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Litter-Free Baltimore:

A trash collection policy framework based
on spatial analysis and social media

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Executive Summary

Litter in Baltimore is a public nuisance that drives down property values, clogs and damages sewers, provides food for rats, and is unhealthy for the Chesapeake Bay. Baltimore spends millions of dollars annually on litter collection, street cleaning, and watershed cleanup, and could save money and improve quality of life by more intelligently targeting increased trash collection efforts. To resolve the multi-faceted impacts of littering in a cost-effective manner, the City of Baltimore should investigate the spatial and social patterns that drive trash generation, encourage Baltimoreans to be more involved in trash and litter reporting, and establish evidence-driven plans to expand trash collection in public spaces.

We outline municipal policy alternatives for public trash collection that: (1) acknowledge spatial and income-related differences in consumption and waste generation patterns in Baltimore; (2) utilize indicators that identify high-risk litter areas; (3) involve Baltimoreans in the process of identifying litter hotspots; (4) are politically feasible; and (5) are cost-effective compared to current litter collection efforts. We propose the following sets of recommendations for the Department of Public Works (DPW), Office of Special Services (OSS), and Office of the Mayor of the City of Baltimore:

Street Cans: The Baltimore City Department of Public Works should conduct an inventory of existing "street cans" (street-side trash cans), review the distance between street cans and the collective capacity of street cans to hold the expected volume of non-residential trash produced in their

vicinity, and add additional cans (with narrow-mouthed lids) where needed.

Litter Distribution and Composition: The City should conduct a litter composition and spatial distribution study to better understand the drivers of litter in Baltimore.

Social Involvement: DPW should label all street cans with unique identifiers, to make it easier for citizens to report trash cans for cleanup through Baltimore's Open311 system. The City can target specific litter issues, such as emptying of street cans and illegal dumping, by promoting the use of hashtags in reports to its Open311 system (e.g. #streetcan, #dumping), and should explore ways to integrate the Open311 reporting process with other social media platforms.

Trash Collection Operations: DPW should reassess its street can emptying schedule to ensure that cans are emptied with sufficient frequency. OSS and DPW should focus on ensuring adequate storage capacity for non-residential trash by strategically planning the quantity and spatial distribution of street cans. There also appears to be significant public support for increased enforcement and penalties for litter violations, as well as for litter-prevention outreach activities that partner schools and businesses.

Introduction: Trash and Litter in Baltimore

Baltimore generates a considerable amount of trash, much of which becomes uncollected litter that spreads around public spaces, clogs sewer drains, and pollutes the Chesapeake Bay, costing tens of millions dollars each year for street cleaning, litter pickup, sewer

We argue that a significant proportion of trash generation in Baltimore occurs when food is consumed outside the home. We do not raise these points to judge the consumption patterns of any Baltimorean. Rather, we seek to explore the City's capacity to capture non–residential trash and prevent non–residential litter.

repairs, and bay cleanup.[1-3] Recently the City has stepped up residential trash collection, rat extermination efforts, and to some extent public *litter* collection, but has done comparatively little to address public *trash* collection. (As listed in the glossary, we define "trash" in this paper as synonymous with municipal solid waste; we distinguish between "residential trash" generated in the home, and "non-residential trash" generated outside the home. The term "litter" denotes trash that is improperly discarded.) One notable recent litter cleanup effort is the solar-powered trash collector in the Inner Harbor – named Mr. Trash Wheel – which costs the City $128,900 a year and siphons litter floating into the Bay.[4] Since program inception in May 2014, Mr. Trash Wheel has recovered at least 218,720 plastic bottles, 280,619 polystyrene "clamshell" containers (used to package food), 137,570 grocery bags, 202,139 snack bags and over 7 million cigarette butts.[1] Four of the top five types of recovered items, by weight, are related to food and drink consumption. With the recent submission of Baltimore's agreement with the U.S. Environmental Protection Agency (EPA) to limit the amount of trash entering the Chesapeake Bay (known as a Total Maximum Daily Load [TMDL] regulation), the time is ripe for Baltimore to consider steps to alleviate litter. So where does the food and drink packaging that Mr. Trash Wheel collects originate, and why does so much food and drink packaging wind up as litter in the Bay?

Over one-third of neighborhoods in Baltimore, home to one-fifth of Baltimoreans, are designated "food deserts," where the nearest supermarket

is more than a quarter mile away, at least 40 percent of households have no access to private vehicles, and median household income is 185 percent of the Federal Poverty Level or lower.[2] In the absence of nearby grocery stores, many of these areas have high concentrations of carry-outs, corner stores, and convenience stores; such areas are known as "food swamps." Meals and drinks from such stores generate significantly more packaging waste than equivalent meals prepared from fresh ingredients.[3] Such to-go meals and drinks are also more readily consumed and disposed of outside the home.

In Figure 1 (page 3), we have outlined the transport of food waste and packaging from neighborhood stores, and its potential impacts on the environment and society, including rat infestations, impaired water quality, and reduced property value. We applaud the City's recent efforts to provide free residential trash cans to citizens, and believe that this will reduce residential littering (e.g., by better preventing residential trash from blowing into the streets).[4] Non-residential litter, however, is a significant and under-addressed issue in Baltimore. In the following sections, we argue that a significant proportion of litter generation in Baltimore occurs when food is consumed outside the home.

We do not raise these points to judge the consumption patterns of any Baltimorean. Rather, we seek to explore the City's capacity to capture non-residential trash and prevent non-residential litter. Potential sources of non-

Figure 1: Conceptual diagram of trash and litter generation in Baltimore City
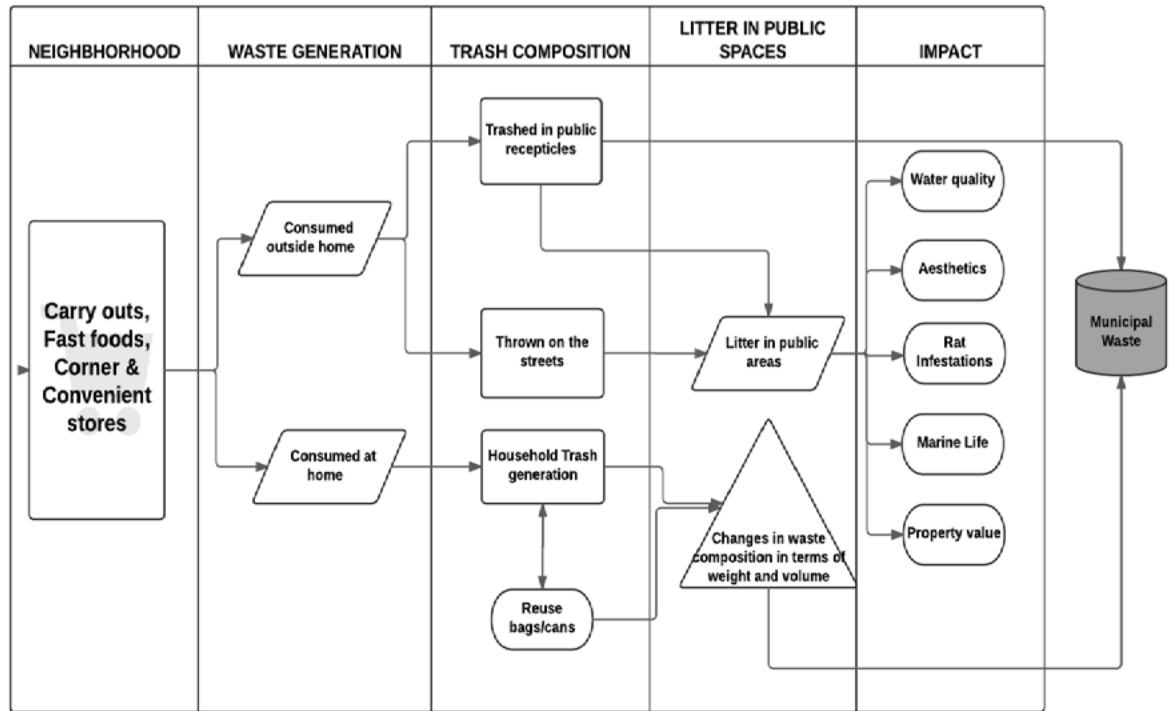
residential trash we examine include carry-outs, corner stores, convenience stores, and grocery stores, as well as middle schools and high schools (which provide single-serving meals and drinks in schools), and bus stops (which commonly host street cans, since food and drink are not allowed on buses).

The main aim of this policy research paper is to suggest municipal policy alternatives for trash and litter *management* given food consumption patterns and existing resources in Baltimore. We explore this aim by: (1) identifying spatial and social aspects of food and drink consumption and food waste generation patterns in Baltimore; (2) consulting with key stakeholders on efforts to manage trash and litter; (3) conducting a review of the existing literature on social aspects of littering; and (4) surveying Baltimoreans on the utility of social media reporting for trash and litter.

Methods

To collect data for the objectives outlined above we conducted spatial and volumetric analysis, administered a public online survey, undertook literature reviews, and conducted interviews with key stakeholders. Methods are organized by objective as follows:

For Objective 1 (Spatial Aspects of Trash and Litter Generation in Baltimore), we obtained spatial datasets related to Baltimore from several sources (including the Maryland Transit Administration, Baltimore City's Open Data portal, and the Maryland Food System Organization[5]) to analyze spatial correlations of littering. We analyzed publicly available spatial location datasets for carry-outs, corner stores, convenience stores, bus stops, food deserts, public schools (covering grades 6-12), and grocery stores in Baltimore to identify potential "litter hot spots." With the exception of food desert areas, all indicators were treated as spatial points, surrounded by a buffer area of a given radius. The indicators were

spatially compared to the locations of all 311 calls made in Baltimore from January 1, 2015 to February 15, 2016 in the "Dirty Alley or Street" 311 category (10,025 calls total), the category used for reporting street trash and litter. (It is important to note that this 311 category is also used to report illegal dumping and residential trash complaints, not just street littering. This is an important limitation of Baltimore's current system for gathering public reports of trash and litter, which we address further in the Limitations section.)

We then calculated a relative ratio (RR) measure for each indicator, which allowed us to examine whether there is a higher concentration of 311 complaints made inside the buffer area of a given indicator compared to the concentration of 311 complaints occurring outside that buffer area.

Since no data were available on the distribution of public trash cans on sidewalks (which we refer to as "street cans" in this paper) in Baltimore, we conducted transect surveys along four street sections in Baltimore with significant foot traffic (see Figure C-1 in Appendix C): (1) Broadway St. (from Fleet St. to North Ave.); (2) North Ave. (from Bentalou St. to Belair Rd.); (3) E. Fayette St. (from I-83 to Broadway St.); and (4) Greenmount Ave. (from Preston Rd. to 34th St.). Each of the 136 street cans thus surveyed was captured with a geo-tagged photo. To estimate the storage capacity of Baltimore street cans, we compared privately purchased trash cans of similar size to those observed along transects. We then evaluated the quantity of food waste packaging items required to fill a typical Baltimore street can, in terms of prototypical single-serving to-go meals (a plastic bag, 9.5" x 9" x 3" three-compartment polystyrene "clamshell" container, and a drink container, alternating 20 oz. bottles and 12 oz. cans), and prototypical convenience store purchases (a 20 oz. drink bottle). We made conservative and generous estimates of the number of to-go meals and drinks that would typically fit into a Baltimore street can by, respectively, dropping the items in a can until full, and then repeating the measurement after pre-compacting the clamshell container

in each to-go meal to reduce volume. Finally, we conducted a review of the relevant peer-reviewed literature on waste management case studies incorporating geography, land use, and income.

For Objective 2, Social Aspects of Trash and Litter in Baltimore City, we conducted phone interviews with senior staff of seven key stakeholder organizations on current litter reduction efforts and future directions for Baltimore. In addition, we consulted Baltimore citizens through a 10-question online survey (319 respondents) made available through Google Forms in February 2016 and promoted through social media outlets Facebook, Reddit, and NextDoor. (Stakeholder information and interview questions, and public online survey questions, are available in Appendix B.) Four of the 10 questions in our public survey pertain to attitudes about and experiences with trash and litter, four questions pertain to experience with and likelihood of using social media to report littering, and the remaining two concern location (whether the respondent lives or works in Baltimore, and optionally their zip code). No personally identifying information was requested. We are aware that social media sampling might bias towards a younger, educated and more affluent demographic. Recent studies conducted by Pew Research Center suggest little racial or gender difference in phone ownership and social media engagement in America.[6,7] However, it is possible that income, age, and education differences remain. (Bias associated with this approach is discussed further in the Limitations section.) We also conducted a literature review on social and psychological aspects of littering to better understand individual littering behaviors.

Objective 1: Spatial Aspects of Waste and Litter in Baltimore

What factors are associated with trash and litter generation?

Street cans overflowing with trash are a

Table 1: Spatial analysis of "Dirty Alley or Street" 311 calls in Baltimore

Location	Buffer Distance (feet)	Number of 311 Calls	Total Buffer Area (sq. mi.)	Fraction of 311 Calls within Buffer Space (%)	Fraction of Baltimore in Total Buffer Area (%)	Relative Ratio of 311 Calls in the Indicator Buffer Area
City of Baltimore	-	10025	80.9	-	-	-
Carry-outs	200	1694	2.0	16.9	2.5	7.95
	600	5633	11.7	56.2	14.4	7.59
Schools	600	1039	4.3	10.4	5.3	2.01
	1500	6216	22.2	62.0	27.4	4.31
Bus stops	200	2514	4.3	25.1	5.3	5.95
	600	5611	36.6	55.9	45.3	1.53
Corner stores and Convenience stores	200	2248	2.63	22.42	3.25	8.60
	600	6780	14.93	67.63	18.46	9.22
Grocery stores	200	36	0.21	0.36	0.26	1.40
	600	499	1.80	4.98	2.23	2.29
Food deserts	Pre-defined regions	2392	8.9	23.9	11.1	2.51

common sight in Baltimore. In 2014, the City produced 1,132,624 tons of municipal solid waste (collected household waste) or 1.8 tons per person, much higher than the Maryland state average of 1.1 tons per person.[8] While other counties in Maryland have embarked on waste composition studies to tailor targeted waste management and reduction efforts, a waste composition study has not been recently conducted for the City of Baltimore.[9, 10] The composition of litter recovered from Mr. Trash Wheel provided the best proxy data we could find.

Given the lack of waste composition data for Baltimore, we conducted a literature review to examine factors that are generally associated with trash and litter generation. A review of the issue in European Union countries found evidence for four major factors affecting waste generation: economic status (expenditure), population density, household size, and expenditure on food and non-alcoholic goods.[11]

Studies suggest that differences in waste composition in comparable socio-economic communities may be due to consumption of processed foods that involve more packaging,[11–13] that areas with heavy foot traffic are more likely to accumulate litter,[14, 15] and that young adults (particularly male) are more likely to litter than their older counterparts.[14]

As noted earlier, one in five Baltimore residents lives in a "food desert" (an area with reduced access to supermarkets). A majority (78 percent) of Baltimore residents living in food desert areas have ready access to carry-out stores, while in non-food desert areas only 50 percent have ready access.[2, 3] A recent study conducted in Baltimore found that consumption of fast food increases by up to 61 percent if there is a fast food vendor nearby (less than a mile or 20-minute walking distance).[16] Another study reported that an average high school student in Baltimore travels more than half a mile to school and is

exposed to at least one convenience or carry-out store en route.[17]

Accordingly, we selected carry-outs, corner stores, convenience stores, bus stops, food deserts, public schools (covering grades 6-12), and grocery stores in Baltimore as non-residential litter indicators, and analyzed spatial concentrations of "Dirty Alley or Street" reports to 311 in Baltimore in the vicinity of these indicators as described in the Methods section.

Results are shown in Table 1 (page 5). For a given indicator, a relative ratio (RR) of 1.0 indicates that "Dirty Alley or Street" 311 complaints were reported within the buffer area (vicinity) of the indicator at the same spatial concentration as outside of the buffer area. An RR greater than 1.0 indicates that "Dirty Alley or Street" 311 complaints were reported at a proportionally higher rate inside an indicator's buffer area than outside it. For all point indicators (everything except food deserts), two buffer distances were considered: (1) a close-range distance to represent litter deposited near an indicator that may have moved under the influence of wind; and (2) a long-range distance intended to represent trash improperly discarded within a three- to five-minute walking distance from the indicator. Wider buffers were chosen for schools, both to represent their larger spatial footprint, and to capture the average distance – 1,263 meters – that children in Baltimore walk to get to school.[17]

These cross-sectional results, though correlative, are compelling. Surveyed calls to 311 about dirty alleys and streets were more than eight times more likely within 200 feet of a corner store or convenience store, almost eight times more likely within 200 feet of a carry-out, almost six times more likely within 200 feet of a bus stop, and more than four times more likely within 1500 feet of a school, respectively, than outside of these areas. Grocery stores and food deserts had much lower relative ratios. The data also correlate with the intuitive notions that schools, carry-out stores, and convenience and corner stores, which *generate* single-serving, to-go food and packaging

waste, maintain a high relative ratio of 311 calls over a wider area than do bus stops, which are frequent *disposal* points for food and drink (since these cannot be taken on to buses). From this analysis, we posit the highlighted areas of Baltimore in Figure 2 (page 7) as potential "litter hot spots." These target cluster areas were generated from spatial co-occurrence of the potential non-residential litter indicators examined.

The fact that the relative ratio of analyzed 311 complaints within food deserts was significantly lower than the relative ratios near, for example, carry-outs and bus stops could mean that these points are the key generators of litter complaints, and that viewing these points at the scale of whole neighborhoods buries the signal under so much spatial noise. Or instead, perhaps this occurs because citizens of Baltimore who live in food deserts may be more resigned to the presence of dirty alleys and streets, or less likely to report complaints via 311. This is a drawback of our methodology, just as it is a drawback of the City's non-residential litter control approach; we are considering spatial patterns of the public reaction to litter, rather than spatial patterns of the litter itself. Furthermore, it is difficult to reliably separate litter complaints from non-litter complaints because the "Dirty Alley or Street" category (the only complaint category in Baltimore's 311 designed to capture litter) also includes illegal dumping and residential trash complaints. These issues highlight an important point: while 311 complaints are an indispensable tool for reporting litter, cities need to understand the fundamental aspects of trash generation in order to craft municipal policies that effectively target litter reduction.

What is the average distance between Baltimore street cans?

Spatial location data for street cans are not publicly available in Baltimore, so we conducted transect surveys along four major

Figure 2: Baltimore City projected litter hot spots
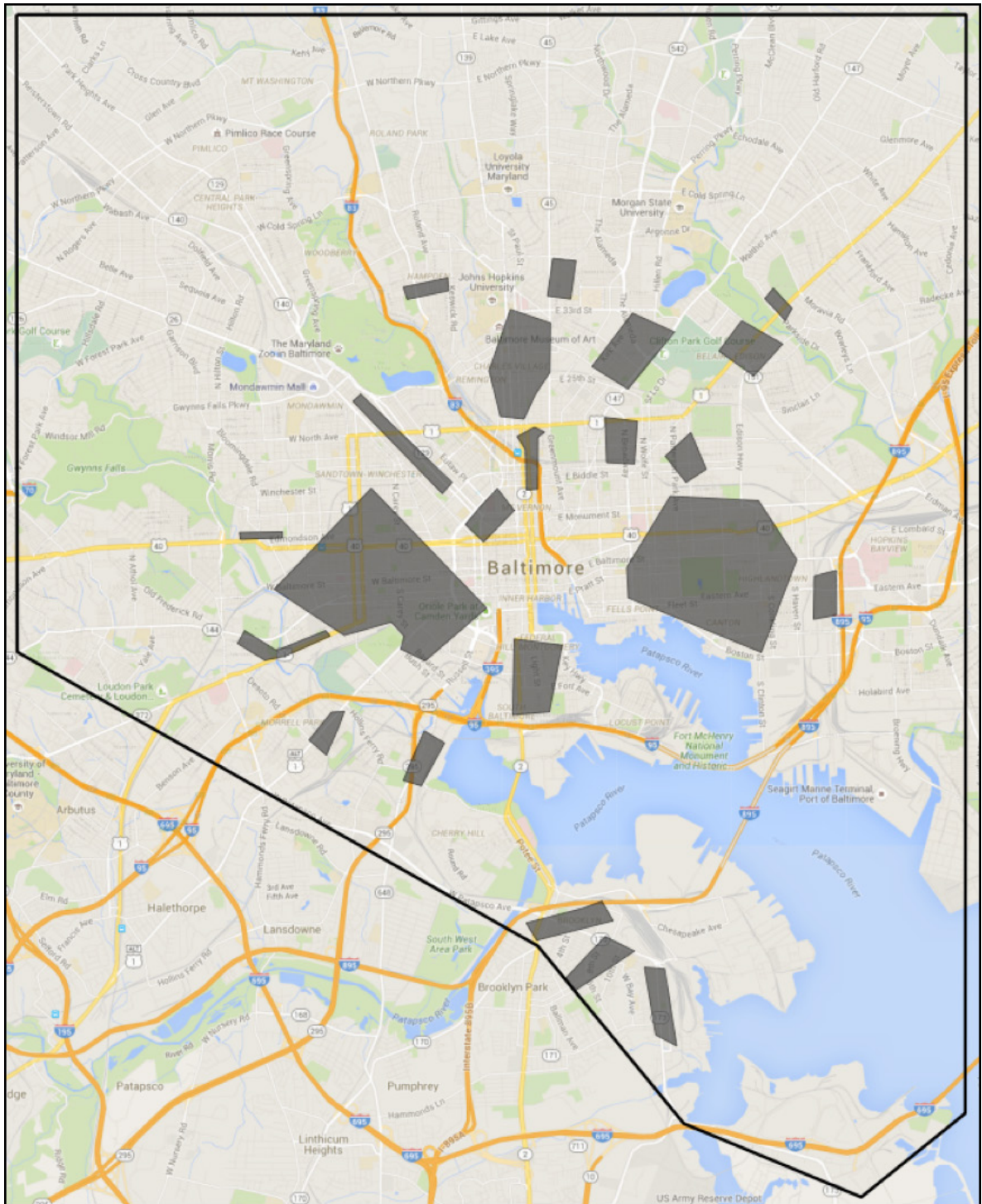
roads in Baltimore with heavy pedestrian traffic, and calculated the median and the inter-quartile range (IQR; the range of the middle half, i.e. the 25th percentile to 75th percentile, of the dataset) of the separation distances of 136 street cans (see Figure C-1 in Appendix C). Median distance between street cans was highest along North Ave. at 788 feet (IQR: 397-1388 feet), followed by Fayette Ave. at 619 feet (IQR: 375-812 feet), Broadway St. at 298 feet (IQR: 82-434 feet) and Greenmount Ave. at 274 feet (IQR: 112-450 feet). On the whole, 50 percent of the street cans along the surveyed transects are within 274-788 feet of another street can. We note that Greenmount Ave. is one of the five neighborhoods targeted by one stakeholder group, Waterfront Partnership, for an increase in the number of street cans. It had a considerably higher density of public trash cans than the other transects and, by personal observations, considerably less litter.

Why does distance to trash can matter?

Studies have shown that spatial distributions of street cans has a large impact on littering rates. For example, a national study concluded that littering increases when the distance to trash cans is greater than 20 feet, up to 60 feet (after which littering rates plateau).[16] The authors call attention to prior studies which indicate that increasing the spatial density of street cans doesn't necessarily reduce littering; the key is to reduce the distance to the nearest trash can. They posit that a well-located trash can will do more good than many inconveniently placed trash cans.[16] This evokes the "Disneyland Theory," reportedly based on a study commissioned by the Disney corporation for its theme parks, that the average distance to a trash can needs to be roughly 30 steps to maintain zero littering. This approach has been recently adopted by the city council in Philadelphia to successfully enact an anti-littering bill.[20]

How much food and drink waste can a street can fit?

Since the majority of litter recovered in the Inner Harbor is food-packaging waste, which has likely traveled from neighborhoods across Baltimore, it is crucial that there is adequate municipal trash capacity to store this waste before it becomes litter. We did not find any published research on the effective volume that food packaging occupies in trash cans, so we conducted a simple volumetric analysis. We estimated the storage capacity of a typical street can in terms of single to-go servings of food and drink, as defined in the Methods section. This was not intended to reflect the full composition of trash in Baltimore street cans, which is unknown and is certainly more heterogeneous, but rather to characterize street can capacity to capture some common lightweight (and thus mobile) elements of street trash that might easily become litter if there is inadequate trash can capacity.

We attempted to estimate the time it would take to fill the street cans identified in the transect survey, assuming that no littering takes place. The typical street cans we encountered during transect surveys were roughly 20 gallons in size (common at bus stops), or 10.5 gallons in size (at some bus stops and along Greenmount Avenue). We modeled food and drink packaging waste in terms of a standard single-serving to-go meal (as described in the Methods section). We were able to fit five single to-go meals in a 10.5-gallon bin, and nine meals in a 20-gallon bin simply by dropping simulated meals in until the cans were full (conservative estimate). When packaging waste was compacted, we were able to fit nine and 17 simulated meals, respectively (generous estimate; see Figure 3, page 9). Plastic drink bottles from convenience stores were estimated to take up one-third the space of a single-serving to go meal, and were resistant to compaction.

Figure 3: Creating and fitting typical single to-go meals in two commonly sized public trash receptacles
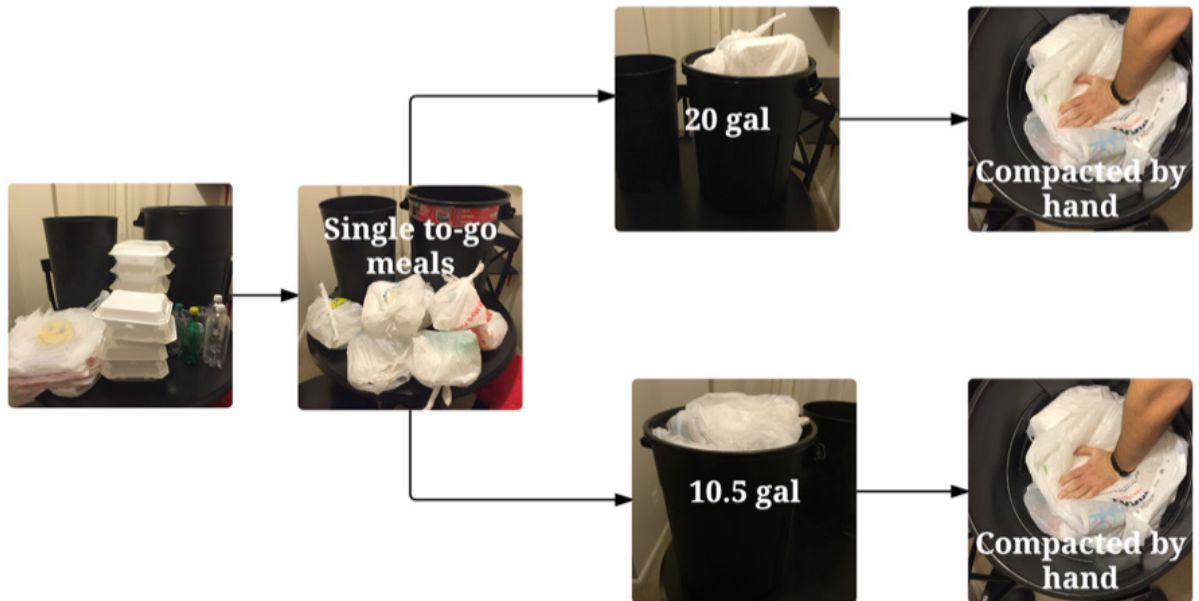
Assume that an average carry-out or fast food store serves 100 meals a day, that the waste from one-tenth of these meals will become non-residential trash or litter, and that meal packaging is hand-compacted before being disposed. Further assume that an average convenience or corner store serves 200 drinks per day or packaging of equivalent size, and that the packaging from one-third of these items will become non-residential trash or litter. Then, for the Broadway transect, trash from the nearby 12 corner/convenience stores and 24 carry-outs will be expected to fill the 35 identified street cans in 15 hours. For the Fayette St., North Ave., and Greenmount Ave. transects, the street cans identified will be filled with food and drink waste from nearby stores in 17.3, 8.4, and 9.7 hours, respectively, using assumed non-residential trash loading rates. Street cans are emptied twice daily in these areas according to DPW, which is only adequate for the Broadway and Fayette transects. The underlying message here is that litter is not always a careless human action, it can also be a consequence of insufficient public infrastructure.

Objective 2: Social Aspects of Trash and Litter in Baltimore

We conducted seven stakeholder interviews between February 9 and 23, of 2016, with the average interview lasting 30 minutes. We recorded notes to the interview questions. (Stakeholders are identified in Appendix B.)

Phone Interviews

The following points were commonly raised during stakeholder interviews.

Plastic bag ban: The majority of these stakeholders voiced support for the proposed statewide plastic bag ban and bottle deposit laws that are now being considered.[18] Some stakeholders considered it to be among the most important things Baltimore could do to address litter, given the number of bags in the City and their mobility.

Food packaging litter: Stakeholders repeatedly noted the high concentration of food waste and packaging items in Baltimore litter, as judged for example by the composition of trash collected by Mr. Trash.

Street cans: Some stakeholders noted that Baltimore has had a mixed history with street cans, with some citizens complaining that the presence of street cans invites littering, and other citizens complaining that the absence of street cans promotes littering. Important issues for street cans are public accountability for their emptying and maintenance, and anti-litter/pro-trash can social messaging. One stakeholder noted that Baltimore has already conducted successful pilot programs increasing the number of street cans in certain neighborhoods, but that these efforts have been limited by lack of funds.

Litter in the Bay: With the recent submission of Baltimore's Total Maximum Daily Load (TMDL) regulation for trash entering the Chesapeake Bay, the time is right to look for litter reduction options.[19]

Dumping: A recent effort by the city to combat illegal dumping with hidden cameras has been largely successful. It would be easier for citizens to report illegal dumping, however, if Baltimore's 311 system had categories more targeted than "Dirty Alley or Street." As one stakeholder noted, however, possibly the biggest success of the City's anti-dumping efforts thus far has been the new availability of video evidence to help secure convictions against accused dumpers.

Residential cans: Stakeholders were very supportive of the recent city initiative for free residential trash cans, but noted the continued importance of initiatives that reduce street litter.

State regulations: Some stakeholders noted that it is generally more effective to work on trash and litter issues at the state level, rather than at the local level, since (to quote one stakeholder) "you often end up regulating businesses" when targeting trash and litter reduction.

Social messaging: Most stakeholders agreed that the City needed to mount a more effective social media campaign to target littering

behaviors. Several opined that this effort would be essential for achieving lasting improvements in littering rates.

Online Survey

We received 319 responses to our online survey of public attitudes towards the issue of litter in Baltimore. Common themes of respondents' comments were manually recorded. The most frequent themes are summarized in Table 2.

The top two themes — more trash receptacles and/ or more frequent pickups and targeting individual behavior — focus on top-down and bottom-up approaches for reducing litter. In the Education/Outreach/Partnership theme, common suggestions include working with store owners and businesses to reduce trash and litter generation, "hold[ing] businesses accountable for cleaning around their properties", and engaging the City's youth by directing the high school service requirement towards anti-litter campaigns and cleanup efforts. Some survey respondents were creative in their suggestions, for example, "x hours of litter cleanup efforts to get out of jury duty" or "hiring homeless or [the] unemployed for litter cleanup." Among those who suggested trash cans with lids, one of the common remarks was that DPW workers, in one respondent's phrasing, "refuse to pick up leftover trash once they dump receptacles. They lose our trash can tops and they leave litter that blows all over the alley."

Social Aspects of Litter

People are likely to litter in areas where there is already litter present.[21] In particular, people participate in two types of littering, *active* and *passive*. Active refers to blatant disregard to littering laws, such as throwing trash in the street, while passive reflects unconscious acts of littering, such as leaving a popcorn bag behind at the theatre.[22] The literature also notes that active littering is easier to target

Table 2: Responses to "What could Baltimore do (better) to keep streets litter-free?"

Broad themes	% of responses	Illustrative Quote*
More trash receptacles and/ or more frequent pickups	44	"There are no trash cans anywhere in my neighborhood. My first thought would be to provide receptacles so people don't need to litter. They should be maintained by the city and emptied often. "
Target individual behavior	28	"Have a monetary fine or mandatory work service (no jail) for folks caught littering. Dramatically increase the fines so more folks choose work service. The fines go directly to efforts to clean up the city."
Education/Outreach/ Partnership	26	"HS students in Baltimore have a community service requirement for graduation (75 hours). I think at least 1 event should be required to be litter cleanup. "
Trash can with lids	10	"One major issue I see is that my neighbors do NOT secure their trash properly in bags and cans when they leave them in the alleys and sides/fronts of buildings and it ends up flying away with wind and all over the alley."
Enforce plastic bag ban	8	"Banning plastic carrying bags from grocery and liquor stores would be good."
More street cleaning	7	"Sweep more effectively and frequently with a different equipment that can reach (maybe sweepers have target weights)? Sweep on recycling days if it's windy."

*Comments that pertained to multiple themes were counted for each theme separately.

than passive littering, even though passive littering happens more frequently. Three successful programs targeting littering show that social involvement, either by modeling behavior, setting norms or making verbal appeals, considerably enhances anti-littering behavior, especially when added to an existing intervention such as adding more trash receptacles.[21,23]

Our volumetric analysis of trash can capacity, described above, demonstrates that littering can also have structural components when the infrastructure for trash disposal is inadequate in volume or spatial distribution. Behavioral and structural aspects of littering may be intertwined: for example, littering because the nearest trash can is too far away (active littering with structural component), or leaving a piece of trash on top of an over-full trash can only for the trash to be later blown into the street (passive littering with structural component). Many of the respondents to our online social survey made comments that acknowledged the structural components of littering in Baltimore. Many other respondents emphasized the social aspects of littering; some asserting, quite vehemently, that trash in Baltimore is predominantly a cultural or even racial issue. When litter is viewed in the street, it is often impossible to divine the circumstances that led to the litter being improperly disposed of. This situation is ripe for misinterpretation and confirmation bias, as people search their existing beliefs to form an explanation for the litter they see. Thus, littering in Baltimore is both a structural and a social issue.

People who live in food deserts and food swamps may generate relatively more food and drink packaging waste, because of the way

Figure 4: Willingness to use social media to report trash and litter issues in Baltimore

If you could use the 311 app to report litter in your neighborhood, would you use this app?

Not Likely: 1	**72**	22.4%
2	**35**	10.9%
3	**40**	12.4%
4	**38**	11.8%
5	**58**	18.0%
Likely: 6	**79**	24.5%
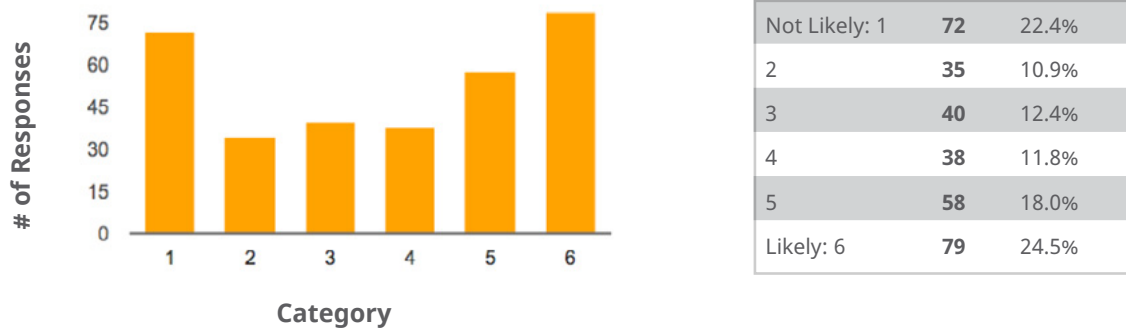
Would you post pictures of litter in Baltimore City on social media (fb, twitter, etc.) if it would help the city to target clean up effort?

Not Likely: 1	**78**	24.2%
2	**31**	9.6%
3	**39**	12.1%
4	**40**	12.4%
5	**43**	13.4%
Likely: 6	**91**	28.3%
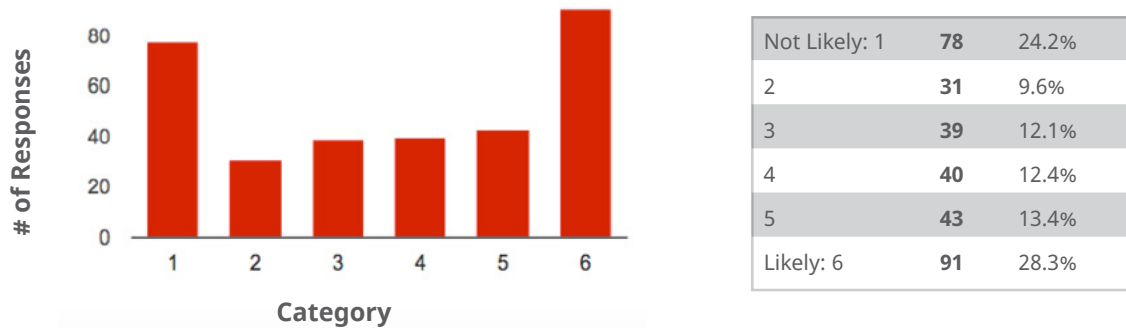
the available food and drink items are packaged. People traveling on foot or taking public transport may generate relatively more non-residential trash, and be more likely to need non-residential trash receptacles, than people who travel in private vehicles. If the City doesn't provide the capacity to handle non-residential trash, that trash is going to become litter. Some observers may then attribute the resulting physical disorder caused by litter to be a social disorder of a given person or community.[20]

How can social media help reduce littering?

Social media helps in setting accepted social norms. The act of 'liking' or 'retweeting' a publicly posted item represents a degree of endorsement while increasing an individual's connectivity to a virtual community. In turn, social media can be a quick and effective way of setting norms that are conducive for changing an individual's attitudes and behaviors.[21]

Research indicates that use of social media for pro-environmental action works through two pathways: (1) as a source of information, and (2) as a tool to strengthen the relationship with the environment, which is highly predictive of individual environmental actions.[21] Here, pro-environmental action refers to participating in behaviors that are environmentally friendly, for example participating in a stream cleanup or signing a relevant online petition.

When litter is viewed in the street, it is often impossible to divine the circumstances that led to the litter being improperly disposed of. This situation is ripe for misinterpretation and confirmation bias, as people search their existing beliefs to form an explanation for the litter they see.

Given these potential advantages of a social media approach to enforcing positive social norms against littering, we asked the survey respondents about Baltimore's mobile 311 app for reporting trash/litter and the likelihood of their participation on such a social media platform if it would help city cleanup efforts. Among the 319 survey respondents, 40.1 percent were not aware that a mobile 311 app existed. Among those who had downloaded the mobile app, 42.2 percent had used it to report trash/litter issues (see Figure C-2 in Appendix C for data on survey questions 1 and 2). The respondents were asked about their willingness to report trash/litter issues, either through the Baltimore 311 mobile app or an alternative existing platform (such as Facebook, Twitter, or NextDoor; see Figure 4). Over half of respondents (sum of categories 4-6 in Figure 4) indicated that they would post pictures if it would help the city in cleanup efforts. The U-shaped pattern of responses to found in both of these questions warrant more attention: almost half of respondents stated that were either likely or unlikely to report litter in Baltimore via 311 or another social media outlet. Many survey respondents commented that they were unlikely to report litter via 311 due to a perceived lack of anonymity on this platform.

An ideal platform for social media reporting of litter should be real-time, targeted, user friendly, and well-publicized. For litter reporting efforts that involve the government,

it should serve as an open communication channel between political entities and residents. An example of this system is the open-source fixmystreet.com platform, employed in the UK, where individuals can report and discuss local problems.[22] This modular platform has been touted as a success for its problem-oriented, democratic structure, and perceived as a more efficient process for affecting civic changes than conventional procedures of addressing issues through local council meetings.[23]

Policy Recommendations & Discussion

Recommendations

Based on our review of the literature, spatial data analysis and transect surveys, volumetric analysis, and qualitative data gathered from key stakeholders and the public, we propose the following policy recommendations (also outlined in Figure C-3 in Appendix C):

Knowledge gathering: DPW should conduct an inventory of street cans. The city can thus review the distances between existing cans, and add additional cans where needed to reduce distance between cans. Also, the City should conduct a trash composition and spatial distribution study, which could be conducted in conjunction with local universities and colleges, to better understand the drivers of litter in the Baltimore area.[24]

Social involvement: DPW should label all street cans with publicly visible unique numeric identifiers. Having a simple way to uniquely identify each street trash can will make it easier for citizens to report full trash cans for cleanup, for example through Baltimore's Open311 system. Also, the City could more effectively target specific litter issues, such as street can emptying and illegal dumping, by promoting the use of hashtags in Open311 reports (e.g., #streetcan, #dumping). Hashtags provide an easy and effective method for automated categorization of a message without adding to the complexity of the underlying system database. Further, based on responses gathered by our public survey, the City should explore ways to integrate the Open311 reporting process with other social media platforms citizens may be more familiar with, such as Facebook and Twitter, and more likely to use.

Hardware: Follow the Office of Sustainability's recommendations for more street cans. Specifically, use trash cans with narrow-mouthed lids to prevent dumping, which have been successfully tested in several neighborhoods in Baltimore. Most importantly, place these additional cans in areas that would be expected to generate more trash, not just where additional cans are requested or where litter generates more complaints.

Operations: DPW and OSS should place street cans in sufficient quantity and with adequate spatial distribution to meet the needs of Baltimoreans. This is better achieved through strategic planning than through placing street cans in an ad hoc manner. DPW and OSS should strongly consider periodic solicitation of public input on street can placement, rather than adding and removing cans only in response to public request. This is in line with our hardware recommendation noted above, and will help Baltimore better focus on litter control by changing the way it responds to the public perception of litter. Also, DPW should reassess its street can emptying schedule, ensuring that cans are emptied with sufficient frequency to provide capacity for the non-residential trash produced and, thus, help prevent non-residential litter. Potential spatial indicators of non-residential litter that may be useful during this process are listed above, and potential litter hotspots identified by the spatial overlap of these indicators are identified in Figure 2. Further, based on responses from our public survey, there is significant support for: (1) increased enforcement and penalties for litter violations, and (2) outreach and partnership with high school students, carry-out stores and business owners on litter prevention activities.

Economic Feasibility

Costs of current litter and trash reduction efforts in Baltimore conducted by various stakeholders were obtained from annual reports, financial audits and through phone interviews. Table 3 shows that City and stakeholders spend over $32 million to collect upwards of 2600 tons of litter annually, at an estimated cost of $10,571 per ton of litter generated (calculated from available data). This does not include the cost of cleanups and legislative advocacy conducted by organizations such as Trash Free Maryland and Baltimore Trash Talk. Most of these efforts are focused at the neighborhood and watershed level, with little done to prevent litter and engage Baltimore residents.

The proposed policy recommendation to use social media is expected to be cost effective based on evidence from other sectors.[21,25] Hardware and operations policy recommendations aim to affordably augment existing services rather than create new interventions. The cost of procuring 1000 public trash cans with two dedicated bins for trash and mixed recycling, for example, is $547,000,[26] though this does not include maintenance and waste removal costs.

Table 3: Current efforts and annual costs of trash and litter collection efforts in Baltimore

Institution	Program	Neighborhood /Street	Household /Individual	Watershed	Legislative	Impact
Department of Public Works[4, 27, 28]	Rat Rubout & Smart Trash cans	$608,334	$8,940,000			Indirect impact
	Alley & Street Sweeping	$15,615,413				1600 tons*
	Mechanical Street Sweeping	$3,217,744				Info not available
	Waste Mgmt., Public Areas ("Cleaning of Business Districts")	$1,550,207				Info not available
	Trash Skimmers & Storm Drain Cleaning ("Marine Operations")			$1,517,737		527.1 tons
Baltimore Waterfront Partnership[29]	Mr. Trash Wheel	$128,900				238.8 tons
	Trash Free Neighborhood (clean team)	Info not available				212.4 tons
Blue Water Baltimore[30]	Advocacy (e.g. Disposable Bag Bill)				$126,312	42.9 tons
	Education & Outreach		$59,297			
	Stormwater reduction				$505,223	
	Water Quality Monitoring			$209,456		
Total	All Programs	**$21,120,598**	**$8,999,297**	**$1,727,193**	**$631,535**	**2621.2 tons**

*Only six months of data available; dataset was not annualized since rate of litter generation may vary with time.

Political Acceptability

The recommendations outlined above address several aspects of current and potential City policy for non-residential trash and litter, and are tailored to be easily implemented. We do not foresee political challenges for the "Knowledge gathering" and "Social involvement" recommendations; they are not expected to be particularly expensive or politically polarizing and could help the City to save money and better respond to litter complaints. The "Hardware" recommendation had wide support among most of those interviewed from the seven stakeholder groups and is likely to be received positively, though the details of specifically where additional street cans get placed may be contentious for some people. Likewise, the recommendation to update the street can emptying schedule is likely to have public support, and could reduce net expenditures, but may be contentious for some because it involves changes to the management practices of a City agency.

Our recommendation against removing street cans is likely to be the most contentious. The City should respond to the needs of the people for adequate non-residential trash can capacity, and this is best addressed by placing a sufficient quantity of street cans at reasonable distances and cleaning these as often as necessary, rather than adding or removing street cans only in response to public requests. It might be most expedient for the City to hold periodic public forums on street can additions and removals, to balance citizen requests and strategic planning needs.

Finally we note that the recommendation for increased penalties for litter violations, and outreach and partnership initiatives, had broad support in the public online survey.

Limitations of the Study

There are several limitations to this report. First, in the online survey we did not ask about socio-economic status or other demographics besides (voluntary) zip code location of the respondents. Online surveys may select participants with high rates of phone ownership and social media affinity. As noted earlier, a recent research study conducted by Pew Center found that there is little difference in phone ownership between gender and races, however, there are likely some age, income, and educational differences in phone ownership and social media affinity.[7] We would like to note that differences in social media use for Facebook (where the online survey was promoted) were minimal among the race and gender demographics investigated in two published studies,[7, 31] but we do not have data on the demographic composition of the users of Reddit or NextDoor.

Second, textual analysis of the "Dirty Alley or Street" 311 calls from 01/01/2015 to 02/15/2016 showed that 24 percent of the 10,025 calls contained one or more keywords such as "furniture," "mattress," "bulk," "construction," or "dumping" (full list of screened keywords available in Table C-1 in Appendix C), which may indicate that a complaint pertains predominantly to bulk trash or illegal dumping rather than to litter. During subsequent visual inspection, we noted that many 311 call reports that contained one or more of the keywords in Appendix C also included other words such as "debris," "loose" or "strewn," "trash," or "litter," so we consider it to be a conservative estimate that 76 percent of the 311 calls analyzed pertain to street trash and litter rather than to bulk trash or illegal dumping. We did not separately analyze the spatial distribution of the 311 calls that contained any of the keywords in Appendix C, for lack of a clear-cut methodology to determine which calls pertain to street litter and which do not. We posit, however, that bulk trash calls and illegal dumping calls are more likely to come from residential neighborhoods or non-residential areas with relatively low pedestrian traffic, so removing these from the analysis would be more likely to increase the RRs reported for most of the indicators examined, rather than decrease them. We also note that this issue of

We have illustrated strong spatial associations of litter reports with carry-out/corner stores and convenience stores, schools, and bus stops. Based on these results, we have produced a map of litter hot spots for potential intervention areas.

difficulty in marking different trash and litter concerns under the current 311 framework was identified by one stakeholder, and that we have proposed a recommendation for the use of hashtags (such as "#litter" and "#dumping") to address this issue.

Finally, we wish to acknowledge the support among stakeholders for legal efforts to enact a plastic bag ban in Baltimore, and similar efforts to enact a styrofoam food packaging ban and a glass bottle deposit law. Some stakeholders also shared the belief that coordinated action at the state level may be more effective than action at the city level. Our efforts are focused on policy recommendations which may be readily pursued by the City of Baltimore, and which complement existing efforts by DPW, though these only represent some aspects of the current litter problem.

Conclusion

Litter is a public nuisance that provides food for rats, poses a public health issue, drives down property values, is harmful to sewers, and is unhealthy for the Chesapeake Bay. While Baltimore has not recently conducted a waste composition study, the evidence at hand suggests that much of Baltimore's litter is food-packaging waste, which is produced in outsized volumes through the consumption of single-serving, to-go food and drinks. In this report, we have illustrated strong spatial associations of litter reports with carry-outs, corner stores and convenience stores, schools, and bus stops. Based on these results, we have produced a map of litter hot spots for potential intervention areas. From a volumetric analysis of food packaging waste, and spatial analysis of trash can distribution in public areas, we have concluded that Baltimore may have insufficient infrastructure to capture non-residential trash and prevent the production of street litter. Our online social survey suggests that Baltimoreans recognize trash and litter as significant issues, though they may firmly hold very disparate and even divisive opinions about the causes of and solutions to these issues. The City of Baltimore is undertaking efforts to address its trash and litter problem, and after consulting key stakeholders we have presented a list of recommendations to complement the City's existing efforts. We believe these recommendations are politically and economically feasible, and readily implementable, to help achieve a cleaner, greener Baltimore.

About the Abell Award in Urban Policy

The Abell Award in Urban Policy is an annual competition for the best student paper that provides a cogent analysis of a critical issue facing the City of Baltimore and proposes well-reasoned, feasible solutions. It is open to matriculated students at all Baltimore area colleges and universities. The submissions are blind-reviewed by a panel of distinguished judges. The winning paper receives a $5,000 award and is distributed to key policymakers and opinion leaders and posted on the Abell Foundation's website.

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The

Abell Report

Litter-Free Baltimore: A trash collection policy framework based on spatial analysis and social media

By Christopher Kelley and Ramya Ambikapathi

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The Abell Foundation is dedicated to the enhancement of the quality of life in Maryland, with a particular focus on Baltimore. The Foundation places a strong emphasis on opening the doors of opportunity to the disenfranchised, believing that no community can thrive if those who live on the margins of it are not included.

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