Circularity Assessment Protocol
Cape Girardeau, Missouri, USA

University of Georgia

Circularity Informatics Lab

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The Circularity Informatics Lab at the University of Georgia is committed to information sharing, data analytics, empowering communities, and systems change related to circular materials management.

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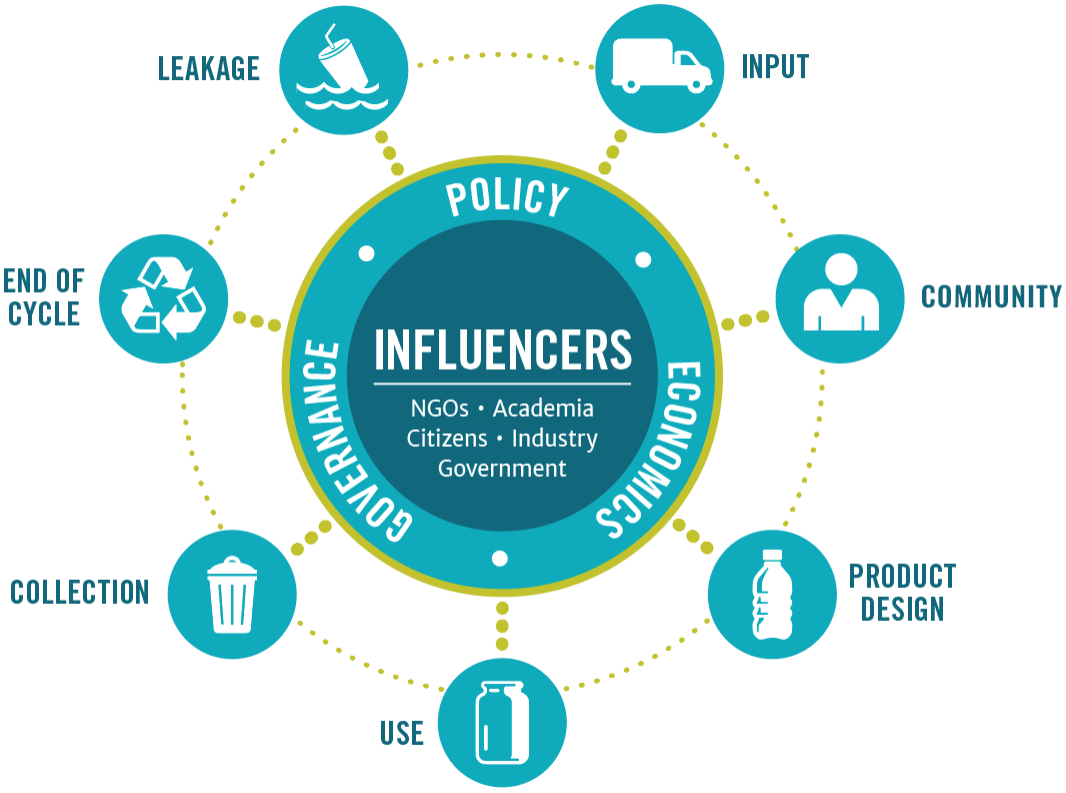
On behalf of:
The Walmart Foundation; Walmart.org

Executive Summary

Developed by the Circularity Informatics Lab at the University of Georgia, the Circularity Assessment Protocol (CAP) is a standardized assessment protocol to inform decision-makers through collecting community-level data on plastic usage. Grounded in materials flow and systems thinking concepts, the CAP uses a hub-and-spoke model to holistically characterize how consumer plastic flows into a community, is consumed, and flows out, either through waste management systems or leakage into the environment. The model, shown below, is comprised of seven spokes: input, community, material and product design, use, collection, end of cycle, and leakage. At the center, the system is driven by policy, economics and governance with key influencers including non-governmental organizations, industry, and government.



In October of 2022, a team from the Circularity Informatics Lab conducted fieldwork in the city of Cape Girardeau, Missouri with support from the Mississippi River Cities and Towns Initiative (MRCTI) and the city's local government. This CAP was conducted with the support of the Walmart Foundation. Fieldwork included product and packaging assessments in stores across the city; key stakeholder interviews with government, industry, and non-profit organizations; material type characterizations for consumer plastic items; cost analysis of reusable products and alternatives to plastic available in the city; visual audits of recycling

contamination; identification of public waste and recycling collection bins; and litter transects in three categories of population. Key findings from each spoke are summarized in the table below.

Key Findings

INPUT

Findings: Regional distribution of products in the United States was common among both manufacturers and parent companies. All beverage and chip manufacturers were located within the USA, while candy had some products manufactured in Canada, Mexico, and Italy in addition to the USA. Of the products surveyed, 5 had parent companies located in Missouri: H2O Technologies LLC, Old Vienna LLC, Russell Stover Chocolates, LLC, and Schnuck Markets, Inc. Additionally, 10% of parent companies were located in neighboring states like Arkansas, Illinois, Iowa, and Tennessee.

Opportunities:

- The large percentage of domestic parent companies and manufacturers for top convenience items lend themselves to engaging companies about end-of-life management, product design, alternative materials, and alternative product delivery systems. Cape Girardeau could lead community initiatives toward working with top local brands and producers that operate locations proximate to the community and Mississippi, with a particular focus on beverage and chip packaging since those tend to leak out still.
    - Through working with these top brands, the City of Cape Girardeau could explore resources and potential local industry partnerships that may be available for effective development, implementation, and enforcement of Extended Producer Responsibility (EPR) guidelines and rules that result from those guidelines. In addition, the city should be as involved as possible in crafting EPR Guidelines at the city and national levels to ensure that they can be effectively implemented at the local level.

COMMUNITY

Findings: The Cape Girardeau community works together to collect and manage solid waste, including plastic waste. At present, successful collection of plastic waste relies heavily on behaviors at the household and individual level. As such, efforts toward education and incentivization strategies can help encourage behavior that helps waste infrastructure run smoothly.

Opportunities:

- The small population and location of Cape Girardeau mean that communication and education campaigns may be easily communicated across households, as well as businesses. Additionally, this supports the opportunity for efficient coordination between the public, the business community, and the local government to collaborate on efforts to manage plastic materials.

PRODUCT DESIGN

Findings: A total of 14 convenience and grocery stores were sampled across the transects. A total of 239 unique convenience items were documented; these items consisted of beverages, candy, and chip products. When considering the ratio of packaging to product, chips were more substantial with 0.08 g of packaging for every gram of product. Candy and beverages both had a ratio of about 0.06 g/g. As such, chips generate the most packaging waste per unit of product delivery of the three categories. Multi-layer film was the most common material type of convenience products, making up 42% of the sampled items.

The CIL team surveyed restaurants in each of the nine transects areas. Plastic comprised 77% of the restaurant to-go items, with the most common type being unmarked hard plastic items including utensils, lids, cups, and straws. Paper was the second most common material for food vendor take-out items, which included food containers, cups, and bags.

Opportunities:

- Plastic alternatives in the form of bio-based, biodegradable, and compostable plastics are likely to continue gaining momentum in Cape Girardeau and beyond. By investing in education around identifying product materials and appropriate disposal options early, the city may mitigate challenges with managing these complex products over time. This approach is particularly important given that there are no commercial composting facilities currently

serving the community, which may leave the possibility for contamination of the waste stream, leakage of items into the environment, and missed opportunities for material diversion from landfills.
    - The city may also be able to push for state-level policy and regulations that standardize labeling of various bio-based, biodegradable, and compostable plastics to aid in education efforts.
- There are funding opportunities that can be used to target education, waste reduction, composting, as well as recycling equipment, support structures, and demonstration projects through the Missouri Department of Natural Resources (MoDNR) Solid Waste Management District Grants. These grants are open to local governments, small and large businesses, schools, sheltered workshops and individuals.

USE

Findings: Alternative options for plastic bags were surveyed among restaurants, grocery stores, and convenience stores; alternatives were not common among the businesses surveyed. Alternatives to plastic bags consisted of paper bags (13%), which were offered at three restaurants and one gas station. The CIL team documented 50 alternative options for common household single-use plastic items. The alternative products were on average more expensive per unit. In 2015, Missouri passed a pre-emptive law preventing legislators from banning single use plastic bags.

Opportunities:

- Local government and businesses could explore ways to encourage or offer common goods in bulk rather than individual packages. For example, personal care products like detergent and soap can be sold through bulk refill stations.
- There is an opportunity for local businesses to lead efforts in waste minimization around commonly supplied plastic items. For example, private retail businesses can choose to implement a 'bring your own bag' policy or fee for using store-provided bags. Privately owned restaurants and food vendors can similarly explore alternative 'to go' containers and a 'straw by request' policy.
- To encourage leadership and innovation among businesses, the city could highlight efforts by local businesses to reduce plastic use, and/or offer financial incentives for businesses that participate in plastic reduction.

- As more complex plastic alternatives are introduced to the waste stream, more education efforts will be needed to combat misleading product labels and encourage appropriate management by individuals and households.

COLLECTION

Findings: The City of Cape Girardeau provides curbside trash, recycling, and yard waste collection to 9,000 households. Plastics are not included in the list of materials picked up curbside to be recycled. There are several private haulers for residential and commercial waste in the area as well. Residents also have the option to drop-off trash, bulky items, and appliances at the Transfer Station located in town.

Opportunities:

- The state of Missouri along with the District R Solid Waste Management Plan, which Cape Girardeau falls under, had set a goal to reduce solid waste going to the landfill by 40%; this goal was met in 2009. The current focus of the state and district to fund recycling efforts and education programs focuses on recycling at a local level. A new recycling or zero-waste goal set in motion by the state or district would provide a clearer vision and guideline for local municipalities to follow when allocating funding and providing solid waste services to the community.
- At present, there is no infrastructure in place to recycle plastics #1 and #2, plastic bags, plastic wrap and film, wax- or plastic-coated cups, plastic lids, and polystyrene foam. Efforts to reduce the usage of these items at the local level could include awareness campaigns encouraging residents to adopt reusing behavior such as bringing their own mugs and cups to take-out restaurants, bringing their own bags to retail venues, and exploring other alternative options in their day-to-day lives to suit their needs

END OF CYCLE

Findings: Landfilling is the primary form of waste disposal in Cape Girardeau; all of the trash collected in Cape Girardeau gets transported to the Lemons Sanitary Landfill in Bloomfield, MO, operated by Republic Services. All recycling collected is taken to the city's Transfer Station and handled by Republic Services. There is no Recycling Center in town to separate the single-stream recycling waste, but the city can separate and bale cardboard to be sold. There are no industrial composting facilities in Cape Girardeau.

Opportunities:

- Landfilling is the most prominent form of waste management in Cape Girardeau and throughout Missouri. There are ample opportunities to explore diversion strategies through other end-of-cycle outlets like recycling and composting as well as upstream efforts like waste reduction. The most accessible model for sustainable waste management may be sustainable material management approaches that prioritize net reduction in the environmental, social, and economic impacts of waste. Then circular economy and zero waste scenarios may be more appropriate later on as Cape Girardeau develops its own comprehensive approach to improving plastic waste management.
- There are several opportunities through the federal and state government, as well as nonprofits, for financial assistance through grants and trust funds that support the development of waste management planning and programs, post-closure management of landfills, and collection and enforcement objectives.

LEAKAGE

Findings: Nearly 1500 littered items were recorded by the CIL, with plastic fragments being the most common material type. Plastic debris characterizations were similar across population areas, however, some differences in concentrations existed likely due to the level of activities and societal activity in each transect location. For example, the highest litter density was found in the low population areas, while the highest plastic proportion was also found in the upper population areas. Illegal dumping is a concern in the region, which mirrors a challenge faced throughout the United States.

Opportunities:

- The city and local partners could revisit the CAP litter transects and/or areas that have different waste collection schemes to generate comparable data to identify patterns and gaps and inform best practices.
- There may be several opportunities for public education initiatives. Given the prevalence of tobacco-related litter in the high, middle, and low population count areas, educational schemes combined with increased infrastructure targeted toward tobacco waste disposal may be beneficial in reducing the prevalence of those items in the environment.
- Collecting data at cleanup events can help to elicit an understanding of what is cleaned up as well as provide tangible outcomes that encourage and validate volunteer participation.

Strengths

- Most products in Cape Girardeau sampled as part of this project originate from manufacturers and production companies located in the USA, showing that there is a large market in the city for domestic products that can be leveraged for innovation and collaboration with producers and manufacturers.
- Landfill infrastructure is well-established in the region and the Lemons Sanitary Landfill has a reasonable remaining lifetime capacity. Although the city may ultimately want to move toward advancing diversion efforts, this is the current scenario for collecting waste and preventing it from reaching the environment or contaminating other waste streams like recycling. There was a 40% landfill reduction goal in the region as well.
- Local businesses can lead the way forward by creating incentives and retail policies that discourage the use of single-use plastic bags and containers.
- The small population and location of Cape Girardeau mean that communication and education campaigns may be easily communicated across households, as well as businesses. Additionally, this supports the opportunity for efficient coordination between the public, the business community, and the local government to collaborate on efforts to manage plastic materials.
- There are several outlets for waste collection including city-provided services as well as private companies, which help to reduce the burden on the local government's resources.
- Although not an ideal situation, cigarette butts, as one of the major plastic debris items in the community, provide a clear target for reducing plastic pollution through education and enforcement efforts.
- There are several funding opportunities and resources through grants, loans, and trust fund programs across the state and federal government as well as nonprofits and private businesses.
- The MoDNR Waste Characterization data from their 2016 report is a good resource to reference when planning future waste diversion facilities such as increased recycling or composting infrastructure.

Table of Contents

Introduction

As of 2023, the United States (USA) is home to a population of 333 million people (US Census Bureau 2022) and has an average waste generation rate of 2.24 kilograms per person per day, which is more than twice the global average rate of 0.74 kilograms per person per day (Kaza et al. 2018). As a high-income nation, waste management in the USA is considered advanced due to its well-designed and regulated waste management infrastructure providing high coverage of the country's growing population waste needs. These advanced waste management capabilities are met with some of the highest rates of consumption in the world, with the USA generating the largest mass of plastic waste (42 million metric tons in 2016) in the world (Law 2020). Paper and paperboard comprise the largest percentage of U.S. waste composition, followed by organic materials such as food waste (23%), and plastics (12%). While nearly 100% of waste is collected in the USA, plastic waste is generally disposed of via landfill (76% by mass), combustion (12%), or recycling (8.7%) (US EPA 2020). However, the USA has gained attention in recent years for exporting some of the highest quantities of plastic scrap out of the country for management elsewhere, often to developing countries (Brooks et al. 2018, Law 2020). Further, an estimated 0.28 million metric tons of plastic waste are mismanaged in the USA, with an estimated 0.51-1.45 million metric tons lost to the coastal environments in the USA (Law 2020). The focus of this CAP project was to look at how plastic and organic materials circulate through the Cape Girardeau community.

As one of the largest countries in the world, both in terms of population and land coverage, the USA has substantial variation in infrastructure and development across regions, states, and cities. For example, the city of Seattle generates 0.95 kilograms per capita per day (Kaza et al. 2018) compared to 3.6 kilograms per person per day in Miami (Circularity Informatics Lab 2021). Substantial focus has been given to large cities and states with progressive waste management strategies, yet there is a lack of focus and funding for regions that need assessment to develop appropriate, context-sensitive solutions. In the state of Missouri, an estimated 5.8 million tons were disposed of in 2016, of which 2.2 million tons were MSW (MoDNR 2018).

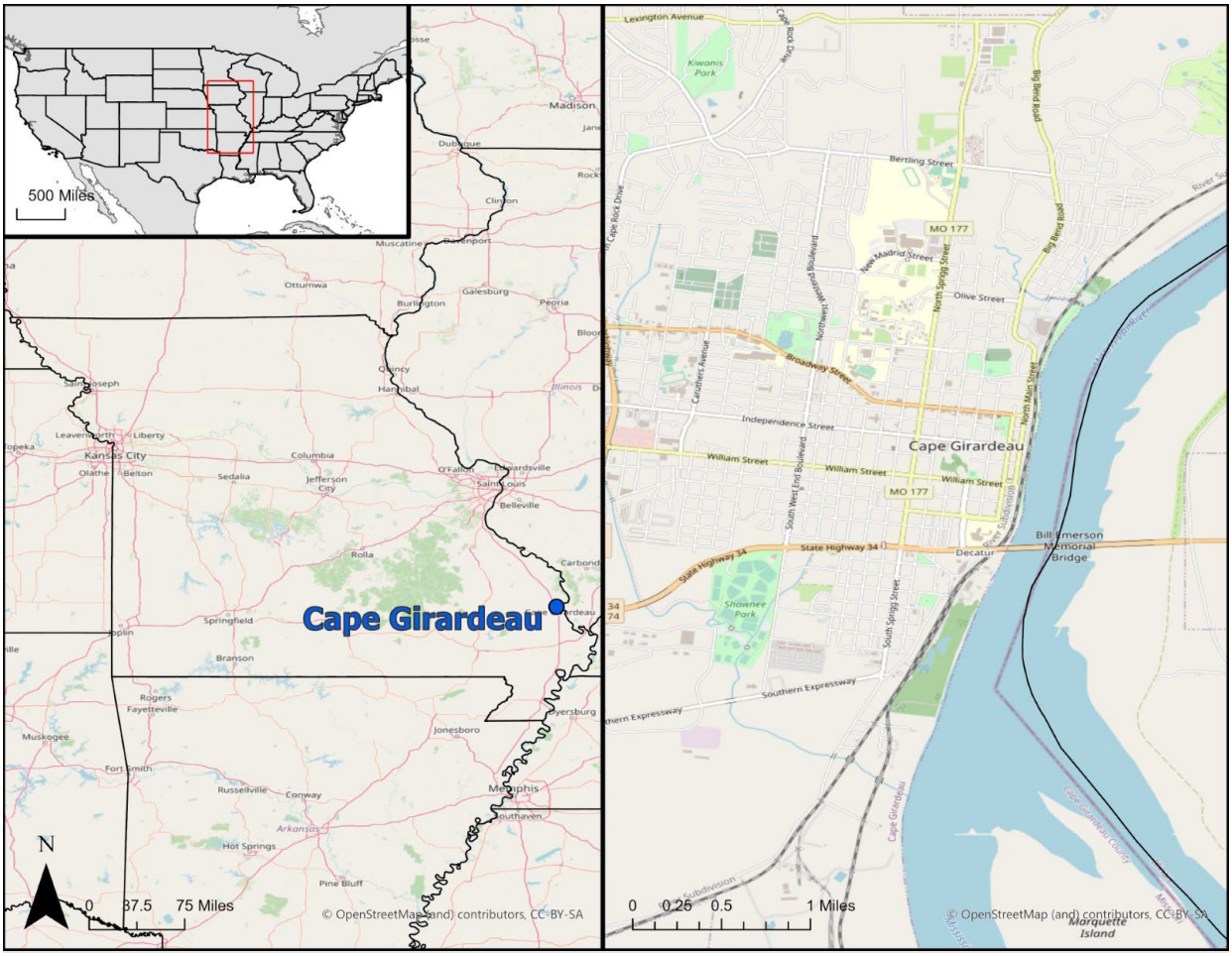
Cape Girardeau, Missouri is situated along the Mississippi River, about 115 miles south of St. Louis, Missouri. White people comprise the largest racial group (78%) followed by Black people (14%). The median household income is around $48,000 USD and 22% of residents live below the federal poverty line (US Census Bureau 2020).

Cape Girardeau is home to Southeast Missouri State University with about 8,000 students, making it one of the larger employers in the city. The largest industry in the city is healthcare, with two healthcare systems located in the city. It is estimated that about 90,000 people, more than double the population, come to Cape Girardeau each day for work, school, or to visit the doctor (City of Cape Girardeau 2024). With the opening of the Bill Emerson Memorial Bridge in 2003, travel between Missouri and Illinois is easier allowing approximately 26,000 cars to cross each day (City of Cape Girardeau 2024).

The quantity of people that travel into or through Cape Girardeau leads to more than 266,000 pounds of solid waste being picked up weekly door-to-door by the Department of Public Works (Cape Girardeau 2024). The waste is taken to the Cape Girardeau Transfer Station before it is transferred to the Republic Services Lemons East Sanitary Landfill about 50 miles from Cape Girardeau (Cape Girardeau 2024). Cape Girardeau is in Missouri's Region R Solid Waste Management District; its central goal, set in 1990, was to

achieve the state's goal of reducing materials going to landfills by 40%, there have been no quantified recycling goals, but there is financial support available for locally implemented educational programs on an application basis (MoDNR 2019).

Figure 1: Overview map of survey area

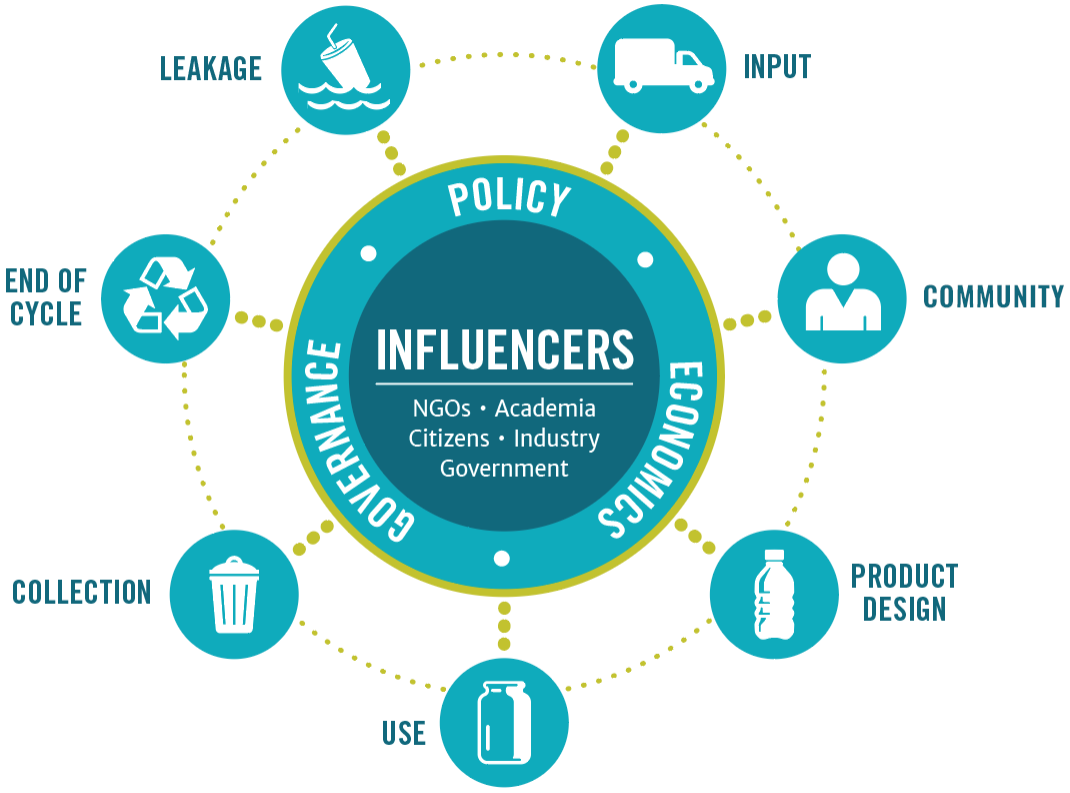


The Circularity Informatics Lab (CIL) at the University of Georgia (UGA) developed the Circularity Assessment Protocol (CAP) in 2018, which is a standardized assessment protocol used to collect community-level data to inform decision-makers (Figure XX). The CAP characterizes seven community components:

1. **Inputs** – What products are sold in the community and where do they originate?
2. **Community** - What conversations are happening and what are the stakeholders' attitudes and perceptions?
3. **Product design** - What materials, formats, and innovations are found in products, particularly packaging?
4. **Use** – What are the community trends around use and reuse of product types?

5. **Collection** – How much and what types of waste are generated? How much is collected and what infrastructure exists?
6. **End-of-cycle** – How is waste disposed? What is the fate of waste once it is properly discarded? How is it treated?
7. **Leakage** - What waste ends up in the environment? How and why is it getting there?

Figure 2: Circularity Assessment Protocol (CAP) hub-and-spoke model.

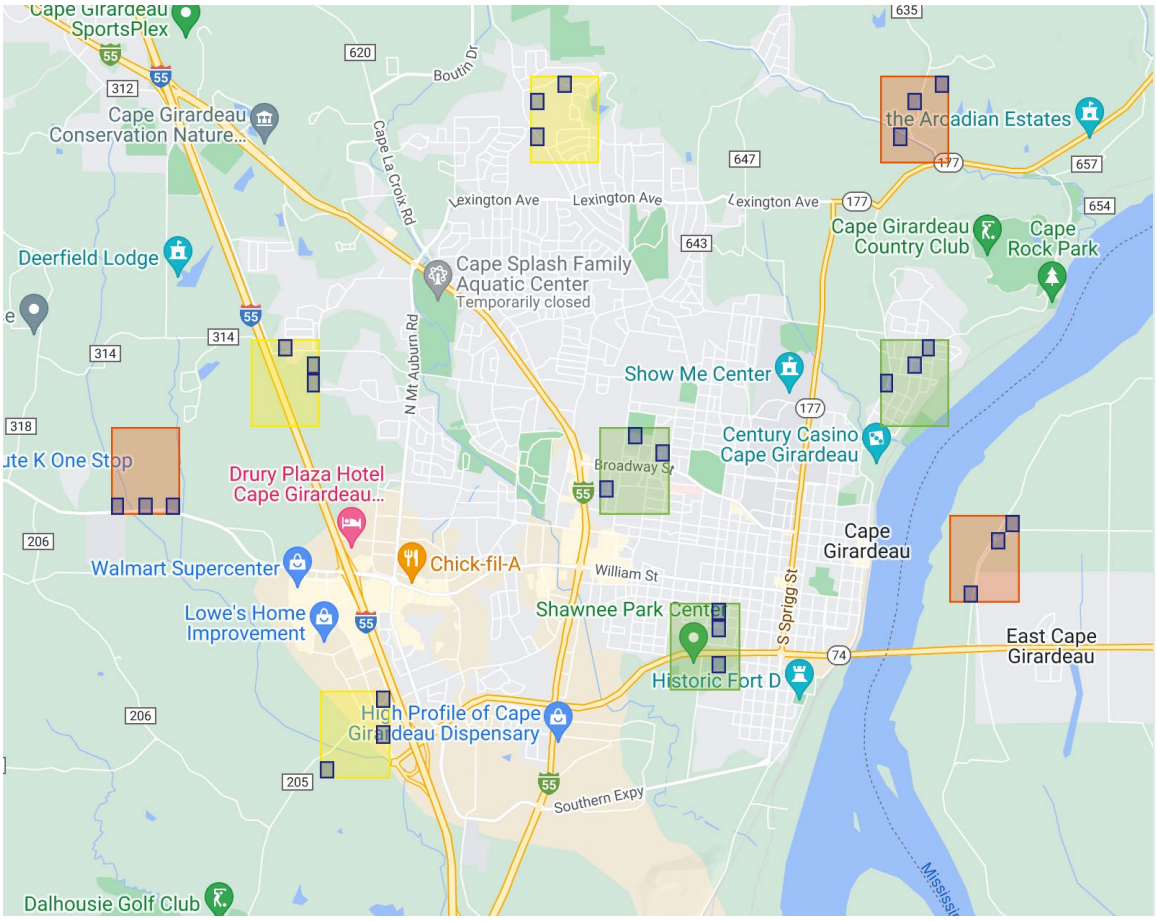


In October of 2022, a team from the Circularity Informatics Lab conducted fieldwork in the city of Cape Girardeau, Missouri with support from the Mississippi River Cities and Towns Initiative (MRCTI) and the city's local government. This CAP was conducted with the support of the Walmart Foundation. The CAP report is split into the following sections, which include results and discussion of each: Input, Community, Product Design, Use, Collection, End of Cycle, and Leakage, followed by Opportunities. The intent is for the data in this report to inform ongoing stakeholder engagement around solutions to strengthen the circular economy and waste management in Cape Girardeau, MO.

Sampling Strategy

To randomly sample various locations in a city, the CAP typically identifies a 10 x 10km area over the city (with the center of the city in the center of the area). In this area, the ambient population is sectioned into three groups, or 'tertiles' (Figure 3). Ambient population count can be described as "where people go" and "societal activity" — it is not population density of where people live. These three areas typically form samples of different land uses and higher and lower trafficked areas of a city.

Figure 3: Population tertiles and survey sites in Cape Girardeau.



Typically, three 1 x 1 km surveying areas are randomly selected within each population tertile using NOAA's Sampling Design Tool, resulting in nine 1km2 areas for surveying. In total, 9 sites were surveyed, three in each of the high, middle, and low population count tertiles.

Input

In 2020, the USA and its partner countries in the North American Free Trade Agreement (NAFTA) contributed to 19% of the world's plastic production, producing about 70 million metric tons of plastic products. According to the Plastics Industry Association, nearly 18,810 people (or about 0.3% of the 2022 state population) in Missouri are employed in the plastics industry, including professions related to processing and marketing. Similarly, 843,230 people (about 14% of the 2022 state population) work in plastic-dependent industries (US Census Bureau 2022 and Plastics Industry Association 2024). Missouri is ranked 21st in plastics industry employment in the country.

To get a snapshot of the characterization, scope, and source of common plastic packaged items that are entering Cape Girardeau, samples of fast-moving consumer goods (FMCG) in four popular categories were taken within the nine 1 km^2 transects in Cape Girardeau. The team selected three convenience or grocery shops to sample within each 1km2 transect area, where shops were present and open at the time of surveying. In total, 240 unique brands of convenience products were collected and sampled, including 130 candies, 49 chips, and 61 beverages (Figure 4). Samples of identical brands were not collected multiple times, even when present in multiple stores. Common brands of tobacco products were also visually assessed in stores, although samples were not purchased. In total, 22 brands of cigarettes are included in the input analysis.

Figure 4: Typical convenience store packaging in Cape Girardeau

For each of the top products documented, the team noted the type of packaging (including polymer, if possible), the brand, and the parent company. From there, the team was able to determine the manufacturing location, which was determined from manufacturing locations listed on product packaging or through desktop research, as well as the headquarters location for the parent company of the brand

(largely determined by desktop research). It should be noted that manufacturing locations for products in the USA are often difficult to find as companies are not required to provide this information online. Therefore, if the manufacturing location of a product was unable to be found, the parent company location was used as the manufacturing location for the estimations in this study. Manufacturer and parent company distances (Table 1) are intended to estimate the distance in kilometers between the city and the origin of each product.

The top brands of each category were determined based on a visual assessment of shelf space in each store, conversations with shopkeepers, and repeated occurrences of the brands across all stores. These top brands consisted of the following:

- **Beverages**: Coca-Cola, Powerade, and BODYARMOR
- **Candy**: Reese's, Snickers, and Skittles
- **Chips**: Lay's, Cheetos, and Doritos
- **Tobacco Products**: Camel, Newport, Marlboro, Grizzly, Sonoma, City Life, Swisher Sweets, and USA Gold

Average distances for each product category were similar for product manufacturers. However, the average distance to parent companies was the greatest for candy (3,269 km), followed by beverages (1,818 km), and chips (1,665 km). For parent companies, candy had the highest average distance. Beverages had the highest maximum distance for parent companies (14,597 km) with some product parent companies being located in Sydney, Australia. In contrast, drink items had the lowest minimum distance to manufacturers and parent companies, with the nearest source manufacturer and parent company being only 90 km from stores located in Cape Girardeau (Table 1). Based on the origins of the convenience categories, regional distribution of products in the United States was common among both manufacturers and parent companies. All beverage and chip manufacturers were located within the USA, while candy had some products manufactured in China, Canada, Mexico, and Italy. Within the USA, Pennsylvania, Illinois, and New Jersey had the highest proportion (15%, 13%, and 13% respectively) of manufacturers, together making up 41% of all manufacturers. Of the products surveyed, 9 were manufactured in Missouri, which include the following: H2O Technologies LLC, Save A Lot, LTD, Schnuck Markets, Inc., Vess Soda, Russel Stover Chocolates, LLC, and Old Vienna LLC. Additionally, 18% of the products surveyed were manufactured in the neighboring states of Arkansas, Illinois, Iowa, Kentucky, and Tennessee, as seen in Table 2.

Table 1: Distances between Cape Girardeau and manufacturer and parent company locations for top FMCG convenience items

	Length Store to Parent Company (km)				Length Store to Manufacturer (km)			
	Minimum	*Maximum*	*Avg*	*Median*	*Minimum*	*Maximum*	*Avg*	*Median*
Beverages	90	14,597	1,818	1,443	90	3,544	1,284	1,348

Candy	541	10,441	3,269	1,250	210	11,152	1,542	1,250
Chips	226	10,441	1,665	1,494	226	3,531	1,420	1,192

*Note: Distances were projected using an Azimuthal Equidistant projection. Values have been rounded to the nearest km.

Like manufacturer locations, parent company locations were heavily concentrated in the USA. By product category, many candy and beverage items had parent companies located outside of the USA. Chips had all but one parent company located in the USA, with the outlier being located in Japan (Figure 6). Of all 239 parent company locations, 192 (80%) were in the USA, followed by 8% in Italy, 2% in Germany, and 2% in the UK. Additionally, for the states in the USA, Pennsylvania had the highest proportion (15%) of parent companies for products sold in Cape Girardeau followed by New York, Virginia, Illinois, and Georgia which all together comprised 31% of all parent company locations. Of the products surveyed, 5 had parent companies located in Missouri: H2O Technologies LLC, Old Vienna LLC, Russell Stover Chocolates, LLC, and Schnuck Markets, Inc. Additionally, 10% of parent companies were in neighboring states like Arkansas, Illinois, Iowa, and Tennessee.

A handful of states in the USA have implemented Extended Producer Responsibility (EPR) policy legislation that encourages producers of products to bear some responsibility for their end-of-life management. Generally, EPR legislation requires packaging producers to join a producer responsibility organization (PRO), or stakeholder organization, to develop a plan and manage the program (Sustainable Packaging Coalition 2022). EPR can take many forms, but common approaches throughout the world and the USA include product-take-back and deposit-refund schemes as well as waste collection and take-back guarantees (UNEP 2018). The plastics industry in the USA tends to oppose EPR schemes arguing that waste management relies on consumer practices and behaviors (Nash and Bosso 2013), and that the schemes can lead to increased costs, food waste, and life cycle impacts (ACC 2021). At current, Missouri has a statute which requires manufacturers to have a recovery plan for desktops, e-readers, laptops, monitors, and tablets (Missouri State Legislature 2008 and NCSL 2023). EPR schemes are typically supported by state-level governance, suggesting that Cape Girardeau state-level representatives could advocate for more legislation targeting EPR efforts or engagement with packaging producers. There is an opportunity to partner with manufacturers and parent companies local to Missouri or in the neighboring states shown in Table 2. EPR can be a requirement of the companies doing business in a state no matter where products are manufactured, or where companies are located. A full list of parent companies and manufacturers documented across the Cape Girardeau product surveys is available in the Appendix.

Figure 5: World Map displaying manufacturing locations for top convenience items in Cape Girardeau

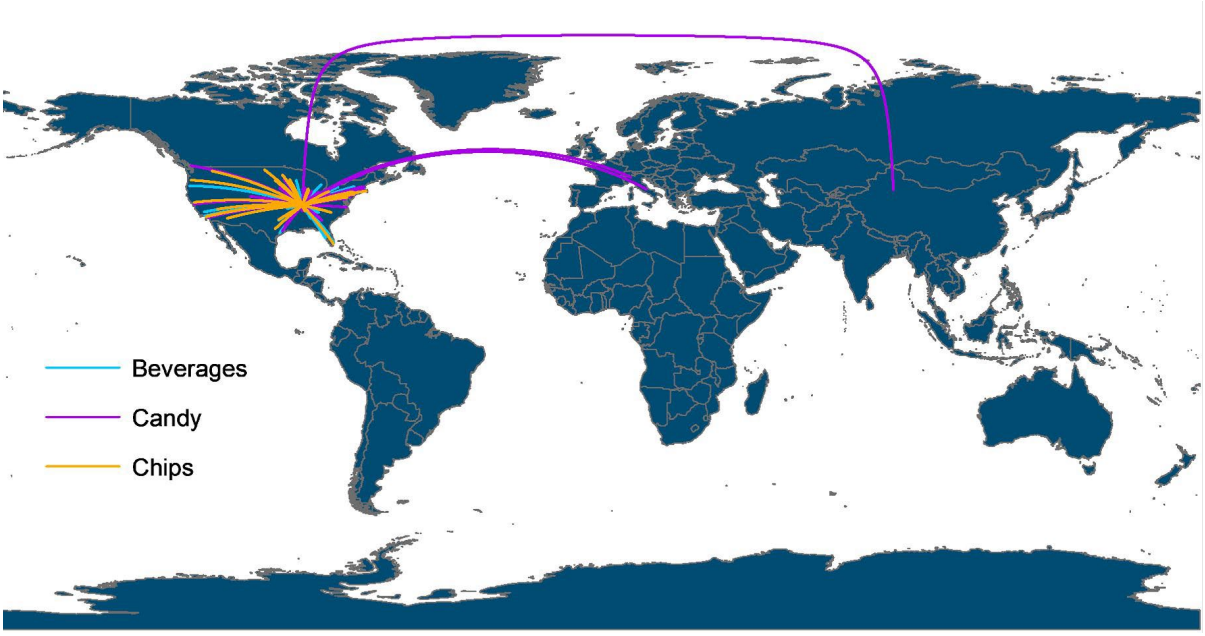


Figure 6: World Map displaying parent company locations for top convenience items in Cape Girardeau

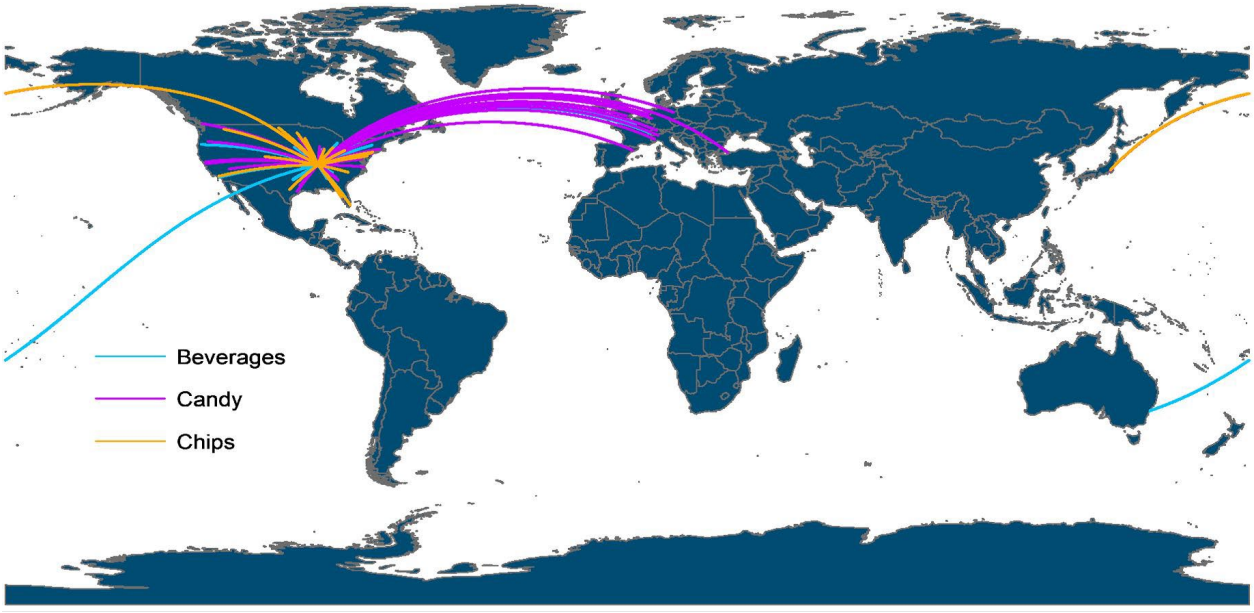


Table 2: Domestic products and materials produced or manufactured in states neighboring Cape Girardeau, MO

Neighboring state **Company name**	**Product category**	**Packaging types**
Arkansas		
Sam's West, Inc.	Beverage	PET; hard plastic; film
Greenbrier International, Inc.	Candy	Film
Illinois		
Aldi	Beverage	PET; hard plastic; film
Gushers	Candy	Multilayer plastic
Excel Bottling Company, Inc.	Beverage	PET; hard plastic; film
The Gatorade Co.	Beverage	PET; hard plastic; film
Ferrara Candy Company	Candy	Film; multilayer plastic; hard plastic; coated paper
Storck USA LP	Candy	Film
Tootsie Roll Industries, LLC	Candy	Film; multilayer plastic; coated paperboard
Evan's Food Group LTD	Chips	Film
Conagra Brands	Chips	Multilayer plastic
Walgreen Co.	Candy	Film
Prairie Farms Dairy, Inc.	Beverage	HDPE
Pepsi Mid America	Beverage	PET; hard plastic; film
Haribo of America	Candy	Film
Popcorn Indiana	Chips	Multilayer plastic
Iowa		
The Foreign Candy Company, Inc.	Candy	Multilayer plastic; film
Palmer Candy Co.	Candy	Multilayer plastic; film
Missouri		
H2O Technologies LLC	Beverage	PET; hard plastic; film
Save A Lot, LTD	Beverage	PET; hard plastic; film
Schnuck Markets, Inc.	Beverage	PET; hard plastic; film
Vess Soda	Beverage	PET; hard plastic; film
Russel Stover Chocolates, LLC	Candy	Multilayer plastic
Old Vienna LLC	Chips	Film
Kentucky		
Perfetti Van Melle	Candy	Film; hard plastic
Tennessee		
CG Roxane	Beverage	PET; hard plastic; film
Charms	Candy	Multilayer plastic
Pringles Manufacturing Co.	Chips	Multilayer canister; hard plastic
Pepsico	Beverage	PET; hard plastic; film

Community

To understand current attitudes and perceptions of plastic waste, interviews were conducted. In Cape Girardeau, as a smaller community, the interview took place as a group discussion with the Mayor, the Director of Public Works Assistant Director of Public Works and the Head of Solid Waste. In addition, Jennifer Wendt from MRCTI was present, along with 3 staff members of CIL. A summary of the discussion is provided below.

At the time of this interview (Ort 25, 2022), the city had a contract with Republic Services for solid waste and recycling collection. The waste goes to a landfill (Lemons East Landfill near Bloomfield) and recycling goes to a transfer station. Recycling is single stream with no glass accepted. The household routes for collection are set up on a 4-day basis with, for example, trash collected on Monday and recycling on Thursday. Residents pay for trash and recycling in one bill. Further details on collection and management will be in each respective section.

In the area of I-55 and Kings Highway, MODOT maintains the grass and conducts litter cleanup – this could occur more frequently. Cape Girardeau does have an adopt-a-street program through the city. They provide bags to the 203 groups that do this volunteer program. The Parks Department has also worked with these groups in the past. There is an annual cleanup with Keep Cape Beautiful that a lot of community members come out to, there is a cook-out to go along with it as well.

According to city staff, litter is sporadic. Some spots where they observe it are south and east side near the college, Reno Park Area where people gather, around fast food restaurants, gas stations, and next to trash containers. In some of the older parts of the cities, there are alleys that make collection of waste challenging, although the city will help people that may need it by taking an old truck down the alleys to pick up waste from those that cannot bring it out. Nuisance abatement can clean up litter in alleyways, which is usually illegal dumping like mattresses and furniture. MODOT has an adopt-a-street program as well and Highway 74 is covered by MODOT. In terms of solid waste fees (more given in the Collection section), the city staff note that there is a state law that you can't increase a fee without a vote.

Product Design

To characterize material types used in common consumer products, samples of common convenience were obtained as described in the Input section. The CIL team sampled stores in each of the nine 1km2 transects areas. At least 30 unique forms and brands were purchased to obtain packaging weights. The average weight of both the packaging and the product itself was collected for all samples (Table 3).

Table 3: Average weight of products and their plastic packaging for common convenience items.

Product Type	Number of Samples	Average Weight of Plastic Packaging (g)	Average Quantity of Product (g or mL)
Beverages	61	32	543

Candy	130	4.5	80
Chips	49	4.8	64

In total, 14 convenience and grocery stores were sampled across the transects. Two of the stores were large grocery chains such as Target and Walmart. Two were pharmacy chains like Walgreens and CVS. Three were convenience stores such as The Outlet, Capemart, and Depot City Mini Mart. The remainder were seven gas stations such as Amerimart, Phillips, and Mobile. 239 items were sampled. Beverages had both the highest product mass and packaging mass (Table 3, Figure 7), largely due to the high density of liquid product as well as the higher density polyethylene terephthalate (PET) commonly used in plastic bottles. Candy had a high product mass and chips had a lower product mass compared to other CIL assessments. However, their weight of plastic packaging is in alignment with another USA-based CAP conducted in Vicksburg. Packaging for both candy and chip products consisted largely of multilayer film, but there were some instances of cardboard, hard plastics, paper, and foil among candy packaging (Figure 8). Multilayer film is difficult and costly to recycle due to the varying characteristics that give it a low mass, which makes it difficult to capture in recycling machinery and provide less material value (Moss 2017). Its food preservation capabilities are also reflected in the multiple layers, which make it difficult to isolate individual materials within the packaging for recycling.

Cigarettes were excluded from the purchasing of samples in this case, but cigarettes generally have an average of about 10 g of plastic packaging to about 15 g of product. This relatively high plastic packaging to product ratio means cigarettes generate larger amounts of plastic waste per unit of product, which is likely driven by the cellulose acetate filters in cigarette butts that typically weigh about a gram each.

Together, beverage products and packaging had the greatest mass by far of the three product types (Figure 7). However, when considering the ratio of packaging to product, chips were more substantial with 0.08 g of packaging for every gram of product, compared to candy and beverages which both had a ratio of about 0.06 g/g. As such, chips generate the most packaging waste per unit of product delivery out of the three categories. Reducing the ratio of plastic packaging to product through minimal packaging design and/or increasing quantities of products can make product delivery more efficient (Youngblood et al. 2022). For each convenience item surveyed, the CIL team also documented the polymer/packaging type (Figure 8).

Figure 7: Convenience store plastic to product ratios, shown in grams (not including unknown products or tobacco as there is no weight data for tobacco)

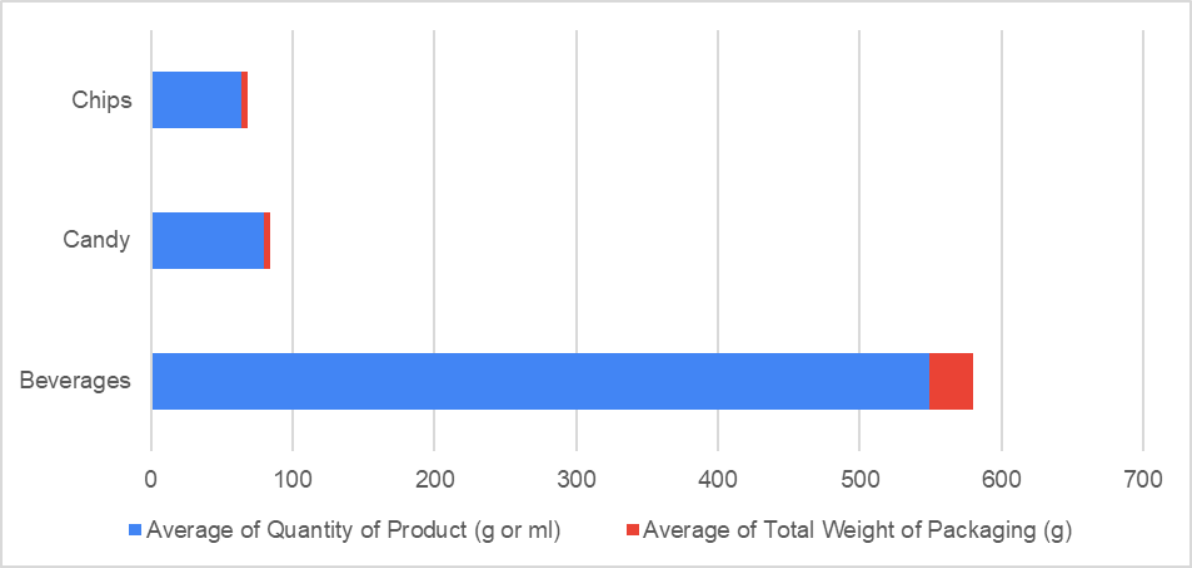
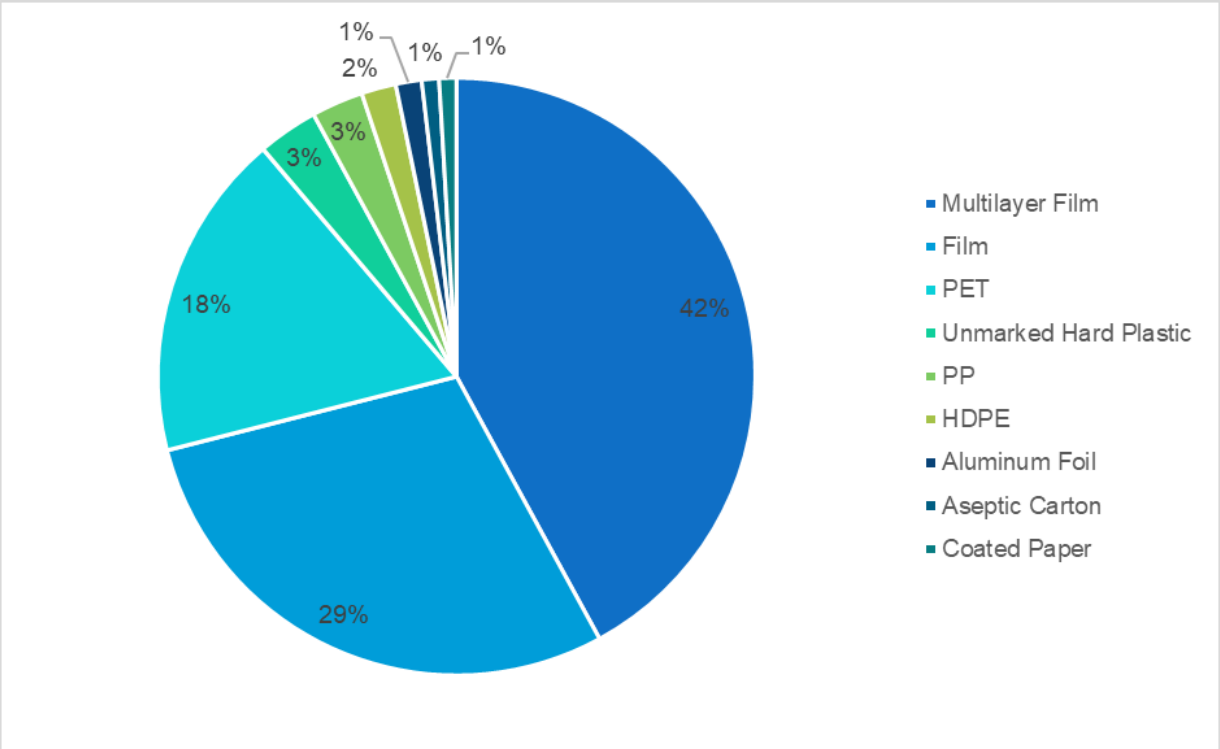


Figure 8: Material breakdown of top convenience items in Cape Girardeau



In addition to surveying convenience and grocery stores, the CIL team surveyed restaurants in each of the nine 1 km2 transects areas. Through visual assessments and discussions with restaurant owners, we assessed the material type for to-go food items like containers (including their lids), cups, utensils, and

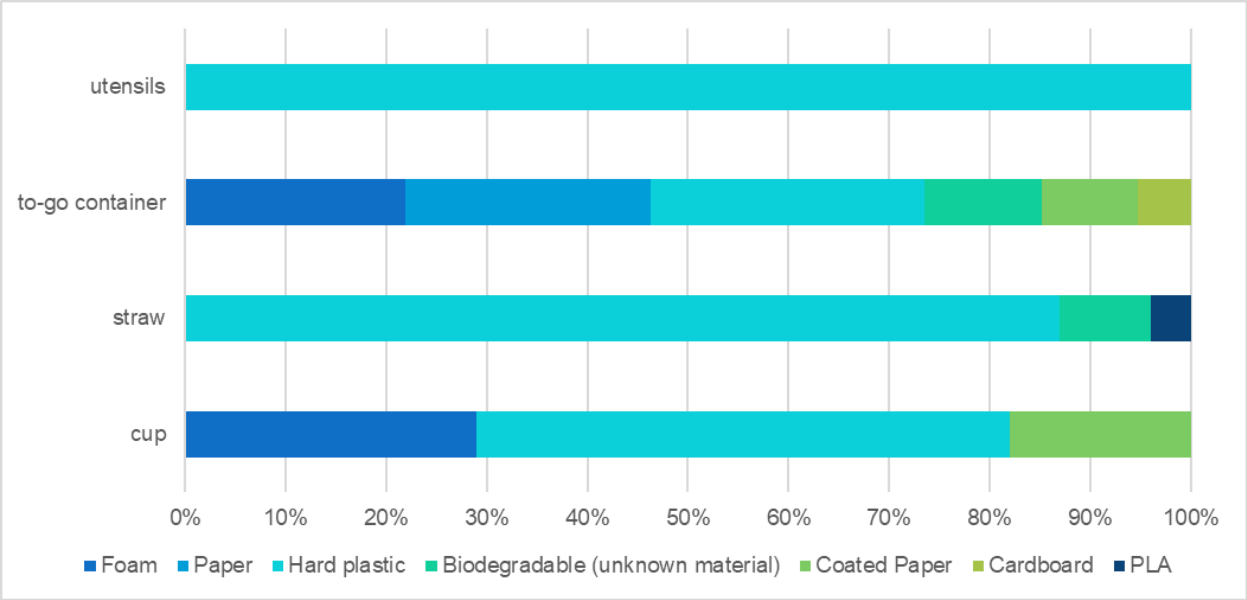
straws. Twenty-seven food vendors were sampled across the transects, of which six were national fast-food chains, six were convenience stores or delis, four were fast-casual restaurants, four were casual sit-down restaurants, three were full-service sit-down restaurants, three were local café and bakery vendors, and one was a brewery. Across these vendors, 200 takeout items were collected such as cups, straws, utensils, bags, etc. (examples in Figure 9). The most common items acquired were food containers and cups, both of which varied by material type. Most of the other items were generally comprised of one to three different material types. For example, all fourteen utensils obtained were made of unmarked hard plastic, while all 23 straws collected were made from unmarked hard plastic, polylactic acid (PLA), or other "compostable" materials. Often, PLA and other compostable plastics are only able to break down in an industrial composting facility, meaning that they are not compostable if they merely end up in the environment. By material type, 77% of the items were made of plastic, with the most common type being unmarked hard plastic items including utensils, lids, cups, and straws. Paper was the second most common material for food vendor take-out items including food containers, cups, and bags. Table 4 and Figure 10 summarize the food containers, cups, utensils, and straws by product type and material.

Figure 9: Example to-go materials surveyed in Cape Girardeau

Table 4: Products and material types surveyed in restaurants and food vendors.

Product	Material Type	Number of Observations
To-Go Containers (including lids if applicable)	Unmarked Hard plastic	6
	Foam	9
	Paper	9
	Cardboard	2
	Coated Paper	5
	PET	2
	PP	3
	PS Hard Plastic	1
Cups	Coated Paper	7
	Unmarked Hard Plastic	3
	Foam	11
	PET	8
	PP	7
	PS Hard Plastic	2
Straws	PLA	1
	Unmarked Hard Plastic	20
	"Compostable"	2
Utensils	Unmarked Hard Plastic	14

Figure 10; Material breakdown of to-go items surveyed in Cape Girardeau

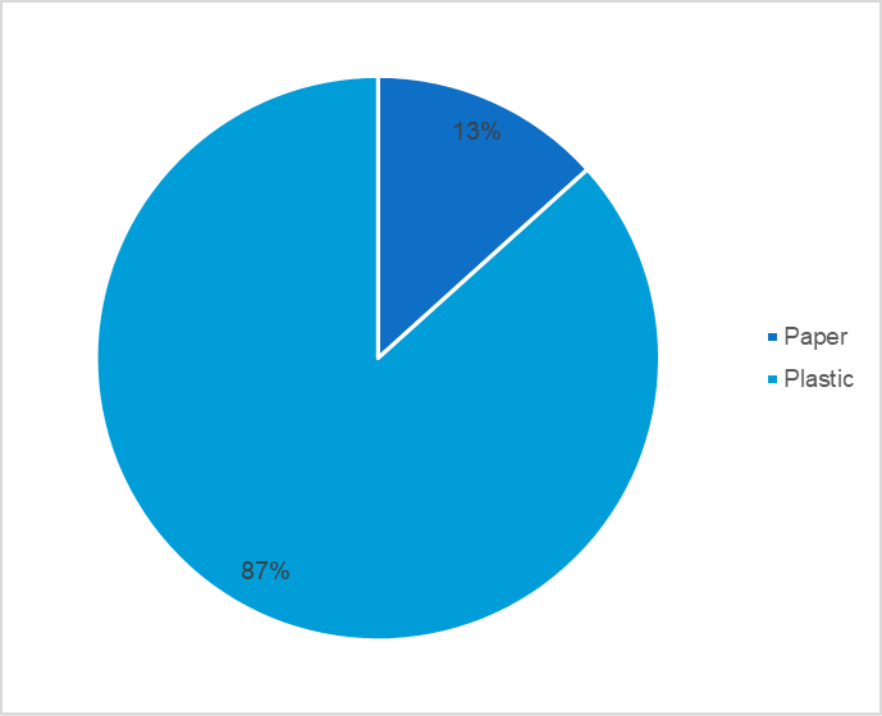


Use

Throughout the transects, the CIL team surveyed what types of bags business provided at check-out. A total of 27 bags were assessed across twenty businesses. These businesses consisted of 20 retail stores and 7 food vendors. Across the food vendors, 43% only offered plastic bags, 43% offered plastic and paper bags, and 14% offered paper bags. Similarly, the team surveyed twenty retail stores consisting of seven convenience stores, two drug stores, five gas stations, and six grocery stores. At all locations plastic retail bags were provided to customers at no additional cost. Of these plastic bags, 92% were made of HDPE.

Alternative options for plastic bags were not common among the businesses surveyed. Most bags offered by businesses were typical HDPE bags. Alternatives only included paper bags (13%) which were offered at three restaurants and one gas station. (Figure 11) Some of the grocery and convenience stores offered a small paper bag that is typically used for small items and alcohol only. As mentioned above, about half of the food vendors that offered bags used paper bags, but there were no discernable patterns indicating that bag type was related to vendor type (in other words, both plastic and paper bags were used by all vendor types). Customers shopping at large retailers such as Walmart, Dollar General, and Target have the option of buying reusable bags for the price of $0.99 - $1.99.

Figure 11: Material breakdown of bags surveyed from convenience and grocery stores and restaurants



In addition to plastic bags, other common plastic items and their respective alternatives were examined by price, material, and disposability. Reusable items were generally much more expensive than disposable

and recyclable items. For example, the price of reusable sandwich bags ranged from $4,00 to $12.99 USD per unit, while single-use plastic bags cost $0.04 to $0.12 USD per unit. Similarly, items labeled as "compostable" were a typically more expensive alternative to disposable and recyclable items. For example, compostable straws were four times more expensive than their cheapest single-use plastic alternative. Of all the item types, reusable plastic storage bags (e.g., zipper sandwich bags) were the most expensive largely due to the use of more expensive synthetic materials (i.e., silicone and ethylene-vinyl acetate (EVA). The least expensive items were polypropylene straws (Table 5), which are generally not accepted in recycling waste streams due to their size, shape, and light weight characteristics which tend to get stuck in recycling machinery. Alternatives available at one grocery store are shown in Figure 12. Items like these were not available equitably across the city at the various types of stores.

It is worth noting that misleading nomenclature and public information can cause confusion due to confusing labeling on different types of plastic, particularly when it comes to "compostable" items. Based on the CAP survey, plastic items labeled as compostable were typically designated as having been made of natural and organic materials like bamboo, plant material, fiber, and sugar cane. Plastics marketed as "biodegradable" do not necessarily degrade in the natural environment as they do in laboratory conditions, with many biodegradable items requiring specific conditions provided in industrial composting facilities. Bio-based plastics can be chemically identical to fossil-fuel-based plastics but can be confused for compostable or biodegradable items. These items can also be mistaken as recyclable (Moss 2017). These subtleties can lead to consumer confusion due to uncertainty around material types and categories, as well as ambiguity around appropriate management. Recent studies highlight the challenges associated with bio-based and biodegradable plastics driven by the combination of inadequate legal provisions for effective collection and treatment, unharmonized waste collection infrastructure, and social attitudes and awareness around consuming, sorting, and managing these materials (Stasiškienė et al. 2022).

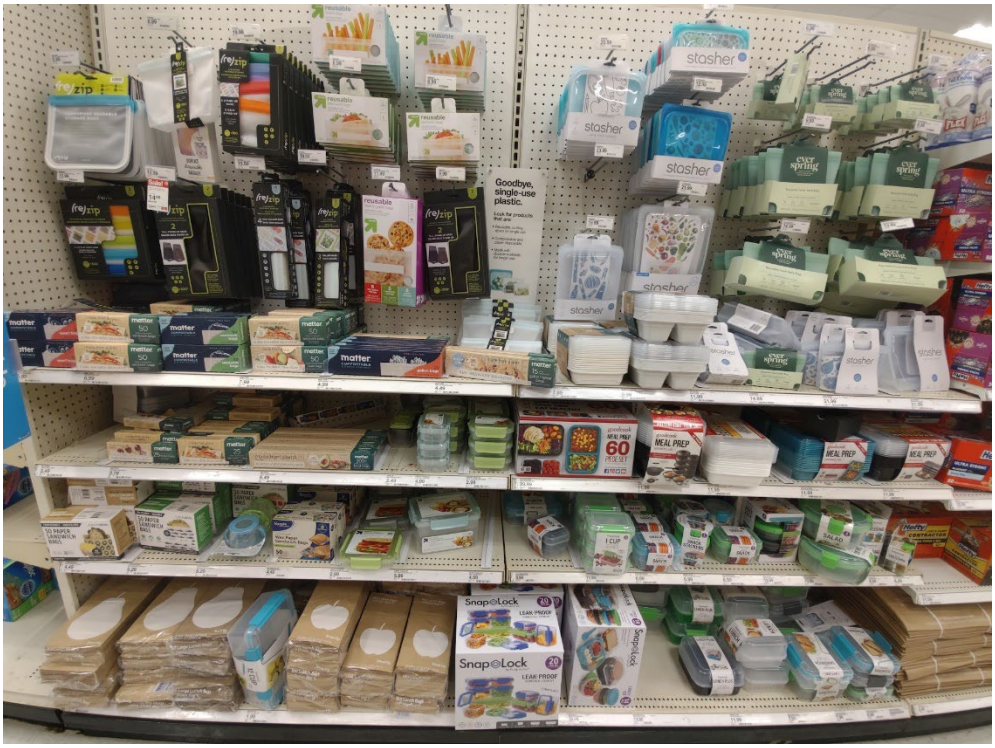
Table 5: Average cost comparison of alternatives and refillable alternatives available in Cape Girardeau of cost/unit (n=number of samples for average; if blank, n=1)

Material	Reusable	Compostable	Refillable	Refill	Biodegradable	Single-Use
Bathroom Cleaner						
Plastic			$0.0065	$0.0032		$0.0045
Body Wash						
Cardboard						$0.43 (n=2)
Plastic			$0.53 (n=2)			$0.15 (n=2)
Stainless Steel			$0.94			
Deodorant						
Cardboard					$0.12	$0.14 (n=3)

Plastic				$0.09 (n=3)
Stainless Steel		$0.32 (n=4)		
Food Wrap				
Made from Plants	$0.032			
Plastic				$0.013
Freezer Bags				
Made from Plants	$0.30			
Plastic				$0.21
Trash bags				
Made from Plants	$0.33 (n=2)			
Plastic				$0.20 (n=2)
Hand Soap				
Plastic			$0.0073	$0.0080
Multi-purpose Cleaner				
			$0.0054 (n=2)	
Cardboard				
Glass		$0.022 (n=2)		
Plastic		$0.0064 (n=3)	$0.0037 (n=2)	$0.0063 (n=4)
Parchment Paper				
	$0.084 (n=2)			
Paper				
Sandwich Bags				
Made from Plants	$0.16			
Paper	$0.095 (n=2)			

Plastic	$6.45 (n=5)					$0.017
Silicone	$10.24 (n=2)					
Shampoo						
Paper						$0.044
Plastic				$0.016		$0.017
Stainless Steel			$0.021			
Shower Cleaner						
Plastic				$0.0037		$0.0052
Snack Bags						
Made from Plants		$0.15				
Plastic	$0.75					$0.039
Silicone	$9.99					
Straws						
Bio-based Plastic		$0.082				
Plastic						$0.016
Average	**$5.86**	**$0.13**	**$0.17**	**$0.0023**	**$0.12**	**$0.088**

Figure 12: Alternative use section in grocery store in Cape Girardeau

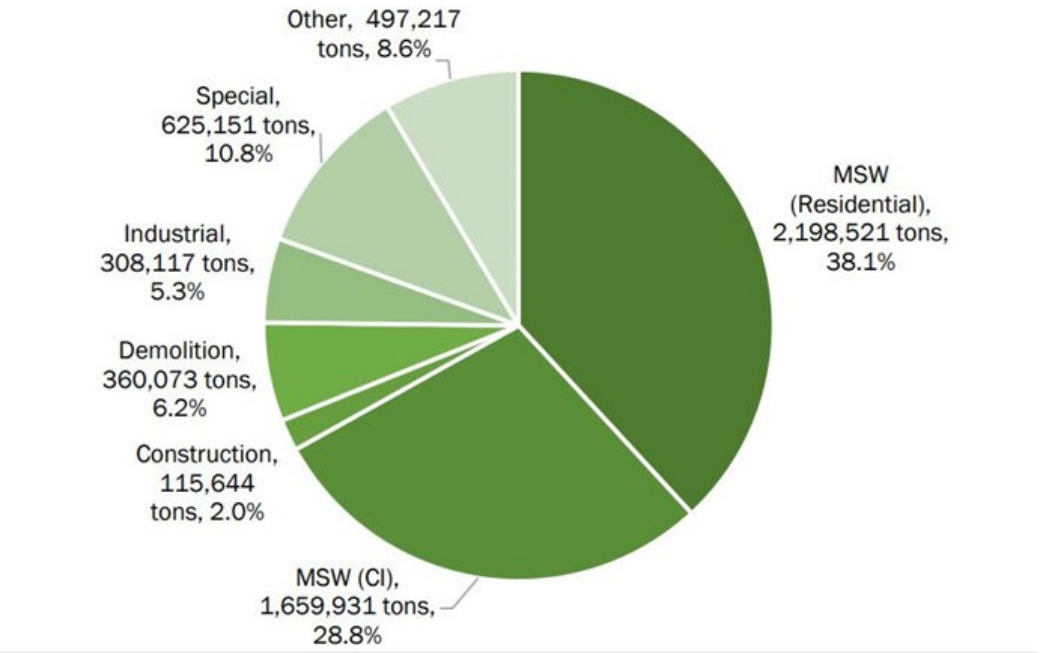


One common approach to reducing plastic consumption is through policy efforts, such as bans or fees, that disincentivize their use. Although plastic bag bans can be relatively non-invasive among consumers' day-to-day patterns, in the United States there are several examples of governments seeking to 'ban the ban'. In 2015, Missouri passed a pre-emptive law preventing legislators from banning single use plastic bags (Missouri State Legislature 2015). In 2020, one representative proposed House Bill 227 which would have repealed this state law and allowed cities to decide for themselves whether to introduce a single use plastic bag ban, but the bill died in committee (Negozio 2021). In terms of upstream management of plastic waste, this law undermines opportunities for material to become waste in the first place, which can be accomplished through reducing consumption of plastic products that in many instances can be easily replaced or avoided entirely like straws, bags, and many food containers. Policies related to other single-use plastic items, such as plastic beads in cosmetics, are lagging in the state as well. Despite being limited by government policy, the implementation of product bans or fees could still be carried out by private businesses in Cape Girardeau. Alternatively, businesses could explore cost-effective alternatives to bags or simply ask their customers to bring their own for a small discount on their purchase.

Collection

In 2016, the state of Missouri sent 5.8 million tons of waste to their landfills, a decrease from 6.2 million tons in 2007 (MoDNR 2018). Based on a waste characterization study conducted between 2016-2017, 2.2 million tons of this total, just over 38%, is Municipal Solid Waste (Figure 13). In addition to the waste generated in the state, as of 2003, Missouri imported 206,873 tons of waste per year (McCarthy 2004). The average Missouri resident generates over one ton of waste each year, which translates to about 2.5 kg of waste per person per day (MoDNR 2024). Compared to the national waste generation rate of 2.2 kg per person per day, Missouri residents have a higher waste generation rate per capita (Kaza et al. 2018).

Figure 13: Missouri Solid Waste Disposal by Waste Type from 2016 (MoDNR 2018)



In the USA, many cities mandate the provision of household waste collection. Typically, waste is collected via curbside bins, dumpsters, or drop off points. Trucks then transport waste to their final disposal site, or to transfer stations or sorting facilities that temporarily store waste for further transport over longer distances. Effective plastic waste management at the city level requires not just efforts toward waste reduction, but also consistent collection services. At present, successful collection of plastic waste relies heavily on behaviors at the household and individual level. As such, efforts toward education and incentivization strategies can help encourage behavior that helps waste infrastructure run smoothly. There are 20 solid waste management districts within the state of Missouri, and Cape Girardeau falls into District R, along with the cities of Perry, Bollinger, Madison, Ste. Genevieve, St. Francois, and Iron. (MoDNR 2019). As of 1990, the state of Missouri had a goal to reduce material going into the landfills by 40% through providing grants-in-aid to local organizations engaged in recycling efforts. According to the Missouri Recycling Association, this waste diversion goal was met in 2009 (MORA 2024). District R is focusing on supporting new, localized programs when they arise instead of quantifying recycling goals. Going forward, the district will slightly shift towards an emphasis on recycling education. (MoDNR 2019). The Missouri

Department of Natural Resources also provides an online directory that allows users to find local contractors, vendors, and drop off locations that offer recycling, reuse, and disposal services; this directory can be found in the Appendix.

The City of Cape Girardeau provides curbside trash and recycling pick-up services to over 9,000 households. The Public Works Department picks up over 266,000 lbs (about 120655.47 kg) of waste weekly through their curbside collection (City of Cape Girardeau 2024). The city provides a 96-gallon recycling cart and a 64-gallon trash cart, unless a smaller cart is requested. Their trash and recycling pick-up service is $25.66 a month and is billed monthly along with the water and sewer services. In addition to curbside pick-up, residents can drop off waste, bulky items, and appliances at the Cape Girardeau transfer station. The fees for the transfer station can be found in Table 6. If residents have bulky items they would like to be picked up, they can schedule a pick-up for their items through the Public Works Department on Wednesdays. Each resident is allowed one free bulky items pickup per calendar year. After the first pickup, bulky item pickups are charged based on how much time it takes to pick up the items. The prices for these pickups can also be found in Table 6.

Table 6: Service and Cost Table for Residential Waste Disposal in Cape Girardeau

Service	Cost
Residential Curbside Trash and Recycling Pick-up	$25.66/month
Transfer Station Drop-off Fees:	
General Disposal	$75.60/ton
Limbs and Brush	$74.60/ton
White Goods (Appliances)	$9/item
Minimum Disposal Fee	$6
Residential Bulky Items Curbside Pick-up:	
First Pick-up of a Calendar Year	Free
Bags, Boxes, and Limbs:	
1-6 Minute Pickups	$6
6-10 Minute Pickups	$12
10 Minute or Longer Pickups	$12 base charge plus $1.45/worker/minute
Large Items Pickup (Furniture, Refrigerators, Dryers, etc.)	$12

In addition to the waste collection services provided by the City, there are three other private haulers that service Cape Girardeau and the surrounding area. Waste Connections services Southeast Missouri State University, which is in the city of Cape Girardeau. Waste Connections also offers commercial and residential curbside trash and recycling pickup, leaf and limb litter pickup, and dumpster and compacter rentals. (Waste Connections 2024) (Figure 14). Republic Services, another private hauler to the area, picks up the trash from the hospital. They also offer residential and commercial trash and recycling pickup and dumpster rentals (Republic Services 2024). The third private hauler that exists in the area is Sonny's Solid Waste, who provide commercial, roll-off, and dumpster services within the Cape Girardeau city limits.

(Sonny's Solid Waste Service 2024). All trash goes to Lemons Sanitary Landfill in Bloomfield, MO, operated by Republic Services, while the recycling gets taken to the Transfer Station operated by the city.

Figure 14: Collection bin in Cape Girardeau

The city of Cape Girardeau operates a 24/7 drop-off recycling site that accepts paper, cardboard, metal, plastic, glass, and electronics. The city contracts with Midwest Recycling Center (MRC) so there is no charge to drop off any of the following materials: computers, speakers, non-CRT Monitors (flat screens),VCRs, printers, DVDs, keyboards, fax machines, laptops, answering machines, hard drives, stereos, cell phones, and microwaves. Motor oil, power steering fluid, transmission fluid, differential oil, and kerosene oil can also be dropped off at the recycling drop-off; these oils are used to heat the City's Fleet Maintenance area and the Recycling Processing Facility. The recycling collected via curbside operates on a single stream system that is able to collect corrugated cardboard, gray board, chipboard, newspaper, magazines, catalogs, junk mail, paper, aluminum, steel, and tin (City of Cape Girardeau 2024). All glass must be dropped off separately and is picked up by Rippel Glass based out of Kansas City, MO. There are additional drop-off locations for glass at the fire stations in Cape Girardeau (which was disclosed during

the stakeholder interview process). All recycling goes to the city's Transfer Station where they separate cardboard to be baled and sold separately. The rest of the recycling is hauled off by Republic Services. Plastic bags, plastic wrap and film, wax- or plastic-coated cups, plastic lids, and polystyrene foam are not permitted in the recycling stream for Cape Girardeau (City of Cape Girardeau 2023). As such, efforts to target reduction in these items may help to reduce the generation of those plastic items that cannot be recycled. Examples of these potential efforts could include awareness campaigns encouraging residents to adopt reusing behavior such as bringing their own mugs and cups to take-out restaurants, bringing their own bags to retail venues, and exploring other alternative options in their day-to-day lives to suit their needs.

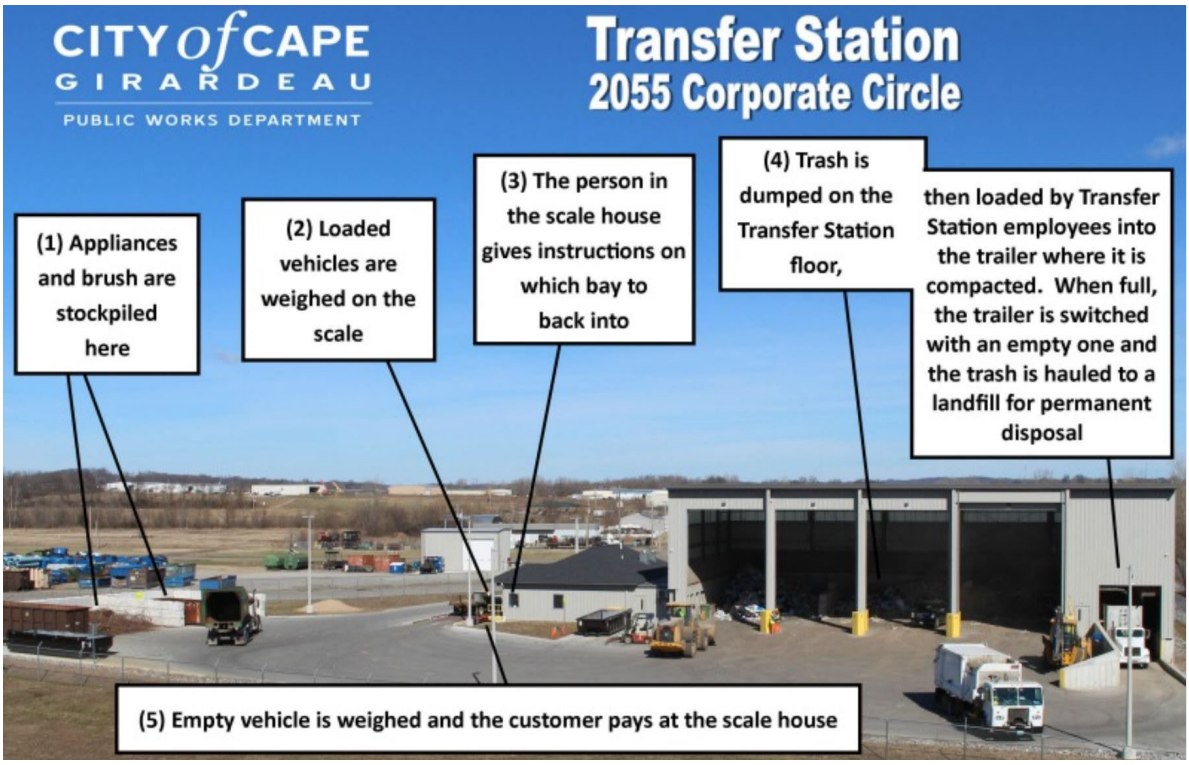
In addition to trash and recycling pick-up, the city provides pick up for yard waste. The city will also provide 5 compost bags for $7.45 if requested. Collected yard waste is ground into mulch and made available to the public on a first come, first served basis. Yard waste picked up at curbside must be scheduled ahead of time by calling Public Works. Yard waste can also be taken to the recycling center or the transfer station. (Cape Girardeau 2024). The weekly leaf litter collection is only offered starting in October and running through March. Any other pickups throughout the year must be scheduled ahead of time with the city. The transfer station, drive-through recycling center, and an adopt-a-street program are all operated by the Public Works Department (Cape Girardeau 2024).

The Missouri Department of Natural Resources (MoDNR) has many grants available for solid waste and recycling initiatives. The Missouri Market Development Program promotes the development of markets for recovered materials and recycled content, scrap tire cleanup and disposal reimbursement, and scrap tire surface material grants (MoDNR 2024). The Southeast Missouri Solid Waste Management District, with oversight from the MoDNR, also awards grants to cities, counties, recycling nonprofits, and for-profit recycling entities to reduce the amount of waste deposited in landfills (SEMO Regional Planning Committee 2024). Cape Girardeau has used this grant to periodically offer a household hazardous waste drop-off event (Cape Girardeau 2024).

End of Cycle

An adequate volume of waste is needed to justify the establishment and investment in local waste management infrastructure. With a population of only 39,540 people as of 2020 (US Census Bureau 2020), Cape Girardeau must rely on multi-step collection, transportation, and disposal of waste. For end of cycle management of plastic waste following collection in Cape Girardeau, the waste will either go through the city's transfer station to be taken by a private hauler, or it will end up at the Lemons Sanitary Landfill in Bloomsfield, MO. There are no active landfills in Cape Girardeau County; therefore, the waste must travel approximately 50 miles to reach Lemons Sanitary Landfill located near Bloomfield in Stoddard County. All the trash collected by the city of Cape Girardeau goes to this landfill which is owned and operated by Republic Services (MoDNR 2024). In 2020, Lemons Landfill received 211,703 tons of waste and collected a total of $437,759 in fees; these numbers increased to 222,021 tons of waste and $459,094 collected in fees in 2022 (MoDNR 2022). The Missouri DNR provides an interactive map of all the closed and active transfer stations, sanitary landfills, utility waste landfills, waste tire processors, material recovery facility, special waste landfill, infectious waste processors, demolition landfills, and closed/inactive landfills online; this resource can be found in the Appendix.

Figure 15: Informative Photo from the Transfer Station in Cape Girardeau (City of Cape Girardeau 2024)



There is one active transfer station in Cape Girardeau County that is operated by the City of Cape Girardeau (Figures 15-17). Transfer stations can aid communities that do not have appropriate sites or

sufficient populations by supporting already existing waste management infrastructure like municipal landfills. Transfer stations can be used to temporarily store and then transfer waste to more appropriate facilities further away. All the recycling picked up in Cape Girardeau goes to the city's transfer station that opened in 2016. Any trash that is dropped off at the transfer station gets compacted and transported to the Lemons Sanitary Landfill. There is also temporary storage at the transfer station for leaves, limbs, and appliances (City of Cape Girardeau 2024).

Missouri ranks 22nd in the country for recycling with a 30% recycling rate for the following materials: rigid plastic packaging, glass bottles and jars (including and excluding aggregate use), aluminum cans, steel cans, cardboard and boxboard (Eunomia 2021). In Cape Girardeau, plastics are not accepted into the recycling stream, meaning all plastics disposed of in the city get taken to the landfill. At the time of our stakeholder interviews, the disposal rate for trash at the Lemons Sanitary Landfill to Republic Services was $43/ton, and the rate to haul off recycling was $115/ton.

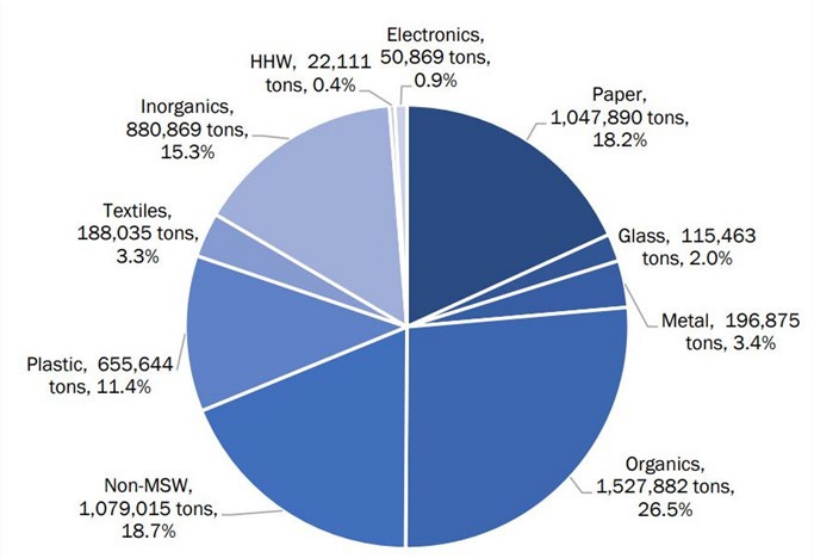
Figure 16: Photos from Transfer Station in Cape Girardeau

Figure 17: Baled material ready for sale at a recycler.

Waste Characterization

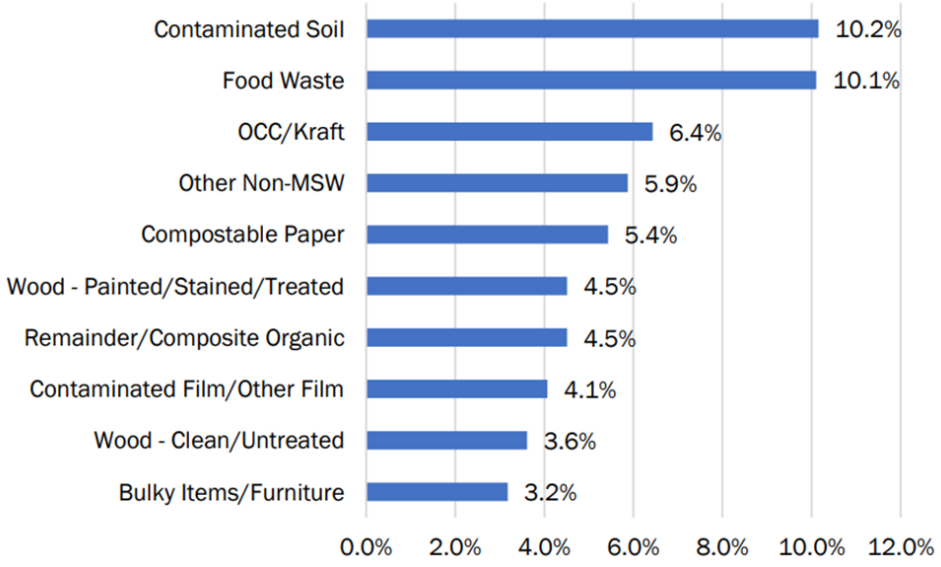
According to a waste characterization study undergone by the Missouri Department of Natural Resources Solid Waste Department, a majority of the waste disposed in the state is organic (26.5%), non-MSW (18.7%), and plastic (11.4%) (Figure 18) (MoDNR 2018).

Figure 18: Missouri Statewide Waste Composition and Quantities Disposed (MoDNR 2018)



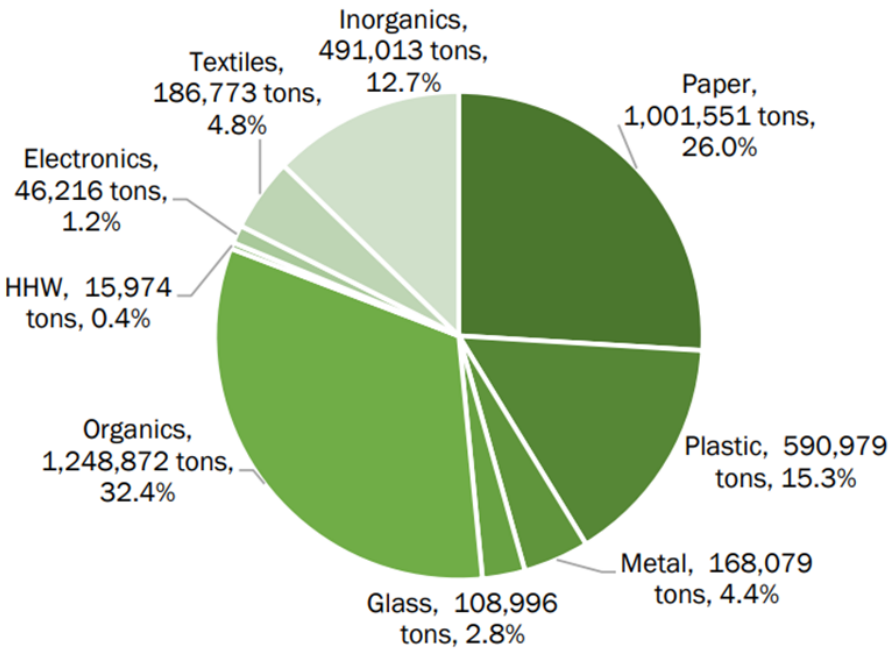
Also included in the report were the most prevalent materials disposed of statewide, with the top two contributors being contaminated soil (10.2%) and food waste (10.1%). (Figure 19) (MoDNR 2018).

Figure 19: Missouri Top 10 Most Prevalent Materials Disposed of Statewide in 2016-2017 (MoDNR 2018)



Additionally, the study found that 32% of MSW was organic materials and 26% of the MSW was paper (Figure 20). The study also found that food waste was the most prevalent material, comprising 15% of the MSW stream. Other notable findings of the study include a meaningful amount of corrugated cardboard being disposed of rather than recycled, and over 25% of the state's waste stream (including all types of waste, not just MSW) is made up of organic materials (MoDNR 2018).

Figure 20: Missouri Statewide Municipal Solid Waste Composition 2016-2017 (MoDNR 2018)



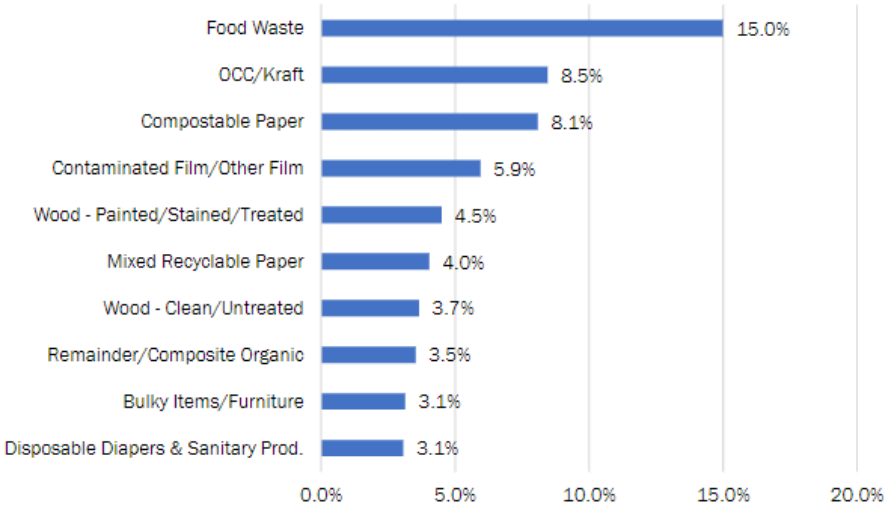
Composting

The city of Cape Girardeau collects leaf and limb litter curbside from the residents as long as the limbs are smaller than 0.25 in in diameter. This material is ground up into mulch and offered to the public on a first come, first served basis. There are no active commercial composting sites in Cape Girardeau or Cape Girardeau County. While industrial composters can be useful for processing compostable plastic items, introducing those products in the waste stream (eg., compostable plastic cups or bags), these efforts require public education due to widespread confusion over the difference between compostable and recyclable plastic items. Because compostable plastics are not equivalent to traditional plastic items that can be mechanically recycled, compostable items contaminate the recycling stream when they are incorrectly sorted.

According to a waste characterization study conducted by the Missouri Department of Natural Resources between 2016-2017, the most prevalent material in the Municipal Solid Waste stream is food waste, making up 15% of the total MSW stream. Compostable paper is the third most prevalent item in the MSW stream making up 8% of the total waste stream statewide (Figure 21) (MoDNR 2018). With the lack of

access to a municipal or commercial composting program in Cape Girardeau County, the county and the city of Cape Girardeau have an opportunity to create a residential composting program for their residents. By introducing a commercial composting facility, the city and county of Cape Girardeau would be able to divert a substantial portion of their MSW away from landfills.

Figure 21: Top 10 Most Prevalent Materials in Statewide MSW Stream (MoDNR 2018)



Since their focus is funding projects to increase the diversion from their landfills, there may be opportunities for funding through the MoDNR and Southeast Missouri Solid Waste Management District for the creation of a composting facility (SEMO Regional Planning Committee 2024).

Using the Residential Source Separated Organics Collection Performance Model by SAIC Energy, Environment & Infrastructure, LLC and the WARM Model from the EPA, we have calculated the estimated households covered in the program, the mass of organic waste to be collected, potential GHG Reduction from the program, and the area required to create a composting facility for the organic waste (Table 7). The calculations will vary based on the range of estimated participation between 50-100% for the curbside collection and 25-50% for the drop-off collection. These calculations are based on the City of Cape Girardeau's waste collection of 226,000 lbs per week from 9,000 households. This equates to about 0.78 tons/household/year of waste produced, which is low compared to the EPA's national average of 2.26 tons/household/year (EPA 2018).

Table 7: Estimated Mass of organic waste, GHG Reduction, and Area Required for introducing a residential compost program based on the Residential Source Separated Organics Collection Performance Model by SAIC Energy, Environment & Infrastructure, LLC

Cape Girardeau City and Cape Girardeau County				
	Households Covered	**Mass (Tons)**	**GHG Reduction (MTCO2E)**	**Area Required (Acres) ****
County-Curbside* (50-100%)	31,578	2,669 - 5,339	1,060 - 2,121	0.97 - 1.94

City Curbside* (50-100%)	9,000	750- 1,499	298 - 595	0.27 - 0.54
City Drop-off (25-50%)	9,000	500 - 999	198 - 397	0.18 - 0.36

*assumed capture rate of 75% for all curbside calculations, range of percentage applies to participation rate

** calculated conversion rate of 2,757.58 tons/acre from https://www.biocycle.net/calculating-a-composting-facility-footprint/

To calculate the GHG Reduction that would come with the introduction of a residential composting program, several assumptions needed to be made using the WARM Model from the EPA. Those assumptions can be found in Table 8.

Table 8: Assumptions made for calculating the GHG Reduction using the WARM Model from the EPA

Assumptions for GHG Reduction
Using only net change in materials diverted from landfill to composting facility in GHG Reduction model
Total Refuse for County Calculations: 24,631 tons/year
Total Refuse for City Calculations: 6,916 tons/year
Using West North Central region for electricity grid mix emission factor
Using National Average for LFG recovery in landfills
For Landfill gas collection efficiency, assuming Typical operation suggested by WARM model of:
Years 0-1: 0%
Years 2-4: 50%
Years 5-14: 75%
Years 15 to 1 year before final cover: 82.5%
Final Cover: 90%
Moisture conditions and associated bulk MSW decay rate is national average according to WARM model: weighted average based on the share of waste received at each landfill type
Emissions that occur during transport of materials to the management facility are default accoriding to WARM Model
Percentages of Materials used for WARM model:
Fruits and Vegetables: 3.75%
Bread: 3.75% (in place of bakery)
Mixed Organics: 13.4% (in place of non-recyclable paper, wood, and other organics)
Food Waste: 5.9% (in place of Other Food Scraps)
Yard Trimmings: 2.1%

*Composition of Materials derived from the Georgia Statewide Waste Characterization Study located at http://www.dca.state.ga.us/gasolidwaste/GADCAWebCalc/Report/GA%20WCS%20Final%20Report%20200 50726.pdf and adapted to enter into the WARM Model

Using the Residential Source Separated Organics Collection Performance Model by SAIC Energy, Environment & Infrastructure, LLC, we were also able to create a cost estimation for a residential curbside composting collection with 70% Participation (Table 9). Those costs and the associated assumptions made in order to calculate the costs can be found in Table 10.

Table 9: Cost Estimation of a City Curbside Composting Program with 70% Participation using the Residential Source Separated Organics Collection Performance Model by SAIC Energy, Environment & Infrastructure, LLC

Cost Estimation for City Curbside with 70% Participation	
Summary of Annual Costs of Residential SSO Collection Program:	
Personnel Costs	$225,000
Equipment Costs	$1,121,356
O&M Costs	$60,000
Fuel Costs	$0
Processing Costs	$5,247
Other Costs	$0
Total	$1,411,603
Summary of Annual Revenues/Savings of Residential SSO Collection Program:	
Fuel Savings*	$0
Mulch/Compost Revenues**	$0
Mulch/Compost Savings	$0
Disposal Cost Avoidance	$45,121
Other Revenues and Savings	$0
Total	$45,121
Estimated Monthly Net Costs per Household	

Monthly Cost per Household (Includes all Households in Community)	$12.65
Monthly Cost per Household with Access to Residential SSO Collection Program	$12.65
Monthly Cost per Participating Household	$18.08

* Did not estimate fuel savings for difference in routes because the location of potential composting facility is unknown

** Did not anticipate selling the mulch/compost in this cost estimation

Table 10: Assumptions made for Cost Estimation of a City Curbside Composting Program with 70% Participation using the Residential Source Separated Organics Collection Performance Model by SAIC Energy, Environment & Infrastructure, LLC

Assumptions for Cost Estimation of Municipal City Curbside with 70% Participation	
Vehicle type used for collection	Automated Side Loader
Frequency of Pick-up	Every Week
Is yard waste included in program	Yes (not including amount currently collected separately)
Composition of Refuse Materials Targeted by Program Disposed by Community:*	
Fruits, Vegetables, and Bakery	7.50%
Other Food Scraps	5.90%
Non-Recyclable Paper	10.70%
Yard Trimmings	2.10%
Wood (non-C&D)	1.40%
Other Organics	1.30%
Capture Rate	75%
Number of households served on single route	700
Routes per week	9
Number of vehicles	2
Carts, estimated number assumes purchase of an extra 10% of carts for replacements	9,900
Cost per vehicle (average between new and used automated side-loader)	$200,000
Interest rate for vehicle	5%
Payment Term or Depreciation term (years)	7
Cost per cart	$55

Interest rate for cart	5%
Payment Term or Depreciation term (years)	7
Annual Operation and Maintenance of Vehicles per Unit	$30,000
Jobs created:	
One Crew Leader	$65,000
Two Truck Drivers	$55,000 (each)
One Public Education Officer	$50,000
Processing cost per ton of organic waste excluding personnel, equipment, and fuel impacts	$5
Estimated amount of mulch/compost needed by city that is currently purchased (cubic yards)	0 (city already creates mulch)
Cost per cubic yard of mulch/compost	$30
Disposal Cost Avoidance per ton**	$43.00
Will the city sell the mulch/compost created	No

* Composition Assumption is based on the Georgia Statwide Waste Characterization study located: http://www.dca.state.ga.us/gasolidwaste/GADCAWebCalc/Report/GA%20WCS%20Final%20Report%2020050726.pdf

** Based on tipping fee for Republic Services in Cape Girardeau, MO

There are some state level funding opportunities that may be useful for targeting education, waste reduction, composting, as well as recycling equipment, support structures, and demonstration projects through the Missouri Department of Natural Resources (MoDNR) Solid Waste Management District Grants. These grants are open to local governments, small and large businesses, schools, sheltered workshops and individuals (MoDNR 2024).

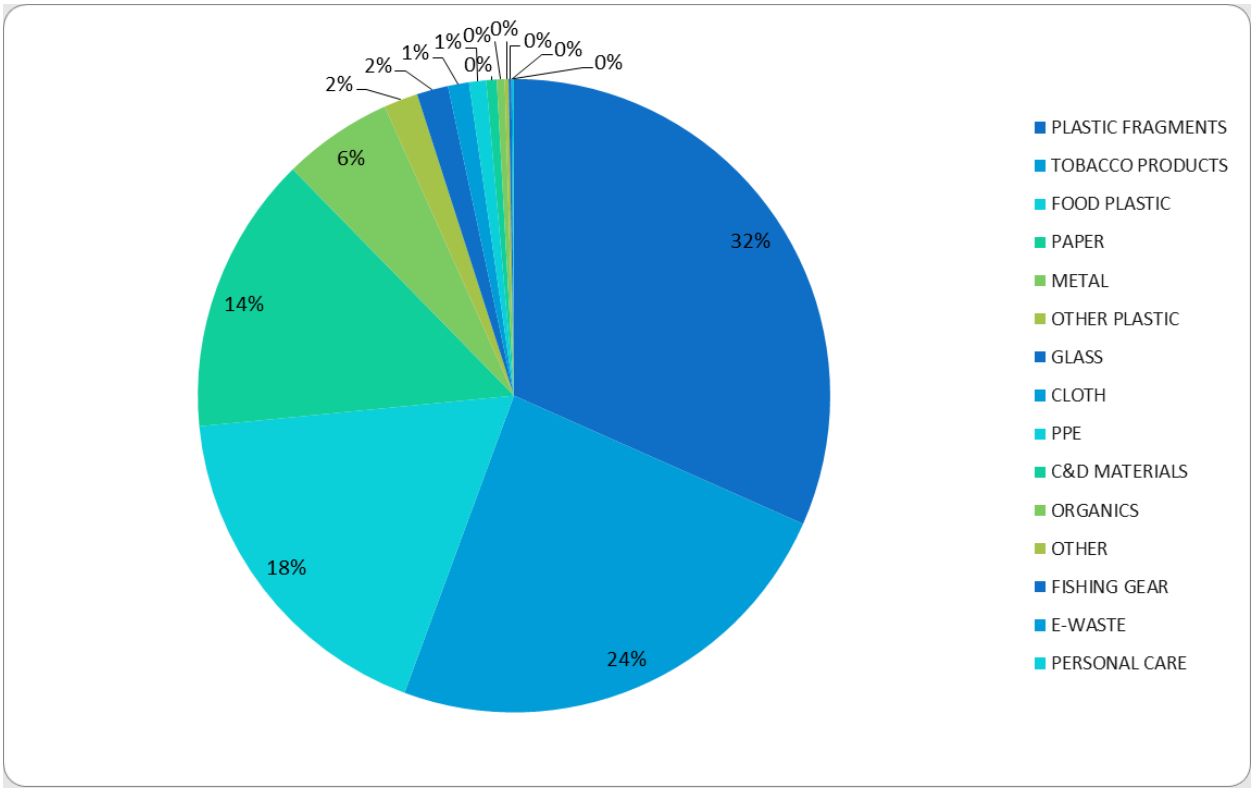
Leakage

A spatially stratified random sampling method generated survey areas for conducting transects, which were selected within nine 1-square kilometer areas and were distributed across three groups of population count (upper, middle, lower) across Cape Girardeau. These population counts were based on the Oak Ridge National Laboratory's LandScan global ambient population data for 2021 (Sims et al. 2022) (shown previously in Figure 3). Litter items were recorded using the open-source Debris Tracker mobile application ('app') (Jambeck and Johnsen 2015). A full list of items available in the app and their associated material categories can be found in the Appendix. Litter was examined based on abundance, proportion of material and product types, and product densities across all transects, and was aggregated across the three population groupings.

In total, 1492 items were logged across 27 transects (each 100m^2) characterizing 9 different square kilometer areas in October of 2022. Across all surveyed transects, plastic fragments were the most prevalent item by item type, representing 32% of all items recorded (Figure 22). The second largest

category was tobacco products (24%), followed by food plastic (18%), paper (14%), and metal (6%), The remaining categories represented 6% or less of all litter items. The total percentage of common plastic items (the sum of food packaging plastic, other plastic, PPE, plastic fragments, and personal care items) found was 52% of the total items.

Figure 22: Litter Material Breakdown in Cape Girardeau



By individual product types, cigarettes and foam fragments were the most recorded items with each making up 21.2% and 11.6% of the total count respectively (Table 11). Common food plastic packaging, like candy wrappers and chip packets, made up 8.2% of the total count and have low packaging-to-product ratios (Table 11), which are generally less valuable for recycling compared to plastic bottles made of PET, which only comprised 2.5% of the litter recorded in Cape Girardeau, suggesting that there may be effective collection of plastic beverage bottles for disposal or recycling currently in the community.

Table 11: Count and percentage of total transect count of debris items by item type

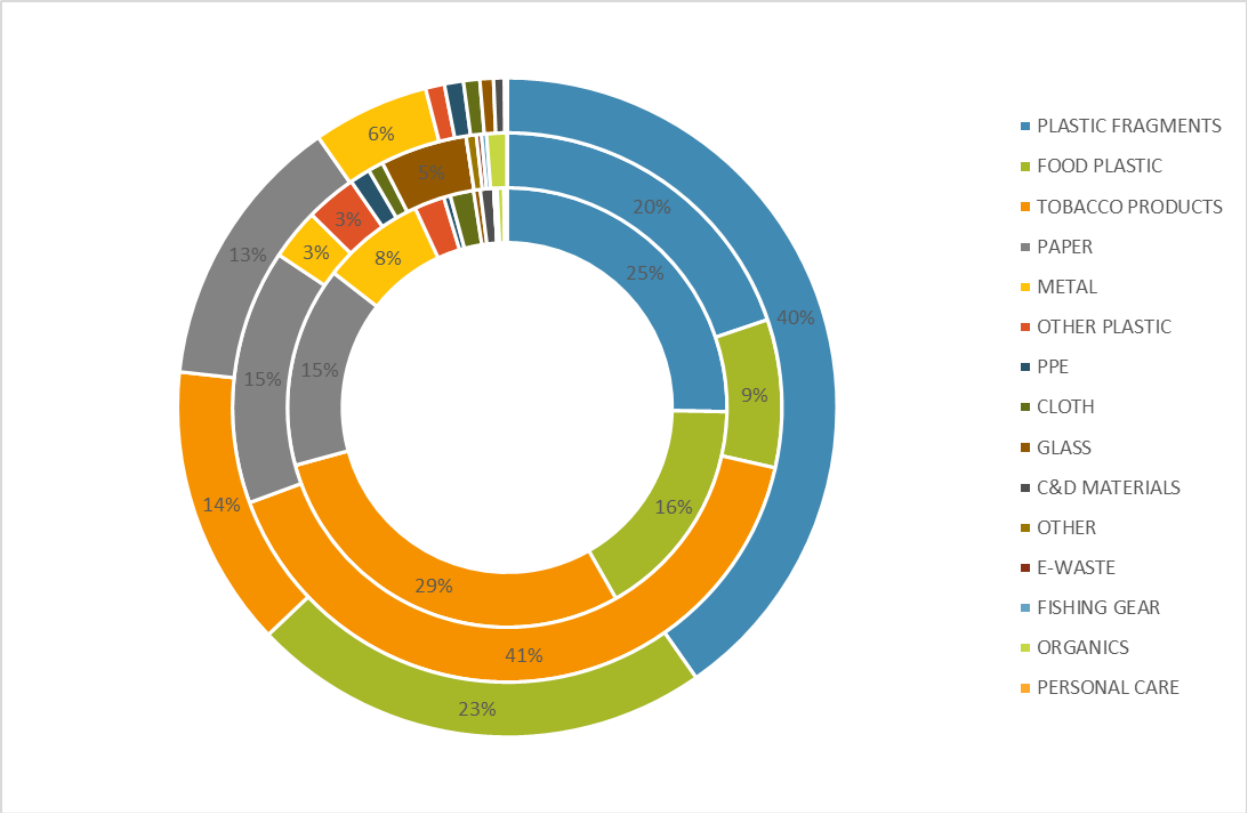
Item Type	Count	Percent of total
Cigarettes	283	21.18%
Foam Fragments	155	11.60%
Film Fragments	133	9.96%
Hard Plastic Fragments	109	8.16%
Plastic Food Wrappers	109	8.16%
Paper	101	7.56%
Foam or Plastic Cups or Lids	46	3.44%
Aluminum or Tin Cans	44	3.29%
Other Paper	44	3.29%

Plastic Bottle	34	2.54%
Straws	32	2.40%
Coated Paperboard	21	1.57%
Aluminum Foil	19	1.42%
Non-coated Paper Food Wrappers	19	1.42%
Other Plastic	19	1.42%
Glass or Ceramic Fragments	17	1.27%
Plastic Bottle Cap	14	1.05%
Other Cloth	12	0.90%
Metal Bottle Caps or Tabs	8	0.60%
Cigarette Packaging	7	0.52%
Total (top 20)	**1241**	**92.89%**

When examining the litter characterization based on the population count, some similarities and distinctions can be seen between the three groups. The mid and low population count areas followed a similar pattern to the compiled litter data shown in (Figure 23), with tobacco products making up a majority of the mid (41%) and low (29%) populations areas. In contrast, the most common litter item for the high population area was plastic fragments at 40%. Comparatively, plastic fragments made up 20% and 25% of litter in the mid and low population count areas, respectively. The next most common material types for litter in the high population area were food plastics (23%) and tobacco products (14%). In the mid and low population areas, food plastic only made up 9% and 16% of the litter items respectively. All three population areas had similar amounts of paper with the high population areas having 13%, mid population areas having 15%, and low population areas having 15% paper litter items.

The variation in proportions of litter types across the three population count groups can provide insight into material use and disposal patterns that differ across the areas. For example, the high prevalence of littered tobacco products in the middle and lower population count areas could suggest high tobacco use or a lack of infrastructure for proper disposal in comparison to that of the upper area. Similarly, the large proportion of plastic fragments in the upper area is notable given the challenges related to collecting, managing, sorting, and disposing or recycling plastics once they break down to a small size.

Figure 23: Composition of surveyed litter items in low (inner), mid (middle), and high (outer) population count areas in Cape Girardeau



When aggregated across all surveys, Cape Girardeau has an average litter density of 0.55 items per square meter. However, like the variation seen in litter composition, litter density also differed between the three population count areas. The highest litter density was found in the upper population count areas, while the lowest litter density was found in the middle population count areas. This finding differs from the trends found in other USA cities. wherein lower population count areas typically have the most litter, as seen in Vicksburg, MS. Additionally, variation across the three population groups follows a difference trend than other cities in the USA. For example, Miami had the highest litter density in the lower population areas (3.79 items/m^2), followed by 2.46 items/m^2 in high population count areas and 1.48 items/m^2 in middle population count areas compared to the litter densities of Cape Girardeau found in Table 12. While the upper population area in Cape Girardeau had the highest average density, it also had the most variation in litter density across the transects and ranged from 0.1-3.59 items per square meter.

Compared to other cities in the USA, Cape Girardeau has lower average litter density than those commonly seen in larger cities. Litter density may be lower in the middle population count areas due to increased access to waste infrastructure (e.g., receptacles), more frequent waste collection and cleaning. In contrast, the high litter density in the high population area may suggest a need for publicly available waste receptables in high traffic areas.

Table 12: Litter Density and Top Litter Items for Each Area of Population Count

Population tertile	Top five litter items by product type	Total item count (n)	Total plastic composition (%)	Mean litter density (count/m²)
Upper (420 – 2,896 persons/sq km)	1. Plastic Fragments 2. Food Plastic 3. Tobacco Products 4. Paper 5. Metal	752	65%	0.84
Middle (44 - 420 persons/sq km)	1. Tobacco Products 2. Plastic Fragments 3. Paper 4. Food Plastic 5. Glass	333	33%	0.37
Lower (0 - 44 persons/sq km)	1. Tobacco Products 2. Plastic Fragments 3. Food Plastic 4. Paper 5. Metal	407	45%	0.45

Across all transects, cigarettes were the most common item. They were the most common item in the middle and lower population areas and were the third most common item for the upper population areas. Plastic fragments were the most common item found in the upper population areas and the second most common item found in the middle and lower population areas. Food plastic and paper items were also frequently found in all three of the population areas (Table 13).

Table 13: Count and percentage of top five debris items by item type and population area

Population category		
Item type	**Item count**	**Percent of category total (%)**
High		
Foam Fragments	138	18
Cigarettes	91	12
Hard Plastic Fragments	87	11.5
Plastic Food Wrapper	79	10.4
Film Fragments	78	10.3
Middle		
Cigarettes	135	40
Film Fragments	30	8.9
Paper	29	8.6
Foam Fragments	18	5.3
Hard Plastic Fragments	17	5
Low		
Cigarettes	115	28
Foam Fragments	43	10.5
Paper	37	9
Hard Plastic Fragments	33	8
Film Fragments	27	6.6

The Missouri Department of Transporation hosts a volunteer litter clean up event every April called No MOre Trash! They provide trash bags and brightly colored vests to volunteers who work on the state's highways; this event saves the state $1 million a year in litter cleanup. Missouri spends more than $6 million each year on litter cleanups, with another $1.5 million worth of labor from Adopt-A-Highway

volunteers. The organization the Missouri Stream Team also removed 869 tons of litter and dedicated $2.5 million worth of volunteer work to the state in 2009 (MoDOT 2022). Littering in the state of Missouri can result in a fine of up to $1000 and/or a year in jail. The Missouri Department of Conservation (MDC) in partnership with the Cape Girardeau Parks and Recreation Department also team up to host an annual Bashin' Trash litter cleanup that focuses on cleaning up Cape LaCroix Creek in Cape Girardeau (MDC 2024).

Figure 24: Example litter in Cape Girardeau

Opportunities

CIL found the following opportunities to expand and enhance circularity in Cape Girardeau, MO based on the findings of this report. These opportunities are categorized based on the seven spokes of the CAP model. Stakeholder engagement with community members in Cape Girardeau would help to further expand, refine, and prioritize these opportunities based on local context, impact, feasibility, and cost. It is important to note that the opportunities listed below are individualized based on the findings, but

solutions cannot happen in a vacuum and are most impactful when strategically combined within a holistic system framework.

Input

- The large percentage of domestic parent companies and manufacturers for top convenience items lend themselves to engaging companies about end-of-life management, product design, alternative materials, and alternative product delivery systems. Cape Girardeau could lead community initiatives toward working with top local brands and producers that operate locations proximate to the community and Mississippi, with a particular focus on beverage and chip packaging.
    - Through working with these top brands, the City of Cape Girardeau could explore resources and potential local industry partnerships that may be available for effective development, implementation, and enforcement of Extended Producer Responsibility (EPR) guidelines and rules that result from those guidelines. In addition, the city should be as involved as possible in crafting EPR Guidelines at the city and national levels to ensure that they can be effectively implemented at the local level.

Community

- Bullets

Product Design

- Plastic alternatives in the form of bio-based, biodegradable, and compostable plastics are likely to continue gaining momentum in Cape Girardeau and beyond. By investing in education around identifying product materials and appropriate disposal options early, the city may mitigate challenges with managing these complex products over time. This approach is particularly important given that there are no commercial composting facilities currently serving the community, which may leave the possibility for contamination of the waste stream, leakage of items into the environment, and missed opportunities for material diversion from landfills.
    - The city may also be able to push for state-level policy and regulations that standardize labeling of various bio-based, biodegradable, and compostable plastics to aid in education efforts.

- There are funding opportunities that can be used to target education, waste reduction, composting, as well as recycling equipment, support structures, and demonstration projects through the Missouri Department of Natural Resources (MoDNR) Solid Waste Management District Grants. These grants are open to local governments, small and large businesses, schools, sheltered workshops and individuals.

Use

- Local government and businesses could explore ways to encourage or offer common goods in bulk rather than individual packages. For example, personal care products like detergent and soap can be sold through bulk refill stations.
- There is an opportunity for local businesses to lead efforts in waste minimization around commonly supplied plastic items. For example, private retail businesses can choose to implement a 'bring your own bag' policy or fee for using store-provided bags. Privately owned restaurants and food vendors can similarly explore alternative 'to go' containers and a 'straw by request' policy.
- To encourage leadership and innovation among businesses, the city could highlight efforts by local businesses to reduce plastic use, and/or offer financial incentives for businesses that participate in plastic reduction.
- As more complex plastic alternatives are introduced to the waste stream, more education efforts will be needed to combat misleading product labels and encourage appropriate management by individuals and households.

Collection

- The state of Missouri along with the District R Solid Waste Management Plan, which Cape Girardeau falls under, had set a goal to reduce solid waste going to the landfill by 40%; this goal was met in 2009. The current focus of the state and district to fund recycling efforts and education programs focuses on recycling at a local level. A new recycling or zero-waste goal set in motion by the state or district would provide a clearer vision and guideline for local municipalities to follow when allocating funding and providing solid waste services to the community.
- At present, there is no infrastructure in place to recycle plastic bags, plastic wrap and film, wax- or plastic-coated cups, plastic lids, and polystyrene foam. Efforts to reduce the usage of these items at the local level could include awareness campaigns encouraging residents to adopt

reusing behavior such as bringing their own mugs and cups to take-out restaurants, bringing their own bags to retail venues, and exploring other alternative options in their day-to-day lives to suit their needs

End of Cycle

- Landfilling is the most prominent form of waste management in Cape Girardeau and throughout Missouri. There are ample opportunities to explore diversion strategies through other end-of-cycle outlets like recycling and composting as well as upstream efforts like waste reduction. The most accessible model for sustainable waste management may be sustainable material management approaches that prioritize net reduction in the environmental, social, and economic impacts of waste. Then circular economy and zero waste scenarios may be more appropriate later on as Cape Girardeau develops its own comprehensive approach to improving plastic waste management.
- There are several opportunities through the federal and state government, as well as nonprofits, for financial assistance through grants and trust funds that support the development of waste management planning and programs, post-closure management of landfills, and collection and enforcement objectives.

Leakage

- The city and local partners could revisit the CAP litter transects and/or areas that have different waste collection schemes to generate comparable data to identify patterns and gaps and inform best practices.
- There may be several opportunities for public education initiatives. Given the prevalence of tobacco-related litter in the high, middle, and low population count areas, educational schemes combined with increased infrastructure targeted toward tobacco waste disposal may be beneficial in reducing the prevalence of those items in the environment.
- Collecting data at cleanup events can help to elicit an understanding of what is cleaned up as well as provide tangible outcomes that encourage and validate volunteer participation.

Glossary

CAP: Circularity Assessment Protocol

CIL: Circularity Informatics Lab

EPR: Extended Producer Responsibility

EPS: Expanded polystyrene

FMCG: Fast moving consumer goods

HDPE: high density polyethylene

MoDNR: Missouri Department of Natural Resources

MSW: municipal solid waste

PET: polyethylene terephthalate

PP: polypropylene

SUP: single-use plastic

UGA: University of Georgia

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Appendix

Table A1: Full List of Debris Tracker Litter Items and Associated Material Categories

Material	Items
C&D Materials	Aggregate & Brick Bolts, Nails, and Screws Building Materials Lumber Other C&D
Cloth	Clothing Towels or rags Fabric Pieces Other Cloth
E-Waste	Batteries E-Waste Fragments Wire Other E-Waste
Fishing Gear	Buoys and Floats Fishing Line Other Fishing Gear Plastic Net or Net Pieces Plastic Rope
Glass	Glass Bottle Glass or Ceramic Fragments Other Glass
Metal	Aluminum Foil Aluminum or Tin Cans Foil to-go container

	Metal Bottle Caps or Tabs Metal Fragments Other Metal
Organic Waste	Food Waste Other Organic Waste
Other	Other Popsicle or lollipop Stick
Other Plastic Products	Bulk Bags Flip Flops or shoes Plastic String, Tape, or Packing Straps Rubber Bands Trash bag Tires Balloons Plastic toys or balls Car Parts Hard plastic jugs or containers Other Plastic
Food-Related Paper	Paper cups Paper food box or container Paper plates or bowls Compostable paper cups Paper food wrapper Compostable food box or container Napkins Other Food-Related paper

Paper	Office paper and newspaper Tags, tickets, and receipts Corrugated Cardboard Paper fragments Other Paper
Personal Care Products	Blister Pack or other pill packaging Cotton Buds Ear plugs Personal Care Product Sachet or packet Toothbrushes Toothpaste or Other Product Tube Flossers Feminine products Needles and syringes Other Personal Care Product
Food-related plastic	Foam cups Plastic cups Compostable plastic cups Cup Lids Plastic Bottle Aseptic cartons Mini alcohol bottles Plastic Bottle Cap Plastic Food Wrapper Condiment packet or container Plastic Grocery Bag Sandwich or snack bags Plastic Utensils

	Straws Foam to-go container or clamshell Plastic to-go container or clamshell Compostable plastic container or clamshell Other Food-Related Plastic
Plastic Fragments	Film Fragments Foam Fragments Hard Plastic Fragments Rubber/ tire fragments Other Fragments
PPE	Disinfectant Wipes Disposable Gloves Face Masks Other PPE
Tobacco Products	Cigarette Packaging Cigarettes Tobacco Sachets or packets E-cigarettes and vaping Plastic cigar/cigarillo tips Lighters Cannabis-related waste Other Tobacco Product

Table A2: Full table of manufacturers of top convenience products

Manufacturer	Manufacturing City	Manufacturing State	Manufacturing Country
Actual Candy LLC	Stafford, TX	Texas	USA
Aldi	Batavia, IL	Illinois	USA
American Licorice Co	Laporte, IN	Indianna	USA
Amplify Snack Brands, Inc	Austin, TX	Texas	USA
Andes Candies LLC	Delavan, WI	Wisconson	USA
Angie's Artisan Treats, LLC	Osseo, MN	Minnesota	USA
Annabelle Candy Co., Hayward, CA	Hayward, CA	California	USA
Atkinson Candy Co.	Lufkin, TX	Texas	USA
BA Sports Nutriton LLC	New York, Ny	New York	USA
Bazooka Candy Brands	Scranton, PA	Pennsylvania	USA
BFY Brands, LLC	Middletown, NY	New York	USA
BioSteel Sports Nutrition Inc	Buffalo, NY	New York	USA
Blue Triton Brands Inc	Stamford, CT	Connecticut	USA
Bolthouse Farms, Inc	Bakersfield, CA	California	USA
Brooklyn Bottling	Milton, NY	New York	USA
Calbee America, Inc.	Fairfield, CA	California	USA
Cap Candy LLC	Canal Winchester, OH	Ohio	USA
Cape Cod Potato Chips	Hyannis, MA	Massachusetts	USA
CG Roxane	Benton, TN	Tennessee	USA
Charms	Convington, TN	Tennessee	USA
Citrus World, Inc	Lake Wales, FL	Florida	USA
Conagra Brands	Chicago, IL	Illinois	USA
Concord Confections	Concord, Canada		Canada
Crown Candy Corporation	Macon, GA	Georgia	USA

Crystal Falls Water	Roseburg, OR	Oregon	USA
CVS Health Corporation	Woonsocket, RI	Rhode Island	USA
Distributed by Snyder's-Lance, Inc., Charlotte, NC	Charlotte, NC	North Carolina	USA
Dole Food Company	Thousand Oaks	California	USA
Dot's Pretzels	Velva, ND	North Dakota	USA
Eagle Family Food Group, LLC	Cleveland, OH	Ohio	USA
Energy Brands Inc.	Queens, NY	New York	USA
Evans Food Group LTD	Chicago, IL	Illinois	USA
Excel Bottling Company, Inc	Breese, IL	Illinois	USA
Fannie May Confection Brands, Inc	North Canton, Ohio	Ohio	USA
Ferrara Candy Co	Chicago, IL	Illinois	USA
Ferrero USA	Parsippany, NJ	New Jersey	USA
Frankford Candy, LLC	Philadelphia, PA	Pennsylvania	USA
Frito-Lay, Inc.	Plano, TX	Texas	USA
Fruit-tella	Abruzzo, Italy		Italy
G.B. Ambrosoli S.p.A	Ronago, Italy		Italy
General Mills Sales, Inc	Minneapolis, MN	Minnesota	USA
Genius Gourmet Inc	Coeur d'Alene, ID	Idaho	USA
Godiva Chocolatier Inc.	Reading, PA	Pennsylvania	USA
Goetze's Candy Co, Inc	Baltimore, MD	Maryland	USA
Good Health Natural Products	Hanover, PA	Pennsylvania	USA
Good2Grow, LLC	Atlanta, GA	Georgia	USA
Greenbrier International, Inc	Marmaduke, AR	Arkansas	USA
Gurley's, Willmar, MN	Willmar, MN	Minnessota	USA
Gushers	Belvidere, IL	Illinois	USA

H2O Technologies LLC	Potosi, MO	Missouri	USA
Haribo of America	Rosemont, IL	Illinois	USA
Herr Foods Inc	Nottingham, PA	Pennsylvania	USA
Hippeas	New York, NY	New York	USA
HP Food LLC	Lynnfield, MA	Massachusetts	USA
Impact Confections, Inc	Janesville, WI	Wisconsin	USA
Innovative Candy Concepts	Atlanta, GA	Georgia	USA
Inventure Foods, Inc	Phoenix, AZ	Arizona	USA
Jelly Belly Candy Company	Fairfield, CA	California	USA
Junior Mints	Cambridge, MA	Massachusetts	USA
Just Born Inc.	Bethlehem, PA	Pennsylvania	USA
Justin's LLC, Boulder, CO	Boulder, CO	Colorado	USA
Karma Culture LLC.	Pittsford, NY	New York	USA
Katjes USA Inc	Warren, NJ	New Jersey	USA
Kenny's Candy & Confections	Perham, MN	Minnesota	USA
Kettle Brand	Salem, OR	Oregon	USA
Keurig Dr. Pepper	Plano, TX	Texas	USA
Kitchen Fresh Candies Inc	Hunt Valley, MD	Maryland	USA
Kitu Life, Inc.	Austin, TX	Texas	USA
Life is Sweet LLC	Cincinnati, OH	Ohio	USA
Lindt & Spungli Inc	Stratham, NH	New Hampshire	USA
Lipton	New York, Ny	New York	USA
Mars Wrigley Confectionary US, LLC	Hackettstown, NJ	New Jersey	Mexico
Midwood Brands, LLC	Chesapeake, VA	Virginia	USA
Monark, LLC	East Brunswick, NJ	New Jersey	USA
Mondelez Global, LLC	Hamilton, Ontario	Ontario	Canada

Monster Energy Co	Corona, CA	California	USA
Morinaga America, Inc	Irvine, CA	California	USA
Naked Juice	Monrovia, CA	California	USA
Nestle	Bridgewater, NJ	New Jersey	USA
New England Beverages, LLC	Bronx, NY	New York	USA
Niagara Bottling, LLC	Diamond Bar, CA	California	USA
North American, Inc.	White Plains, NY	New York	USA
Old Vienna LLC	Fenton, MO	Missouri	USA
Ozarka Water	El Campo, TX	Texas	USA
Palmer Candy Co., Sioux City, IA	Sioux City, IA	Iowa	USA
Pepsi Mid America	Marion, IL	Illinois	USA
Pepsico, Inc.	Knoxville, TN	Tennessee	USA
Perfetti Van Melle	Erlanger, KY	Kentucky	USA
PIM Brands	Allendale, NJ	New Jersey	USA
Pop Rocks	Atlanta, GA	Georgia	USA
popchips, LLC.	Las Vegas, NV	Nevada	USA
Popcorn Indiana	Waukegan, IL	Illinois	USA
Prairie Farms Dairy, Inc	Edwardsville, IL	Illinois	USA
Premium Waters, Inc	Minneapolis, MN	Minnesota	USA
Pringles Manufacturing Co	Jackson, TN	Tennessee	USA
Quest Nutrition, LLC	El Segundo, CA	California	USA
RAP Snacks	Miami, FL	Florida	USA
Russell Stover Chocolates, LLC	Kansas City, MO	Missouri	USA
S.P. Enterprises, INC	Las Vegas, NV	Nevada	USA
Sam's West, Inc	Bentonville, AR	Arkansas	USA
Save a Lot, Ltd	St. Ann, MO	Missouri	USA
Schnuck Markets, Inc	St. Louis, MO	Missouri	USA
ShineWater LLC	Bay City, MI	Michigan	USA

Simply Orange Juice Company	Apoka, FL	Florida	USA
Smart Sweets Inc	Vancouver	British Columbia	Canada
Snack it Forward LLC	Los Angeles, CA	California	USA
Snyder's-Lance, Inc	Charlotte, NC	North Carolina	USA
Spangler Candy Company	Bryan, OH	Ohio	USA
Splash Beverage Group	Ft. Lauderdale, FL	Florida	USA
Sport Water LLC	Commerce, CA	California	USA
Star Brands North America	White Plains, NY	New York	USA
Storck USA LP	Chicago, IL	Illinois	USA
Tapatio Foods, LLC	Los Angeles, CA	California	USA
That's How We Roll LLC	Montclair, NJ	New Jersey	USA
The Coca-Cola Company	Atlanta, GA	Georgia	USA
The Dakota Style Family	Clark, SD	South Dakota	USA
The Foreign Candy Company	Hull, IA	Iowa	USA
The Gatorade Co	Chicago, IL	Illinois	USA
The Hershey Company	Hershey, PA	Pennsylvania	USA
The Madaleine Chocolate Company	Rockaway Beach, NJ	New Jersey	USA
Tootsie Roll Industries	Chicago, Il	Illinois	USA
Tropicana Manufacturing, INC	Bradenton	Florida	USA
Tweaker Energy	Dallas, TX	Texas	USA
Utz Quality Foods, LLC	Hanover, PA	Pennsylvania	USA
Vess Soda	St. Louis, MO	Missouri	USA
Walgreen Co.	Deerfield, IL	Illinois	USA
World Confections, Inc	Maplewood, NJ	New Jersey	USA
World Gourmet Marketing, LLC	Butler, NJ	New Jersey	USA
Zapp's Potato Chips	Hanover, PA	Pennsylvania	USA

ZenWTR Inc	Long Beach	California	USA

Table A2: Full table of parent companies of top convenience products

Parent Company	Parent Company City	Parent Company State	Parent Company Country
Actual Candy LLC	Stafford, TX	Texas	USA
Aldi	Batavia, IL	Illinois	USA
Amplify Snack Brands	Austin, TX	Texas	USA
Annabelle Candy	Hayward, CA	California	USA
Apax Partners LLP	London, UK		UK
Atkinson Candy Company	Lufkin, TX	Texas	USA
August Storck KG	Berlin, Germany		Germany
Benestar Brands	Chicago, IL	Illinois	USA
Blue Triton Brands Inc	Stamford, CT	Connecticut	USA
Brooklyn Bottling	Milton, NY	New York	USA
Calbee, Inc	Chiyoda City, Tokyo, Japan		Japan
Campbell's Soup Company	Camden, NJ	New Jersey	USA
Candy Alliance LLC.	Bend, OR	Oregon	USA
Canopy Growth Corporation	Smiths Falls	Ontario	Canada
Citrus World, Inc	Lake Wales, FL	Florida	USA
ConAgra Brands Inc	Chicago IL	Illinois	USA
Crown Candy Corporation	Macon, GA	Georgia	USA
Crystal Falls Water	Roseburg, OR	Oregon	USA
CVS Health Corporation	Woonsocket, RI	Rhode Island	USA
Dollar Tree	Chesapeake, VA	Virginia	USA
Doscher's Candies	Cincinnati, OH	Ohio	USA
Dot's Pretzels	Velva, ND	North Dakota	USA

Eagle Family Food Group, LLC	Cleveland, OH	Ohio	USA
Family Dollar Stores, Inc.	Charlotte, NC	North Carolina	USA
Ferraro SpA	Alba, Italy		Italy
Ferrero Group	Alba, Italy		Italy
Frankford Candy, LLC	Philadelphia, PA	Pennsylvania	USA
G.B. Ambrosoli S.p.A	Ronago, Italy		Italy
General Mills	Minneapolis, MN	Minnesota	USA
Genius Gourmet Inc	Coeur d'Alene, ID	Idaho	USA
Goetze Candy Co	Baltimore, MD	Maryland	USA
Good2Grow, LLC	Atlanta, GA	Georgia	USA
Green Park Brands	Los Angeles, CA	California	USA
Gurley's Foods	Willmar, MN	Minnesota	USA
H2O Technologies LLC	Potosi, MO	Missouri	USA
Haider Corporation	Farmers Branch, TX	Texas	USA
Hain Celestial Group, Inc.	Hoboken, NJ	New Jersey	USA
Haribo	Bonn, Germany		Germany
Heron Holding Corporation	Clearwater, FL	Florida	USA
Herr Foods Inc	Nottingham, PA	Pennsylvania	USA
Hormel Foods	Austin, MN	Minnesota	USA
Impact Confections, Inc	Janesville, WI	Wisconson	USA
Innovative Candy Concepts	Atlanta, GA	Georgia	USA
Jelly Belly Candy Company	Fairfield, CA	California	USA
Just Born Inc.	Bethlehem, PA	Pennsylvania	USA
Karma Culture LLC.	Pittsford, NY	New York	USA
Katjes International	Emmerich, Germany		Germany
Kellogg's	Battle Creek, MI	Michigan	USA
Keurig Dr. Pepper	Frisco, TX	Texas	USA

Kitu Life, Inc.	Austin, TX	Texas	USA
KLN Family Brands	Perham, MN	Minnesota	USA
Lindt & Sprungli	Kilchberg, Switzerland		Switzerland
Magical Brands	Tampa, FL	Florida	USA
Mars Inc	McLean, VA	Virginia	USA
Mill City Capital	Wayzata, MN	Minnesota	USA
Mondelez Global	Chicago, IL	Illinois	USA
Monster Energy Co	Corona, CA	California	USA
Morninga & Co., LTD	Minato City, Tokyo		Japan
National Grape Cooperative Association	Westfield, NY	New York	USA
Nestle	Vevey, Switzerland		Switzerland
Niagara Bottling, LLC	Diamond Bar, CA	California	USA
Old Tyme Holdings Group, LLC	New York City, NY	New York	USA
Old Vienna LLC	Fenton, MO	Missouri	USA
Otsuka Holdings Co, Ltd	Chiyoda City, Tokyo		Japan
PAI Partners	Paris, France		France
Pepsi Mid America	Marion, IL	Illinois	USA
PepsiCo, Inc	Purchase, NY	New York	USA
Perfetti Van Melle	Breda, Netherlands		Netherlands
Prairie Farms Inc.	Edwardsville, IL	Illinois	USA
R.M. Palmer Company	West Reading, PA	Pennsylvania	USA
Rap Snacks INC	Miami, FL	Florida	USA
Real Food From the Ground Up	Fairfield, NJ	New Jersey	USA
Refresco Beverages, Inc	Tampa, FL	Florida	USA
Russell Stover Chocolates, LLC	Kansas City, MO	Missouri	USA
S. P. Enterprises, Inc.	Las Vegas, NV	Nevada	USA

SAL Acquisition Corp	New York City, NY	New York	USA
Schnuck Markets, Inc	St. Louis, MO	Missouri	USA
ShineWater LLC	Bay City, MI	Michigan	USA
Simply Good Foods Co	Denver, CO	Colorado	USA
S-L Snacks National	Charlotte, NC	North Carolina	USA
Smart Sweets Inc.	Vancouver, Canada		Canada
Snack it Forward LLC	Los Angeles, CA	California	USA
Snak-King, Corp.	Los Angeles, CA	California	USA
Spangler Candy Company	Bryan, OH	Ohio	USA
The Chesterman Company	Sioux City, IA	Iowa	USA
The Coca-Cola Company	Atlanta, GA	Georgia	USA
The Dakota Style Family	Clark, SD	South Dakota	USA
The Double Cola Company	Chattanooga, TN	Tennessee	USA
The Foreign Candy Company	Hull, IA	Iowa	USA
The Hershey Company	Hershey, PA	Pennsylvania	USA
The Madaleine Chocolate Company	Rockaway Beach, NJ	New Jersey	USA
Tootsie Roll Industries LLC	Chicago, IL	Illinois	USA
Utz Brands Holdings, LLC	Hanover, PA	Pennsylvania	USA
Walgreens Boots Alliance	Deerfield, IL	Illinois	USA
Walmart Inc.	Bentonville, AR	Arkansas	USA
Waterco Ltd.	Sydney, Australia		Australia
World Confections, Inc	Maplewood, NJ	New Jersey	USA
Yildiz Holding	Istanbul, Turkey		Turkey
ZenWTR Inc	Long Beach, CA	California	USA
Zeta Espacial S.A.	Catalonia, Spain		Spain

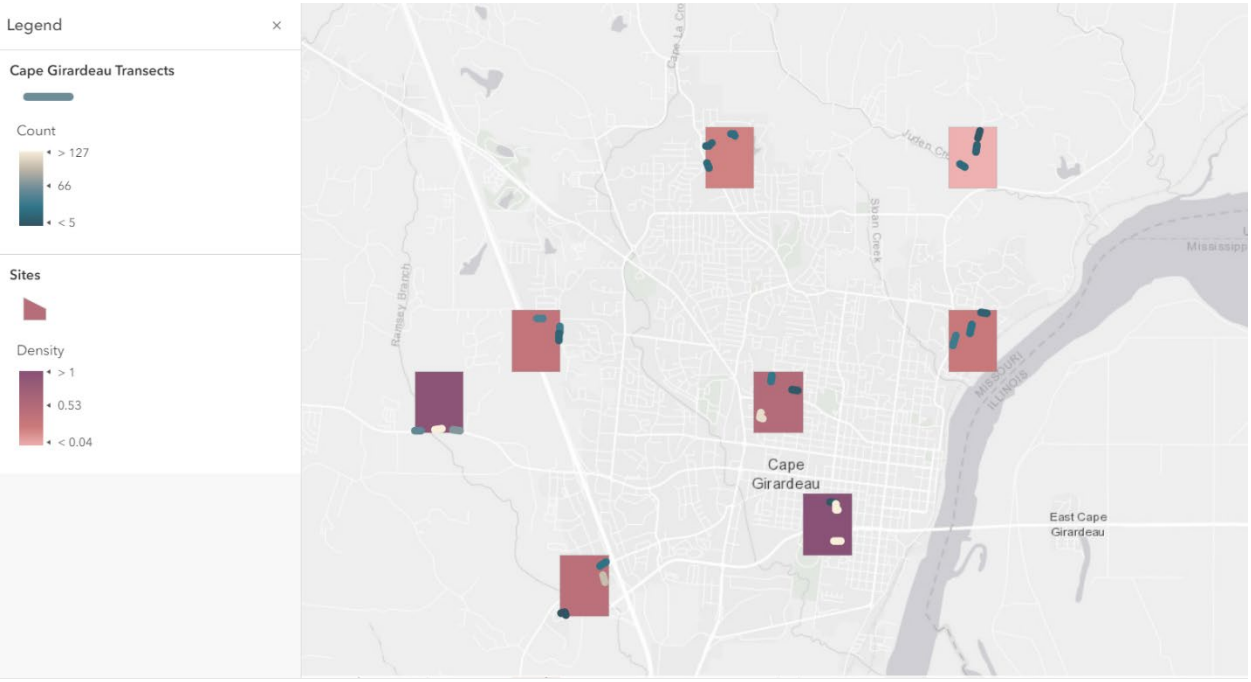
Link A1: Missouri Department of Natural Resources Materials Management Directory

Missouri Department of Natural Resources Materials Management Directory:
https://recyclesearch.com/profile/mo-directory

Missouri Department of Natural Resources Interactive Map of Landfills, Transfer Stations, etc.:

https://modnr.maps.arcgis.com/apps/webappviewer/index.html?id=f261c6069e324f48a8cbc6ce74343f41

Figure A1: Litter densities in transects and sites surveyed in Cape Girardeau.



An interactive web map version of this map is available at:

https://usg.maps.arcgis.com/home/webmap/viewer.html?webmap=a3cd72095dd147c9ac604a80893ee65b