Mississippi River Plastic Pollution Initiative

Apex Report

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Executive Summary

Mayors of cities and towns along the Mississippi River made a commitment to reduce plastic waste in the Mississippi River Valley in September 2018. Under the leadership of the Mississippi River Cities and Towns Initiative (MRCTI), mayors invited public and private entities to reduce their plastic use or waste stream by 20% by 2020. The United Nations Environment Programme (UNEP) North America Office, the Mississippi River Cities and Towns Initiative (MRCTI), the University of Georgia's Debris Tracker, and other partners worked together on the Mississippi River Plastic Pollution Initiative (MRPPI) to generate a first-ever snapshot of the state of plastic pollution along the Mississippi River.

Thousands of community volunteers surveyed targeted areas all along the river to understand the movement and accumulation of plastic pollution, generating key data through a community science approach. Community members collected data with Debris Tracker, an open data community science movement and free mobile phone app founded at the University of Georgia. The app is designed to replace paper data cards, leveraging technology to allow users to tag debris where they see it to create highly accurate geospatial data points, empowering volunteers to record data at scale and enabling data sharing among communities. The goal was to generate as rich a picture as possible, within a dedicated timeframe, of the extent and type of litter that can make its way to the river. Cities participating directly in data collection through the three phases of this work include: Baton Rouge, Louisiana; St. Louis, Missouri; St. Paul, Minnesota; Davenport, Iowa; Bettendorf, Iowa; Rock Island, Illinois; Moline, Illinois; East Moline, Illinois; Rosedale, Mississippi and Greenville, Mississippi.

A total of 174,868 items have been logged on the Mississippi River Plastic Pollution Initiative list on the Debris Tracker app, considering data logged both in and outside the timeframe of the Initiative. 75% of the items found were plastic, followed by paper (9%), metal (7%), glass (5%) and PPE like masks, wipes, and gloves (2%). The top ten items logged by participants were: cigarette butts (11,278), food wrappers (9,809), beverage bottles (6,723), foam fragments (5,747), hard plastic fragments (4,239), paper and cardboard (4,210), plastic bags (3,882), aluminum or tin cans (3,640), foam or plastic cups (3,260), and film fragments (3,149).

Participants also collected brand information (on 341 items) with the top 5 brands as: PepsiCo, Inc. (23), Mars, Inc. (12), The Coca-Cola Company (10), AB InBev (9), and Mondelez International, Inc. (8).

Risk clusters were generated from a multivariate analysis illustrating correlations of litter concentrations with high societal activity, income, and distance to materials recovery facilities (MRFs). Each 1 km^2 site within 10 km of the Mississippi River was assigned a risk level based on demographic characteristics. Sites with ambient population values above 10,000 people fell into the high-risk category (17 sites). Sites with median household income levels above $80,000 fell into the low-risk category (8,967 sites). Sites more than 100 km away from a MRF fell into the high-risk category as well (41,106 sites) (sites that also had over $80,000 in median household income were excluded). All other sites were assumed to be in the "at-risk category" (19,470 sites), made up of two clusters with similar demographic profiles. One of the clusters, which contained about 10% of sites with these characteristics, had the highest litter densities, likely based upon hyper-local influences. Higher risk could be correlated to more industrial and commercial areas (instead of residential and green space), more cigarette butt litter, or proximity to major highways. These at-risk areas may need additional hyper-local data to identify areas of concern in a given community. High-risk sites represent appropriate targets for resources and interventions within a community.

The risk map shows areas that are more likely and less likely to have litter. When considering use of resources and intervention actions, risk maps can help prioritize areas for community decision makers. For example, additional collection infrastructure could be targeted in high-risk areas, while low-risk areas may not need additional investment. Based on the characteristics and assigned areas above, an interactive Mississippi Corridor Risk Map was generated, available on a public dashboard on ArcGIS Online. Average litter densities from empirical data collected through the MRPPI are also displayed on the map relative to their litter concentration. Explore the map at: https://bit.ly/483QFyo.

Applying the range and median values of litter densities for each empirically surveyed cluster grouping to all sites in each risk profile within 10 km of the river stem, and an average proportion of plastic of about 75%, an estimated 87 million plastic litter items are on the ground in communities along the Mississippi River Corridor (45.6 million – 143.1 million). This represents a snapshot in time, not an annual amount.

The data from the Mississippi River Initiative points towards specific items that could be targeted for interventions, and specific areas where these solutions should be implemented to maximize impact are identified as in the risk map. Strategies for solutions discussed in this report, along with examples of interventions, are summarized here.

Strategy	**Examples**
Reuse & reduce	• Establish reusable foodware systems, such as refillable cups or returnable take-out containers • Install water refill stations, which have been supported by grant funding in some Mississippi River cities • Encourage the use of reusable grocery bags • Enact policies to discourage or eliminate use like taxes or bans
Re-design	• Maximize recyclability by using high value materials and sizing for local sorting infrastructure • Design for compostability, where appropriate in the context of the community infrastructure (Consider: Does commercial composting exist? Is it accessible to community members?)

Recycling	• Expand and maintain collection and sorting infrastructure, such as material recovery facilities (MRFs) and recycling drop-off centers • Engage with local markets to increase value of recyclables
Education	• Increase awareness around plastic filters in cigarette butts • Share messaging that connects the river to the ocean as a conduit of plastics
Targeting resources to high-risk areas	• Focus above actions and resources to areas of higher risk for litter • Install additional infrastructure like waste collection bins or cigarette disposal containers in high-risk areas • Leverage extended producer responsibility (EPR) to engage corporations about providing funding to under-resourced areas
Further examination of at-risk areas	• About 10% of the sites in the at-risk areas may have high concentrations of litter based upon hyper-local influences. Further examining these areas for litter could help to discover areas in need of interventions.
Last-chance capture	• Capture litter before it enters the environment through street sweeping and stormwater filters • Use in-stream litter capture devices to prevent litter from flowing downstream to the ocean

Introduction

to the Mississippi River Plastic Pollution Initiative

The Mississippi River flows over 2,000 miles from its headwaters in Minnesota to the Gulf of Mexico. The basin drains 40% of the United States and encompasses 32 states. It is one of America's most essential inland waterways, supporting the livelihoods of people along the river, and it is home to diverse plant and animal species. The Mississippi River generates over $400 billion in revenue and supports over 1.5 million jobs. But plastic pollution is a significant problem throughout the Mississippi River Basin, and the river is often impacted by our actions on land. Items that we use every day – like disposable coffee cups, water bottles, masks, and plastic bags – can end up in the environment and ultimately be blown by wind or washed by rainfall into the river.

Recognizing the urgency of the plastic pollution problem, state legislators and mayors of cities and towns along the Mississippi River made a commitment to reduce plastic waste in the Mississippi River Valley in September 2018. Under the leadership of the Mississippi River Cities and Towns Initiative (MRCTI), mayors invited public and private entities to reduce their plastic use or waste stream by 20% by 2020.

To support this commitment, The United Nations Environment Programme (UNEP) North America Office, the Mississippi River Cities and Towns Initiative (MRCTI), the University of Georgia's Debris Tracker, and other partners worked together on the Mississippi River Plastic Pollution Initiative (Mississippi River Initiative, https://unep.org/mississippi) to generate a first-ever snapshot of the state of plastic pollution along the Mississippi River. Following an initial pilot phase in April 2021, data collection was expanded to the Quad Cities region in October 2021 and the Mississippi Delta Region, specifically with a focus on Environmental Justice, in 2022.

Thousands of community volunteers surveyed targeted areas all along the river to understand the movement and accumulation of plastic pollution, generating key data through a community science approach. Community members collected data with Debris Tracker, an open data community science movement and free mobile phone app. Cities participating directly in data collection through the three phases of this work include: Baton Rouge, LO; St. Louis, MO; St. Paul, MN; Davenport, IA; Bettendorf, IA; Rock Island, IL; Moline, IL; East Moline, IL; Rosedale, MS, and Greenville, MS. The data gathered for this entire project was examined to understand the state of plastic litter in these river cities and to develop a risk map for litter all along the waterway. The goal was to generate as rich a picture as possible, within a dedicated timeframe, of the extent and type of litter that can make its way to the river.

Data collection

on plastic pollution using community science

In order to create a "snapshot" of plastic pollution along the Mississippi River, community members in participating cities were trained to use the Marine Debris Tracker app to record data on litter in their communities. Debris Tracker is a free, open-data app, originally developed in 2011 and housed in the University of Georgia College of Engineering. Available on both Android and iOS and as a web interface, the easy-to-use app simplifies data collection and upload, empowering volunteers to record data at scale and enabling data sharing among communities. The app is designed to replace paper data cards, leveraging technology to allow users to tag debris where they see it to create highly accurate geospatial data points.

Debris Tracker (Figure 1) supports open data collection by hosting a series of customized lists, each with unique debris items of interest in local languages or dialects, which are cross-referenced to a master material categorization. The MRCTI/ Mississippi River Plastic Pollution Initiative list was adapted from the National Oceanographic and Atmospheric Administration (NOAA) Shoreline Survey method item characterization and was developed in consultation with local partners on the ground in Mississippi River communities already familiar with items of interest to the region.

Figure 1: Debris Tracker, the free mobile app used for litter data collection in the Mississippi River Plastic Pollution Initiative.

Community volunteers were informed that all data collected was valuable, including data from cleanups and tracking floating debris. However, the initiative emphasized that data collected using transect methods was the most valuable for scientific analysis. All data logged by community members was included in the litter characterization data, but only transect data was used to calculate litter densities and inform the river corridor risk map.[1] To obtain comprehensive look at what items are ending up on the ground from societal activities close to the source, and in order to capture active, upstream litter input, community members were asked to conduct transects in identified urban areas (as opposed to just riverbanks). In each community, the urban area was gridded, and 200 x 200 m (about 650 x 650 ft) priority sampling areas were randomly selected and identified on the map, provided to volunteers through Google Maps to allow for mobile accessibility. Volunteers were asked to select a priority sampling area square on the map for their city (Figure 2, with starting locations denoted by yellow squares. To spread data collection to a variety of locations, once transects totaling at least 300 m in length were completed in any 1 x 1 km grid cell, that square was changed to blue to denote completion and encourage volunteers to collect data elsewhere. To determine length and calculate density, litter data points were downloaded from the Debris Tracker website and uploaded to ArcGIS, where the pathway of points from a tracking session was measured. The total quantity of litter items was divided by the transect length to calculate litter density; litter densities among all transects were weighted by their respective lengths and averaged for a given square kilometer site to obtain an average litter density for the grid cell.

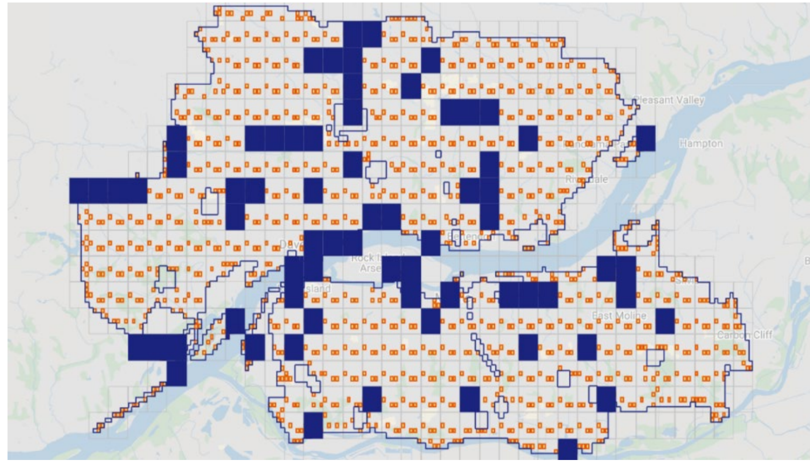

Figure 2: Priority sampling area map, with randomly selected starting points in each grid cell and blue areas denoting adequate data collection in a given cell.

Once a volunteer arrived at their selected area, they were asked to determine a safe public place to collect data along a roadside, sidewalk, or other walkable area where litter often accumulates, e.g., a pathway on the side of a road, between a roadway and sidewalk or along a walkway in the park. If multiple pathways existed, the volunteer determined which to take.

Volunteer training was given by UGA in multiple ways, on various days, and times for each of the three initiatives, both virtually and in person. In addition, the "train the trainer" model was encouraged. Outreach was led by MRCTI and primarily focused on organizations with existing local volunteer bases that could reach their networks. Recorded training and online guides were provided to supplement events and are available at https://debristracker.org/events/mississippi/. More detailed methods and results for each separate initiative can be found in their respective reports at https://unep.org/mississippi.

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[1] In addition to data from the initiative, litter data collected by UGA's Circularity Informatics Lab in communities along the river was included in the density data used to develop the risk map. This data included sites in Minneapolis, MN; Cape Girardeau, MO; Blytheville, AR; Vicksburg, MS; and Cairo, IL. In these sites, a 10 x 10 km area was isolated around the city center. A grid with approximately 1 x 1 km square areas was created based on LandScan ambient population activity data, and population activity levels were divided into three tertiles specific to each city. Three sites from each population activity tertiles were randomly selected using the NOAA Sampling Design Tool for ArcGIS. Within each site, a 5 x 5 fishnet grid was created, resulting in 25 survey locations about 200 m x 200 m in area for each site. The NOAA sampling design tool was used again then to select three random areas out of the survey locations. Survey locations were adjusted if they were not reachable and re-selected to ensure they included roadways if needed.

Insights & lessons learned

from community partners

Engaging the public in data collection goes beyond making data collection more scalable and efficient. Community science empowers residents to collect data in areas that matter to them, and open data can spark context appropriate innovation.

"A lot of people going about their daily routine don't even notice plastic pollution and litter. With citizen science, you get engagement that you otherwise wouldn't get by getting them to notice the scale of the problem in their own neighborhoods, and you empower them to start to understand the relationship between their daily activities and activities of their neighbors and the problem."

Dr. Mark Benefield, Louisiana State University

"I think it's all just about ownership and engagement – those are the two biggies, and Debris Tracker did both of those. You can track something right away and be part of a bigger picture. The fact that you can get the data from the website allows people to realize what's going on in their communities."

Katie Lodes, St. Jospeh's Academy

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"Locally, we do have a strong volunteer base with some of our partners like XStream cleanup... By giving volunteers the right tools with Debris Tracker, it helped that engagement to go further...We used the app ourselves first to better understand how it worked and how it could help provide data we need for solutions, and then we utilized promotion on existing platform so felt to our residents like a more community-oriented event."

Megan Fox, Waste Commission of Scott County

Partners noted a long list of community organizations that were included in outreach, such as: K-12 schools, universities, informal educational institutions like aquariums and zoos, student organizations, campus sustainability coordinators, corporate environmental programs, government solid waste management officials, local cleanup groups, health care organizations, local fraternities and sororities, fishermen, and community activists. Partners also cautioned that lower income areas may be less likely to be surveyed because of negative public perception and highlighted the need to engage community members living in those areas to take ownership of the project for their neighborhood. Data collection in these areas can help highlight – and hopefully encourage leadership to resolve – inequitable distribution of resources.

Delivering communication in a variety of ways can help to reach audiences across government, business, and education. Partner used various channels for outreach including social media, television commercials, local talk shows, radio advertisement, existing volunteer network newsletters, in-person meetings with community groups, and community events.

"My advice is to start earlier with communication to better engage, so that stakeholders can see what's in it for them and make their own communication tools to get outreach that works best… Start early, have those conversations more often, and hear them out on their ideas."

- Megan Fox, Waste Commission of Scott County

The involvement of community leaders and the potential for localized change was also key to the success of the initiative in engaging volunteers.

"Mayors can help rally the troops and bring community leaders together to combat this never-ending plastic problem."

- Brian Waldrop, Missouri Stream Team

"The value of having our data upfront is we can look at that data, implement solutions, and then collect more data to see what initiatives can make a difference."

- Kathy Morris, Waste Commission of Scott County

Litter characteristics

in Mississippi River communities

By the conclusion of data collection efforts, community partners had logged litter items in 6 states and determined litter density in 10 urban and city areas along the river stem. During data collection (March-April and October 2021 and June-July 2022), 82,414 litter items were logged, including 80,779 items recorded on the Debris Tracker app and 1,635 items input manually on the Debris Tracker website. The city of St. Louis had the most litter logged with 28,537 items (note that St. Louis had the most items logged but is not necessarily the most littered). Community members were queried in an optional survey on the Debris Tracker app immediately after data collection if they also cleaned up the items they logged. Of users who answered the survey, 73.2% reported that they cleaned up the items they tracked, resulting in over 47,000 items being removed from the environment as part of the initiative.

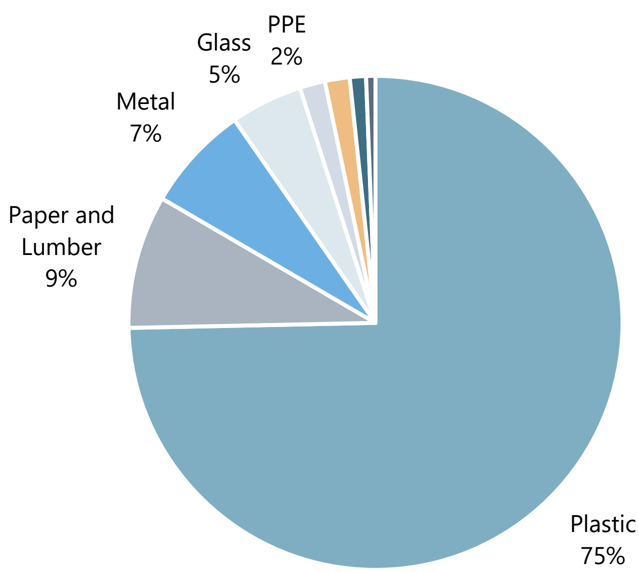


Figure 3: Categorization of litter items by percent.

The top material categories were plastic (75%), paper and lumber (9%), and metal (7%) (Figure 3). A total of 174,868 items have been logged on the Mississippi River Plastic Pollution Initiative list on the Debris Tracker app, considering data logged both in and outside the timeframe of the Initiative.

A wide variety of items were recorded, but the most common types were cigarette butts, food wrappers, and beverage bottles (Figure 4). Both foam and hard plastic fragments are in the top five litter types. These pieces may originate from commonly used products like food containers or drinking cups.

Reduction is the first line of defense in decreasing litter in the environment. Identifying recurring items can focus community efforts on targeted interventions. Cigarette butts were the most logged item out of all item types; the filters are made of cellulose acetate, a type of plastic. In addition to introducing plastic into the environment, cigarettes can also leach toxic chemicals into water bodies[2]. Foam fragments were among the top items logged, which may originate from foam cups or containers. Foam is widely used in these consumer contexts because of its lightweight, affordable, and insulative properties; however, its structure lends it to easily break repeatedly into smaller pieces when littered. These small fragments are especially difficult to retrieve from the environment; therefore, foam has already been targeted for reduction efforts by policies in other cities and states. Beverage bottles and aluminum cans were both in the top ten litter items, and both items could be targeted for recycling, through for example, buy-back schemes or

[2] Javad Torkashvand, Mahdi Farzadkia, Hamid Reza Sobhi, Ali Esrafili, Littered cigarette butt as a well-known hazardous waste: A comprehensive systematic review, Journal of Hazardous Materials, Volume 383, 2020, 121242, ISSN 0304-3894, https://doi.org/10.1016/j.jhazmat.2019.121242.

source-separated collection. Foam cups, plastic cups, and plastic bags were also among the top ten litter items, all items with existing reusable alternatives.

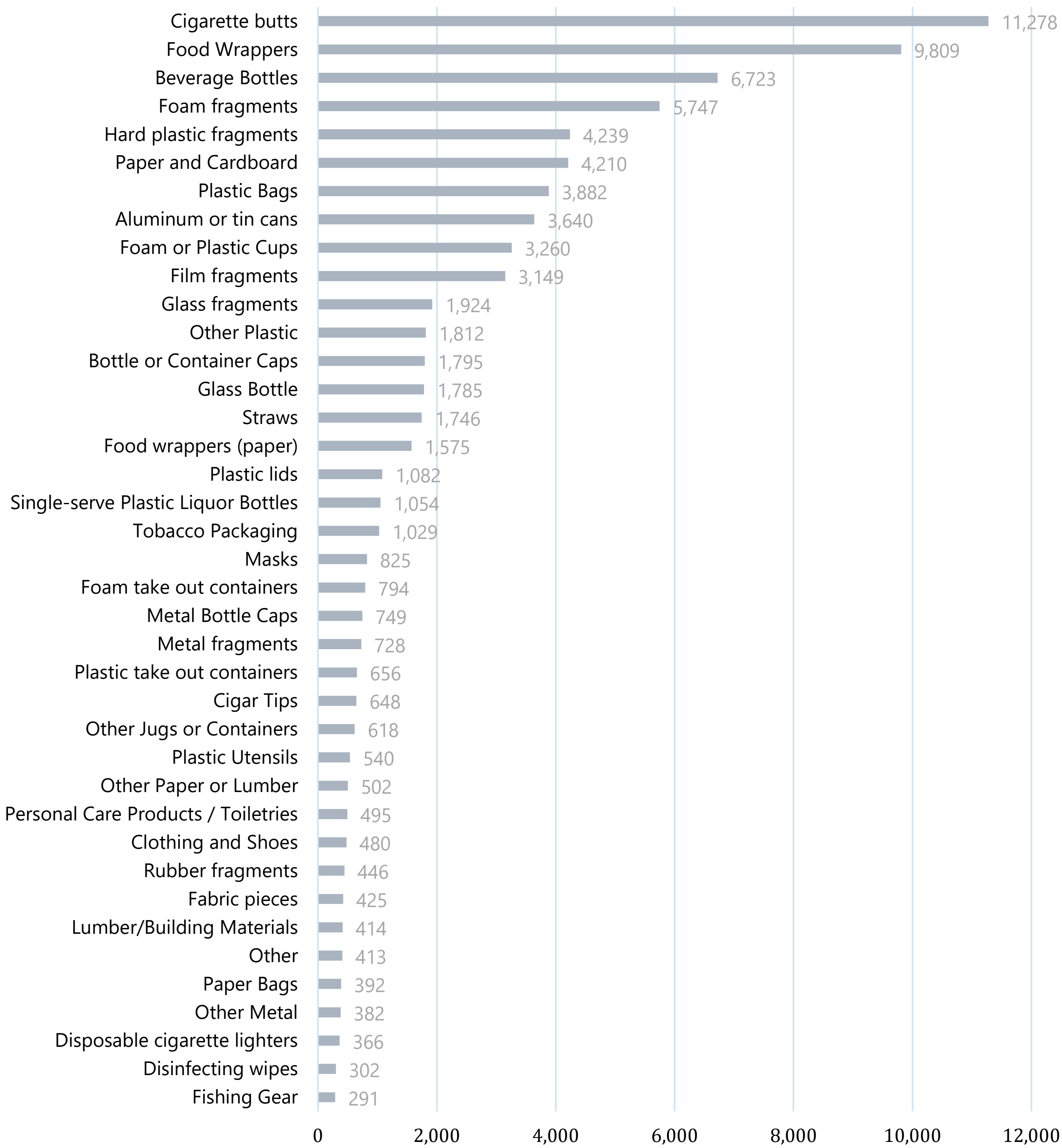


Figure 4: Top items logged in Mississippi River communities by count.

Debris Tracker app users were encouraged to note brands on items when possible. Brands were identified on 341 total litter items, with 324 unique brand names. Brand names were mapped back to 197 associated parent companies. The top parent companies were PepsiCo, Inc. (23 items), Mars, Inc. (12 items), and the Coca-Cola Company (10 items) (Figure 5). PepsiCo, Inc. produces both beverages and snacks, which may explain its top position. To identify more specific opportunities for engagement, top parent companies were also mapped to specific items of concern in the litter dataset (Figure 6). Of particular note are beverage bottles and aluminum can parent companies; these highly recyclable items present a clear opportunity for corporate engagement around litter reduction and extended producer responsibility.

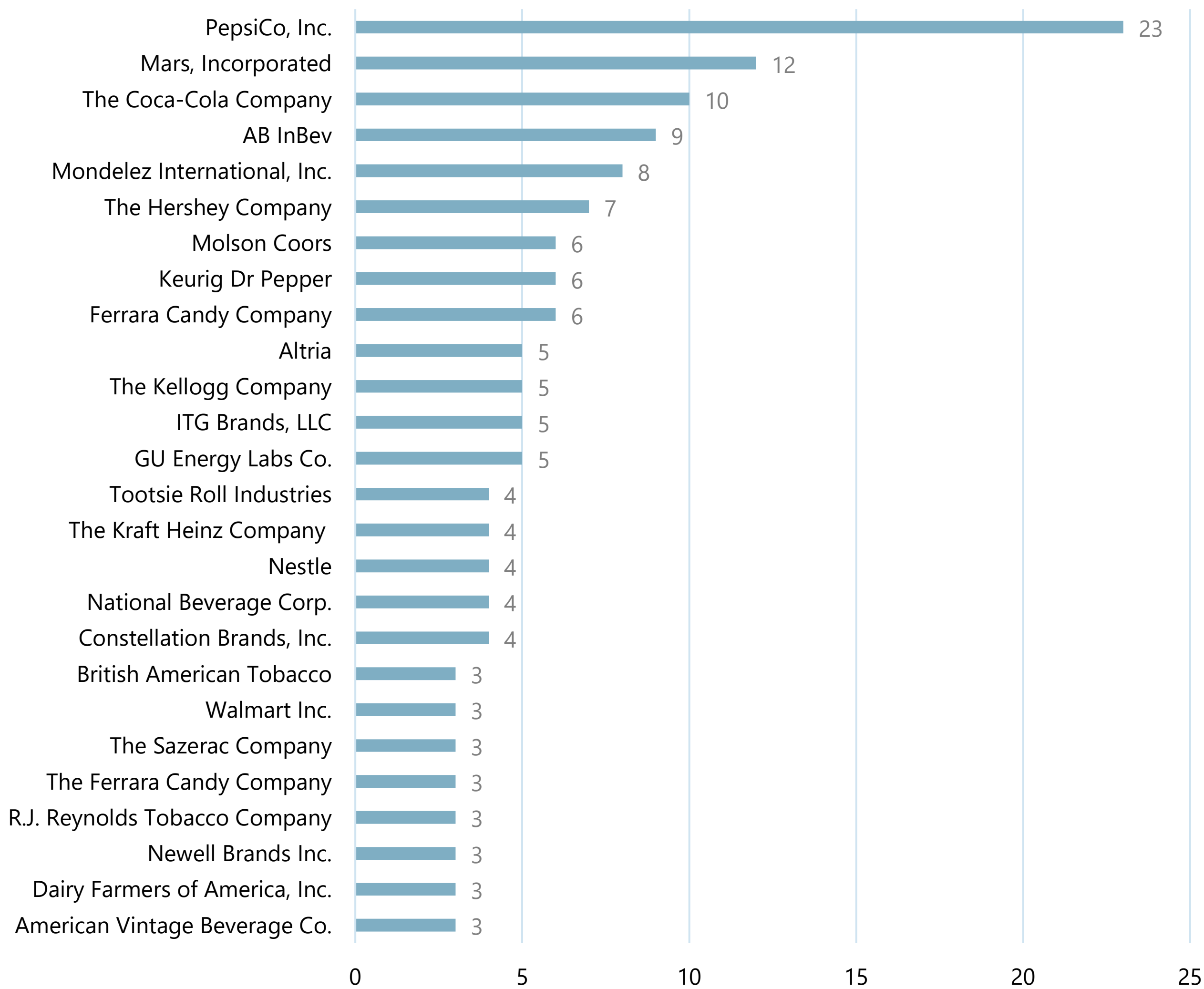


Figure 5: Parent companies of the brands identified in litter, by count (n ≥ 3)

Compared to the amount of litter items logged, the number of branded items and unique brand names identified is small. With this small sample size, caution should be taken when referring to this data. Despite the sample size, presenting brands here can initiate discussions for brand engagement.

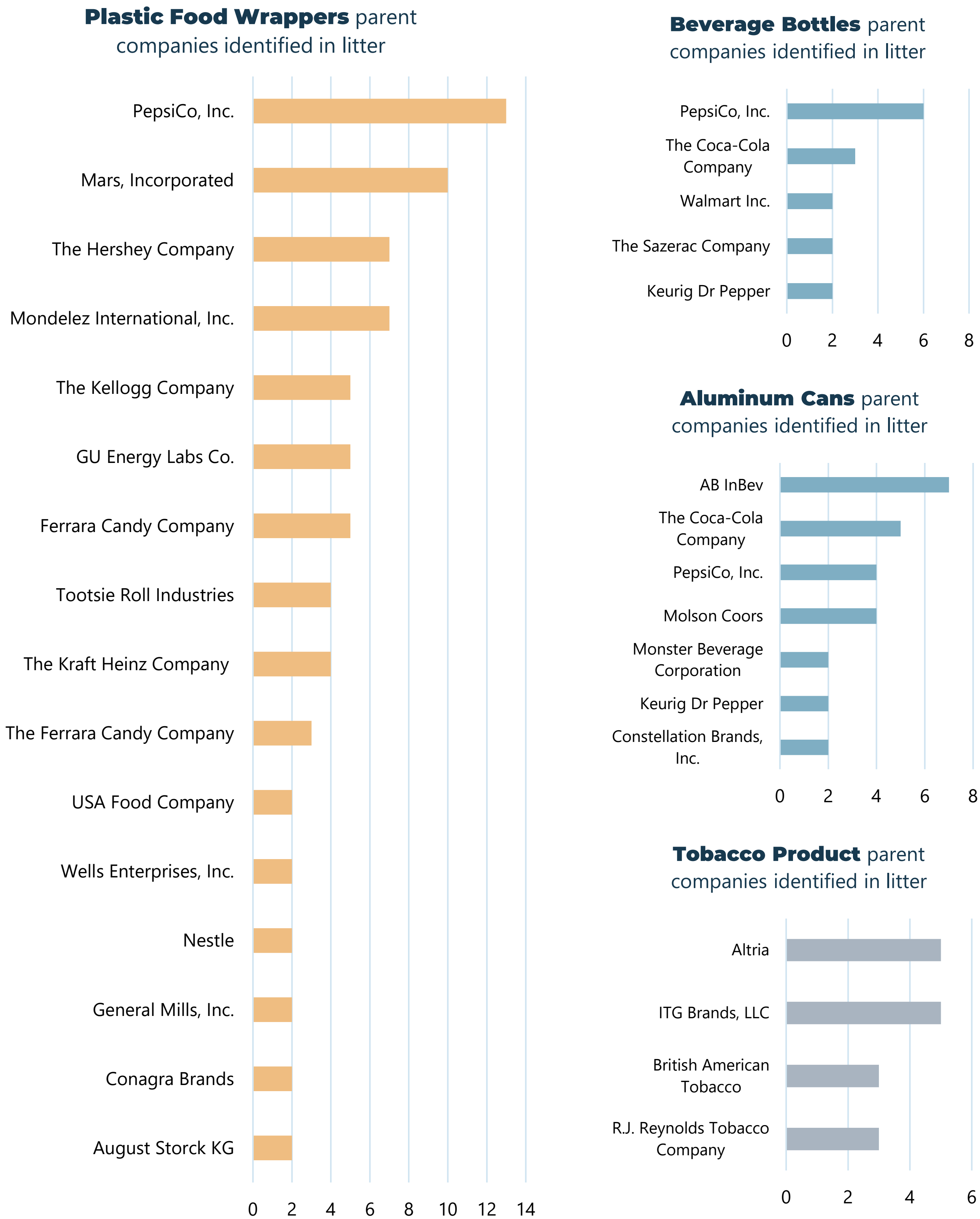
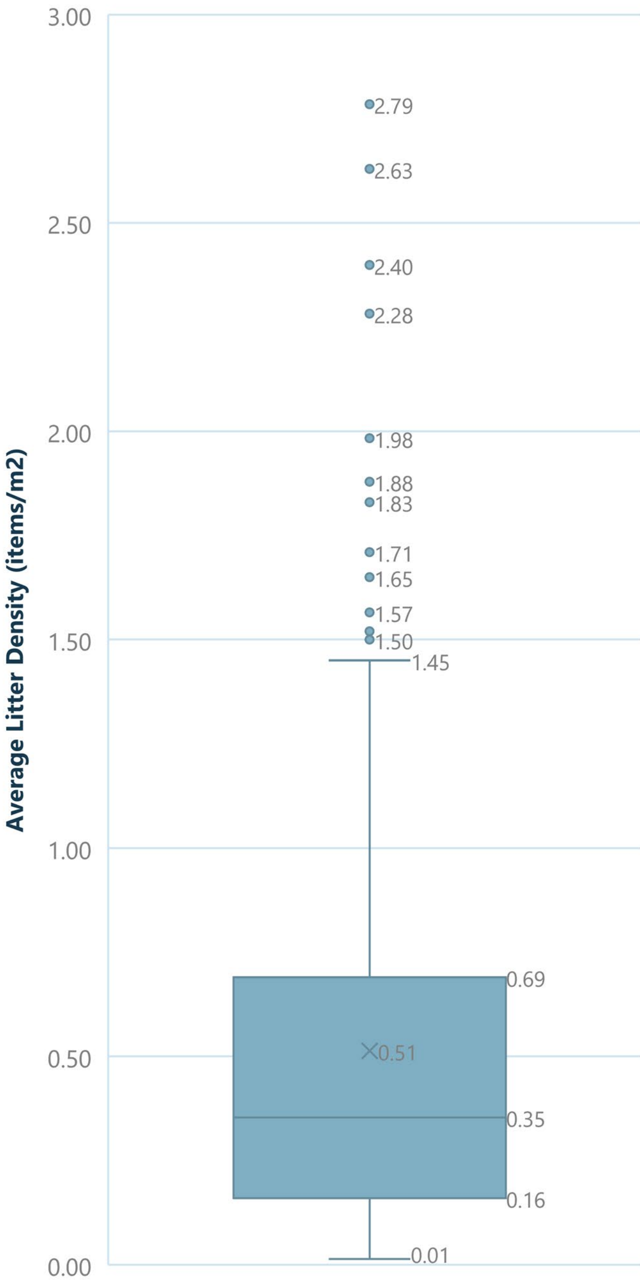


Figure 6: Parent companies of brands by item type, by count (n≥2)

Litter densities

along the Mississippi River corridor



The litter density (number of litter items over the area surveyed in count/m2) across all sites in the river corridor ranged from 0.01 to 2.79 items/m2. The average litter density across all Mississippi River communities was 0.51 items/m2 across 195 sites (Figure 7). To visualize this density, imagine that when observing a 1-m (3-ft) wide path while walking along a city block (about 100m), one would see 51 litter items.

Figure 7 (left): Litter density box-and-whisker plot illustrating range, average, and quartiles.

To identify areas at risk for litter along the river stem, a variety of potentially correlating demographic variables that have been shown to influence litter in various ways[3], were considered and tested. The ambient population count for each site (approximately 1x1 km2) was obtained from a dataset called LandScan, which disaggregates census data over a 24-hour period, incorporating other variables such as light emissions to map where people go in a day, not just where they live.[4] This variable therefore reflects societal activity. Median household income (USD/year) was extracted from the American Community Survey 2020 census data, using the median household income in the past 12 months (in 2021 inflation-adjusted dollars).[5] This data was obtained at the census block group level, and LandScan grid cells (which are approximately 1 km2 in size) were intersected with the block groups with the largest overlap. Finally, data on material recovery facilities (MRFs) was obtained from The Recycling Partnership's map of residential MRFs in the U.S.[6]

[3] Q. Schuyler, B.D. Hardesty, T.J. Lawson, C. Wilcox, (2022). Environmental context and socio-economic status drive plastic pollution in Australian cities, Environ. Res. Lett., 17, Article 045013; K. Youngblood, A. Brooks, N. Das, A. Singh, M. Sultana, G. Verma, T. Zakir, G.W. Chowdhury, E. Duncan, H. Khatoon, T. Maddalene, I. Napper, S. Nelms, S. Patel, V. Sturges, J.R. Jambeck, (2022). Rapid characterization of macroplastic input and leakage in the Ganges river basin, Environ. Sci. Technol. 56, 7, 4029–4038.
[4] Land Scan, Oak Ridge National Laboratory. https://landscan.ornl.gov/
[5] U.S. Census Bureau. https://www.census.gov/
[6] The Recycling Partnership. Map of Commingled Residential MRFs in the U.S. https://recyclingpartnership.org/residential-mrfs/

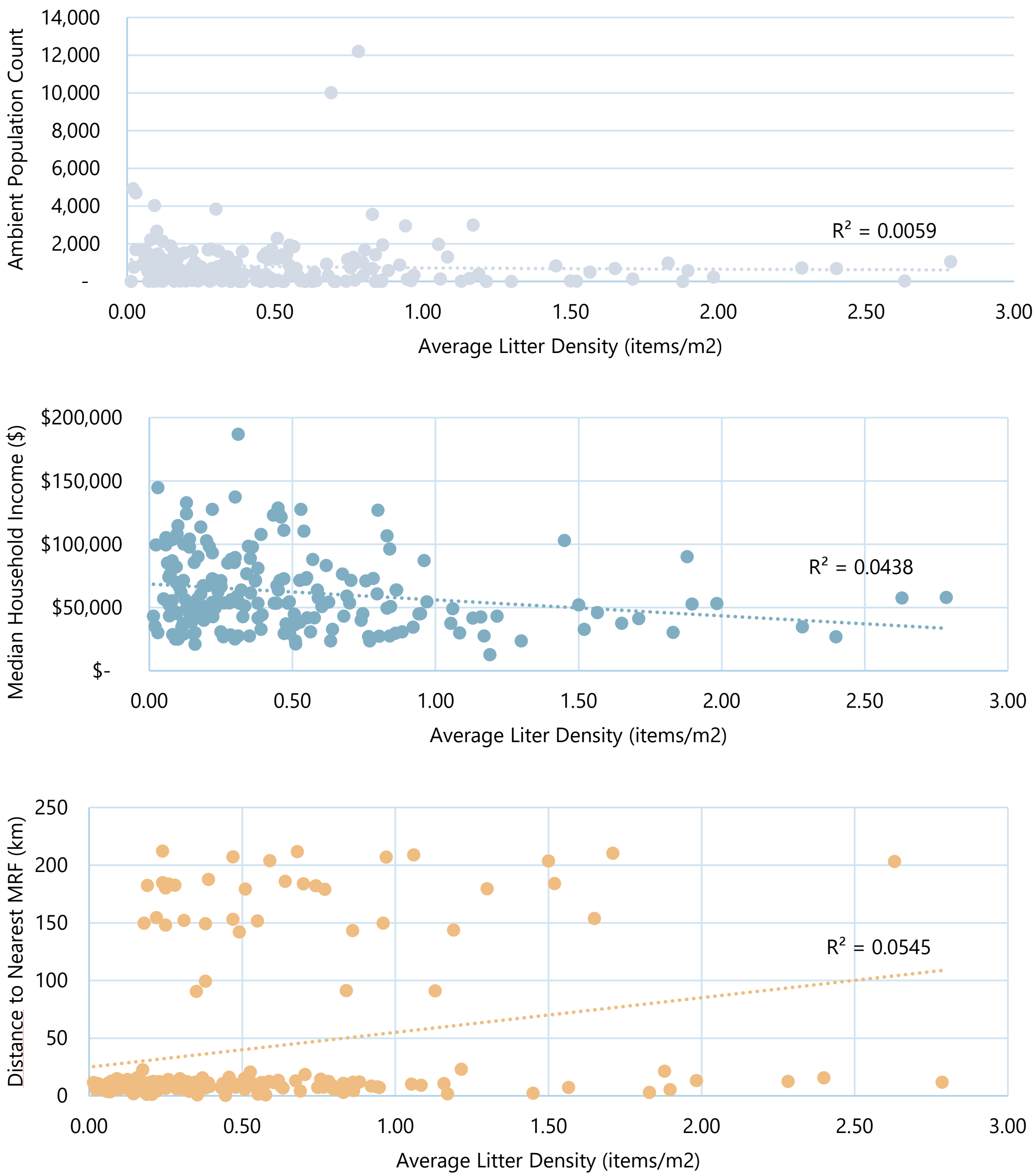


Figure 8: Relationship between average litter density (items/m2) in sites and demographic variables.

While no statistically significant correlations are present, there is some indication of potential trends (Figure 8). The two sites with extremely high population activity have above-average litter densities. There is a slight negative correlation between average litter density and household income, where higher household incomes correlate with lower average litter densities.

For distance to MRFs, it is notable that most sites are within 50 km of a MRF, but those further away from MRFs tended to have higher than average litter densities. By isolating LandScan grid cells within a 10 km buffer on either site of the river stem, the total population activity within 10 km of the river was calculated to be 6,307,123 (because this number represents activity, it will be higher than population counts based on residential data). A 100 km buffer was added to MRFs near the river corridor to evaluate proximity to MRFs. As seen in Figure 8, large areas in northern Minnesota, to the north and south of St. Louis, and between Mississippi and Louisiana have less access to MRFs within 100 km, representing both a proxy for ruralness and a lack of access to infrastructure. The total ambient population activity along the river corridor more than 100 km from a MRF is 1,224,83 people, or 19.42% of the total population activity along the river does not have access to a MRF within 100 km.

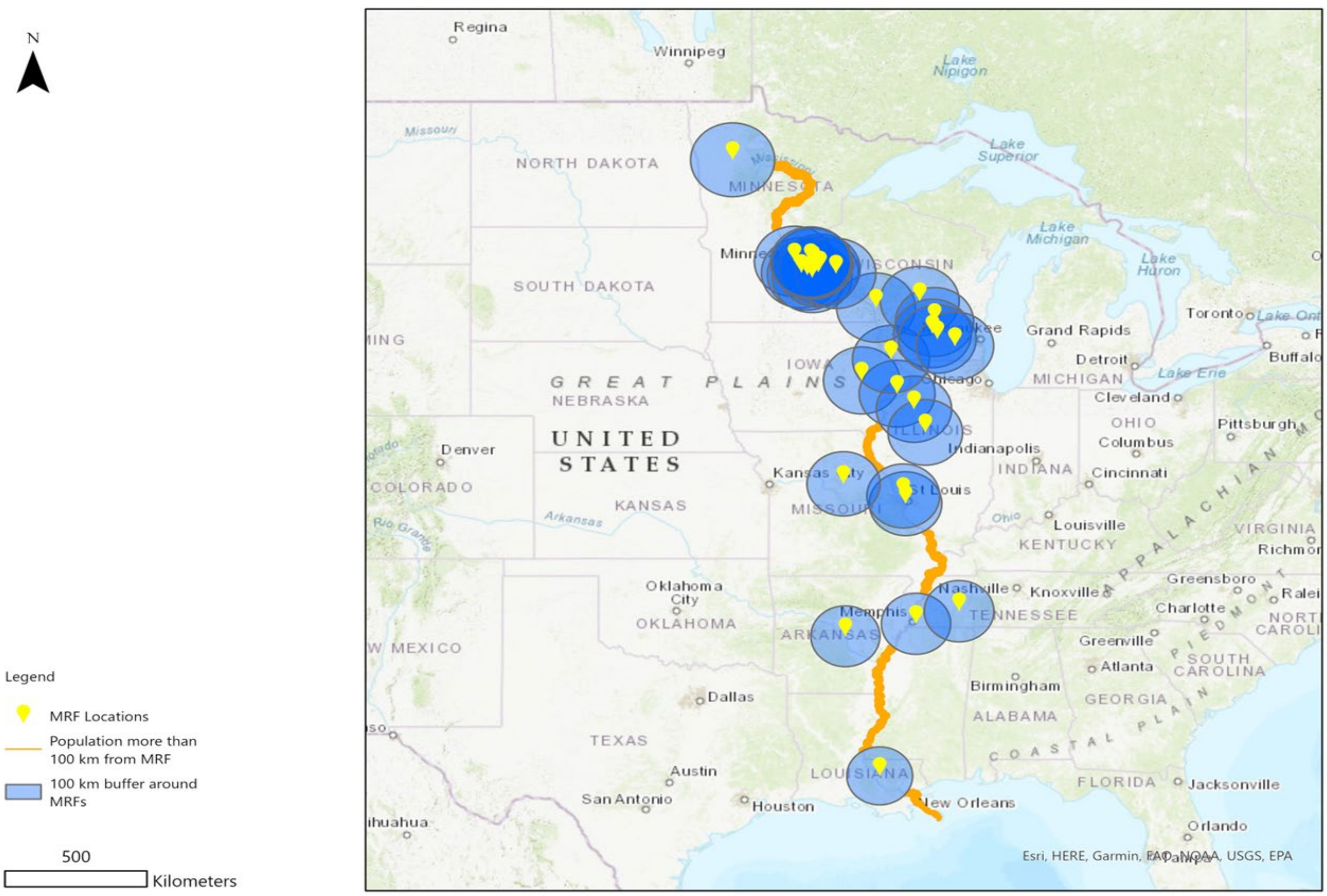


Figure 9: Location of MRFs along the Mississippi River corridor with 100 km buffers.

Because no clear correlation to litter density was identified from the variables above, a multivariate cluster analysis was conducted using ArcGIS Pro to further explore trends. This functionality identifies the ideal number of groupings from a given dataset to maximize similarities within each group as well as differences between the groups. Each data point is assigned to a respective group, or cluster.

Clustering the 195 sites surveyed along the Mississippi River resulted in five cluster groupings. Clusters 1 and 3 had average litter densities equal to and above the third quartile (meaning higher than 75% of the average litter densities in the dataset), while Cluster 2 had the highest average litter density, which would have been considered an outlier in the dataset.

Table 1: Summary statistics for each cluster grouping identified through multivariate clustering analysis of 195 sites along the Mississippi River.

Cluster ID	**Count**	**Average Litter Density (items/m2)**	**Population Count**	**Median Household Income (USD)**	**Distance to Nearest MRF (km)**
		Mean	*Mean*	*Mean*	*Mean*
1	36	0.69	199	$48,139	170
2	12	1.92	474	$53,158	27
3	2	0.74	11,107	$66,068	8
4	45	0.28	970	$106,274	9
5	100	0.38	836	$48,248	10

Examining the box plots for each cluster (Figure 10) shows that Cluster 1 has both above average litter densities and the sites tend to be at least 100 km away from a MRF. Cluster 3, with above average litter densities, also has above average population activity, with the lower end of the range around 10,000 people in each site. Cluster 4 sites tended to have lower litter densities, and median household incomes of greater than $80,000/year. Notably, Clusters 2 and Clusters 5 have similar demographic profiles in terms of population, income, and distance to the nearest MRF. However, Cluster 2 had the highest litter densities of all cluster groupings, while Cluster 5 had relatively low litter densities. 12 sites were assigned to the Cluster 2 grouping, while 100 sites were assigned to the Cluster 5 grouping, so approximately 10% of sites with these similar demographic characteristics had high litter densities.

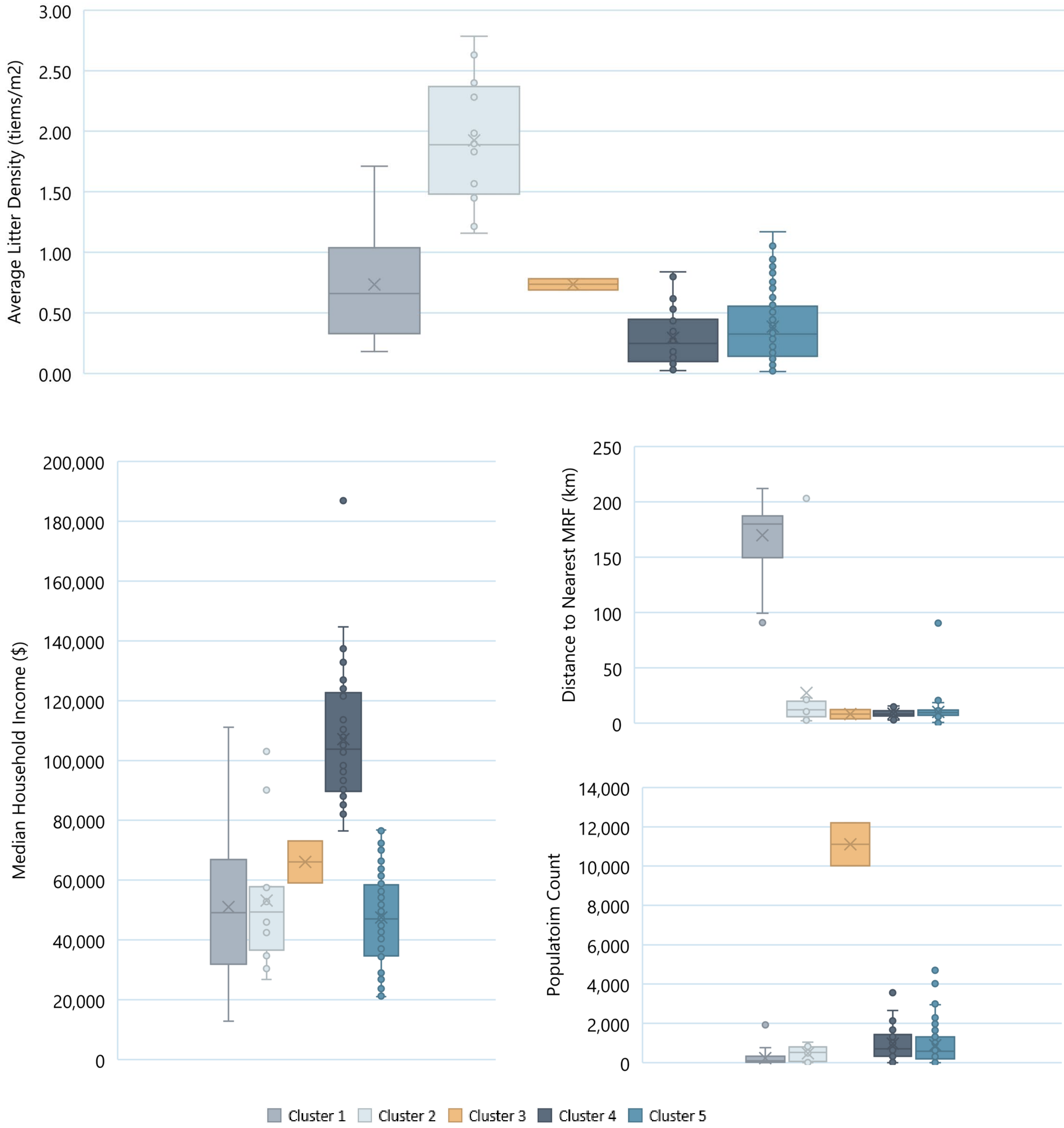
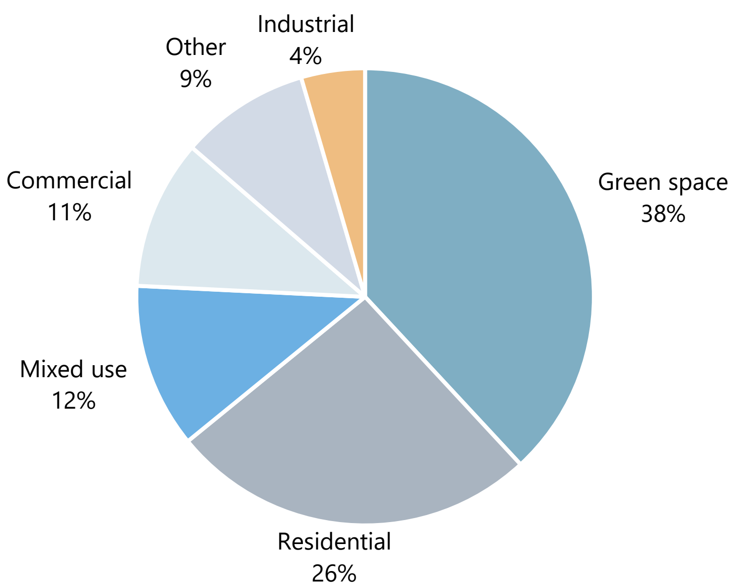


Figure 10: Box plots of variables of cluster groupings.



To further explore potential differences between Clusters 2 and 5, hyperlocal land use based on volunteer survey responses was examined. After logging litter with the Debris Tracker app, volunteers had the option in the survey to report the approximate surrounding land uses. 74% of tracking sessions had a land use type reported. Overall, most litter data was collected in green space (41%) and residential areas (27%), and to a lesser extent mixed use (12%) and commercial areas (12%). Few surveys reported tracking in industrial (3%) or other (5%) areas (Figure 11).

Figure 11 (left): Overall distribution of transect location local land use, as reported voluntarily by users.

Green space was still the most reported land use type in Clusters 2 (high average litter density) and 5 (low average litter density) (Figure 12). Cluster 5 (low litter densities) did have slightly higher proportions of both green space and residential areas, compared to Cluster 5's higher proportion of mixed-use and commercial or industrial areas. In conversations with community leaders, the sense of local ownership and responsibility was highlighted as a preventative factor for litter; this feeling could be stronger in green space and residential areas compared to mixed-use, commercial, or industrial areas.

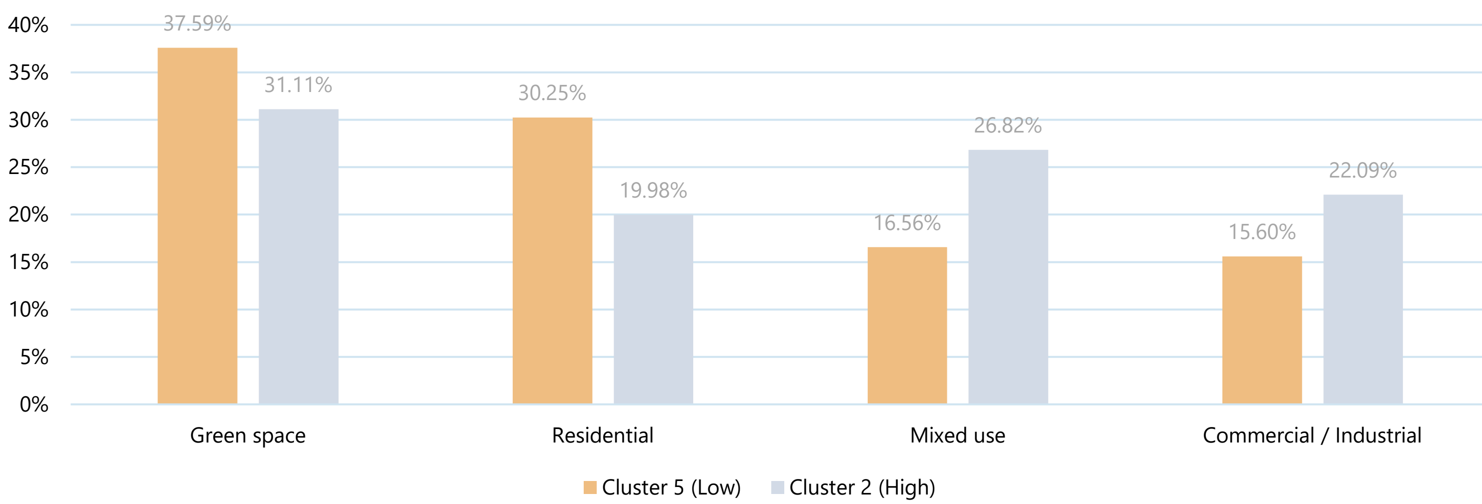


Figure 12: Distribution of transect location local land use, as reported voluntarily by users, for Cluster 2, which had high average litter densities, and Cluster 5, which had low litter densities.

Slight differences were also identified in the proportion of top litter items in Clusters 2 and 5 (Figure 13). The most obvious difference was the proportion of cigarette butts, which comprised nearly 25% of the data in the high litter density sites in Cluster 2, but only about 15% of the data in the low litter density sites in Cluster 5. There is also a higher proportion of plastic bottles and foam take-out containers in the high litter density areas in Cluster 2.

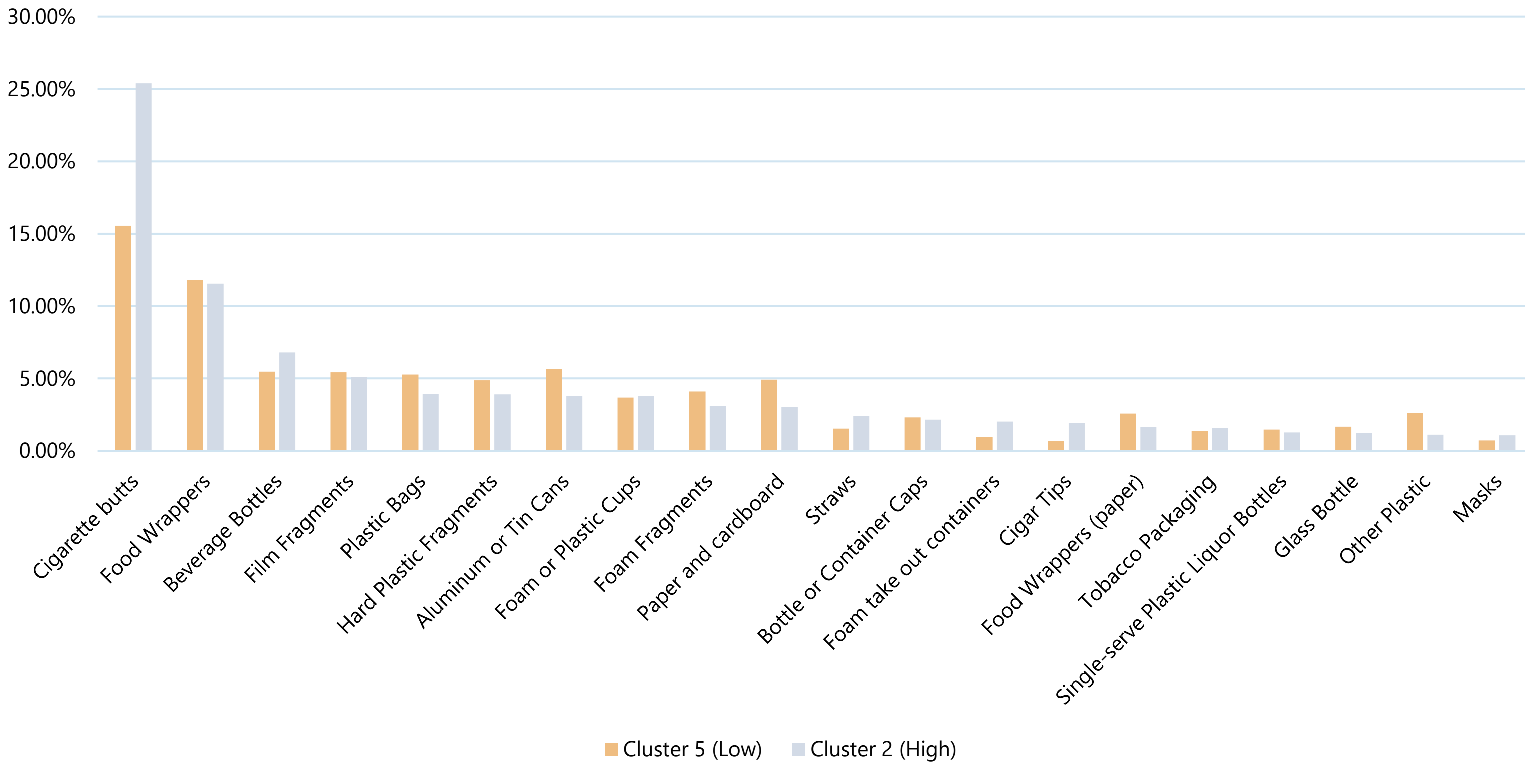


Figure 13: Proportion of top items in Cluster 2, which had high average litter densities, and Cluster 5, which had low litter densities.

Using the National Transportation Dataset[7], the proportion of total roadways in each site comprised of major highways and ramps was calculated for each site. Cluster 2 sites (higher average litter densities) tended to have a higher proportion of highways compared to Cluster 5 sites (Figure 14) (Ferry routes, tunnels, closed roads, and unknown roads were excluded from the total road length for each site). This difference was not statistically significant (one-way ANOVA, p = 0.09), but may point to the influence of the proximity of highways to higher levels of litter in some cases.

[7] USGS. National Transportation Dataset. https://www.sciencebase.gov/catalog/item/4f70b1f4e4b058caae3f8e16

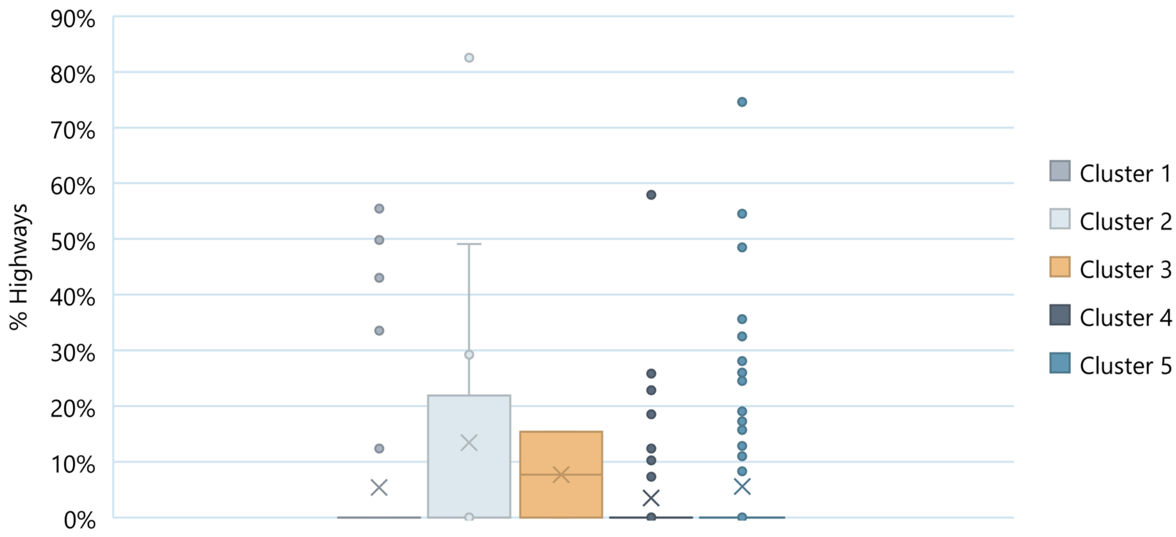


Figure 14: Proportion of highways out of total road lengths for each site in identified cluster groupings.

While Clusters 2 and 5 are difficult to distinguish based on high-level demographic characteristics and similar profiles, there is notable variability in litter quantities and characterization based on hyperlocal variables that may be influenced at the community level. While about 10% of these sites may be at risk for more litter, many will not likely have high litter levels (especially those in residential areas and greenspaces).

Risk map

for exposure to litter in Mississippi River communities

The risk map shows areas that are more likely and less likely to have litter. When considering use of resources and intervention actions, risk maps can help prioritize areas for community decision makers. For example, additional collection infrastructure could be targeted in high-risk areas, while low-risk areas may not need additional investment.

Using the profiles (cluster groups) generated from the multivariate analysis, sites within 10 km of the Mississippi River were assigned a risk value. First, sites were identified with ambient population values above 10,000 people (Cluster 3) and assigned to the high-risk category (17 sites). Sites with median household income levels above $80,000 (Cluster 4) were considered low risk (8,967 sites). Sites more than 100 km away from a MRF (Cluster 1) were assigned to the high-risk category as well, although sites in this category that also had over $80,000 in median household income were excluded (41,106 sites). All other sites were assumed to be in the “at-risk category” (19,470 sites) made up of Clusters 2 and 5, where 10% of these sites were of the highest litter densities likely based upon hyper-local influences, but potentially correlated to non-residential or greenspace (more industrial and commercial areas) and more cigarette butt litter. Outside of where empirical data has been collected, these at-risk areas may need additional data collection or characterization to identify areas of concern in a given community. However, high-risk sites represent appropriate targets for resources and interventions that the cities feel are appropriate.

Based on the characteristics and assigned areas above, an interactive **Mississippi Corridor Risk Map** was generated. It is displayed on a public dashboard of ArcGIS Online. Average litter densities from actual data collected through the Mississippi River Initiative are also displayed on the map as blue dots relative to their litter concentration. In addition, highways are shown as lines on the map as well.

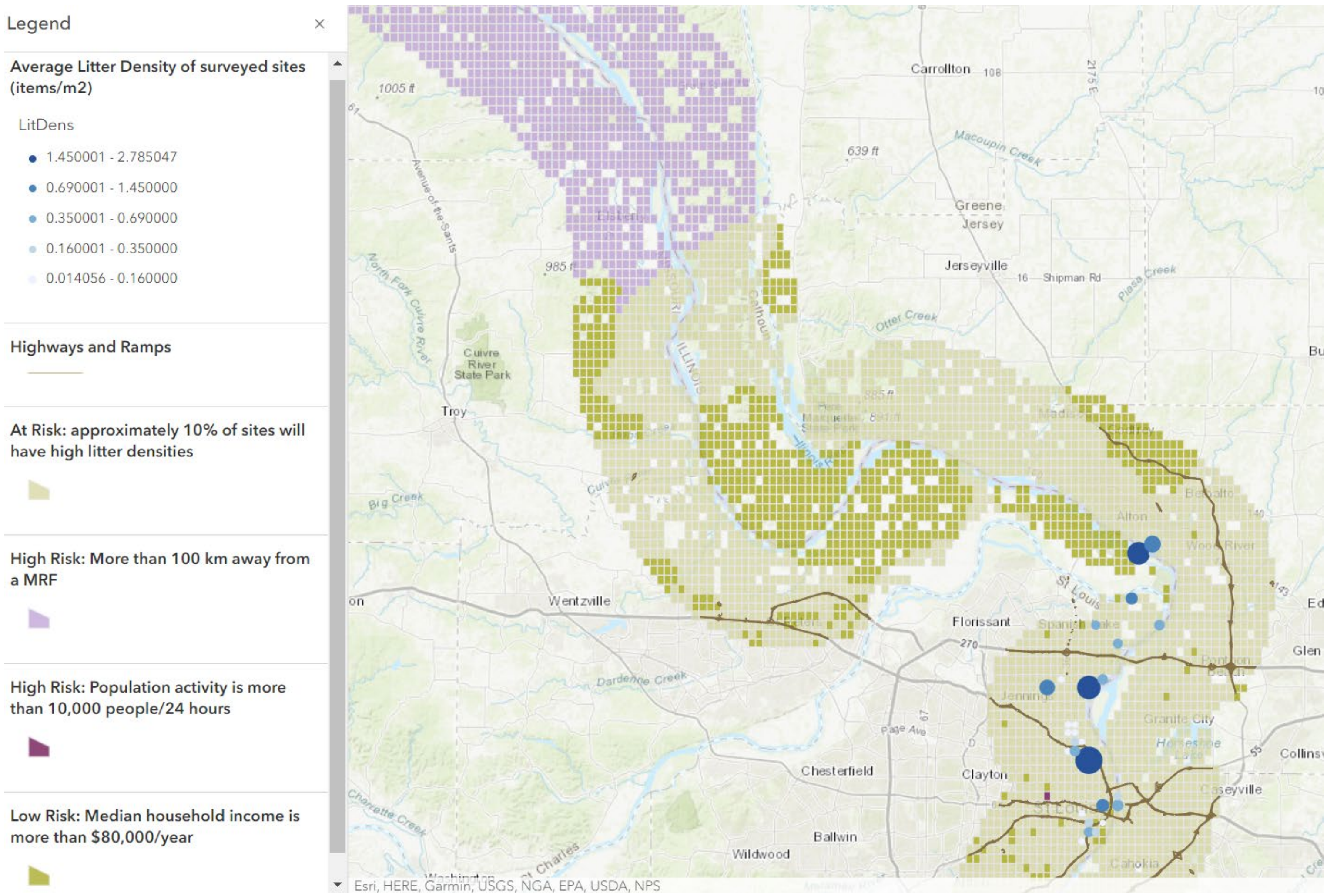


Figure 15: Mississippi Corridor Risk map, available as an interactive online version.

Based on the range and median litter densities for the Cluster Groups (1-5) associated with each risk category, the total road length from the National Transportation Dataset (excluding ferry routes, tunnels, closed roads, and unknown roads) was quantified for each square site. Based on road type and length, the total number of litter items in each area was estimated. The litter accumulation area assumed for the calculation was a 1 m wide path (what we measured) on either side of the roadway. To extrapolate the litter densities, the first quartile (Q1, the value which is higher than 25% of the dataset), the median, and the third quartile (Q3, the value which is higher than 75% of the dataset) of the cluster grouping associated with each risk category were used as a median and range value for litter items in each risk category (e.g., high-, low- and at-risk) in the Mississippi River corridor. For the at-risk category, which reflects both Clusters 2 and 5, the values were weighted at 10% of sites having high litter densities (representing Cluster 2), and 90% having lower litter density levels (Cluster 5). This total estimate is 60.7 million to 109.8 million litter items with a median of 116 million. With an average of 75% of these items being plastic, we estimate as a snapshot, 87 million plastic litter items are on the ground in communities along the Mississippi River Corridor based upon data used in this analysis. The range of plastic items is 45.6 million – 143.1 million. It is important to note that this estimate represents a snapshot in time; further studies would be needed to understand the frequency of turnover, seasonality, as well as the likelihood of litter on the ground in urban areas reaching the waterway if input is of interest. Further detailed estimates of common litter items are included in Figure 16 below and these include median values of 15.8 million cigarette butts, 13.8 million food wrappers, 9.5 million plastic beverage bottles, 5.5 million plastic bags, and over 5 million aluminum cans.

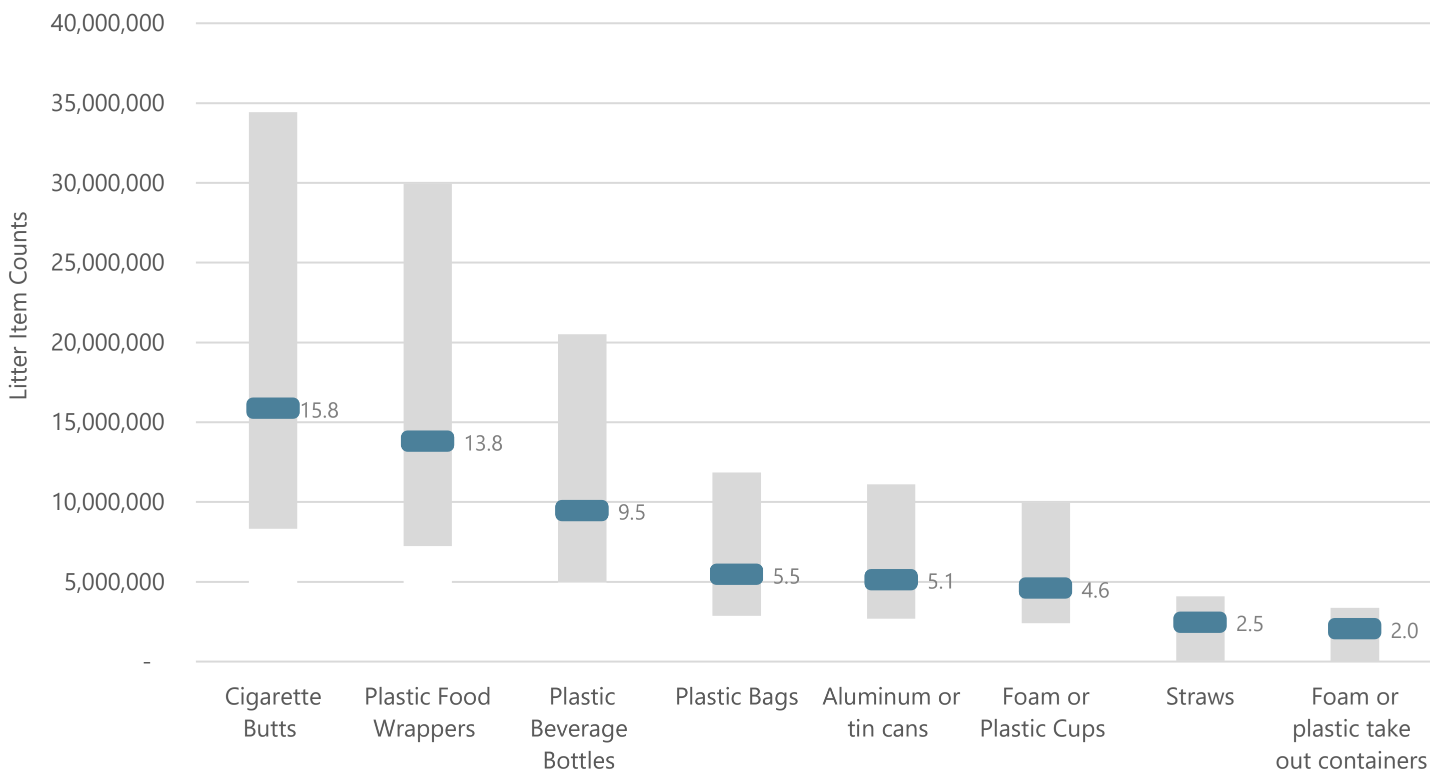


Figure 16: Litter item count (in millions) and ranges in communities within 10 km of the Mississippi River.

The Mississippi River Initiative sought to collect data on what was leaking out of cities along the river – portions of this estimate might be picked-up, collected, or prevented from getting into waterways by various measures (e.g., street sweeping, stormwater filtering or waterway capture); however, this analysis does reflect what was on the ground at the time of data collection, i.e., what was not captured initially. Last-chance capture devices and methods like filters and mechanisms in stormwater systems, as well as regular street sweeping activities would mitigate this leakage, but come at a significant cost to communities.

Opportunities

The data from the Mississippi River Initiative points towards specific items that could be targeted for interventions, and specific areas where these solutions should be implemented to maximize impact are identified as in the risk map. Strategies for solutions discussed in this report, along with examples of interventions, are summarized here.

Strategy	Example Interventions
Reuse & reduce	• Establish reusable foodware systems, such as refillable cups or returnable take-out containers • Install water refill stations, which have been supported by grant funding in some Mississippi River cities • Encourage the use of reusable grocery bags • Enact policies to discourage or eliminate use like taxes or bans
Re-design	• Maximize recyclability by using high value materials and sizing for local sorting infrastructure • Design for compostability, where appropriate in the context of the community infrastructure (Consider: Does commercial composting exist? Is it accessible to community members?)
Recycling	• Expand and maintain collection and sorting infrastructure, such as material recovery facilities (MRFs) and recycling drop-off centers • Engage with local markets to increase value of recyclables
Education	• Increase awareness around plastic filters in cigarette butts • Share messaging that connects the river to the ocean as a conduit of plastics
Targeting resources to high-risk areas	• Focus above actions and resources to areas of higher risk for litter • Install additional infrastructure like waste collection bins or cigarette disposal containers in high-risk areas • Leverage extended producer responsibility (EPR) to engage corporations about providing funding to under-resourced areas
Further examination of at-risk areas	• About 10% of the sites in the at-risk areas may have high concentrations of litter based upon hyper-local influences. Further examining these areas for litter could help to discover areas in need of interventions.
Last-chance capture	• Capture litter before it enters the environment through street sweeping and stormwater filters • Use in-stream litter capture devices to prevent litter from flowing downstream to the ocean

Our partners

The Mississippi River Cities and Towns Initiative (MRCTI) is a coalition of 101 mayors from across the Mississippi River Basin, which spans nearly a third of the country. The Mississippi River is of significant importance in the region, providing drinking water to more than 20 million people and 50 cities. More than 60 billion gallons of fresh water is withdrawn from the river daily. The River's resources support 1.5 million jobs and create $496.7billion in annual revenue.

The United Nations Environment Programme (UNEP) is the leading global authority that sets the environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment. UNEP provides leadership and encourages partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

The University of Georgia's Debris Tracker is a free mobile app designed to help community members make a difference by contributing data on plastic pollution. Developed in 2010 in partnership with the National Oceanographic and Atmospheric Administration (NOAA) and currently supported by Morgan Stanley, the Debris Tracker community is creating a bigger picture of marine debris and plastic pollution through collecting open data, generating scientific findings, informing policy, and inspiring upstream design. Every day, dedicated educational, non-profit, and scientific organizations and passionate citizen scientists from all around the world record data on inland and marine debris with the easy-to-use app, with over 7 and a half million items logged to date.

Local partners joined at participating cities to engage in data collection, identify areas of concern for litter, organize cleanups that happened during the project period, and to receive and facilitate training on effective data collection for this project. A list of city partners for each of the three initiatives are contained in each report located at unep.org/mississippi.

UN environment programme   MRCTI   UNIVERSITY OF GEORGIA   Marine Debris Tracker

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On behalf of:
The Mississippi River Plastic Pollution Initiative

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