# Best Practices in Zero Waste: A Qualitative & Quantitative Analysis

## Report for the Philadelphia Office of Sustainability

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# Summary & Introduction

## Topline Conclusions

- Composting is an important part of many cities zero waste goals. Working to overcome policy barriers are worth it.
- Outreach is resource intensive, but even pilots such as putting 'oops' stickers on contaminated recycling bins can still have big effects.
- Coordination among different city departments, in conjunction with continuing to advocate for more resources and staff, will be essential to meet zero waste goals.
- Usage-based fees like pay-as-you-throw (PAYT) are correlated with increases in diversion rate…
- …however, educational attainment is more strongly correlated with diversion rates than most policy choices. Socioeconomic context cannot be forgotten when working on waste policy.
- Overall, more rigorous, accessible data collection is needed in municipalities across the country to enable further policy research and comparison between cities.

## Introduction

This report covers two separate efforts to gather information and make recommendations for Philadelphia's zero waste planning. First, interviewing local officials in six cities around the country about their city's waste policies, collection methods, and so on. Second, collecting data from municipalities in North Carolina, Massachusetts, and Rhode Island, and counties in Florida.

The report will start by explaining the process and the insights of the interview project. Then, it will cover the process, results, and interpretation of the data project. This will be followed by a set of five recommendations drawn from both projects, and a conclusion.

# I. Interviews

## Process

The first step was choosing cities to contact. I included cities that were well-known for their zero waste goals, such as San Francisco, but also included other large cities like Atlanta and smaller ones like Portland, Maine. Contact information was found on city websites or using the Urban Sustainability Directors Network (USDN), and I reached out to 11 cities. I was able to set up interviews with people in six: Portland (Maine), Los Angeles, San Francisco, San Jose, Phoenix, and Atlanta. With the interviews scheduled, I adapted my list of overall questions to fit each city's unique waste policy context. For example, I was curious about San Jose's system to incentivize haulers to increase their diversion rate. Then, I conducted the interviews and recorded any of my findings.

## Insights

### *Goal Setting*

Most cities have public-facing goals to increase their diversion rate, for example, to divert 90% of waste from the landfill by 2050. San Francisco, San Jose, and Los Angeles' goals reflect state laws that require them to meet certain diversion goals. Cities are also focusing more and more on other goals like source reduction and/or fostering a circular economy. However, these goals can be harder to communicate because they go beyond individual action. Achieving zero waste or building a circular economy necessitates looking at entire supply chains. It goes beyond the consumer, who has less say in things like plastic packaging.

Nevertheless, priorities are shifting towards focusing less on diversion and more on reducing waste overall. Portland is looking forward to having an Extended Producer Responsibility law applied to plastic packaging, which will help them focus on reduction. San Francisco is also looking upstream in the manufacturing process to see how they can prevent waste.

## *Waste Collection Methods*

Cities manage multiple waste streams, sources of waste (such as residential, commercial, and industrial), and even variances in these sources (like high-rise apartment buildings versus single-family homes). These varied problems have created different management methods, but one stood out. Los Angeles, San Francisco, and San Jose contract waste collection out to private hauling companies. In the case of San Francisco, one company, Recology, collects waste for the entire city. San Jose has four different collectors, and Los Angeles is broken into a dozen or so 'wastesheds'.

Overall, this system enables cities to work towards their waste goals even if they are not collecting the waste themselves. These cities write extensive data reporting requirements, requirements to provide recycling to all customers including multifamily homes, and other priorities into the haulers' contracts. This means they can delegate waste pickup without compromising on their goals. San Jose and San Francisco, they require their haulers to reduce the amount of waste going to landfill or alter compensation structures so they get paid more for recycling more. In San Jose, waste characterization studies are built into the contract to occur every two years, something other cities often found difficult to pull off with their own resources.

However, this system comes with its own challenges and still can require a lot of attention and staff capacity to implement. Implementation was difficult in Los Angeles, creating 'sticker shock' for residents who used to contract with haulers individually, and requiring resilience and patience on the part of City and RecycLA employees as they adjusted. Furthermore, maintaining these contracts also requires ongoing support from staff to ensure accountability, manage the data received from haulers, and build a working relationship. In San Jose, the contracts can be 10-15 years long, requiring long-term collaboration with haulers. This collaboration and the data they get from haulers gives them a clearer picture of their waste production and helps ensure haulers work towards their goals. In cities like Phoenix and Atlanta, data on the waste picked up by the city is collected. However, waste from multifamily homes or commercial customers is usually collected by haulers who do not provide the same level of data. Thus, they have trouble tracking their waste and working on their waste priorities at the same time.

## *Pay-As-You-Throw (PAYT)*

Portland, San Francisco, and San Jose use PAYT in some format. Portland's PAYT program is a more traditional system: residents must buy regulated bags for their trash, and the funds go towards payment for waste pickup. In San Francisco and San Jose, residents pay a greater refuse rate to have a larger cart. Notably, the PAYT model is not used for recycling in any of the cities surveyed.

PAYT faces obvious political and implementation barriers. In San Jose they had some issues with the cart system: they found that, instead of requesting larger carts and paying more, residents were instead forcing their trash into too-small carts. Still, it is not hopeless. In Portland they introduced the system in 1999, alongside curbside recycling. Even though they paid more, residents felt like they were getting more services, making the transition easier. Nevertheless, it would be difficult to implement PAYT in many cities because of the political or financial barriers.

## *Compost*

Cities like San Francisco and San Jose have the most widely accessible composting systems of the cities surveyed, with composting available for all city residents in San Francisco. Composting service is expensive both politically and financially. Composting facilities must be permitted, built, and maintained. In Los Angeles for example, expanding the availability of composting services is challenged by regulations that make it difficult to compost within city limits. Then, there is the financial cost of building these facilities. These barriers must be addressed to create the capacity needed to provide citywide composting services. In Portland, they have partnered with local companies, Agricycle and Garbage to Garden, to expand drop-off and curbside composting respectively. Partnerships like these help cities expand composting services without bearing the costs of setting up all the infrastructure, something that private companies may have more resources to do.

In addition, Portland provides examples of how composting services can be combined with other policies. The city requires organic land care practices in the city, restricting the use of pesticides and fertilizers; compost from resident waste helps fill that gap. In addition, composting works well with Portland's PAYT program. Residents can save on PAYT fees by throwing less of their food waste into the trash, motivating them to compost. While it helps that Portland residents seem to be more supportive of composting and even of PAYT overall, the combination of these two policies contribute to their success.

### *Outreach*

Outreach takes time, energy, and resources. Sorting trash, composting, and reducing waste can be confusing without proper guidance. San Francisco's story is incomplete without recognizing the door-to-door outreach they've done to educate residents on composting and sorting trash correctly. To make a zero waste program successful, people need to know how to sort their household waste, take steps to reduce it, and use services like composting. Ultimately, this information must be transmitted to residents, and this requires a lot of effort in any city.

This research found examples of relatively cost-effective and powerful outreach methods. Phoenix and Atlanta ran pilot projects to check residents' bins for recycling contamination. In Phoenix they used positive and negative stickers on recycling bins to score their recycling sorting and suggest they take action. This created a light form of social pressure for residents to better sort their recycling, since neighbors could see which sticker they got. It also gave residents rare feedback about whether their recycling was contaminated or not. In Atlanta, their 'Feet on the Street' program also checked people's recycling, but then would not pick up the recycling until the problems they noted were fixed. Both programs reduced recycling contamination dramatically. More information about Phoenix's 'Oops/Shine On' Program can be found here.

### *Size of Office/City Government Context*

San Francisco has a dozen staff people working on their zero waste team alone, while in Atlanta there is only one person working on zero waste. In addition, many of San Francisco's grassroots outreach efforts are enabled by a dedicated outreach team, who can go out and check residents' bins or help implement new engagement programs.

Furthermore, the structure of the offices and zero waste teams vary widely, creating their own challenges and making comparison difficult. For example, in San Jose the Department of Environmental Services works closely with the Sanitation Department on zero waste, so it is difficult to identify total staff capacity. Overall, it is worth being aware of how overtaxing an already under-resourced department can create challenges. In addition, a lack of coordination among departments with overlapping efforts in zero waste only compounds this issue, duplicating efforts across departments that are already stretching their resources to meet zero waste goals.

# II. Data Project

## Introduction

The second part of this report is a quantitative analysis of waste policies and outcomes in a different set of municipalities. I will explain the process used to collect the data and analyze it, then share the results and my interpretation.

## Process

### *Deciding What to Collect*

The first step was deciding what data to collect. This study was largely inspired by the Ecomaine Community Recycling Comparison Tool, which contains municipal-level data on waste and recycling tonnage, as well as policy information about curbside pickup, pay per bag (or PAYT), food waste recycling, and more. I then found a dataset from the Massachusetts Department of Environmental Protection, which contained information from municipalities across the state, including policy and tonnage information. Then, I made a list of the data I would to collect:

- **Unit of Analysis:** city or county
- **Timeframe:** Primarily 2020, none earlier than 2020.
- **Population Information:** Population/number of households, households served by the municipality.
- **Waste Generation Information:** Tons of trash collected, tons of recycling collected, tons of other diverted waste collected.
- **Policy Information:** Trash and recycling service types (curbside or drop-off), if they offer food waste services, types of Fees (including PAYT), mandatory recycling ordinances.
- **Demographic Information / Controls:** Population density, average and median household incomes, Gini coefficients (a measure of economic inequality), and educational attainment.

## *Gathering Data*

Finding this information was challenging. Tonnage had to be reported at the local level (county or municipality), to match local ordinances with local tonnage data. In addition, the data had to be recent: the large changes in personal habits created by the COVID-19 Pandemic may dilute any effects that a policy has between municipalities. Most states either did not report this data or did not fit these criteria. For example, the data from Ecomaine is from 2019, and so could not be used.

| ***State*** | **Population + Waste Generation Data** | **Policy Information** | **Demographic Data** |
|---|---|---|---|
| *Massachusetts* | Online: Massachusetts Dept. of Environmental Protection Website | Same as population data. | Census data from the County Subdivision Geography |
| *Rhode Island* | Online: Rhode Island Resource Recovery Corporation website | Same as population data. | Census data from the County Subdivision Geography |
| *Florida* | Provided by the Florida Dept. of Environmental Protection | Contacted county recycling coordinators, receiving 17 responses. | Census data from the County Geography |
| *North Carolina* | Provided by the North Carolina Dept. of Environmental Quality | Same as population data. | Census data from the Place Geography |

## *'Cleaning' Data & Producing a Dataset*

Each state formats their data differently, and some had some policy information but not other information. I manipulated the data into a consistent format using the coding language R, keeping data common among states that could be analyzed. With each state reformatted to be consistent, I combined them to create a dataset with over 850 municipalities. Then, I reviewed the combined data and made final changes. The R scripts to manipulate the original data, the final dataset, and other documents to reproduce my results are available upon request.

## *Analysis*

With this data, I calculated a diversion rate for each municipality, as well as the waste-per-household, which excludes diverted waste. I cleaned the data further by removing municipalities with missing or erroneous data. Next, I started 'fitting' or creating a model that might show the relationship between diversion rates and the different policy options. More information about fitting the model can be found in the appendix. With the model created for diversion rate, I repeated the process for waste per household. The full regression outputs for both models can be found in the appendix. Finally, it was time to interpret results, and create the figures and tables used in this report.

# Descriptive Statistics

These figures can be used to contextualize the data being analyzed. Some takeaways worthy of note:

- As Figure 1 shows, Massachusetts and North Carolina represent the greatest amount of data.
- In Figure 3, 'Pctl' means 'Percentile'. These statistics show, for example, that the standard deviation of the variable 'Percent with a bachelor's degree or Higher' is 18.4. So, while a 10%-point change in that variable would be a considerable change, a 1%-point change is not.

Figure 1: The number of municipalities in each state in the dataset.

| State | Frequency |
|---|---|
| FL | 17 |
| MA | 243 |
| NC | 549 |
| RI | 38 |
| Total | 847 |

Figures 2 & 3: Descriptive statistics of the variables most important to the final analysis

| Fee Type | Number of Municipalities |
|---|---|
| Flat Fee Only | 534 |
| Flat Fee & Usage-Based Fee | 138 |
| Usage-Based Fee Only | 32 |

**Descriptive Statistics for Significant Dependent & Independent Variables**

| Statistic | Mean | Median | Pctl(25) | Pctl(75) | St. Dev. | Min | Max |
|---|---|---|---|---|---|---|---|
| Percent with a Bachelor's Degree or Higher | 31.0 | 28.2 | 16.4 | 41.7 | 18.4 | 0.0 | 84.9 |
| Diversion Rate | 26.5 | 25.7 | 16.5 | 35.4 | 13.5 | 0.0 | 77.3 |
| Waste per Household (Tons/Year) | 0.9 | 0.9 | 0.7 | 1.1 | 0.4 | 0.05 | 3.8 |
| Waste per Household (Lbs/Day) | 5.1 | 4.7 | 3.7 | 5.9 | 2.4 | 0.3 | 21.1 |

# Results

Figure 4 (below) summarizes findings from the diversion rate model and the household waste model.

| Baseline Policy | Change | Effect on Diversion Rate (in %-points) | Effect on Waste Per Household (Tons/year) | Effect on Waste Per Household (Lbs per Household/day) |
|---|---|---|---|---|
| Fees: Both | Flat Fee Only | -5.30 | 0.13 | 0.71 |
| Fees: Both | PAYT or Access Fees Only | 5.30 | -0.13 | -0.71 |
| Current % w/ a Bachelor's Degree or higher | 10%-point Increase | 3.00 | -0.06 | -0.33 |

Figure 4

Interpreting these results fairly is important. First, these results represent correlations, not causations. This analysis does not establish whether different kinds of fees *caused* the resulting changes to diversion rates. Moreover, while the direction and relative strengths of the relationships are valid, the values should not be taken to be exact in the real world. Interpreting the values as exact, such as "If Philadelphia's percent of the population with a bachelor's degree increases by 10%-points, the city's diversion rate will increase by 3%-points" overestimates the exactitude of the correlations and implies causation that has not been established. Nevertheless, the correlations provide interesting evidence and information.

## *Diversion*

Of the policies tested in the model, only changes to fees have a statistically significant effect. The baseline is having both flat fees (such as an annual fee) and usage fees (like PAYT). Compared to this baseline, only using flat fees is correlated with a diversion rate 5.3%-points lower than the baseline. Having only usage fees is correlated with a diversion rate 5.3%-points higher. However, most municipalities use either flat fees alone or a hybrid model: only 32 cities have only usage fees.

Among the controls, only educational attainment (represented by the % with a bachelor's degree or higher), is statistically significant. For every 1%-point increase, the diversion rate increases by 0.3% in the model. This seems like a modest effect, but a 1%-point change is rather small; a 10%-point increase would be correlated with a 3%-point higher diversion rate. Furthermore, educational attainment and median household income were highly correlated in the model: this means that both may describe a similar characteristic in municipalities such as socioeconomic health.

Offering both composting services and drop-off trash services are associated with an increase in diversion rate, but this correlation is not statistically significant. This means that there is not enough data to be sure this relationship is not a quirk of the cities sampled, not that the relationship was too small. More data is needed to be sure they are correlated. Other variables tested in the model that are not statistically significant include providing compost bins and having recycling enforcement personnel. A regression output of the model with all the variables and their statistical significances can be found in the appendix. Finally, the R-squared of the diversion model is approximately 0.3, which indicates that approximately 30% of the variance in the data is explained in the model. This means that there are other things affecting the diversion rate that are not in the model, and that we probably have more to learn about what contributes to the diversion rate.

### *Waste Per Household*

The waste per household model produces similar findings. As Figure 4 showed, changes in fees and educational attainment had statistically significant effects. Flat fees are correlated with an increase in the waste produced per household, and usage fees with a decrease. Educational attainment is also associated with a decrease in waste per household. The R-squared for this model is approximately 0.13, meaning that only about 13% of the variance is explained by the model. Thus, the exact values to quantify the relationship are less significant than the relationships themselves.

## Interpretation

The positive correlations between fees based on usage and diversion indicate that shifting some of the financial costs of waste management may improve diversion rates. If you pay for every bag of trash you use, or if you must pay every time you go to the dump (both fees based on usage), then you might also be more conscious of your trash generation. Policies that make residents more personally responsible for their trash may force them to be conscious of it in a way that has benefits. The key is maintaining equity at the same time.

On the other hand, the correlation between educational attainment and diversion shows how a city's socioeconomic context can be a stronger predictor of their diversion rate than waste policy choices. Educational attainment is a good proxy for socioeconomic conditions that may influence waste services in a city. Highly educated residents may also be more concerned about recycling right, though this specific theory was not tested. Regardless, in this model, switching from only flat fees to only usage fees creates a change of approximately 10.6%-points in the diversion rate. However, cities with only usage fees are quite rare, and most municipalities would likely only be able to implement a hybrid system, producing a 5.3%-point improvement. On the other hand, changes to educational attainment can have larger effects if the change is considerable, such as 20%-points or more.

In addition, the fact that only about 30% of the variance is explained by the model means we probably need to learn more about what else could be influencing diversion rates. With waste per household, where only 10% of the variance is explained by the model, there is not much we can predict using this model. However, it seems that socioeconomic factors may be just as important as policy decisions in affecting diversion rate or waste per household, if not more impactful. Going forward, further attempts to investigate these questions should consider these factors as data is collected and analyzed.

## Limitations & Further Work

Each state and municipality managed their municipal data differently. For example, yard waste was not categorized by whether it was diverted (through composting or another method) or landfilled in municipalities outside of North Carolina, so was not included in the calculation of diversion rate. Furthermore, most values were self-reported by municipalities. These methodological inconsistencies do not mean the dataset cannot fit together, and this analysis represents the best effort to bridge state and reporting boundaries and tell a cohesive story. However, there is a clear need for more consistent, reliable, and easily accessible reporting. This will provide richer data for further analyses and will be essential as municipalities work towards zero waste and compare among their national partners.

# Recommendations

### *1. Expand Composting*

Lack of access to composting is a key barrier to achieving zero waste in Philadelphia. While drop-off options exist and some residents can pay for curbside service, the city has a long way to go before every resident has access to composting services. Among surveyed cities it is an almost universal priority. While policy barriers exist, there are ample examples of public-private partnerships to expand access once policy barriers have been overcome. While access to composting was not a statistically significant predictor of higher diversion rates in the model, it would be a mistake to discount it. This statistical outcome is likely due to a lack of adequate data (only 75 cities in the dataset had any access to composting provided), rather than it being an ineffective policy. Opening the organic waste stream to diversion should be a key priority.

### *2. Engage in Outreach*

Outreach is difficult and resource intensive. However, even small actions like putting an 'oops' sticker on a recycling bin have been shown to have big effects. The data does not indicate whether these kinds of outreach programs are correlated with diversion rate or less waste production. Again, this is due to a lack of data on the policy. The experiences from the cities surveyed demonstrate that these programs have big impacts.

### *3. Improve Coordination among Departments within Cities*

Many sustainability offices feel their resources are unequal to the task at hand. The challenges are enormous, and while continuing to advocate for more resources it is important to use those already available as best as possible. Cities that have had more success improving diversion are often able to coordinate across departments, especially when their goals overlap. Clear cooperation and agreement on goals are key tools moving forward.

## *4. Explore other Policy Options*

There are two other policy changes that seemed to be effective but need more research to evaluate their fit for Philadelphia and other cities. Based on interviews with other city leaders, it seems like contracts with haulers for waste collection are a powerful way to help cities reach their waste goals. More progressive contract stipulations in Philadelphia would be a significant change, but it is still worth exploring. Many municipalities already contract out their waste collection, and could ensure these contracts include provisions that contribute to their data collection and their zero waste goals.

Secondly, the data indicates that usage-based fees like PAYT can be effective at improving diversion. However, while financial incentives are effective, they are also politically costly and raise concerns over equity and implementation. While PAYT may not be immediately feasible in Philadelphia, local policy makers can experiment with more equitable options. The most important priority is increasing accountability for waste. This could mean personal accountability, along the lines of a usage fee, or it could focus on industry, such as through Extended Producer Responsibility laws. Regardless, there is a need for policies that encourage people and corporations to prioritize waste reduction.

## *5. Support & Advocate for Rigorous Data Collection*

Good data collection is essential to measure progress. There are many shortcomings to the way that waste data and waste policy choices are reported on a municipal level. This makes it difficult to accurately measure diversion locally, where a lot of policy work happens. Without better data, it is hard to compare among cities and understand what policies work. While Philadelphia is only one municipality, we can still be model for other municipalities, and advocate for more cooperation and comparison among cities in Pennsylvania and beyond.

# Conclusion

This project has identified some key areas for growth to help Philadelphia and other municipalities work towards their waste goals. Improving access to composting, implementing usage-based fees, and even changing the whole structure of how waste is collected are all options. Doubtlessly, there are more changes that can be inspired by the information in this report. All have their challenges, and different cities may find one change easier to implement than another. Furthermore, the socioeconomic context of a city cannot be overlooked. A lack of city resources constrains the ability to act, and the political concerns around raising the costs for residents or building up composting sites within city limits are real and must be navigated. If nothing else, public servants are good at finding innovative solutions in constrained situations, threading the needle to work towards their goals. However, it is also important to continue work and advocacy that uplifts whole communities, generating the capacity for the larger, systemic changes that we will need to truly achieve zero waste.

# Thank You's

## City Interviews

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## Data Project

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# Appendix

## Full Regression Outputs

| | *Dependent variable:* | |
|---|---|---|
| | Diversion Rate | Effect Sizes |
| | (1) | (2) |
| Trash Pickup: Curbside, Both, or Dropoff | 1.356 | 0.098 |
| | p = 0.153 | p = 0.153 |
| Offer Composting | 2.341 | 0.169 |
| | p = 0.161 | p = 0.161 |
| Provide Compost Bins | 0.303 | 0.022 |
| | p = 0.816 | p = 0.816 |
| Recycling Enforcement Personnel | 1.204 | 0.087 |
| | p = 0.412 | p = 0.412 |
| Fees Based on Usage | 5.329*** | 0.386*** |
| | p = 0.00001 | p = 0.00001 |
| Population Density (logged) | -0.442 | -0.032 |
| | p = 0.413 | p = 0.413 |
| Median Household Income (10k) | -0.160 | -0.012 |
| | p = 0.551 | p = 0.551 |
| % Bachelor's Degree or Higher | 0.300*** | 0.022*** |
| | p = 0.00000 | p = 0.00000 |
| Constant | 22.574*** | -0.292 |
| | p = 0.000 | p = 0.226 |
| Observations | 468 | 468 |
| $R^2$ | 0.316 | 0.316 |
| Adjusted $R^2$ | 0.304 | 0.304 |
| Residual Std. Error (df = 459) | 11.129 | 0.806 |
| F Statistic (df = 8; 459) | 26.543*** | 26.543*** |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | |

Figure a: The Regression output for the Diversion Rate model.

| | *Dependent variable:* | |
|---|---|---|
| | Waste Per Household | Effect Sizes |
| | (1) | (2) |
| Trash Pickup: Curbside, Both, or Dropoff | 0.033 | 0.074 |
| | p = 0.337 | p = 0.337 |
| Offer Composting | -0.024 | -0.054 |
| | p = 0.695 | p = 0.695 |
| Provide Compost Bins | -0.065 | -0.145 |
| | p = 0.176 | p = 0.176 |
| Recycling Enforcement Personnel | -0.001 | -0.003 |
| | p = 0.977 | p = 0.977 |
| Fees Based on Usage | -0.129*** | -0.288*** |
| | p = 0.003 | p = 0.003 |
| Population Density (logged) | 0.064*** | 0.143*** |
| | p = 0.001 | p = 0.001 |
| Median Household Income (10k) | 0.004 | 0.009 |
| | p = 0.657 | p = 0.657 |
| % Bachelor's Degree or Higher | -0.006*** | -0.013*** |
| | p = 0.002 | p = 0.002 |
| Constant | 0.617*** | -0.707*** |
| | p = 0.00000 | p = 0.007 |
| Observations | 553 | 553 |
| $R^2$ | 0.131 | 0.131 |
| Adjusted $R^2$ | 0.118 | 0.118 |
| Residual Std. Error (df = 544) | 0.416 | 0.930 |
| F Statistic (df = 8; 544) | 10.227*** | 10.227*** |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 | |

Figure b: The regression output for the Waste per Household model.

The first column in both has the coefficients and their statistical significance. This is where one could see that a 1%-point increase in education is correlated with a 0.3%-point increase in Diversion Rate. Diversion Rate is in %-points. Waste per Household is in tons/year.

Effect Sizes are one way of quantifying the strength of the relationship, and are found in the second column. As a rule of thumb, an effect size of greater than 0.25 is considered to be a significant effect. Thus, for diversion, you can see that a 1%-point change in education does not have a large effect. It would take a change of around 10%-points or higher to have a significant effect.

Lastly, there are other pieces of information about the model, such as the R-squared and number of observations the model draws upon.

# Fitting the Models

The process of fitting the model essentially meant choosing which variables to include. Much of this decision making was driven by information in the table below.

| Variable/Question | ↓ Number of Municipalities with Data |
|---|---|
| Provide Compost Bins? | 847 |
| Provide Food Waste Management? | 839 |
| Have Recycling Enforecment Personnel? | 792 |
| Trash Service type offered? | 733 |
| Type of Fees? | 704 |
| Waste per Household | 620 |
| Diversion Rate | 546 |
| Provide Recycle Bins or Carts? | 298 |
| Have a swap shop? | 278 |
| Have a Mandatory Recycling Ordinance? | 260 |

No municipality had data for every variable contained in the dataset. For example, Florida lacked information on if recycling enforcement personnel were used, while North Carolina did have that data. Meanwhile, the North Carolina data did not include if a 'swap shop' was used, even if Massachusetts did. If too much data was missing for a policy, then it was excluded to ensure that there was a large enough sample for the model to work on. The last three were dropped from the model precisely because so few municipalities had complete data for those questions, which would have constrained the model.

# Notes about the Data or Models

- Estimates for Households and Population in the dataset used data received from the states where available instead of the census. This allowed me to compare like with like when calculating things like waste per household, and relegated census data to being used as a control in the model.
- Municipalities in Massachusetts and Rhode Island sometimes included data for schools, municipal buildings, and businesses in their tonnages. It is unclear if this happened in North Carolina or Florida. However, it does mean that one cannot assume that data only comes from

the residential waste stream. Clarifying what tonnages come from which waste streams (residential, commercial, and industrial) is an important step in standardizing reporting.

- The Waste per Household model excludes Florida because the state contained errors that would interfere with calculating that variable.
- The model for Diversion Rate is not Homoscedastic, meaning that variance increases as the Diversion Rate increases. This is likely due to the large variation in Diversion Rates, which range from almost 0% to 70%. Waste Per Household does not seem to be subject to the same heteroscedasticity, perhaps another reason it may be a better measure to use in future studies.

There are other notes contained within the code that was used to manage all of the data. They note when decisions are made about dropping variables or cities, or altering the structure of the data. If you are interested in more details, including the tests run on the models to ensure their validity and help interpret them, data and code are available upon request.