004). These statistics reflect New York City's remarkable diversity, but also point out the challenges inherent in devising policies and programs for such a heterogeneous population. Who recycles, and can recycling rates be predicted by socio-demographic indicators?

2. A brief history of New York City's recycling program

New York City's recycling program began in 1988 with pilot programs introduced every few months, which were deployed in different parts of the city and collected different types of recyclables (see Fig. 1). In 1993 the DOS unified its program, collecting metal cans and foil, glass bottles, plastic jugs and bottles, newspaper, magazines, phone books and corrugated cardboard. In 1996 mixed paper, bulk metal objects, grey cardboard, and wax paper cartons were added. In 1998 the city council passed a local law to require collection of recyclables on a weekly basis citywide in an attempt to make the program simpler and increase participation. By June, 2002, the city's diversion rate for recyclables was about 19% of the entire waste stream, and its capture rate of targeted recyclables averaged 46% (New York City Department of Sanitation, 2002a). Diversion rate is the recyclable percentage of the total discards that were set out for collection; capture rate is the percentage of recyclable

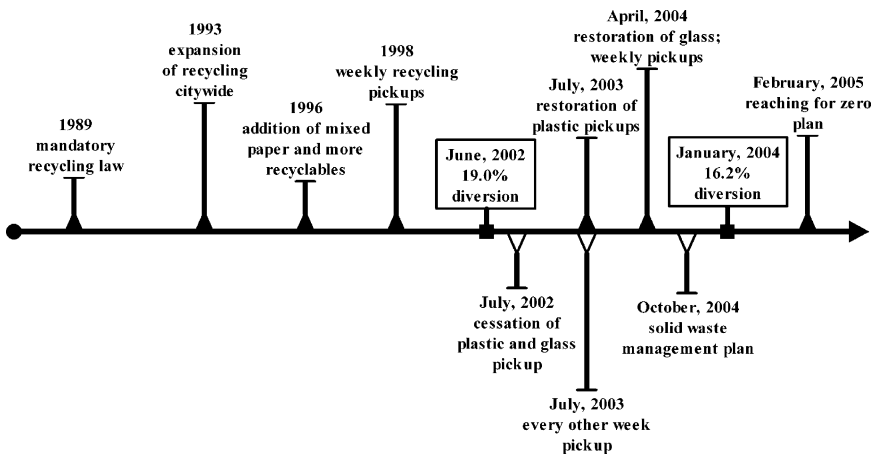

Fig. 1. Timeline of major recycling policies and implementation strategies in New York City, 1989–2005.

items targeted by the DOS for recycling that are set out for recycling. The DOS targeted about half the waste stream for recycling during fiscal years (FY) 2001, 2002, and again since April, 2004. For New York City's government, the fiscal year is from 1 July to 30 June; for instance, FY 2002 is from July 1, 2001 to June 30, 2002.

In January, 2002, within days of assuming office, Mayor Bloomberg announced that recycling was costing too much and that he wanted to stop the metals, glass, and plastic recycling programs. The Mayor said the city would save as much as $50 million if it stopped collecting metal, glass and plastic, and instead exported that tonnage with the rest of the unrecycled materials. By July 2002, the city's recycling program began to be scaled back. News reports (not always precise or accurate) were frequent on the topic for 6 months. Two months prior to the final budget decision, the New York City Waste Prevention Coalition, a non-governmental, non-profit organization, issued a report with a number of recommendations on ways to save tens of millions of dollars by instituting programs like grasscycling ("leave it on the lawn") and more efficient collecting routes, and criticized the methodology the city used to estimate the $50 million in savings (New York City Waste Prevention Coalition, 2002). In a compromise to save the program, the city council arranged with the Mayor to keep metal and paper/cardboard recycling in place (since the city was making a profit from these operations), and to reinstate plastics in July 2003, and glass in 2004.

These changes to the program had impacts on recycling participation. First, this decision necessitated three discrete educational programs to instruct residents first not to set out glass or plastic, then a year later to reinstate plastics, but to go from weekly to alternate week set outs, and then 10 months later, to reinstate glass and restore weekly set outs. There was potential for confusion and anger amongst participants. In the 3 months immediately after cessation of plastic and glass collections, data showed that paper collections also went down by over 12% from 1 year before even though paper recycling had been unaffected by the program changes (New York City Department of Sanitation, 2002b). This was not unexpected, as research findings stated in a US Environmental Protection Agency (US EPA) report indicated that the number of items targeted in a recycling program have a significant impact on both the costs and the participation rate, with costs decreasing and participation increasing with an increase in the number of items targeted (United States Environmental Protection Agency, 2001).

A few weeks after plastics were restored to the program in July 2003, in the name of improving the economics of the recycling program, the DOS changed the program from collecting weekly to once every 2 weeks, angering residents and building superintendents who were now forced to store recyclables for an additional week. In April 2004, glass was added back to the recycling program and weekly collections were restored. As per a 9th June, 2004 memorandum entitled "Preliminary May Curbside Recycling," from the DOS Deputy Commissioner, the citywide diversion rate was 15.8% in May 2004, which was down from 19.0% in June 2002, just before the program changes were implemented (New York City Department of Sanitation, 2002a). The May 2004, citywide capture rate was 36.6%, more than a 17% loss in participation from the 46% capture rate of June 2002. By early 2005, the citywide diversion rate had still not returned to the rate prior to program changes (Cipollina, 2005). A year later, the citywide curbside and containerized total diversion rate was 16.5% for April 2005, versus 16.3% for April 2004, when glass and weekly recycling

were restored. The capture rate was 38.2% for April 2005 versus 37.6% for April 2004. It is unclear how long it might take for diversion and capture rates to recover to FY 2002 levels, if, indeed, they ever will.

Not only did the program changes impact participation, but the expected cost-savings did not materialize. A report issued by the City's Comptroller detailed how the Mayor's "cost-saving" plan was based on faulty economic data and assumptions (Thompson, 2002). The $50 million that the Mayor had expected would be saved by suspending glass and plastic collections and by going to bi-weekly collections did not occur, according to the City Comptroller, because: paper recycling went down by 10%, adversely affecting revenues from sale of paper; trucks returned partially filled and this reduced collection efficiency; and participation rates did not recover to early 2002 levels because of those disaffected by the city's lack of commitment to recycling, or by those who could not remember which week to recycle.

3. City programs to motivate increased participation in recycling

Since the beginning of its recycling programs in the late 1980s, the Department of Sanitation has followed a two-pronged strategy to motivate New Yorkers to recycle: education and enforcement. The DOS considered that people would recycle if they knew what was expected of them and if there was threat of a fine for not recycling.

While there are benefits to natural resources, the environment, and our energy supplies from recycling, as well as to local economic development and job creation resulting from sorting and manufacturing new products from recyclables, and those intrinsic motivations are reasons that some recycle, there are no direct monetary benefits to the recyclers in New York City except for the bottle deposit system. (In New York and other states consumers pay five cents on each aluminum, PET and glass bottle at point of purchase, and bottles are collected by retailers for recycling.)

There are monetary disincentives not to recycle built into the local law that mandates recycling (New York City Local Law 19, 1989) and recycling regulations, with fines up to $10,000 per day after multiple violations. However, recycling enforcement is inconsistent, with most enforcement actions against single-family homeowners, and virtually none against apartment dwellers, and enforcement is not well funded or studied, so its efficacy as an incentive to recycle is not well understood.

The enforcement program has been administered unevenly. There were different patterns of enforcement for single-family homes versus apartment buildings, and different aspects of the regulations were focused upon by the sanitation department depending upon the type and density of dwelling units. The vagaries of enforcement likely created confusion in the minds of residents and for many was a disincentive to recycle.

Educational materials and media have primarily been employed when program changes occurred, not on a continuing basis. DOS began sending educational materials to residents primarily via mailed brochures, once every few years on average. Educational materials are sent to every part of the city including apartments. Until 2004, TV public service ads were only on cable channels (accessible only by those paying monthly service charges). Billboards and advertisements in public transit locations ran a couple of times, briefly.

New York City's population includes speakers from hundreds of nationalities, with 25 major languages spoken. Incomes vary substantially, with 20% of residents living below the poverty level, and a majority (60%) having incomes between $15,000 and $75,000. Only about 9% of homes are single-family detached and over 30% are apartment buildings having 50 or more dwelling units.

Since 1988, DOS has issued recycling information in both English and Spanish. DOS placed notices in English and Spanish language papers, as it is required by the New York City mandatory recycling law to reach every person in the city with recycling education. At its heyday in the late 1990s, prior to the cuts in recycling service, recycling information was distributed in many languages, including Hebrew, Yiddish, Chinese, Korean, Russian, Polish, in addition to Spanish and English, in an attempt to inform the populations who speak these languages exclusively. Pictures of recyclable and non-recyclable materials were featured to increase understanding.

4. Recycling rates in different New York City neighborhoods

If the people in all New York City's neighborhoods did understand what to recycle, one might logically expect for all neighborhoods to have similar recycling (diversion) rates, as DOS expected. But Fig. 2 illustrates a very wide disparity in recycling rates across the city, from below 10% to above 30%, prior to service modifications starting 2002. Visual examination of Fig. 2 shows that the highest and lowest recycling rates are concentrated in a few major areas. This noticeable disparity in recycling rates across New York City led us to wonder if there was something special about the neighborhoods at the extremes of the spectrum that could explain the disparity. Might differences in demographics, educational levels, or other socio-economic indicators help explain the disparity in recycling rates? What other factors might account for the wide range of recycling rates? This paper characterizes the relationships between certain socio-demographic indicators and recycling diversion rates, using GIS to develop a weighted linear index model.

We obtained data from the NYC Department of Sanitation for average tonnes per day of recyclables collected in each of New York City's 59 sanitation districts, as well as average tonnes per day of all other waste. NYC DOS collects residential and institutional solid waste, with private companies collecting most of the commercial and industrial solid waste in the city. Therefore, commercial and industrial solid wastes are not included in the calculations. The DOS uses sanitation districts as their geographic unit for collection and reporting, and the boundaries of these districts are coincident with those of New York City's 59 community districts. Figures for tonnage of recyclables and tonnage of all other refuse are obtained directly from measured amounts from truck scales at each recycling vendor or transfer station. Average tonnes per day (annual) of curbside and containerized recycling were totalled. Average tonnes per day (annual) of all non-recycled municipal solid waste collected by the NYC DOS (primarily residential) were then added to the recyclable total to arrive at a total waste stream (given in average tonnes per day, TPD) for each CD. The average TPD of recyclables was divided by the average TPD of total waste to obtain a diversion rate—the proportion of the waste stream for each CD that was diverted to recycling. This was converted into a percentage by multiplying by 100.

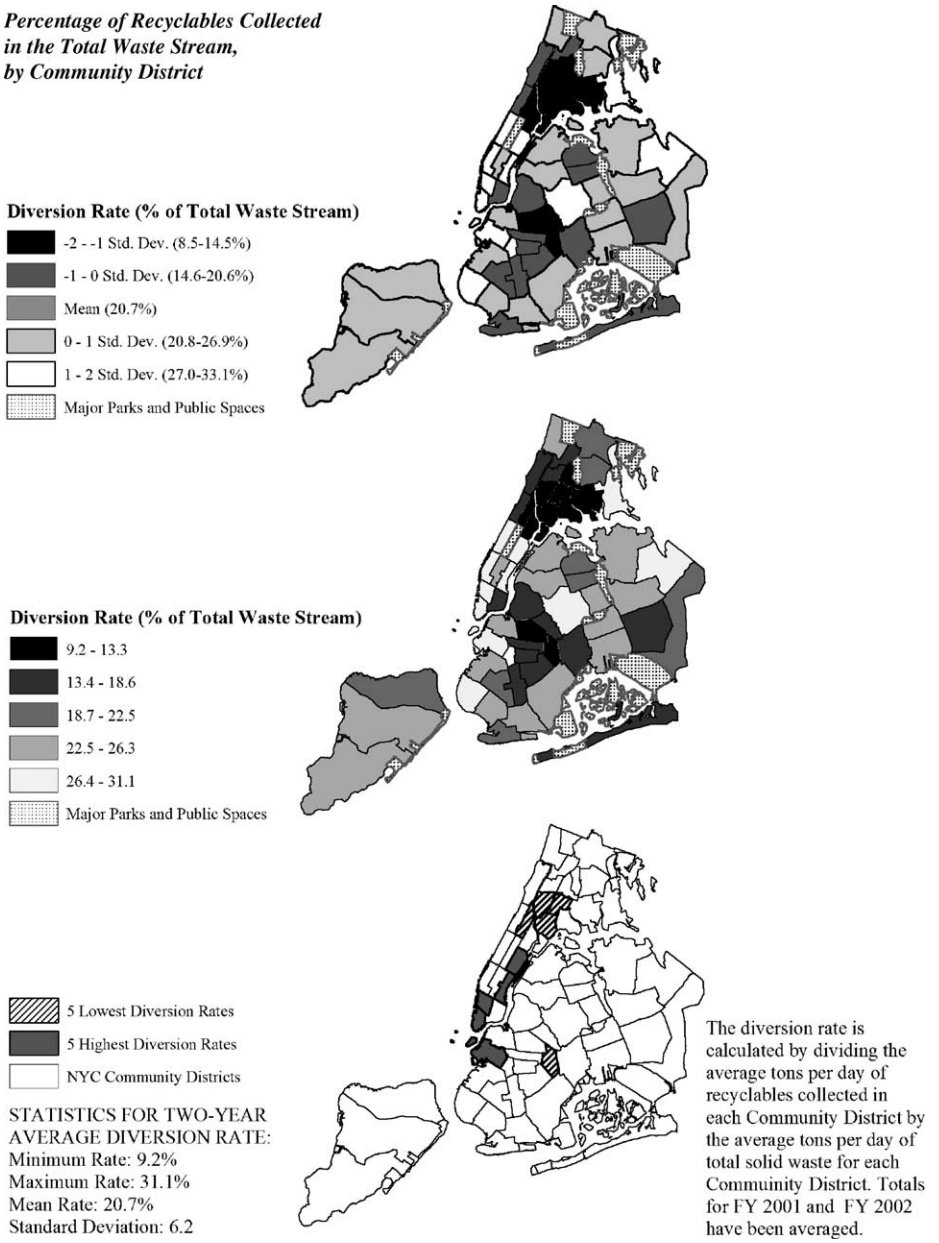

Fig. 2. Diversion rates by New York City community district, with five highest and five lowest recycling participation community districts.

The recycled average TPD and total waste average TPD totals for FY 2001 and FY 2002 (1 July, 2000 to 30 June, 2002) were used to produce a 2-year average diversion rate. The data for FY 2001 and 2002 were averaged to generate a more representative indication of recycling rates in each community than a 1-year "snapshot" of the data would have provided.

Although recycling data from 1999 to 2003 were available, FY 2001 and FY 2002 were selected because the recycling program was at its greatest extent during these two fiscal years, targeting categories comprising about 50% of the waste stream as recyclable, and collecting recyclables citywide on a weekly basis.

Diversion rate attribute tables were then joined to a spatial database of community district boundaries, and mapped as choropleth maps. The diversion rates were classified by various methods, and we determined that Natural Breaks (Jenks optimization algorithm) with five classes, and standard deviation (using one-deviation intervals) were the best ways to display the data. The CDs having the five highest and five lowest diversion rates were also mapped (see Fig. 2).

5. Demographic and socio-economic analysis of sanitation districts

Demographic and socio-economic data for each CD was obtained from the NYC DCP. This data is based on the census tract-level data from the 2000 US Census (New York City Department of Planning, 2004; US Department of Commerce, 2000a, 2000b). Each CD contains several census tracts, which have been aggregated. The data at the CD level was used in this study, since that is the unit of reporting of the NYC DOS for the waste collection data, allowing for consistency and direct comparability in analysis. We wanted to examine how well various demographic and socio-economic factors might "explain" or "predict" recycling rates. We selected or constructed the following variables:

- *Percentage of minority population*: the percentage of the population in each CD that reports themselves as belonging to a minority racial or ethnic classification (non-Hispanic Black, Hispanic of any race, non-Hispanic Asian, Native American or Alaskan, Native Hawaiian or Pacific Islander, other race, or persons of two or more races.) We constructed this variable by subtracting the field "non-Hispanic White" from the field "Total Population," and dividing the result by the Total Population, multiplied by 100.
- *Percentage of persons below the poverty level*: the percentage of individuals in each CD reported to be living on an income below the federally-defined poverty level, currently set at approximately $14,000 per year income for a family of four.
- *Percentage of adults without a high school diploma*: the percentage of the adult population (age 25 and older) who do not have a high school diploma. This was derived by a two-step process: first subtracting the adult population with a high school diploma or higher level of education from the total adult population, then dividing the result by the total adult population, times 100.
- *Percentage of households headed by a female with children*: the percentage of family households in each CD, which is comprised of a female head of household with children under 18 years of age.

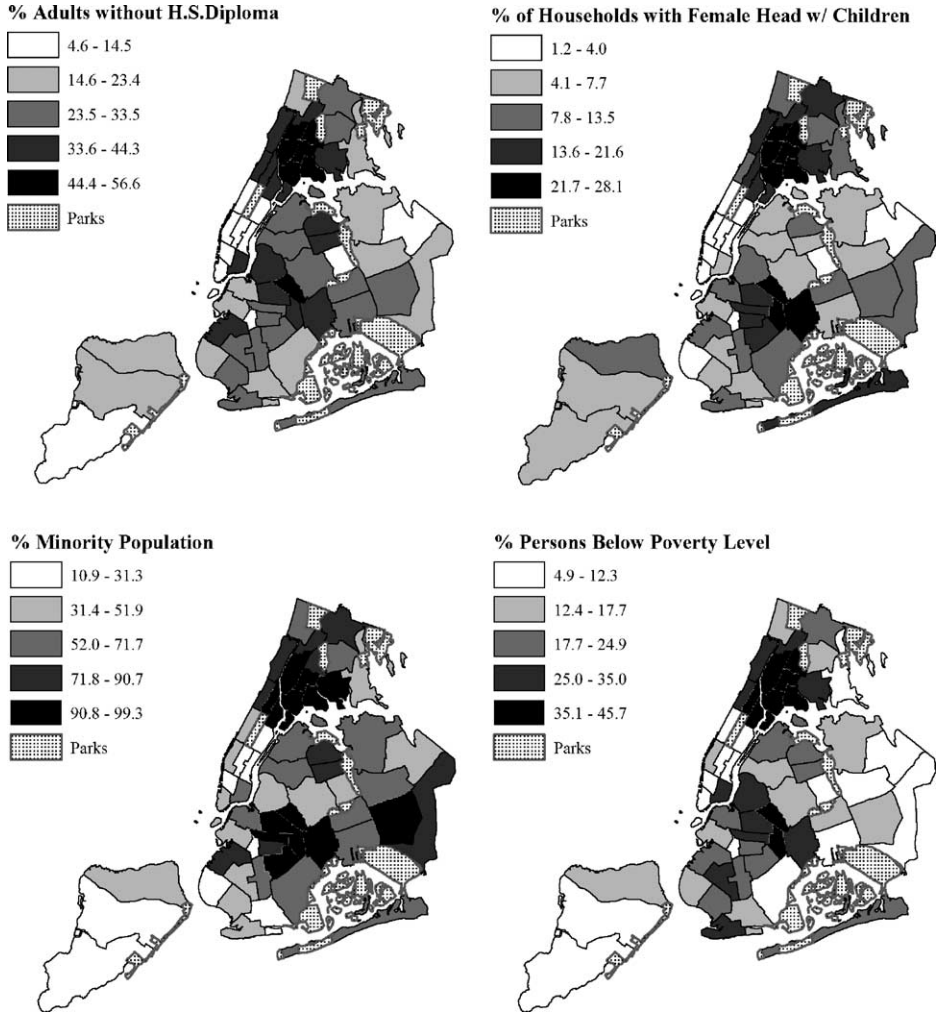

Fig. 3. Socio-demographic variables by New York City community district, using Natural Breaks method of classification (Jenks optimization).

These variables were selected as salient factors, based on a visual inspection of preliminary mapped data. Maps of census data with each of these four variables appeared to have substantial spatial correspondence with recycling rates.

These four variables were also joined to the spatial data base of CD boundaries and plotted as choropleth maps, again using Natural Breaks (Jenks optimization algorithm) with five classes, and standard deviation methods of classification, to enable valid visual comparison with the recycling diversion rate maps (see Fig. 3).

Table 2
Pearson's product–moment and Spearman's rank order correlations of New York City community district socio-demographic variables and diversion rates

Variable Associated with Diversion Rate	*r*-value	r^2-value	*p*-value	r_s-value
Adults without H.S. diploma (%)	−0.8556	0.7320	6.14141E−18	−0.8628
Persons below poverty level (%)	−0.8841	0.7816	1.74807E−20	−0.8708
Female head with children (%)	−0.8783	0.7714	6.4279E−20	−0.8863
Minority population (%)	−0.8354	0.6978	1.92618E−16	−0.8607

6. Correlation and regression analyses

Descriptive statistics were calculated for each of the demographic variables and the diversion rates. Minimum, maximum, arithmetic mean (average), median, and standard deviations for each are shown in Table 1. As can be seen, there is a wide data range for each variable among the CDs, showing the extreme variability amongst New York City's CDs.

Correlation: each of the four demographic and socio-economic variables was correlated with the diversion rates, using two different measures of correlation: the Pearson product–moment correlation and the Spearman's ranked order correlation. The *r*-value for each of the correlations is approximately −0.8, indicating a significant negative association between each of the four variables and the recycling diversion rates. The *r*-, r^2, *p*-, and r_s-values are given in Table 2. The correlations show that a large proportion of the variation in the diversion rate is explained by these variables. Poverty status is the variable most closely correlated with low diversion rates, followed by percent female head of household, level of educational attainment, and percent minority population, in descending order. However, all the variables are highly correlated with low diversion rates, with only a very small difference between the highest and lowest *r*-values.

Scatterplots were created for each of the variables paired with the diversion rates. Linear trend lines were superimposed on each scatterplot, and *r*-values are indicated to show the strength of the correlation (see Fig. 4).

Regression analysis: results of the regression analysis are given in Table 3. It shows that all four variables are strongly associated with diversion rates, and that each of them could be used to accurately "predict" the value of the diversion rate.

Table 3
Regression analysis of New York City socio-demographic variables and diversion rates

Variable associated with diversion rate	*r*-value	Intercept	Slope
Adults without H.S. diploma (%)	0.8556	32.5982	−0.4032
Persons below poverty level (%)	0.8841	31.2319	−0.4672
Female head with children (%)	0.8783	28.7312	−0.6788
Minority population (%)	0.8354	33.2589	−0.1903

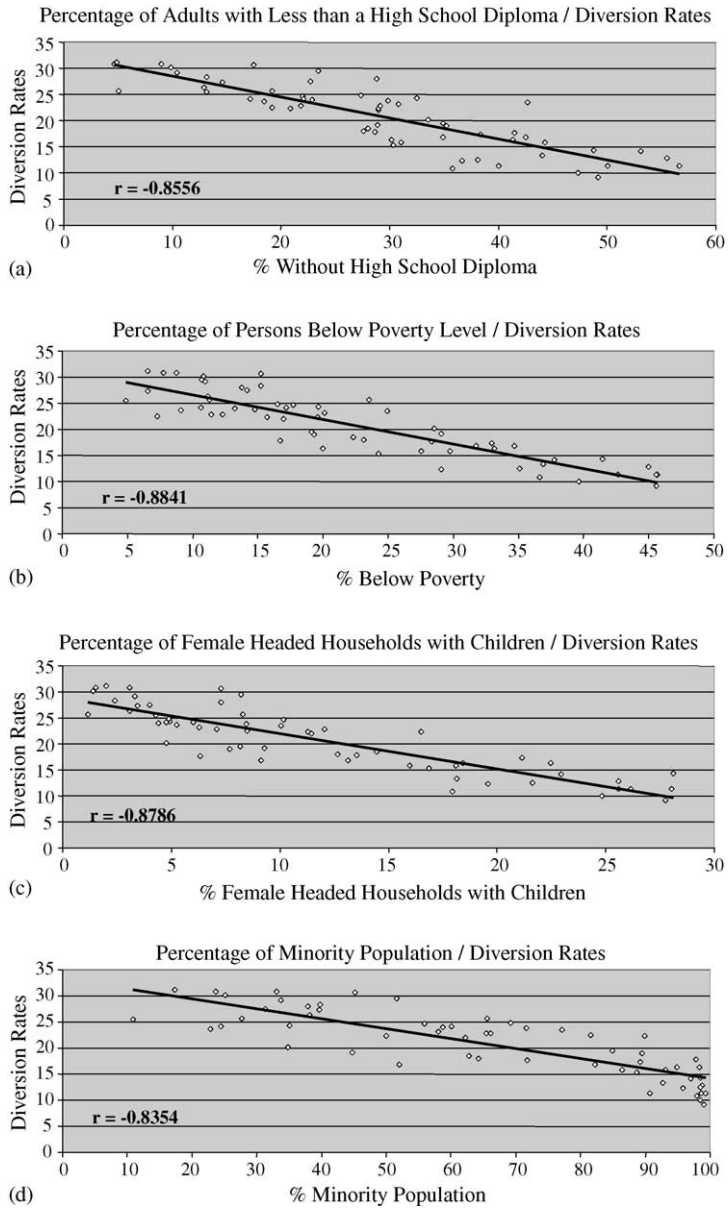

Fig. 4. Scatterplots of socio-demographic variables and diversion rates, by New York City community district.

7. Developing the REAP index

The REAP (recycling education, awareness, and participation) index is a one-figure summary statistic that is applied to each CD, indicating the relative priority for developing

strategies to increase recycling awareness and participation. A high REAP score signifies that the CD has a low diversion rate, and high percentages of those factors which historically have been associated with low diversion rates. These are the CDs that recycling awareness efforts should be directed towards. In addition, other strategies for increasing resident (and landlord) participation should be investigated.

The REAP index is constructed using a weighted linear index model, and is derived as follows: the values of each of the four variables were standardized by linear transformation, to a number between 0.0 and 1.0. This was done so that all the variables' values would be on a standard scale, and could be weighted and summed in a consistent manner, since the data ranges of the original values were not standard. The linear transformation equation is

$$S_i = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}}$$

where S_i is the standardized value for the original value X_i, $X_{\min}$ is the lowest original value, and $X_{\max}$ is the highest original value.

The diversion rate was also transformed to a standard scale in a similar manner, but because of the negative association between diversion rates and the other four variables, the equation was altered to reverse the rank order of the transformed values

$$S_i = 1 - \frac{X_i - X_{\min}}{X_{\max} - X_{\min}}$$

The importance ratios used as weights were based on the Pearson's r^2-values. The importance ratio reflects the strength of the predictive value of the variable in estimating diversion rates. Larger importance ratios denote higher predictive values.

$$\text{REAP index} = \frac{(0.7320 \times [\text{edu\_tran}]) + (0.7816 \times [\text{pov\_tran}]) + (0.7714 \times [\text{fem\_tran}]) + (0.6978 \times [\text{min\_tran}]) + (1.0 \times [\text{div\_tran}])}{3.9828\{\text{the sum of the weights}\}}$$

Each standardized transformed value for each variable is multiplied by its importance ratio. All weighted values are summed and added to the transformed and weighted diversion rate values, and the sum of the weighted values is divided by the sum of the weights (see formula). This generates an index for each CD that is based on the four variables, weighted by importance, and the weighted diversion rate. The REAP index values range from 0.00 to 1.00.

The REAP index values were then mapped by choropleth method, using Natural Breaks method of classification (see Fig. 5). Values between 0.58 and 1.00 (a high REAP index), indicate neighborhoods where greater effort is required to increase participation in recycling.

8. Waste generation rates

The average pounds per day of waste generated, per capita and per household, were also plotted on maps, and these rates are shown to vary considerably amongst districts. Some low diversion districts generated less waste and some generated more than the average. The

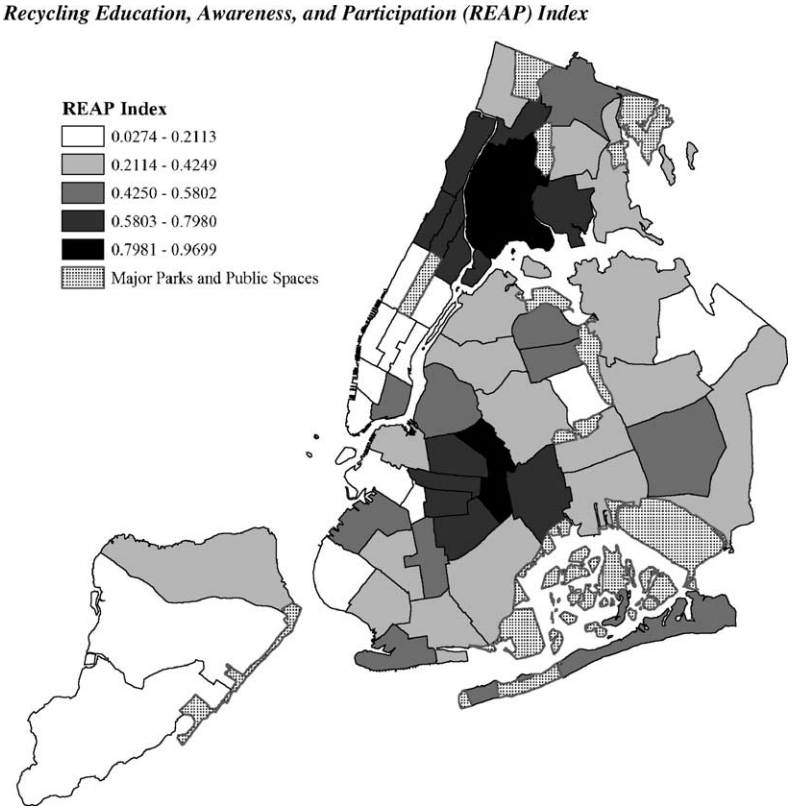

Fig. 5. REAP index by New York City community district.

same was true of high diversion districts. The correlation between diversion rates and per capita waste generation is quite weak, at 0.102.

The ideal scenario for maximum recycling and waste prevention would be a high diversion rate and low per capita waste generation rate. However, few community districts currently have both (see Fig. 6). Diversion rates are sometimes lowest in areas having a very low per capita waste generation. Some of these low diversion/low waste generation areas are among the poorest of New York's communities. Conversely, diversion rates are often highest in areas with high per capita waste generation. Significantly, many of these high diversion/high waste generation areas are in the most affluent parts of the city. Some areas have low diversion rates and high per capita waste generation, the worst of both worlds.

9. Discussion of the analysis and limitations of the data

Although there is a strong negative correlation between each of the four variables and diversion rates, we are not suggesting that high percentages of minority residents, high

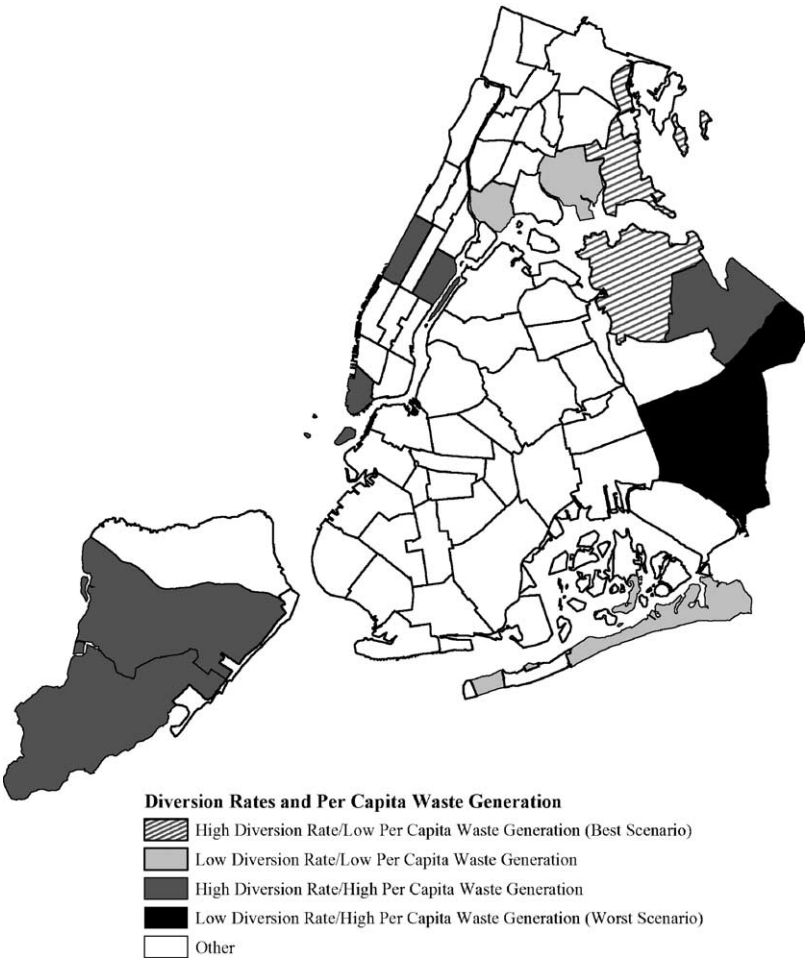

Fig. 6. Diversion rates and waste generation rates by New York City community district.

percentages of female-headed households, etc. are the causes of low recycling behavior in certain CDs, merely that there appears to be an association between these variables and low diversion rates, and we should use that knowledge to inform decisions about how to increase recycling awareness and participation in those communities.

Far from being a cause and effect relationship, there are likely many other factors which may be indirectly linked to low socio-economic status that contribute to low recycling rates in these communities, for instance, lack of space in apartments or buildings to store recyclables for the weekly pick-up, discouragement of good recycling behavior by landlords/building owners who do not provide adequate recycling space or containers, problems with vermin from stored recyclables, and inadequate targeted education for and enforcement of recycling rules in apartment buildings. There may also be an issue with public housing

projects' participation in recycling programs. Public housing projects were not designed with provisions for recycling as a programmatic element, so residents often have to walk across the street or down the block to participate in recycling, thus reducing the participation rate. In some neighborhoods, public housing is the one of the primary contributors to the waste stream, and low participation by public housing projects could adversely affect the entire CD's diversion rates.

Anecdotal reports by residents claim that there are often inconsistent weekly recycling pickups by DOS in poorer communities. This could lead to fewer items being segregated for recycling by residents and landlords, who may see themselves as unfairly being passed by in terms of recycling collection. Similarly, there is often more litter on the streets in low income/minority areas of the city, and this might also work to discourage residents from participating in recycling.

Different socio-economic groups use different materials, resulting in very different waste streams (Emery et al., 2003). It is possible that diversion rates differ so markedly by neighborhood because some communities may use a lesser amount of recyclable goods, and therefore have fewer recyclables to dispose of, thus making up proportionally less of the total waste stream. We assumed for the purposes of this study that residents in all CDs have a similar proportion of recyclables to other waste. However, anecdotal information would suggest that poorer neighborhoods might have lesser amounts of newspapers, magazines, mail order catalogs and the like to dispose of than more affluent neighborhoods, and that these items weigh correspondingly more than plastic items. Since the diversion rates are calculated based on tonnes collected (as opposed to volume), this may impinge on the tonnage reported as collected in poorer neighborhoods, and thus create lower diversion rates when divided by total tonnage. At the time this data was collected, New York City had weekly collection of only recyclable paper, plastic, and metal. Since items in these three categories have very different weights, lifestyle differences could likely affect the tonnage of recyclables in different communities.

Another factor that may impact diversion rates is the unknown quantity of reuse of recyclables, rather than recycling them in the waste stream. Many cultures throughout the world have a very high level of reuse of still useable items, and this may influence what gets thrown out in New York City, especially amongst many communities with high proportions of immigrants from these reuse-friendly cultures.

10. Recycling participation—a search for answers

Recycling participation is obviously influenced by many factors. New York City's recycling program has been inconsistent in its application, implementation, and its enforcement of regulations, and this has undoubtedly had a negative impact on recycling participation. Clearly, program changes can affect capture rates, as the rate dropped from a high of 35% in June, 2002, to a high of 21% in June, 2003, in the worst 12 recycling districts (New York City Department of Sanitation, 2003). This precipitous drop in participation was probably due to the decision to stop collecting plastic, glass, and wax paper containers in July 2002, and considerable negative publicity about the recycling program prior to the reduction in service. This illustrates that recycling behavior depends

to a great degree on attitudes towards the program, and that program changes can be disruptive, perhaps for a long time. The best 12 recycling districts also suffered a drop in capture rates after plastic and glass recycling was dropped, but not to the degree suffered in the low-diversion districts. Research has shown that the quality of the recycling experience can affect participation. Taylor (1988) found that if awareness programs were poorly run, if communication, consistency, and dependability of the program were poor, then households were confused and uncooperative. However, de Young (1986, 1989) and Crosby and Taylor (1982) found that if sufficient time and help were given to overcome barriers or difficulties in recycling, behaviors were more reliably improved.

Other studies have shown that lack of understanding of the recycling program on the part of the residents can negatively affect the recycling participation rate. Programs that are complicated and poorly communicated may contribute to low participation rates (Thomas, 2001). However, comprehension of the rules of the recycling program is not, by itself, sufficient to guarantee high recycling participation rates. Surveys that the NYC DOS conducted since 1998 show that "[a majority of the respondents] correctly identify the major recyclables, most at very high rates (over 90%). High knowledgeablity is seen regardless of where residents live, what type of housing they reside in, or whether English or Spanish is their primary language" (New York City Department of Sanitation, 2001). DOS itself notes that "these self-assessed compliance rates do not match the measured diversion rate of 20% and capture of 50% for NYC" (New York City Department of Sanitation, 2001). This is an indication that there is a serious disconnect between DOS' education efforts and actual diversion rates. After a person has full understanding of a new behavior, several additional steps are required before the behavior is actually put into practice and maintained. Awareness and comprehension must be followed by a good attitude towards the program, an intention to participate, and once participation has taken place, good experiences with the program to maintain the recycling behavior (Kok and Siero, 1985).

Although demographic and socio-economic indicators appear to be good predictors of recycling participation in New York City, we cannot conclude that these indicators are necessarily the causes of recycling behavior. What attitudinal, physical, or knowledge-based factors are associated with low socio-economic status communities in New York City that generally result in their lower recycling participation rates? In order to devise appropriate and effective solutions to address the uneven recycling participation rates, (as well as to improve the overall low average diversion rate in New York City), we must understand the motivations for good recycling behavior.

According to De Young (1986), there are both intrinsic and extrinsic motivations for recycling. Intrinsic motivations arise from internal feelings towards recycling ("It is the right thing to do"), while extrinsic motivations arise from outside factors such as fear of fines and peer pressure. De Young reported a close association between derived satisfactions (i.e., the structure of satisfactions people derive from behaving in an environmentally responsible manner) and intrinsic motivation. He also found that intrinsic motivation mechanisms rather than overt extrinsic solutions result in a greater likelihood of continuation of behaviors for the long-term.

Research has shown that intrinsic plus extrinsic motivations produce the greatest effect (de Young and Zweizig, 1991). Extrinsic motivation strategies, those outside the self that motivate behavioral change, can include rewards for performing the desired behav-

ior (e.g., recycling lotteries) as well as reductions in cost (e.g., discounts for particular environmentally-preferable products). Monetary incentives (a form of extrinsic incentive) have been found to be successful reinforcers of behavior in energy conservation research (Winett, 1977). Other extrinsic incentives and disincentives include increased or decreased comfort or convenience, and social approval or disapproval (Cook and Berrenberg, 1981; Nielsen and Ellington, 1983). Lyben and Cummings (1981) found that the combination of a prompt, lottery, and contests was more effective in promoting beverage container recycling than a baseline educational treatment using only the prompt and convenient recycling containers.

Personal attitudes and social norms were found to contribute heavily to behavioral intentions regarding recycling in a study focusing on Hong Kong (Chan, 1998). However, the relationship between attitudes, intentions, and actual behavior is very complex, and "proper" attitudes and intentions regarding recycling do not always translate into high recycling participation (Barr et al., 2001). Research in Brixworth, UK, shows that residents' pro-recycling attitudes are of paramount importance to the success of recycling programs, but that these attitudes are influenced by having the opportunities and knowledge to recycle, as well as having the time, space, and convenient environment to promote recycling (Tongler et al., 2004).

Limitations and conditions of the physical environment have been shown to be a critical factor in recycling behavior. In a study in Sheffield, UK, a main reason for non-participation in recycling was given by survey respondents as lack of space for the recycling bin. (McDonald and Oates, 2003). There can be many physical barriers to recycling, making it inconvenient or unpleasant to recycle. Depending on where one lives, recycling can be easy or difficult. For instance, those living in New York City Housing Authority buildings (low-income housing) must typically go outside the building some distance away to deposit recyclables, and others may need to go to down to dark, vermin-ridden, and garbage-strewn basements. In more affluent multi-family dwellings, recycling areas are generally conveniently located on each floor and are well tended by the building superintendent.

In 2003–2004, environmental science and geography students from Lehman and Hunter Colleges conducted street corner surveys of residents in high and low recycling participation neighborhoods. Several hundred residents were asked about their recycling experiences in order to explore the extent and geographic location of barriers to recycling as well as to assess the efficacy of DOS' educational and enforcement efforts. Survey statistics have not yet been tabulated, but preliminary results show the following trends:

- In low recycling participation neighborhoods, a majority of the respondents said they felt unsafe going into the recycling areas, noting that lighting, number of recycling bins, and frequency of emptying them was insufficient. In high recycling participation neighborhoods, most respondents said the opposite.
- Respondents in both high and low recycling participation neighborhoods had approximately similar knowledge about the recycling program, with respondents from both types of neighborhoods commonly having misconceptions about which items are recyclable.
- In low recycling participation neighborhoods, a majority of respondents said that improved cleanliness in the streets would make them recycle more, whereas only a quarter of those in the high recycling participation neighborhoods gave that response.

- In low recycling participation neighborhoods, respondents said more often that they saw litter on the streets and corner waste cans overflowing, while respondents in the high recycling participation neighborhoods said they almost never did. Cleanliness conditions reported by the respondents were verified by the survey team in a cursory "ground-truthing" or "windshield survey" of each neighborhood.

Based on these preliminary findings, there may be an association between recycling diversion rates and the cleanliness of the neighborhood and the recycling areas, and the convenience and pleasantness of the recycling experience (Clarke, 2004).

11. Policy recommendations

What can a municipality do to maximize participation in recycling? This research indicates that attention to removing barriers to recycling is one measure that needs to be in place. People must know how to recycle, be motivated to recycle, and recycling must be convenient, not costly, and have few or no barriers.

Subject to fiscal constraints, optimizing economic incentives to recycle and disincentives to discourage non-compliance can increase motivation to recycle. Measures to optimize understanding, motivation, and ability to recycle fall into three categories: education, enforcement, and street cleanliness. The funding level, and in the case of education, the level of innovation, repetition, variety of approaches, etc., likely play a large role in the efficacy of these measures. Additionally, constancy of the program helps to build and reinforce habits; the frequent changes in what was collected and the pickup frequency between 2002 and 2004 caused confusion and irritation and have not yet been repaired.

12. Future research steps

What are the real reasons for the wide disparity in recycling rates in New York City neighborhoods? Do the disparities mainly reflect cultural differences, involving social norms, or are they based on individual attitudes and beliefs about one's personal responsibility to recycle? Or are the disparities in recycling participation affected by the ability and opportunity to participate, the magnitude of the physical barriers, and quality of experiences with recycling? Is it possible that there are inadequate education and enforcement efforts, or that efforts are not targeted to where they will have the greatest impact? These are all subjects for future investigations, and will be explored in ongoing survey research in the neighborhoods of New York City. The answers are important, since they impact participation, and therefore, according to the United States Environmental Protection Agency, (2001) also impact the cost of recycling. Researching disparities in recycling, policy making, implementation, and enforcement will lead to a greater understanding of the entire recycling process, and potentially enable significant improvements in the system.

Further research into the attitudes and reasons for non-recycling behavior is needed in order to improve recycling attitudes and behaviors in New York City, and by extrapolation, other urban locations. It is likely that the level of household income indirectly plays

a role in how well each community recycles. For instance, low-income apartments are typically smaller and therefore there may be limitations on space for recyclable storage, negatively affecting recycling participation rates. It would be beneficial to include a measure of dwelling square footage per person in the REAP index. Another barrier to recycling participation may be the primary language spoken by residents. Although DOS provides education materials in many of New York's multiplicity of languages, the primary language (other than English) spoken at home might be incorporated into the REAP index to further refine the analysis. Surveys of residents in different neighborhoods may reveal more insights about the characteristics of recyclers versus non-recyclers, and the physical conditions associated with recycling and not recycling.

Future research should

- incorporate primary language data and household square foot/per person into REAP index;
- analyze clean streets data and possible spatial correspondence with diversion rates;
- expand the behavioral survey of residents in high and low REAP index neighborhoods;
- create a new index for cleanliness issues (basement recycling areas, streets, corner waste baskets);
- conduct an inventory of street cleanliness, recycling area conditions, inconvenience and barriers to recycling;
- undertake GIS analysis to see if barriers to recycling are clustered geographically;
- compare DOS data on street cleanliness with survey and "ground truthing" results;
- establish factors that may result in non-participation in recycling, and make recommendations to DOS as to remedies.

This study has identified the geographic patterns of recycling participation in New York City, and has characterized the communities using socio-demographic indicators. The REAP index is a first step in the investigation of differing recycling participation rates, and how to use this information to improve these rates.

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