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A Recycling Recommendation for Auburn, Maine

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A Recycling Recommendation for Auburn, Maine

Completed in Partnership with the Auburn, Maine Recycling
Committee

Annie Sedoric, Erin Bucki

Environmental Studies Program, Bates College, May 2020

Executive Summary

The purpose of this research was to propose an effective and feasible recycling program to the City of Auburn, Maine. We worked closely with Auburn's Recycling Committee and with Bates College in order to accomplish the goal of increasing Auburn's recycling rate and decreasing their contamination rate.

We examined a variety of scholarly and practitioner sources in order to grasp the effectiveness of respective recycling practices and programs implemented around the country. From this extensive research we were able to conclude that there is a clear consensus on the effectiveness of curbside recycling, single stream recycling, container attributes (i.e. color, size), and composting programs in raising town and city recycling rates. Throughout the recycling literature there were also areas of competing claims, most notably, regarding unit pricing schemes; some studies found the intervention to be successful, while others concluded this practice to be ineffective. Educational programs were found to be ineffective in raising recycling rates, but more effective in lowering contamination rates. That being said, educational programs are very diverse. Interventions that target social norms and social pressures, such as feedback, were more effective than educational programs built on brochures and meetings.

We conducted outreach to several municipalities around Maine in order to obtain results that could be easily comparable to Auburn, ME specifically. We collected waste management experiences from representatives in South Portland, Bangor, Biddeford, and Farmington, Maine. From that outreach we determined that, in practice, the most successful and effective interventions were a composting program, and a feedback system; both achieved an increase in recycling rate and a decrease in contamination rate.

After analyzing the results of our scholarly literature review and outreach to Maine Municipalities we considered feasible options for the City of Auburn specifically. This consideration ultimately led to our three-part recommendation and proposal. Part one is to implement a composting program in order to redirect waste and lower Auburn's total Municipal Solid Waste weight. Part two is to introduce a feedback system that educates residents on their own recycling and contamination habits. Part three encourages a new contract with a different

company and poses EcoMaine as a prime option due to the variety of services offered as well as its popularity among other Maine Municipalities. We hope our recommendation(s) can serve as a foundation for discussions revolving potential recycling interventions and implementations in Auburn, ME.

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Introduction

Currently, the world is facing an escalating multidimensional waste crisis largely driven by plastic piling up in developing countries, as well as in the ocean (Holden, 2019). Waste is piling up around the globe, landfills are overflowing in the United States, and the costs associated with Municipal Solid Waste (MSW) continue to increase. Every year, there are over two billion tonnes of municipal solid waste being produced globally. That being said, only 16% is recycled, while 46% is disposed of unsustainably, meaning the potential impact is disregarded (McGrath, 2019).

This waste crisis not only poses a threat to the environment, but poses a threat to our health and safety as well. At a time in which the pressures of climate change are increasingly urgent, interventions need to be made in order to mitigate the most devastating effects; the waste and recycling industries are a clear point of intervention. Slashing methane emissions released from landfills represents a huge opportunity for the waste and recycling industries to support a prompt decline in greenhouse gas emissions. In 2017, municipal solid waste landfills were the third largest source of human-related methane emissions in the United States (EPA, 2019). For context, methane emissions are 84 times more powerful than carbon dioxide emissions (Bailey, 2019).

Notably, the United States is one of the worst waste offenders contributing to this crisis; producing three times the global average of waste, and recycling only 35% overall (McGrath, 2019). Furthermore, the United States is the only developed nation with waste generation that outstrips its ability to recycle; referring to the relationship between what it generates and its capacity to recycle (McGrath, 2019). That being said, when it comes to recycling in the United States specifically, the issue seems to be one of political will, costs, and infrastructure (McGrath, 2019). Across scholarly and practitioner literature a variety of conducted studies reveal external and internal factors that influence rates of recycling, while many others analyze the effectiveness of certain municipal solid waste recycling programs. Studies of human behavior have illuminated how behavior-changing interventions that target personal and social norms ultimately increase communal recycling participation (Schultz, 1999; Hopper and Nielsen, 1991). Factors such as cost, incentives, education, convenience, attitude, demographics, and policy broadly affect

recycling rates to varying extents (Park and Berry, 2013; Sidique et. al., 2010). These factors are global, national, and local, and all have the potential to influence the success or failure of a recycling program.

In 2018, China banned all waste imports, including recyclables. The ban, implemented for various reasons, one being high contamination rates, greatly affected recycling industries worldwide. Ever since China closed its doors to millions of tons of waste, both the global and national recycling dynamics are continuously changing, and the United States recycling programs have felt the burden (Ivanova, 2019).

Since 1989 it has been Maine's goal to reach a recycling rate of 50% of the municipal solid waste generated by the state (Maine Department of Environmental Services, 2016). More recently, this goal was given a deadline; by January 1, 2021 50% of the municipal solid waste tonnage generated each year within the state is to be recycled or composted (Maine Department of Environmental Services, 2017). As of 2016, the state's municipal solid waste recycling rate lays at 36.79% (Maine Department of Environmental Services, 2016), standing above the national average, but well below the state's target. Cities and towns across Maine are working to figure out the best recycling practices and implementation strategies in order to cultivate a successful recycling future state-wide.

While some Maine municipal recycling programs have improved considerably over time, many programs continue to fight an uphill battle to increase their recycling rates. Among them, is Auburn, Maine. Auburn's municipal recycling program struggles with low participation rates, coupled with high rates of contamination. In 2019, the city's recycling rate was recorded at just 7.3%, which is based on the tonnage of waste and recycling collected through their curbside service (Lasagna, 2020). Recent discussion of suspending the city's recycling program altogether ultimately led to the creation of the Auburn recycling committee in the fall of 2019 (Bailey, 2019). To ensure that Auburn is not the first major municipality in Maine to cut its recycling program, the recycling committee is tasked with examining the current recycling model, while exploring and comparing alternative models and their potential.

Research Aims and Objectives

This study aims to increase the effectiveness of recycling in Auburn, Maine. In doing so, this study helps Auburn determine the best management practices in order to divert waste from landfills, cultivate a recycling culture, and ultimately reduce costs, both financial and environmental.

Objective 1 - Identify most effective ways to increase curbside recycling participation.

Objective 2 - Identify most effective ways to decrease curbside recycling contamination.

We accomplished the objectives by creating a comprehensive, scholarly and practitioner literature review of the most effective recycling practices, producing a thorough report of recent experiences of comparable municipalities in Maine, and ultimately compiling the information to make a sound recommendation for Auburn, ME.

Methodology

Context: We began our project by cultivating a better understanding of the context of the work we were doing; on a global, national, state, and town (Auburn, ME) scale. We organized information regarding the global impacts of recycling, recycling in the United States, recycling in Maine, and the current recycling situation in Auburn, ME. When focusing on Auburn, we felt it was important to gather information, both from communicating with members of the recycling committee, as well as through articles in news outlets. This allowed us to grasp the conditions, circumstances, and ultimately the framework, of our project and its potential implications. The contextual process involved collecting various forms of knowledge and helped us to create the narrative for our project and how to relay its information.

Scholarly Summary: We read through a variety of applicable scholarly and practitioner sources, which we then used to produce a comprehensive literature review summarizing and outlining the ‘best’ recycling practices. We were able to gather information on the various recycling programs used in the United States, including single stream, dual stream, and variable pricing. We also highlighted other characteristics and factors, such as education programs, psychological feedback, and container attributes. Overall, the research and data collection allowed us to better understand what makes a respective recycling method successful.

Outreach: We communicated, both over email and the phone, with public works members in Biddeford, Bangor, South Portland, and Farmington, Maine to acquire information, data, and insight on each respective recycling program. In doing so, we were able to gain a better understanding of the progression of particular recycling programs, including the successes and failures of certain practices that municipalities in Maine have done. The information we collected during outreach provided us with tangible experiences, and data that we could realistically reflect to Auburn, ME.

Feasibility: In order to highlight the best recycling practices we synthesized all of the information gathered from our literature review and municipal outreach report. By organizing the information into categories for consideration, including cost, timeliness, and effectiveness, we were able to more clearly see how a variety of practices could be translated into Auburn's existing practices and infrastructure. Essential to the success of our project for Auburn, ME specifically, we worked to address and include the distinct context of the Auburn community through our feasibility process.

Recommendation: Lastly, we used all of the compiled information, as well as the feasibility considerations, to advise and recommend the best recycling practices and steps for Auburn, ME specifically. We engaged heavily with the work we had accomplished during prior methodology in order to conclude on a beneficial, efficient, and relevant, recommendation. Our recommendation is a 3 part proposal, as we felt it was important to note that a successful

recycling program does not happen with one change, but rather with connected interventions, and advancements.

Results

1. Literature Review Results

There are several broad classes of literature regarding recycling practices, ultimately highlighting the successes and failures of particular municipal programs. Contemporary household recycling research has been divided into main stream of research including the effects of curbside recycling ((Dormina and Koch, 1999, 2002; Ewing, 2001; Folz, 1991; as cited in Park & Berry, 2013), the economic perspectives (Chowdhury, 2009; Reschovsky and Stone, 1994; as cited in Park & Berry, 2013), and notion of altruism (Ewing, 2001; Kalinowski et al., 2006; as cited in Park & Berry, 2013). Scholars have produced articles that use comprehensive models to incorporate the behavior of governments, and consumers, and articles that focus on consumer reactions to various pricing schemes and recycling programs (Linderhof et. al. 2001). Another stream of research takes a social psychological approach that explores the role of moral and social norms as important drivers of recycling behaviors (Siddique et. al. 2010). Some scholars have focused more narrowly on the influence of secondary factors on recycling programs, such as containers attributes (Lang & Wagner, 2013). Across the literature there are areas of clear consensus, as well as topics with competing claims, and uncertainty.

1.1. Clear Consensus

1.1.1 Curbside

Curbside recycling has emerged as the most prevalent recycling practice that municipalities have invested in, and scholars have agreed that curbside is the most effective recycling practice for increasing recycling rates and participation rates (Dormina and Koch, 1999, 2002; Ewing, 2001; Folz, 1991; as cited in Park & Berry, 2013). In a case study of recycling performance in Florida, Park and Berry's (2013) convenience-based hypothesis was

supported by showing that curbside recycling had a positive effect on MSW [Municipal Solid Waste] recycling performance. Ultimately, convenience is highly valued when it comes to residential recycling practices, and curbside recycling programs provide this for residents.

1.1.2. Social Psychology

Pulling from the broad search of psychological strategies, there was a clear consensus of certain methods as successful. One method, being the provision of feedback, is highly successful in increasing recycling rates. Schultz (1999) suggests that individual feedback (information on individual recycling behaviors) may only be effective while the feedback is being given, while group feedback (information comparing individual recycling behavior to group recycling behavior) has the potential to produce a template for comparing current and future behavior.

Throughout literature, motivation appears to be a powerful determination of recycling participation; social norms playing a large role in motivation (Schulz, 1999; Varotto & Spagnolli 2017). Mee (2005) found concise results of the effect of social interaction on recycling rates highlighting “profile”, “pull”, “push” and “consultation” outreach strategies as successful. A profile strategy is centered around the media and newsletter repeatedly portraying the information. A pull method praises the effective changes people make through personal letters. A push strategy asks community partners to also endorse the message. Finally, through consultation, questionnaires allow the city to receive feedback on their methods of outreach.

1.1.3 Food Scraping

One way to increase recycling rates is to decrease the amount of initial waste through food scrap and composting programs. Furthermore, implementing food scrapping programs can decrease recycling contamination rates (Pollan et. al., 2017). While food scrapping is still considered an emerging practice, there is clear consensus regarding the benefits it has for Municipal Solid Waste Programs.

Pollan's et. al. (2017) found that cities are more likely to adopt new solid waste diversion programs, such as food scrap collection, when they can build upon existing infrastructure and service programs was supported; food scrap collection is more likely in places that have current

division programs, like curbside recycling. The study highlights that source-separated recycling programs show a negative correlation with curbside composting, whereas areas that have shifted to single stream follow the food scrap trend.

1.1.4. Container Attributes

Different characteristics of containers are a factor that may be considered secondary, though they remain important when considering change. In general, residents prefer large, wheeled recycling bins with lids for convenience (Lang & Wagner, 2013), and it has been concluded among literature when recycling bins are larger than waste bins recycling rates and participation increases.

In terms of the distribution of containers, it is found that city or town provided bins have been associated with higher participation rates, in some cases the rate increased more than 50% (Lang & Wagner, 2013). This notable increase can be partially attributed to the fact that uniformed bins act as a social cue, utilately driving peer pressure (Everette and Piere, 1993 as cited in Lang & Wagner, 2013). That being said, proesenting single-stream recycling containers for a small municipality of about 10,000 households can cost around \$650,000 (Lang & Wagner, 2013). If free containers are regulated as the only acceptable container choice, or residents are required to buy certain containers, it can have a negative image on participation (Lang & Wagner, 2013)

Both color and signage are important visual cues with substantial effects. In terms of color, Curfew and Hinchy (1993) found that residents supplied with blue recycling containers have a 4% higher participation rate than those with black containers (as cited in Lang & Wagner, 2013). Duffy and Verges (2008) state that signage illuminating the different types of materials, such as trash versus recycling, increased recycling by 34%, and reduced containeration by 95%.

1.2. Competing Claims

1.2.1 Unit Pricing

When discussing various incentives to recycle, unit pricing is heavily engaged with, both in practice and in literature, with some competing claims. Unit pricing, also known as variable rate pricing or pay-as-you-throw (PAYT), is a system under which residents pay for municipal waste management services per unit of waste collected rather than through a fixed fee (EPA, 1994). While unit pricing is often said to decrease waste tonnage while simultaneously increasing recycling tonnage (Siddique et. al. 2010), this is not always the case.

Fullerton and Kinsman (1996) reported that the incremental benefits of unit-pricing programs are small and outweighed by the administrative cost (as cited in Siddique et. al. 2010). Park and Berry's financial incentive based hypotheses were only partially supported, suggesting that individual incentives have the potential to increase recycling performance more so than financial incentives (2013). Their respective study shows no evidence that pay-as-you-throw has a significant effect on recycling rates (Park & Berry, 2013).

1.3. Uncertainty

1.3.1 Education

Though education is the most commonly used and studied form of intervention to improve recycling, the results on the effectiveness of education are mixed, and somewhat uncertain (Schultz, 1999). Environmental concern is something that is found to positively affect the fundamental amount of recycling collected, while Park and Berry (2013) found no significant findings resulting from increased education.

That being said, various studies have found educational interventions to be positively influential, especially when addressing contamination rates. According to Rogoff and Ross (2016), contamination rates can be partially solved with improved public education. Hossain, Santhanam, Norulaini, and Omar (2011) point out that a lack of legislation and uneducated staff and participants are common threads in unsuccessful recycling programs. Siddique et. al. (2010) reveal that the enactment of recycling ordinances, as well as cumulative expenditures of recycling education were found to be effective measures.

2. Municipal Report Results

2.1. Reasoning for Intervention

2.1.1. Cost

Since China closed its doors to United States recyclable materials back in 2018, the cost of recycling programs has increased across the country. As cities and towns consider their yearly spendings, the costs of Municipal Solid Waste programs are a place of stress, especially if the program is unsuccessful. Thus, oftentimes the reason for intervention is to reduce costs. Right now, Auburn spends a huge quantity of money on recycling per ton and per person each year in comparison to other Maine municipalities, as demonstrated in Figure 1 and 2. In addition to that comparison, Table 1 shows the costs and tonnage of recycling and trash in Auburn per year.

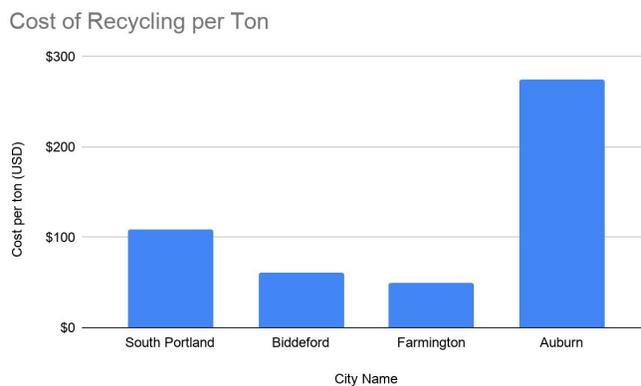


Figure 1: Cost of Recycling per ton on average across various Maine municipalities. These costs include the cost of hauling. Farmington's cost per ton is slightly skewed due to the cost of curbside pick up being paid by the household directly to the contractor, so their cost is the lowest due to that expense being covered by residents. Note that Bangor was not included due to lack of information provided from the city representative.

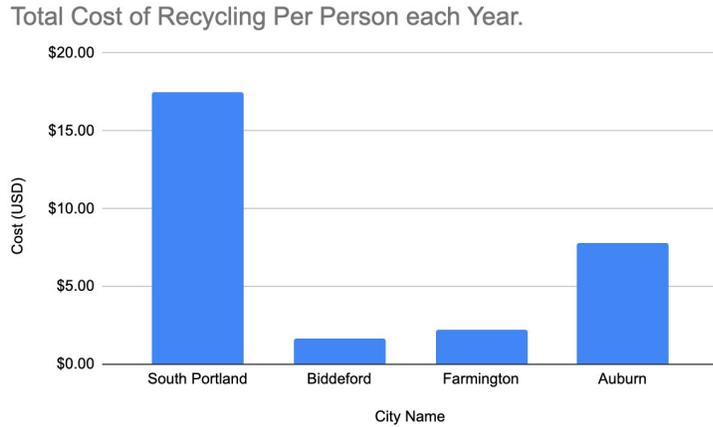


Figure 2: Total cost of recycling per person each year on average across various Maine municipalities. These numbers were calculated by dividing the total cost of recycling per year by the total population. Note that Bangor was not included due to lack of information provided from the city representative.

	Total Cost	Total tons	Cost per ton
MSW	\$998,624	8421	\$119
RW	\$178,550	650	\$275

Table 1: Summary of Auburn's recycling and waste data in terms of tonnage and costs. MSW stands for municipal solid waste and RW stands for recyclable waste. All of these numbers are for one calendar year.

2.1.2. Rates

Currently, Auburn has an especially low recycling rate and high recycling contamination rate in comparison to other Maine municipalities, as demonstrated in Figure 3. Overall, numerical rates are the initial way in which a recycling program is judged. That being said, low recycling rates, as well as high contamination rates, are main indicators that changes need to be made in a respective program.

Recycling and Contamination Rate in Maine Municipalities

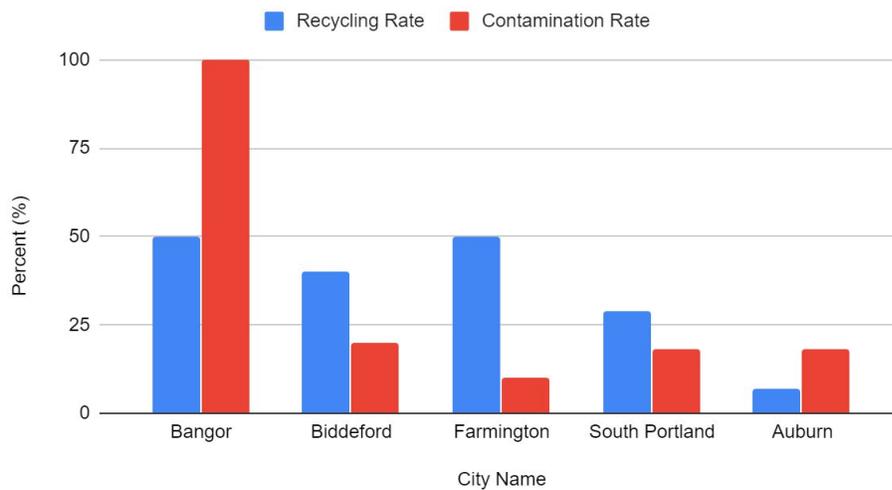


Figure 3: Recycling Rate and Contamination Rate across Maine Municipalities.

2.1.3. Perception

While recycling practices have clear environmental benefits, there are also an array of social benefits that a successful recycling program can cultivate. When speaking to representatives from other municipalities in Maine, it was clear that being perceived as an environmentally aware town or city was essential; having a successful recycling program is a key component of that. Because there are benefits in a city being viewed as ‘green’ or ‘sustainable’, notably the attraction to younger generations, cities and towns have made recycling interventions to improve public perception.

2.2. Programs and Interventions

The following information explores the successes of particular interventions and highlights which Maine municipalities use them. Alternatively, Table 3 depicts this information according to the city or town engaging in specific recycling interventions and compares it to Auburn.

2.2.1. Curbside

Curbside collection is a service provided to households for the disposal of waste, including recycling. This process is an essential foundation for a successful recycling program due to its inherent convenience. All Maine municipalities included in the outreach, Bangor, Biddeford, South Portland, Farmington, employ curbside recycling. South Portland and Biddeford have a mechanical collection system, Bangor is transitioning to mechanical in the near future, while Farmington retains its traditional collection system.

2.2.2. Single Stream

Single stream recycling is a one bin per residence system for all recyclable material. This bin would include paper, plastic, cardboard, cans, and bottles to be sorted at an alternate location. A single stream recycling program has increased recycling participation in cities all over the country due to the convenience and simplicity of only one recycling bin. Currently, Biddeford and South Portland, Maine are practicing the single stream method.

2.2.3. Dual Stream

Dual stream recycling is two or more bins per resident system. Typically, one bin holds paper and cardboard and another holds glass, plastic, bottles, and cans. Some systems also separate by cans and bottles in one container, glass in another, and the remaining recyclables in another. The main idea is that households are required to do the sorting of their recyclables. This system has lowered the contamination rate in some locations and according to statements from municipalities in Maine, dual stream recycling has saved them money. Currently, Farmington, Maine practices dual stream.

2.2.4. One Bin, All In

One Bin, All In is a new recycling and trash program through Coastal Resources. All recyclables and all waste are thrown into one bin at the household level and then sent to a sorting facility. From there the recyclables are sorted from the waste and cleaned from contamination. Food waste is also separated to be decomposed and turned into gas energy. This program has had success in raising the recycling participation rate. Although there is a 100% contamination rate, about half of the waste brought to the facility is able to be recycled. Currently, out of the four municipalities contacted, Bangor, Maine is the only one involved in the One Bin, All In system.

2.2.5. Education

2.2.5.1. Feedback

Personal feedback on residential units have shown to be an effective way to decrease contamination. Tagging recycling containers, mailing household recycling statistics, and sharing city wide statistics have increased awareness of contamination and elicited change within communities. Currently, Biddeford, Maine is using audits as their feedback system.

2.2.5.2. Technology

Technology has been implemented into cities in order to educate the public on recycling. Apps have been created to instantly inform people on specific items that can be recycled. Websites are used to raise awareness of the cities current recycling program and how the individual can aid in that process to make it the most effective. Currently, South Portland created a Recyclepedia app and Farmington has a link on their city website dedicated to recycling. Both of these methods have decreased contamination in their respective cities.

2.2.5.3. Brochures

Brochures distributed through mail have been an effective method in communicating current recycling information to the public. A color and personalized pamphlet captures the attention of residents and allows for residents to become more aware. This has increased

recycling participation by demonstrating a community that cares about recycling. Currently in Maine, South Portland, Biddeford, and Farmington all mail of brochures.

2.2.5.4. Public Access

Public access involves using social media, television, and news articles. This education strategy is effective in raising awareness to recycling ordinances, goals, and future plans. Currently, Biddeford, Maine incorporates these methods to create a community that values recycling.

2.2.6. Psychology

Psychological based decisions in terms of recycling infrastructure have been incorporated in many municipalities. Having a recycling container larger than the trash container typically allows for a higher recycling rate. Additionally, recycling containers that are blue, compared to other colors, wheelable, and unison in color have a higher recycling rate. Currently in Maine, Farmington, South Portland, Biddeford, and Bangor have wheelable containers. Biddeford has a larger recycling container of 65 gallons paired with a 35 gallon trash container.

2.2.7. Composting

Composting or food scrapping is a method that uses unwanted food and other organic waste to create soil. This practice has gained popularity in many municipalities in Maine because it is an effective way to reduce total waste due to food being heavier than most other waste, as well as its ability to decrease contamination rates. Currently all four contacted municipalities, South Portland, Bangor, Biddeford, and Farmington, have implemented composting into their Municipal Solid Waste programs. In Maine some popular programs for composting are ‘Garbage to Gardens’ and ‘We Compost it!’ that both offer curbside pick up of organic waste. In order for a new municipality to become a partner with either of these programs, there must be enough household interest. Information about costs for composting per household was gathered from their websites and shown in Table 2.

Composting Service	Cost per year per household
We Compost It!	\$107.88
Garbage to Gardens	\$180

Table 2: This table shows the cost of composting per year per household in the composting programs We Compost It! And Garbage to Gardens.

	Type of Recycling Program	Curbside	Contractor Name	Types of Education	Composting
South Portland	Single Stream	Yes- free	Pine Tree Waste/ EcoMaine	Brochures, App	Yes- at resident expense
Bangor	“One bin, all in”	Yes- free	Coastal Resources	Meetings	Yes- free
Biddeford	Single Stream	Yes- free	Casella	Audits Brochures	Yes- at resident expense
Farmington	Dual Stream	Yes- at resident expense	Archie’s Co.	Brochures, Website link School talks	Yes- free
Auburn	Single Stream	No	Casella	Nothing	No

Table 3: Characteristics of the current recycling program in South Portland, Bangor, Biddeford, Farmington, and Auburn Maine.

Feasibility

The combination of the summarized literature review information and the experiential Maine municipal information highlights an array of knowledge regarding the successes of certain recycling practices. What may have been successful in a certain study or town is largely dependent on infrastructure, community culture, and funding; a certain success is not a universal success. It is important to consider Auburn's current program, as well the overall sociopolitical context of the city, when examining and contemplating what practice would best be reflected onto Auburn's current practices and overall situation.

Currently contracted with Casella Waste Systems, Auburn's voluntary bi-weekly curbside recycling program has a low recycling rate of 7%, and a high contamination rate 18% (Note: this rate is not Auburn specific, rather the contamination rate reflects all recyclable material entering Casella's regional facility); both the recycling rate and the contamination rate are key indicators of the effectiveness of a respective program. The city currently does not provide any waste or recyclable containers and does not have any partnership or agreement with a composting, or food scrapping, company. As shown in table 2, Auburn produced 8421 tons of MSW, recycled 650 of RW meaning the cost per ton of MSW is around \$119, and the cost per ton of RW is about \$275. Figure 1 compared the price per ton of recycling in Auburn to other Maine municipalities and it was clearly shown that Auburn spends seven to nine times the per-ton rate of other cities. Our research explains this discrepancy to be fixed costs of collection and processing in the recycling process. Typically, the money earned from recycling material balances out these fixed costs. Because Auburn has a low tonnage of recycling collected, their cost per ton is significantly higher than other municipalities. If the tonnage were to increase the price per ton would decrease.

In summary, Auburn is spending a considerable amount of money on the city's Municipal Solid Waste program, but the rates exemplify the need for improvements and interventions in order to make the program 'worth it'. Evaluating the cost and benefits, as well as the effectiveness of various recycling interventions paints a clearer picture of what is best suited for Auburn specifically. Notably, cost and benefits are not solely monetary, rather there are social costs and benefits associated with certain practices that should be considered.

Each strategy successfully adds to the recycling program of cities. One bin all in significantly increases the convenience of recycling and therefore the recycling rate. Residents do not have to have any knowledge of recycling in order to participate. A change in contract and contractor can offer Auburn more infrastructure and services for a similar price. Other contractors around the state include composting, recycling containers, and education programs. Food scrapping or composting programs, if paid for separately, significantly increase the recycling rate by decreasing the total amount of MSW. Most recycling percentages are calculated by dividing the total RW tonnage by the total MSW tonnage. Food adds a lot of weight to the total MSW if it's thrown away, so by composting, the total MSW would decrease and the recycling percentage would increase; the recycling percentage would increase disproportionately for food compared to other lightweight materials. Finally, education programs are an effective strategy to decrease the contamination rate. Education in the form of brochures or school talks creates a community that cares about the environment in the future and is a part of the process of recycling.

Although these strategies aid to the effectiveness of recycling programs, they are not perfect solutions. One bin all in disconnects the relationship between the residents and the recycling program. They have no part in aiding or hurting the success of the program, therefore there is no recycling community or recycling norm. A change in contract would cause some political debate and negotiation which may take more time than anticipated to implement. Food scrapping has a problem of adding additional costs to Auburn's budget spent on Municipal Solid Waste. Education programs have uncertainty as to if they are effective in raising recycling rates. Moving forward is the evaluation of the most effective solution or combination of solutions for Auburn in terms of costs effectiveness.

Recommendation

There is not one overarching solution that would cultivate a successful recycling program in Auburn, ME, rather we propose a three-part recommendation that can be implemented simultaneously or in differing stages. The recommendation is motivated by summarized

scholarly literature and Maine municipal outreach information and is based on the feasibility of respective interventions for Auburn, ME specifically.

1.1. Composting

Part one of the three-part proposal is the implementation of a composting, also known as food scrapping, program. Research and municipal experience have shown that composting is a ‘win-win’ in the way it increases recycling rates and decreases contamination rates. Food, compared to other sources of waste, adds a lot of weight to the total municipal solid waste if it's thrown away. With composting, the total municipal solid would decrease and the recycling percentage would increase without actually recycling any more material. It is important to note that the recycling percentage would increase disproportionately for food compared to other lightweight materials, so composting would be the most effective intervention to reduce the total municipal solid waste. Additionally, food is one of the main factors contributing to recyclables contamination, so removing food waste from the municipal solid waste collection and processing would inherently decrease Auburn’s contamination rate. From a greenhouse gas standpoint, composting food rather than landfilling, is an effective way to reduce the amount of methane emitted from the waste lifecycle. The Maine municipal outreach exemplifies how composting is seemingly the “to go” tactic right now, and furthermore highlights the interventions' success. That being said there are different options when it comes to implementing a composting program, for example a curbside program, a drop-off program, a backyard program, or a variety of combinations. For Auburn, ME specifically, a program that has curbside composting at the residents’ expense as an option, coupled with free town-wide drop-off bins, would give residents options of cost versus convenience factors. Throughout other Maine municipalities, composting programs are becoming more prevalent and the benefits are reflected in recycling rates closer to the statewide goal of 50%; South Portland’s recycling rate increased about 7% over the course of several months according to a city representative. When speaking with Amy Clearwater, Ward One In Biddeford’s City Council, she encouraged us to look into composting because it is an effective strategy to increase the recycling rate and lower the costs of waste.

1.2. Education & Feedback

Part two of the three-part proposal involves education, as well as feedback, interventions as a way to capitalize on the psychological factors that have been concluded to motivate and improve recycling practices. Easy and effective targets of intervention are the school system and the public news or media. If all school age children are educated on recycling and then bring that knowledge home to their families, a significant amount of people will be involved in their recycling program. The media can be used to raise awareness on the goals of the recycling program and deliver information about recyclable material. These are effective because in the words of Biddeford Ward One City Councilor, Amy Clearwater, “children and little old ladies make great recycling cops.” If a city is making it clear that the environment and trash reduction is a priority, it cultivates a community that cares about recycling, thus inherently increasing the city’s recycling rate; investments in recycling interventions are investments in the community.

Generally, educational interventions take a variety of forms. Notably, education fliers, for example the Do’s and Don’ts of recycling, and informative town meetings are a plausible way to inform a substantial number of residents on key takeaways. There are also services available to help communicate with residents, such as the Recyclepedia app that South Portland has implemented; the app essentially acts as a recycling database for residents. While there is some uncertainty throughout literature of the extent to which educational interventions are effective, municipalities have found education to be successful in improving their program. If residents are unaware of correct recycling practices, recycling rates will decrease, and contamination rates will increase. That being said, it can be beneficial to provide information in relevant languages in order to reach all residents.

In order to provide group feedback, which would involve presenting information to household residents on how their recycling behaviors compare to neighborhood or city-wide behaviors, it is necessary to collect and organize a vast amount of data. While the costs of doing this is largely time and energy, the psychological and societal benefits are notable; using social norms is a great way to increase recycling rates and create a communal recycling culture. An alternative way to provide feedback and tap into the benefits of social norms is to have a

city-wide tagging system in which resident's recycling is tagged, and in some cases not picked-up, if it is inadequate. Not only does a tagging system help educate residents individually, but it also acts as a social signal to others around; societal pressures are enacted. This method is also a cheap and simple way to communicate with the public on how their own recycling practices can be improved.

1.3. Contract

Part 3 of the 3-part proposal is the suggestion of shifting away from the city's contract with Casella Waste Systems and entering a new contract with a new company. With this, there are a variety of factors to consider such as the costs, the provided services, as well as the time needed to implement the new program. We arrived at this conclusion after comparing the total costs of recycling and the services in the Maine municipalities we looked into. Auburn spends significantly more on recycling per ton than other cities (as demonstrated in Figure 1) and also has a total recycling cost higher than Farmington and Biddeford, who have similar populations (as demonstrated in Figure 2). In these cities with lower costs, their contractors provide residents with containers for trash, recycling, and sometimes composting. We believe there are better contract options out there for a similar or lower cost than Auburn is currently paying. Even if the initial investment is higher than the yearly current cost, our research suggests that in the future the cost will even itself out.

The non-profit waste management organization Ecomaine, a company many municipalities throughout Maine are in a contract with, is a feasible option for Auburn, ME. Bates environmental studies students working on a parallel recycling project for Auburn, ME gathered information from Ecomaine representative, Lissa Bittermann. According to Bitterman, if Auburn was to enter a contract with Ecomaine it is guaranteed that the city's recycling rate would increase, and the contamination rate would decrease. Ecomaine's standard tipping fee is \$115 per ton, and it is important to consider that an additional contract, and payment, with a hauler is necessary. Table 2 indicates that even with an additional cost of a hauler added to the \$115 fee with Ecomaine, it is very possible that the current price of recycling per year would stay the same or even decrease. We understand that the hauling cost is a huge factor in the overall

cost of recycling. That being said, we were unable to contact a hauler to get an estimated price. While improvements in rates are initially attractive, a contract with Ecomaine would provide additional services that Auburn does not currently receive, such as outreach, a tagging program, as well as a grant program. A new contract, with a company such as Ecomaine provides services that cover the need for additional interventions discussed, such as feedback and education intervention. These additional benefits are essential to weigh when exploring the cost benefit analysis of each respective intervention.

By incorporating these three parts into the political, social, and economic discussion of the Auburn City Council in the future, we believe it would not take long for the recycling rate to increase and the contamination rate to decrease. We also believe that these parts will create a new recycling culture in Auburn, ME, where residents will consider recycling as a part of their responsibility for their community and environment, now and for generations to come. This shift in culture, and upgraded environmentally conscious image, is not only essential for current residents, but also a fundamental part of attracting a younger demographic to the city. Supported by scholarly literature research and outreach to several Maine municipalities, and ultimately dependent on the feasibility and context of Auburn, ME, our three-part recommendation aims to address a variety of factors in order to support successful recycling practices and outcomes.

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Appendix A: Full Literature Review

Introduction

Material waste has transformed throughout the history of the United States. With disposable household items, extensive packaging, and single use material a part of everyday life, the amount of waste thrown away has hit superlative levels. In fact, the annual municipal solid waste (MSW) generation in the United States has increased from 88 million tons in 1960, to approximately 254 million tons in 2007 (USEPA, 2007 as cited in Sidique S. et. al., 2010). More recent data notes that the tonnage has reached about 267 tons in 2017 (USEPA, 2017). With limited space for this excessive waste leads to go, illegal disposal methods of dumping and burning follow. The results of these activities result in increased CO, CO₂, SO, NO, PM₁₀ emissions that have an effect on the changing climate. Additionally, human health concern arises as mismanaged waste has been documented to lead to flea and insect infestations, contaminated groundwater, and high levels of coliform (Ferronato & Terretta, 2019).

With human and environmental health at risk, the recycling movement 'reduce, reuse, recycle' was a product of the 1970s grass-root environmental movement (Oldenziel & Weber, 2013). Throughout the 1990s municipal recycling programs multiplied throughout the United States largely driven by a combination of the increasing demand for more environmentally responsible waste management solutions, corporate lobbying, and the rise of disposal costs (Pollan's et. al., 2017). Now municipalities all over the country are driven to reform solid waste programs and policies in order to manage the waste of their regions in the most efficient way.

There are several broad classes of literature regarding recycling practices, ultimately highlighting the successes and failures of particular municipal programs. Contemporary household recycling research has been divided into main stream of research including the effects of curbside recycling (Dormina and Koch, 1999, 2002; Ewing, 2001; Folz, 1991; as cited in Park & Berry, 2013), the economic perspectives (Chowdhury, 2009; Reschovsky and Stone, 1994; as cited in Park & Berry, 2013), and notion of altruism (Ewing, 2001; Kalinowski et al., 2006; as cited in Park & Berry, 2013). Scholars have produced articles that use comprehensive models to incorporate the behavior of governments, and consumers, and articles that focus on consumer reactions to various pricing schemes and recycling programs (Linderhof et. al. 2001). Another stream of research takes a social psychological approach that explores the role of moral and social norms as important drivers of recycling behaviors (Siddique et. al. 2010). Some scholars have focused more narrowly on the influence of secondary factors on recycling programs, such as containers attributes (Lang & Wagner, 2013).

The Variety of Recycling Programs

The fundamental goal of recycling programs is to increase the percentage of material collected and ultimately recycled, in order to ensure the diversion of materials from landfill disposal. Curbside recycling has emerged as the most prevalent recycling practice that

municipalities have invested in. In a case study of recycling performance in Florida, Park and Berry's (2013) convenience-based hypothesis was supported by showing that curbside recycling had a positive effect on MSW [Municipal Solid Waste] recycling performance. Ultimately, convenience is highly valued when it comes to residential recycling practices, and curbside recycling programs provide this for residents.

When speaking of curbside programs specifically, increasing the participation rate (the number of individuals engaging in the process), and increasing the recycling rate (the amount of materials recycled and diverted) are two targets that are aimed for in order to be considered a successful program (Wang et. al., 1997 as cited in Lang & Wagner, 2013). Within the guidelines of those two goals, municipalities are continuously altering their recycling programs in search of the best practice. Single stream recycling programs, and variable pricing recycling practices, are two municipal options that have been heavily engaged with.

Bell, Huber, and Viscusi (2017) conducted a longitudinal study on the recycling program in Wisconsin to highlight the transformation of various cities from dual-stream to single-stream recycling containers. They found that cities and towns increased their participation by around 10%, and saved more money, by switching to single stream curbside recycling. The study was used to demonstrate that single stream programs increase recycling within households. In a similar study, Tonjes, Aphale, Clark, L, and Thyberg (2018) followed New York's transition to single stream recycling and found that the city's participation rate increased, but there was not a statistical significance of the amount of recyclables increasing. Tonjes et. al. (2018) showed that single-stream collection reversed long-term declining trends in recyclables collection tonnages; in the study, the recycling percentage increased 22.3% town-wide (Tonjes et. al., 2018).

In addition to single stream recycling, dual stream recycling practice is defined as separate containers for different recyclable material, typically one container for glass and plastic and another for cardboard (Rogoff & Ross, 2016). The benefits and costs of these have mixed results. Rogoff and Ross (2016) illuminate the common theme that single-stream greatly increases the volume of recyclables collection, but also increased the contamination rate. The contamination rate has doubled over the past decade, steadily increasing the costs to process recyclables that meet market regulations. In terms of contamination, review of data from both single and dual stream recycling programs highlight a uniform increase at most United States MRFs (materials recovery facility) to an average of 16% (McCormack, 2015 as cited in Rogoff and Ross, 2016). It is possible that the increased contamination rates can be partially attributed to the increased variety of containers and packaging over the past few decades; processing costs increase while market demand for produce quality simultaneously increases (Rogoff & Ross 2016). The processing required to remove contaminants at the MRF is extensive, ultimately reducing profitability of the recyclables even before considering revenue from sales (Rogoff and Ross 2016).

As a practice, variable pricing focuses on decreasing waste tonnage while simultaneously increasing recycling tonnage. Unit pricing, also known as variable rate pricing or

pay-as-you-throw (PAYT), is a system under which residents pay for municipal waste management services per unit of waste collected rather than through a fixed fee (EPA, 1994). While these pricing programs present variety at the municipal level, they can take two basic forms: volume of waste, using bags, tags, stickers, or prescribed waste bans, or weight of waste, in which the municipality measures at the curbside (EPA, 1994). When discussing various incentives to recycle, unit pricing is a heavily engaged practice with some competing claims.

After analyzing the effect of various recycling and waste management policy variables on recycling rates in Minnesota over an 8-year period, Siddique et. al. (2010) found that variable pricing of waste disposal increases the rate of recycling. In a similar study, Hong and Adams (1999) suggested that an increase in the price of solid waste collection increased the demand for recycling (as cited in Siddique et. al. 2010).

In contrast, Fullerton and Kinsman (1996) reported that the incremental benefit of unit-pricing programs is small and outweighed by the administrative cost (as cited in Siddique et. al. 2010). In most cases there were less bags, but the same weight of waste, while there was also evidence of illegal dumping (Fullerton & Kinsman, 1996 as cited in Siddique et. al. 2010). Park and Berry's financial incentive based hypotheses were only partially supported, suggesting that individual incentives have the potential to increase recycling performance more so than financial incentives (2013). Their study shows no evidence that pay-as-you-throw has a significant effect on recycling rates (Park & Berry, 2013).

All these recycling programs can be accompanied by policy to further work towards the goals of lowering contamination. Rogoff and Ross (2016) suggest that one way to improve the quality of the sales of recyclables is to eliminate materials that are difficult to recycle; some cities have banned plastic bags, and notably, the price of glass is marginal and it is a material that breaks and contaminates other materials. An additional method to lower contamination is a fee for high household contamination. Certain regional based hauls have implemented certain regulations, such as the Vermont-based regional hauler who added a 'sustainability recycling adjustment fee' onto the bills for residential, commercial and municipal consumers. The SPA is so that consumers receive credits with the average commodity prices are relatively high, and subsequently pay more when prices drop (Rogoff and Ross 2016). Siddique et. al. (2010) found that the combination of curbside recycling services and drop-off centers were effective in increasing the rate of recycling when implemented together. This research suggests that cities do not always need to create a new recycling program but can instead add on different policies and methods to adapt it to their specific needs.

Emerging Practices

As the issues of waste production and management pile up, there has been a recent surge of interest in the United States in the diversion of food scraps and other organic wastes from the municipal solid waste programs (Pollan's et. al. 2017). According to the U.S. Department of

Agriculture, 30 to 40 percent of food supply ends up being food waste in the United States. In 2010, there was approximately 133 billion pounds of food waste in the U.S., equating to over 66 million tons (USDA, 2019). In 2014, the EPA estimated the 21.6% of municipal solid waste disposed of in landfills and incinerators was food scraps (Pollan's et. al. 2017). Oftentimes recycling rates are calculated from the amount of recycling tonnage divided by the amount of waste tonnage. This being said, one way to increase recycling rates is to decrease the amount of initial waste through food scrap and composting programs.

Food scrapping programs are an opportunity for municipalities interested in sustainable management for various reasons. Food scrap collection enables options such as energy and resource recovery, the reduction of methane emissions from landfills, and the returning of nutrients to soil (Platt et. al., 2014; U.S. EPA, 2017; as cited in Pollan et. al. 2017). Furthermore, it is clear evidence that food scrap recycling leads to a reduction in the national disposal burden (Pollan et. al., 2017).

Pollan's et. al. hypothesis that cities are more likely to adopt new solid waste diversion programs, such as food scrap collection, when they can build upon existing infrastructure and service programs was supported; food scrap collection is more likely in places that have current diversion programs, like curbside recycling. The Pollan et. al. food scrap study highlights the source-separated recycling programs show a negative correlation with curbside composting, whereas areas that have shifted to single stream follow the food scrap trend. It is ultimately suggested that diversion-oriented policy frameworks, such as pay-as-you-throw, can serve as a strong foundation for many different types of diversion programming to follow (Pollan et. al. 2017).

Secondary Factors

When analyzing recycling programs there are clearly a variety of factors to consider when addressing the influence of recycling rates. Different characteristics of containers are a factor that may be considered secondary, though they remain important when considering change. Lang and Wagner's (2013) work on recycling container attributes reveals that a greater capacity is the most consistently reported factor that increased recycling rates and participation. In general, residents prefer large, wheeled recycling bins with lids for convenience (Lang & Wagner, 2013). Furthermore, the choice of container size has the potential to increase rates because of convenience. Shawnee Recycling Task Force (2009) agree that recycling containers should be as large, or larger than waste barrels in curbside programs.

When looking at the cost of containers, there are collection systems that have implemented certain requirements. In terms of the distribution of containers, it is found that city or town provided bins have been associated with higher participation rates, in some cases the rate increased more than 50% (Lang & Wagner, 2013). That being said, providing single-stream recycling containers for a small municipality of about 10,000 households can cost around \$650,000 (Lang & Wagner, 2013). If free containers are regulated as the only acceptable

container choice, or residents are required to buy certain containers, it can have a negative image on participation (Lang & Wagner, 2013). In the study specifically, 72.7% of the studied governments proceed at least the first recycling container for free.

When considering the provision of containers, it is important to note that a uniformed container can also be a social recycling cue. Everette and Piere (1993) suggest that when recycling containers are uniformed and highly visible, peer pressure will have an influence on households whose containers are absent (as cited in Lang & Wagner, 2013). In terms of color, Curfew and Hinchy (1993) found that residents supplied with blue recycling containers have a 4% higher participation rate than those with black containers (as cited in Lang & Wagner, 2013). Signage is another visual cue that has substantial effects. Duffy and Verges (2008) state that signage illuminating the different types of materials, such as trash versus recycling, increased recycling by 34%, and reduced contamination by 95%.

Education & Social Psychology

Establishing programs and providing infrastructure such as large bins is effective in increasing recycling material, but they often include higher levels of non-recyclable material (Rogoff and Ross, 2016). Though education is the most commonly used and studied form of intervention to improve recycling, the results on the effectiveness of education are mixed (Schultz, 1999). Environmental concern is something that is found to positively affect the fundamental amount of recycling collected, while Park and Berry (2013) found no significant findings resulting from increased education.

That being said, various studies have found educational interventions to be positively influential, especially when addressing contamination rates. According to Rogoff and Ross (2016), contamination rates can be partially solved with improved public education. Hossain, Santhanam, Norulaini, and Omar (2011) point out that a lack of legislation and uneducated staff and participants are common threads in unsuccessful recycling programs. Siddique et. al. (2010) reveal that the enactment of recycling ordinances, as well as cumulative expenditures of recycling education were found to be effective measures.

Oftentimes the analyses of educational interventions are related to the studies of social psychology within the recycling realm. Cheung, Chow, and So (2018) developed “train-the-trainer” that taught student teachers how to be environmental ambassadors and promote plastic recycling behavior in the school they taught at. The goal of this program was to change the behavior of students to include recycling, instead of simply teaching students how to recycle. The student teachers acted as positive, consistent, and familiar role models that encouraged the new behavior in the classroom. The highlight of this program is that it is cost effective because the student teachers only have to be trained one time but carry the learned knowledge to new groups of students every year.

Several studies focus solely on the psychological aspect of recycling, one method being the provision of feedback to individual households. Schultz (1999) conducted a study that

provided individual households with feedback about residents recycling behavior with no reference about other residents, while group feedback intervention included information about other residents behavior. The result suggests that individual feedback may only be effective while the feedback is being given. In contrast, group feedback has the potential to produce a template for comparing current and future behavior. Additional studies of normative feedback interventions show significant increases from baseline in the frequency of participation and the total amount of recycled material for both individual and group feedback interventions.

Pulling from the broad search of education and psychological strategies, there was a clear consensus of certain methods as successful. Schulz's (1999) suggests that motivation appears to be a more powerful determination of recycling participation; a potential motivation being social norms. Varotto and Spagnoli (2017) agree with that statement through their meta-analysis on the best recycling implementation methods. By comparing the correlation coefficient of all analyses, they found that social modeling and environmental alteration is the most effective. Social modeling was defined as personal motivation that shows others how to recycle and be environmentally friendly. Environmental alterations were described as methods that make recycling more convenient and easy to do. The main idea of these methods is that people learn through best through observation and they are more likely to observe and engage in an activity when it is right in front of them.

While these methods are broader, Mee (2005) found similar results of social interaction affecting the recycling rate through a case study in Rushcliffe, UK. With a questionnaire evaluation of their recycling campaign, it was found that a combination of the following strategies allowed for the most outreach to residents; profile, pull, push, and consultation strategy. This allowed their recycling rate to increase from 26.7% to 47%. A profile strategy is centered around the media and newsletter repeatedly portraying the information. A pull method praises the effective changes people make through personal letters. A push strategy asks community partners to also endorse the message. Finally, through consultation, questionnaires allow the city to receive feedback on their methods of outreach.

Municipality Reform

Today, a major barrier that municipalities across the United States are facing is the cost of recycling: including infrastructure, processing etc. Although, what is not considered is that statistically speaking, spending one dollar per person per year will increase the rate of recycling by approximately 2% each year (Siddique et. al. 2010). This finding suggests that even the smallest increase in the recycling education or implementation budget can have significant results. Moving forward, as countries, states, and cities feel the increasing pressures of the waste crisis, municipalities are working to reform their recycling programs and policies in order to develop the most effective practice. The search for the best recycling practice has led municipalities to alter their ways, trying to find the right fit for their city's demographics and characteristics. According to Powell (2011), evidence shows that anytime you change a recycling

program, and it gets publicity, the participation rate actually increases. This information encourages municipalities to continuously reform their practices to keep their community engaged in recycling.

Final Conclusions

Throughout recycling literature there are areas of clear consensus, competing claims, and uncertainty. Scholars have seemingly agreed that curbside is the most prevalent, and effective recycling practice due to its inherent convenience. Though this is agreed upon, policies, programs, and implementation strategies vary across the country. There is also a consensus within literature about the positive influence of social psychology and secondary factors, such as container attributes, on recycling. While those methods are agreed upon, there is uncertainty within the studies of education interventions, and competing claims about the effectiveness of unit pricing systems. The broad classes of recycling literature highlight the successes and failures of particular municipal programs, but it is important to note that several aspects are municipality-specific; what works for one, is not guaranteed to work for another. All of these findings from literature suggest that trial and error of a combination of programs not only creates a community that values recycling, but is necessary to find the most effective strategy.

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Appendix C: Municipal Report

South Portland

a. Introduction

South Portland, the fourth-largest city in Maine, has a population of just over 25,000 people. Census data states that South Portland has around 10,700 households with an average of 2.31 persons per household (U.S. Census, 2019). Notably, the median household income is around \$66,000. In terms of waste management in the city, trash and recycling is collected weekly by a local contracted company, and hauled to EcoMaine, a non-profit, community-owned recycling and waste-to-energy plant in Portland, Maine (South Portland, 2020). We talked with Doug Howard, the public works Director of the city, to gain information on the city's recent recycling interventions and respective impacts.

b. Intervention

In summary, South Portland's waste management is a weekly trash and recycling curbside pickup program. The pickup is an automated system that uses an EcoMaine split truck, allowing for waste and recycling to be collected in one stop. Notably, the city provides a 65-gallon waste container, and a 45 gallon recycling container to all city residents. South Portland has no ordinances requiring residents to recycle, rather it is a volunteer based program. The city has recently implemented a composting program through the company Garbage to Garden where residents are offered 13 gallon bins for free that can be put out curbside at a reduced rate. In addition, residents can bring composting to drop off centers around the city for free. Another point of intervention the city has focused on is education. In secure successful intervention, South Portland hired a sustainability coordinator. For education intervention, the city has partnered with EcoMaine to develop do's and don'ts of recycling magnets, published articles in the local paper, and put up flyers. In South Portland, it was clear that areas where several different languages were spoken had the highest contamination rates, so the city worked to provide information in different languages. Also, to address contamination rates the city had interns go around and tag recycling; if a container received a red tag, it would not be picked up. Notably, South Portland has worked with a software company to introduce the Recyclepedia app which notifies residents of pickups, and acts as a database for information on what and how materials are to be recycled.

c. Impact

Since introducing the option of curbside and drop off composting, South Portland's recycling rate went from 22% to 29%, a 7% increase. Furthermore, the contamination rate decreased by 3%, going from 21% to 18%. It is possible that

the increase in recycling rate, and decrease in contamination rate can be attributed to both the composting and education interventions.

d. Additional Information

In terms of cost, South Portland spends \$1.5 million a year on Municipal Solid Waste management; this includes recycling and composting. Over the course of the year residents generate around 6000 tons of MSW, which costs the city 73 dollars per ton (\$438,000 total), and around 2300 tons of recycling, which costs 33 dollars a ton (\$75,900 total).

Schools are included in the statistics mentioned, as some schools have request carts and participate in curbside pick-up, and some schools are implemented food waste programs, but separately.

Bangor

a. Introduction

With a population of about 32,000, Bangor is Maine's third largest settlement behind Portland and Lewiston. Within the city there are around 14,000 households with an average of 2.11 persons per household, and a medium household income of about \$42,000 (U.S. Census, 2019). Bangor recently changed their waste management strategies completely, and we spoke with public works director Eric Willet to grasp why he considers Bangor's new waste management practices to be "amazing."

b. Intervention

Within the past year, Bangor has started a new contract with Coastal Resources of Maine located in Hampden, ME. Coastal Resources uses innovative second-generation recycling technology developed by Fiberight to recover sustainable resources from waste. Bangor decided to change its program because it was so costly, and the recycling rate was so low. Originally, Bangor was paying for a separate truck or pick up recycling, which was only 8,000 tons a year, in comparison to the 28,000 tons of trash a year; tonnage is residential and commercial. Ultimately, the switch was a financial decision.

Bangor's new motto is "one bin, all in" where residents put all trash and recycling into one bin, which is later sourced at that Coastal Resources facility. Whereas curbside pick-up in Bangor used to be trash every week, and recycling bi-weekly, under the new model it is weekly. Currently, residents use their own bags and bins, but starting in June the city will be providing 96 gallon bins when they switch to automated pickup. There is no need for an additional composting program since Coastal resources separates food waste to decompose in order to

produce gas. Notably, both school waste and commercial waste are included in the Bangor program.

In order to educate residents on the new program, town representatives have meetings around the city with local groups, apartment groups etc. A clear example of this intervention is the fact that representatives brought the new bins and set up an education table at polling booths.

c. Impact

Before contracting with Coastal Resources, Bangor's Recycling rate was around 8% or 10%, and since implementing "one bin, all in" the recycling rate has increased to over 50%. This 50% means that 50% of the waste sent to the facility is extracted and recycled. The contamination rate is 100% before being processed at the facility. The program switch ended up saving Bangor money, but Willet did not provide exact numbers.

Biddeford

a. Introduction

Biddeford was reported to be the 6th largest city in Maine with a total population of 21,514 people in 2020 . In relation to the size of the city that is about 715.13 people/mi² (U.S Census, 2020). They also have a median household income of around \$50,000. We talked with Amy Clearwater, a ward on the Biddeford City Council about their single stream curbside recycling program. We also talked with Jeff Demers, the Public Works Director in Biddeford. Ms. Clearwater spoke to future improvements to their recycling program to include more composting and to create legislation to restrict complex packaging design. Mr. Demers hoped to reduce their level of contamination with more education programs.

b. Intervention

As mentioned before, Biddeford has a single stream curbside recycling program with weekly picks ups. They contract their trash and recycling through Casella, which is the same company Auburn uses. Residents are provided with a 65-gallon bin for recycling, and a 35 gallon trash bin. If residents wish to compost at their homes, they can purchase a container for a reduced rate than average value. In terms of education programs, Biddeford has an audit system where notifications are given to households with excess contamination in their recycling bins; the contaminated recycling bins are then not picked up. This system is written in their ordinances for city recycling. In addition to audits, brochures were distributed to residents on everyday items that can be recycled. Recently, Biddeford has implemented the media as a way of distributing recycling information to the public. Biddeford has ordinances in place that require the city

to provide collection and disposal of waste and recycling to commercial and domestic buildings.

c. Impact

Right now, Biddeford's recycling rate hovers around 40% and their contamination rate is around 20%. Their goal is to bring their contamination rate down to 20%. Through Casella, Biddeford pays around \$59 per ton for trash. They pay a monthly fee of \$34,950 for just recycling. The representatives from Biddeford mention that their cost for recycling has been threatened to increase if their contamination rate gets any higher. They have a budget of \$4,000 dedicated to education needs.

Farmington

a. Introduction

Farmington is the smallest city we looked at, with a population of 4,144 people in 2017. There are around 2,000 employees with a median income of \$33,000. There is a poverty rate of 21.4%. We talked with Richard Davis, the town manager of Farmington about their dual stream recycling program. When asked about his opinions of the current recycling program Mr. Davis spoke about the cost benefits of having recycling compared to a waste to energy program. He explained that when Farmington discussed transitioning to waste to energy they decided not to because not everything can be burned and it is very expensive to dispose of the ash produced from burning. He also expressed the city's plan to pass their LG 224 bill that will require local packages to produce all their plastic in #2 plastic so that material could be sold and made again.

b. Intervention

Farmington's dual stream recycling program is contracted through Archie's Incorporation. Recycling and trash is picked up by Archie if the household chooses to pay for curbside pick-up or the household can drop their trash off in the city provided dumpsters. All infrastructure for curbside pick and drop off has to be paid for at the expense of the resident. As for education programs, Farmington has sent out brochures in the past about dual stream recycling and have done occasional talks in the schools. They also include a recycling link on their website with detailed information on recycling news. Farmington established recycling ordinances in 1992, but they were amended in 2016. Some of those ordinances include any person involved in collection and transportation of solid waste must pay a fee to the city, any person, firm, corporation, partnership, or association with legal agents must partake in the city recycling program. Another

ordinance prohibits the disposal of pathological wastes, chemicals, explosives, radioactive materials, other special wastes, toxic wastes and other wastes defined by the Department of Environmental Protection as hazardous through the city trash and recycling program (City of Farmington, 2016),

c. Impact

Currently, Farmington has a recycling rate of 50%. They calculate that amount through reports given on the total tonnage of trash and total tonnage of recycling. Their contamination rate was estimated to be around 10%. Through Archie, Farmington pays \$44 per ton of recycling. In comparison to the rest of their expenses, Farmington spends a total of \$72,000 a year on recycling, which is only about 2% of their total budget.

d. Additional Information

Uniquely to Farmington is their “swap and shop” program. This allows residents to bring still working, but unwanted, appliances to a store to donate for another to use. This program has had tremendous success and has been adopted by other cities such as Wilton. In addition to this program, Farmington has a composting site in conjunction with the University of Farmington, Hannaford’s, and public works. The compost made from food scraps is then sold to the public twice a year.