Circularity Assessment Protocol
Vicksburg, Mississippi, USA

University of Georgia
Circularity Informatics Lab
September 18, 2023

New Materials Institute
UNIVERSITY OF GEORGIA

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.

Published by:
The Circularity Informatics Lab (CIL)

Location:
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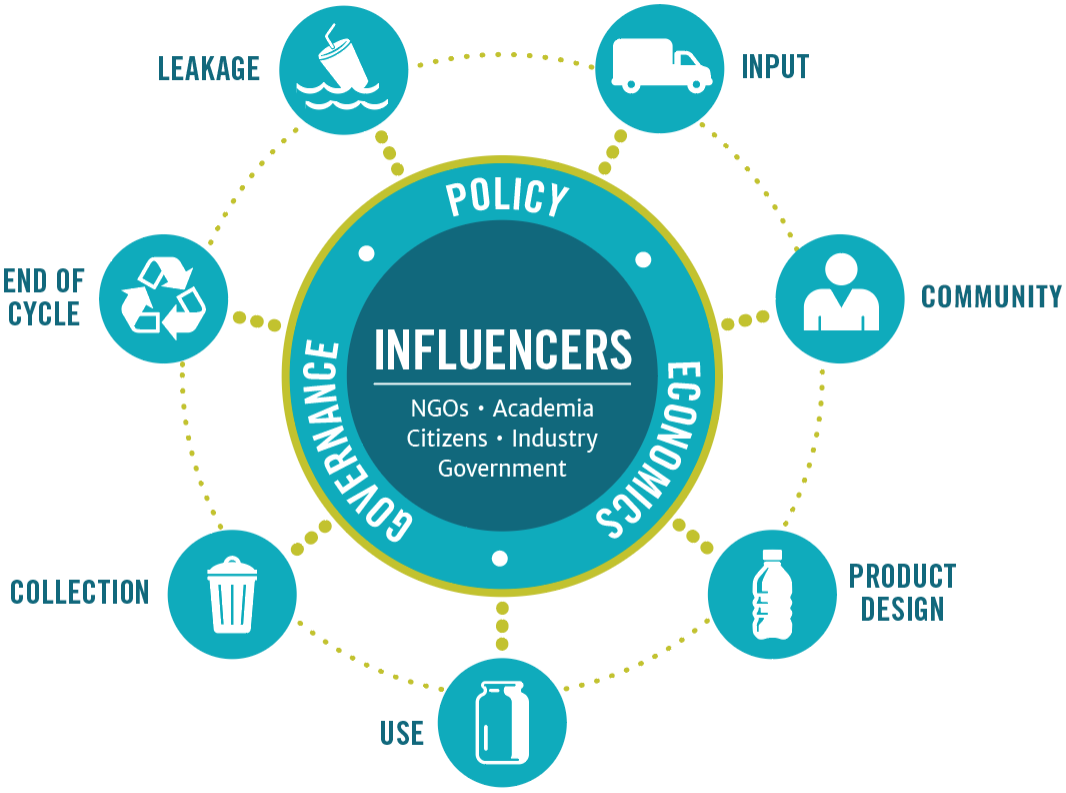
Recommended Citation:
Circularity Informatics Lab, 2023. Circularity Assessment Protocol: Vicksburg, Mississippi, USA, University of Georgia, Athens, GA, USA.

Photo Credits:
Cover: Christine Tibbetts
Pages 19, 20, 22, 23, 25, 26, 29, 30, 31, 32, 33, 38: CIL

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 July of 2022, a team from the Circularity Informatics Lab conducted fieldwork in the city of Vicksburg, Mississippi with support from the Mississippi River Cities and Towns Initiative (MRCTI) and the city's local government. This report was made possible through funding by 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: While several producers and manufacturers of common convenience items found in Vicksburg were sourced from countries in Europe, Asia, and the Middle East, the bulk of companies were sourced in the US, with many located proximally to Vicksburg in Alabama, Florida, Louisiana, and Tennessee. Candy packaging tended to travel the most distance to be sold in Vicksburg, while chips and beverages were typically procured from domestic sources.

Opportunities:

- There may be opportunities to partner with packaging manufacturers and production companies that are proximal to Vicksburg on EPR schemes, product design innovation, and alternative delivery systems.
- Encouraging domestic candy products as opposed to those that come from abroad may reduce the overall footprint that is required to bring products to Vicksburg from overseas.
- Although no EPR schemes exist in Mississippi, Vicksburg could lead an exploratory initiative to examine what EPR policies may be appropriate and cost-effective in the community for both residents and businesses.

COMMUNITY

Findings: More research is needed in the area of community interactions with plastic consumption and waste management. However, the location of Vicksburg along the Mississippi River and a major US thoroughfare (Interstate 20), means that the city is positioned for industrial, commercial, and economic activities. Additionally, the small size of Vicksburg means that local advancement of large-scale waste management schemes may be inappropriate.

Opportunities:

- Further data collection related to awareness, perceptions, and behaviors toward plastic use and waste disposal among the public may provide useful insight into how best to approach waste management in the city.
- There may be opportunities to partner with local commerce and industry companies as well as the US Army Corps of Engineers to explore ways to

innovate with product design, waste infrastructure, and litter and riverine debris prevention in the city.

- At present, sustainable materials management models may provide the most accessible decision-making approach to prioritize waste reduction and recycling outlets in the community in a manner that provides net benefits to the community by leveraging the systems it already has in place and strengthening existing efforts toward desired goals. As the city progresses in its planning, infrastructure, and education programs, it may implement more ambitious waste management strategies like circular economy and zero waste campaigns that target intensive diversion of waste from landfills.

PRODUCT DESIGN

Findings: Multilayer film was common among typical plastic items sold at convenience stores, primarily among chip and candy packaging. Similarly, 70% of food vendor packaging was made of plastic, however, there was high variation in polymer and format.

Opportunities:

- Plastic alternatives in the form of bio-based, biodegradable, and compostable plastics are likely to continue gaining momentum in Vicksburg 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.
- There are funding opportunities that can be used to target innovative product design strategies and delivery systems through the MDEQ Incentive Recycling and Research Grants program, which is open to communities, recycling companies, and research entities.

USE

Findings: There were very few alternative product designs or delivery systems that reduced the use of single-use plastics in Vicksburg. For example, most of the reusable or alternative retail bag options offered by businesses were made of thick woven plastics or disposable paper. There were no recorded instances of bulk sale of items. Mississippi is one of a few US states that has prohibited local bans or fees on common plastic goods, limiting the opportunities for local communities to implement policy-led strategies for reduction in plastic use.

Opportunities:

- Local government and businesses could explore ways to encourage or offer common goods in bulk form 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.
- As more complex plastic alternatives are introduced to the waste stream, more education efforts will be needed to combat misleading product labels and encourage understanding and appropriate management by individuals and households.

COLLECTION

Findings: There are several collection outlets in Vicksburg ranging from curbside collection in the city limits by Waste Management to drop-off locations operated by a local non-profit, MIDD-West Industries (A non-profit organization that operates a variety of employment and skills training programs for the developmentally disabled of Warren County), as well as receptacles provided throughout the public domain.

Opportunities:

- While plastics #1 and #2 have some infrastructure for collection and management, there may be possibilities at expanding collection of film plastics led by private businesses (mainly grocery retailers). Additionally, drop-off events have been successful for the collection of hard-to-recycle materials, so investing in recurring events and infrastructure programs can help to encourage management.
- Mapping out existing receptacles and drop-off locations would provide an opportunity to examine collection gaps and disparities in access across the community.
- A local non-profit is one of the only plastics recovery facilities in the community, however, impacts from COVID-19 highlighted the fragility of these types of organizations. As such, the city and business community should explore ways to bolster local nonprofits and organizations aiming to

improve waste management and provide services that are otherwise missing or inaccessible to some residents.

END OF CYCLE

Findings: Landfilling is the primary form of waste disposal in Vicksburg, with most municipal waste being temporarily stored at local transfer stations before being transported to landfills throughout southern Mississippi. Additionally, some waste is deposited in local rubbish facilities in Warren County. Diversion methods include recycling prepared or managed by MIDD-West Industries or Waste Management, though most recycling of plastics is limited to #1 and #2 plastics. There are no industrial composting facilities in Vicksburg or easily accessible aside from small efforts at the household level.

Opportunities:

- With most waste being landfilled currently, there are ample opportunities to explore diversion measures whether upstream through waste reduction or exploring ways to boost the collection and processing recyclable or reusable materials.
- Given the lack of compost facilities paired with the growing use of compostable and biodegradable items in the waste stream, there is a growing need to educate consumers about what these product designations mean, what product labels entail, and how to appropriately manage different materials based on their disposal designations.
- A curbside compost program is estimated to cost the city about $1.5 million to start (approximately $15/household/month) but could reduce 385 – 769 million tons of CO2 Equivalents per year. A drop-off program could mitigate up to 500 million tons of CO2 equivalents.

LEAKAGE

Findings: Nearly 3,000 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 found in the middle population areas. Illegal dumping is a concern in the region, which mirrors a challenge faced throughout the United States. Lastly, microplastics have been documented in the adjacent Yazoo and Mississippi River waters.

Opportunities:

- Collecting data and monitoring trends over time can provide insight into waste patterns, community needs, and effectiveness of waste management

programs. With continued litter monitoring, the city may be able to identify innovative ways to prevent and abate litter in the community.
- Plastic fragments are the most common item, which makes it difficult to identify intervention points. However, cigarettes are a key litter item, which could be addressed through education campaigns, litter violation enforcement, and further implementation of cigarette collection receptacles in the city.
- Similar to litter monitoring, recording common locations for observed or reported illegal dumping can help to identify hot spots that can be targeted with resources.
- Additionally, recurring clean-up and drop-off events may help to encourage proactive management of hard-to-recycle items that can be illegally abandoned.

Strengths

- Most products in Vicksburg 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 many facilities have 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.
- A statewide ban on the use of microbeads in personal care products was proposed which did not get passed (before the national ban), this demonstrates a potential for state willingness to make policy advancements that preserve the environment and human health in the context of plastic consumption and waste management. However, Mississippi does have a ban on bans of single-use plastic items, which indicates that policies or legislation related to plastic regulation are not always favorable.
- 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 Vicksburg 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 contracted through private companies and nonprofits, which help to reduce the burden on the local government's resources. Further, there is ample infrastructure for the collection and management of plastics #1 and #2, with growing opportunities to expand the collection of plastic films.

- 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.

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Introduction

As of 2023, the United States (US) is home to a population of 331 million people (US Census Bureau 2020) and has an average waste generation rate of 2.24 kilograms per person per day, more than twice that of the global rate of 0.74 kilograms per person per day (Kaza et al. 2018). As a high-income nation, waste management in the US 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 US generating the largest mass of plastic waste (42 million metric tons in 2016) in the world (Law 2020). The waste in the US is 12% plastic, although the largest percentage of the waste stream is paper/paperboard (23%) and organic materials, like food waste, make up 21.6%. And 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 US 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 US (Law 2020). The focus of the CAP for this project was to look at both plastics and organic materials in the waste stream that could be managed through composting, compostable products, biodegradable products, and plastic packaging.

As one of the largest countries in the world, both in terms of population and land coverage, the US is known for 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, however, there is a lack of focus on regions that are in need of assessment in order to develop appropriate, context-sensitive solutions. In the state of Mississippi, an estimated 6.1 million tons of solid waste were collected for disposal in 2019 from both commercial and non-commercial entities. Of this, municipal solid waste comprised 59% (MDEQ 2020). The state is expected to generate 2.6 million metrics tons of MSW by 2025 (American Society of Civil Engineers 2020).

Vicksburg is a small city in western Mississippi home to 21,600 people as of 2020 and a median household income of $38,000 (U.S. Census Bureau 2021). The city is situated at the confluence of the Yazoo and Mississippi Rivers and serves as a major port for riverine transportation (Figure 1). As a result, the city has a history of commercial development and industry which includes the first bottling company for Coca-Cola beverages (Vicksburg-Warren Partnership 2023b). The Mississippi River is the largest river in the United States in terms of discharge draining 40% of the continental US. The mayors in MRCTI have committed to reducing plastic pollution in the Mississippi and have given significant time to this effort through the Mississippi River Plastic Pollution Initiative. As Mississippi is one of 10 states banning legislation that targets the reduction of single-use plastic waste, the community of Vicksburg faces local

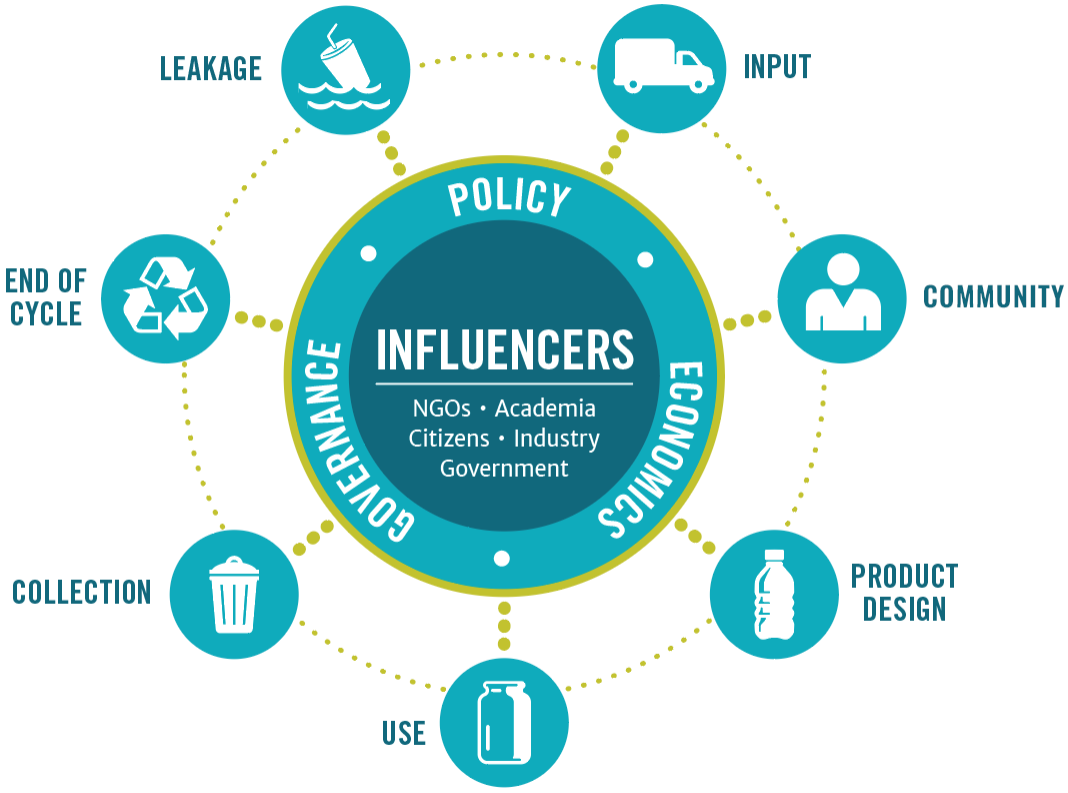
challenges related to its geography, diverse and growing population, commercial industries, and infrastructure needs.

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 2). 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.

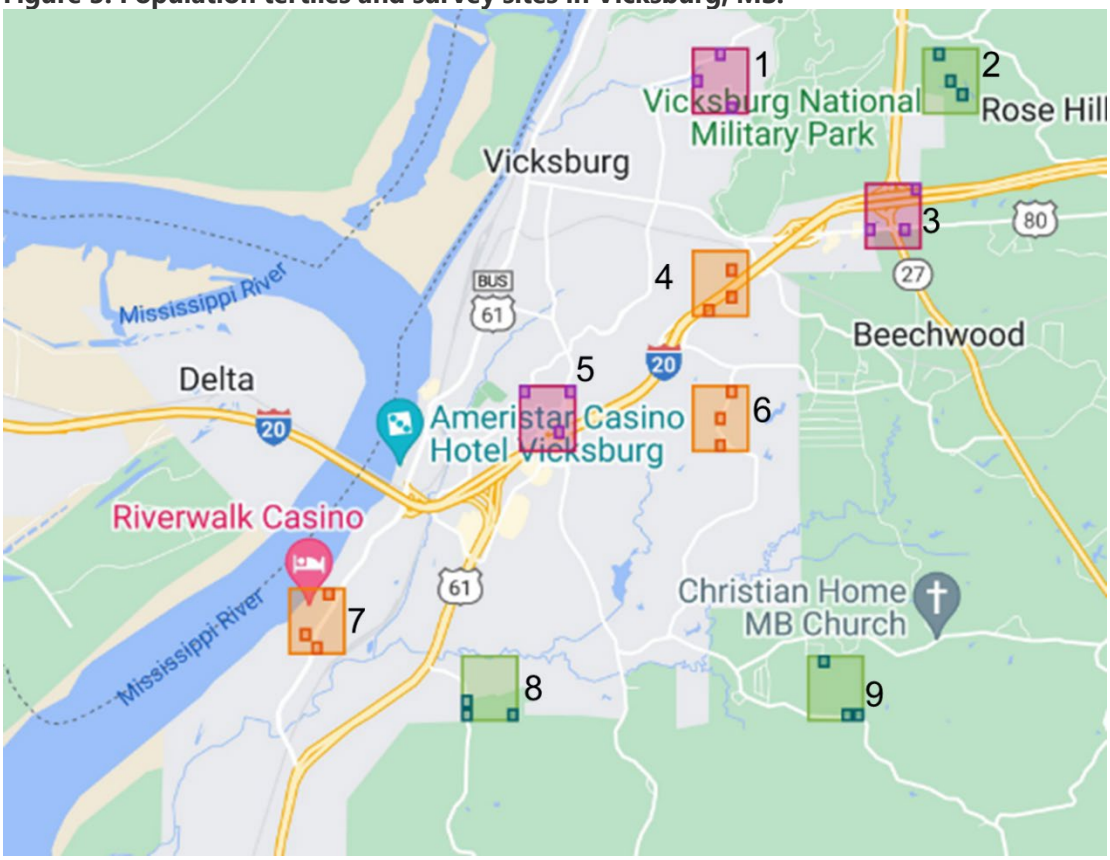


In July of 2022, a team from the Circularity Informatics Lab conducted fieldwork in the city of Vicksburg, Mississippi with support from the Mississippi River Cities and Towns Initiative (MRCTI) and the city's local government. This CAP was conducted with funding support from the Walmart Foundation. 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 Vicksburg, MS.

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, etc. With the City of Vicksburg situated along the river, the sampling area was not exactly square, but situated entirely on the east side of the river.

Figure 3: Population tertiles and survey sites in Vicksburg, MS.



Typically, three 1 x 1 km areas for surveying are randomly selected within each population tertile using NOAA's Sampling Design Tool, resulting in a total of nine 1km^2 areas for surveying. In total, 9 sites were surveyed, three in each of the high, mid and low population count tertiles.

Input

The US and its partner countries in the North American Free Trade Agreement (NAFTA) contributed to 19% of the world's plastic production, having produced about 70 million metric tons of plastic products in 2020. According to the Plastics Industry Association, nearly 380,000 people (or about 12% of the 2021 state population) in Mississippi are employed in the plastics industry including processors, marketing, and support activities as well as plastic-dependent industries (Plastics Industry Association 2023). Within the Mississippi plastics industry, 5,000 people are employed specifically in plastic production, which consists of businesses that process and manufacture machinery, molds, and raw materials related to plastic. Additionally, employment of plastic-dependent industries in Mississippi is primarily concentrated in sub-industries of healthcare, food service, manufacturing, and construction.

To get a snapshot of the characterization, scope, and source of common plastic packaged items that are entering Vicksburg, the CIL team sampled common convenience items in three common product categories: candy, chips, and drinks. These items were recorded during transects held across nine 1 km2 survey areas in Vicksburg — three within each tertile of the population count (Figure 2). The team selected three convenience or grocery shops to sample within each 1 km2 transect area. In total, 169 convenience products were collected and sampled, including 80 candy products, 29 chips, 60 beverages. Samples of identical brands were not collected multiple times, even when present in multiple stores. 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 desktop research, as well as the headquarters location for the parent company of the brand (largely determined by desktop research). For tobacco, top brands were identified only and they consisted of: Marlboro, Newport, Winston, Camel, Skoal, Cheyenne, Black & Mild, Vuse, and Grizzly.

Average distances for each product category were similar for product manufacturers and parent companies, however, candy had the highest median distance for manufacturers due to the large maximum distance of more than 26,000 km away. For parent companies, chips had the highest median distance, however, candy still had the highest maximum distance. In contrast, drink items had the lowest median distance to parent companies, with the nearest source manufacturer and parent company being only 330 km from stores located in Vicksburg (Table 1). Based on the origins of the convenience categories, regional distribution of products in the United States was common among both manufacturers and producers. Most beverage companies were located in the USA, except for two that were in Mexico and France. Chips were primarily manufactured in the USA, while candy had the furthest manufacturer companies located in Pakistan, China, Thailand (Figure 4). Within the US, most California, Pennsylvania, and Texas had the highest proportion (12% each) of manufacturers, together making up 36% of all manufacturers together. No manufacturers of the surveyed products were based in Mississippi, however, 9.0% come from neighboring states of Alabama, Florida, Louisiana, and Tennessee.

Table 1: Distances between Vicksburg 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	330	9,162	1,673	1,692	330	9,395	1,891	657
Candy	402	26,405	3,957	1,885	402	11,724	3,893	1,885
Chips	434	2,710	1,154	594	2,702	1,959	2,164	2,702

*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 US. By product category, a few candy items and some beverages had parent companies based in Europe. Chips similarly tended to emerge from parent companies located in the US (Figure 5). Of all 64 parent company locations, 52 (81%) were located in the USA, followed by 4.7% in Germany, and 3.1% in Mexico. Additionally, California had the highest proportion (13%) of parent companies for Vicksburg products followed by Pennsylvania, New York, Georgia, Texas, Illinois, and Michigan which all comprised 7.7%. Like manufacturers, there were no parent companies located in Mississippi, however, 9.6% of parent companies were located in neighboring states like Alabama, Florida, Louisiana, and Tennessee.

A handful of states in the US have implemented Extended Producer Responsibility (EPR) policy legislation that encourages producers of products to bear some responsibility for their end-of-life management. At current, Mississippi does not have any EPR legislation, which generally 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 US include product-take-back and deposit-refund schemes as well as waste collection and take-back guarantees (UNEP 2018). The plastics industry in the US 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). EPR schemes are typically supported by state-level governance, suggesting that Vicksburg state-level representatives could advocate for legislation targeting EPR efforts or engagement with packaging producers. Although there are no producers or manufacturers local to Vicksburg or Mississippi based on the CIL surveys, there is still opportunity for partnership with companies in neighboring states as shown in Table 2, or beyond that geography. EPR can be a requirement of the companies doing business in a state no matter where products are manufactured, or companies are located. A full list of parent companies and manufacturers documented across the Vicksburg product surveys is available in the Appendix.

Figure 4: World Map displaying manufacturing locations for top convenience items in Vicksburg

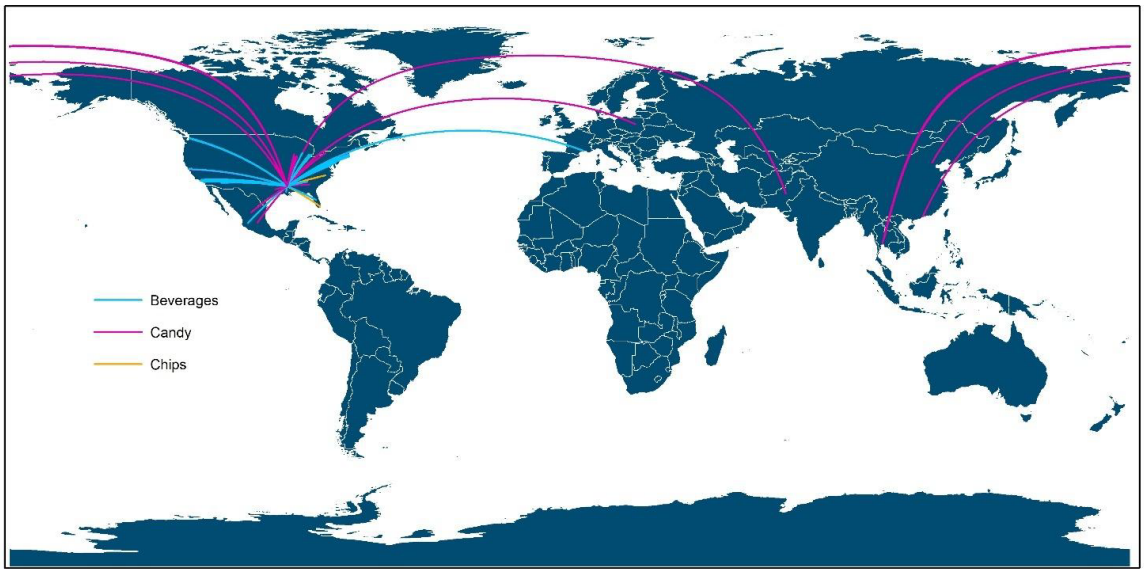


Figure 5: World Map displaying parent company locations for top convenience items in Vicksburg

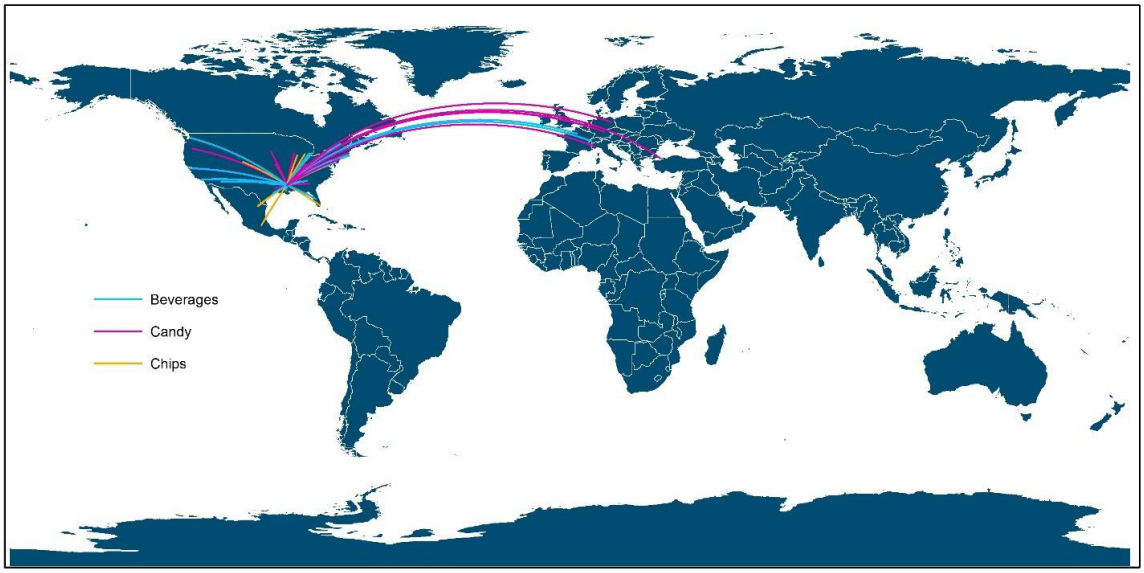


Table 2: Domestic products and materials produced or manufactured in states neighboring Vicksburg, MS

Neighboring state **Company name**	**Product category**	**Packaging types**
Alabama		
Golden Flake Snack Foods	Chips	Multilayer plastic
Red Diamond	Beverage	PETE; hard plastic; film
Florida		
Citrus World	Beverage	PETE; hard plastic; film
Rap Snacks	Chips	Multilayer plastic
Louisiana		
Community Coffee	Beverage	HDPE
Tennessee		
Brimhall Foods Company, Inc.	Chips	Multilayer plastic
Charms LLC	Candy	Plastic film
Pringles Manufacturing Co.	Chips	Hard plastic; multilayer paperboard

Community

Based on field surveys conducted in Vicksburg by CIL in 2022, information about how the community interacts with plastic products and waste is disparate, highlighting an opportunity for the city to invest in educational campaigns about waste reduction, reuse, recycling, and litter prevention. Notably, Vicksburg has a small population of 21,600 as of 2020, making up almost half of the entire Warren County population (US Census Bureau 2020). Although the city may generate less cumulative waste than larger counterparts, smaller communities face their own challenges related to waste management, with many semi-urban communities lacking operational resources, adequate sites, and growing populations that pressure small systems. Local-level waste management strategies have commonly involved voluntary community approaches in which municipalities minimize local impacts from waste through awareness raising, encouragement of proper waste disposal, and voluntary recycling efforts. One 2014 study located in a similarly sized town in Louisiana found that awareness programs, commitment by local authorities, and shared passion for environmental protection contributed to a successful community recycling program (Massawe et al. 2014). Past education and awareness efforts in Vicksburg have included litter clean up and waste drop off events operated by Warren County, Keep Vicksburg Beautiful (an affiliate of Keep America Beautiful), and MIDD-West Industries, the local recycling processor. Further, there are several resources online through the local waste collection provider, Waste Management, pertaining to what materials are permitted in the recycling bin. Additionally, as more alternatives to plastics are introduced into the waste stream, efforts toward educating the public for proper disposal of biodegradable, bio-based, or compostable items will be needed in order to prevent contamination of the recycling waste stream as well as harmful leakage into the environment.

Additionally, Vicksburg's geographic location also plays into its plastic waste management characteristics. The city is located on the banks of the Mississippi River, which has led to a role in modern transportation, commerce, and industrial development. For example, the City of Vicksburg housed the first commercial bottler for Coca-Cola in 1894 (Heartland Coca-Cola Bottling Company 2023). Further, Vicksburg is considered a major port along the Mississippi River, with shipping and commerce activity in the port having led to industrial development as well as a major engineering and research station for the US Army Research and Development Center (ERDC) which is the biggest employer in the city (Vicksburg-Warren Partnership 2023a).

Given the wide array of plastic waste inputs, products, collection, and end of life management needs, the city would benefit from development of a comprehensive solid waste management plan. These plans are required by local municipalities by the MS DEQ, although it is unclear if Vicksburg or Warren County (the county Vicksburg is in) would be completing this plan. These plans are also not currently available online to review. However, there are several approaches to developing a solid waste management plan including prioritization and strategic planning which can target specific materials (e.g., plastic bottles or polypropylene), prioritize different policies and technologies, or prioritize certain community stakeholders. There are also performance metric approaches such as assessing effective recycling rates informed by establishing baseline rates, setting arbitrary performance outcomes based on community goals, or setting technical-based target outcomes based on scientific thresholds. Several states across the US have implemented plans like these with success (Anshassi et al. 2019).

Finally, there are three common waste management models that could be applied to Vicksburg's waste management and environment to effectively target the community's goals and needs. Ambitious models include striving for a circular economy or zero waste model. The circular economy is an alternative approach to traditional linear models ('take-make-waste') that encompasses an industrial economy that is designed to be restorative and regenerative (Ellen MacArthur Foundation 2017) through '4Rs' framework that prioritizes reduction, reuse, recycling, and recovery (Kirchherr et al. 2018). Zero-waste models aim to eliminate waste entirely through volume reduction driven by product design and management processes that recover and conserve all materials and resources and reduce demand on natural resources (Anshassi et al. 2019). These advanced systems like zero waste goals can be challenging to adopt in cities due to the need for harmonized and coordinated efforts, sustainable behavior and consumption patterns, product stewardship, supportive legislation, and near perfect recovery of items (Zaman 2011). Further, zero-waste models encourage complete avoidance of landfill disposal. Given the well-established landfilling practices throughout Mississippi and Vicksburg, one feasible model to focus current sustainable plastic waste management efforts could be through the sustainable materials management model which focuses on use/reuse of resources and minimization of material consumption through decisions based on overall material impacts to environment, society, and the economy (Allen et al. 2009), and which emphasizes a net environmental outcome rather than elimination of landfill disposal practices entirely (Silva et al. 2017).

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 1km^2 transects areas. 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	64	31	544
Candy	81	4.2	49
Chips	29	4.9	84

A total of 14 convenience and grocery stores were present and sampled across four of the transects. Eight of the stores were large grocery chains such as Walmart, Kroger, and the Dollar Tree. Three were convenience and pharmacy chains like Walgreens and CVS. The remainder were two gas stations and one small grocery store local to Vicksburg, Super Junior. A total 174 items were sampled. Beverages had both the highest product mass and packaging mass (Table 3), largely due to the high density of liquid product as well as the higher density quality polyethylene terephthalate (PET) commonly used in plastic bottles. Candy had a high product mass compared to other CIL assessments; however, its mass, as well as that of chips, is in alignment with another US-based CAP conducted in Miami. 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. 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 our purchasing of samples in this case, but they are typically a standard size and we have previously found 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, which typically weigh about a gram each.

Together, beverage product and packaging had the greatest mass by far of the three product types (Figure 6). However, when considering the ratio of packaging to product, candy was more substantial with 0.09 g of packaging for every gram of product, compared to chips and beverages which both had a ratio of about 0.06 g/g. As such, candy wrappers generate the most packaging waste per unit of product delivery 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 7).

Figure 6: Convenience store plastic to product ratios, shown in grams (not including unknown products or tobacco as there is no weight data for tobacco)

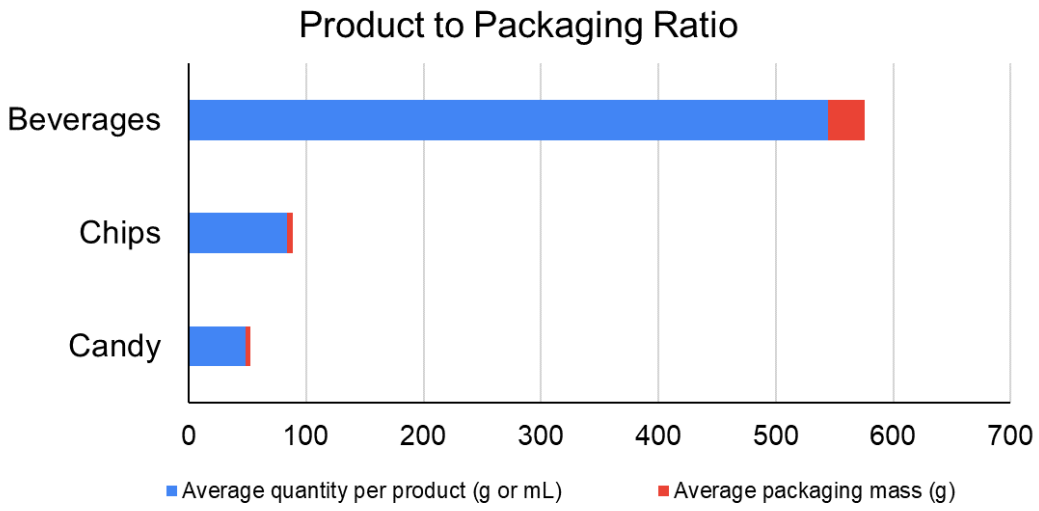
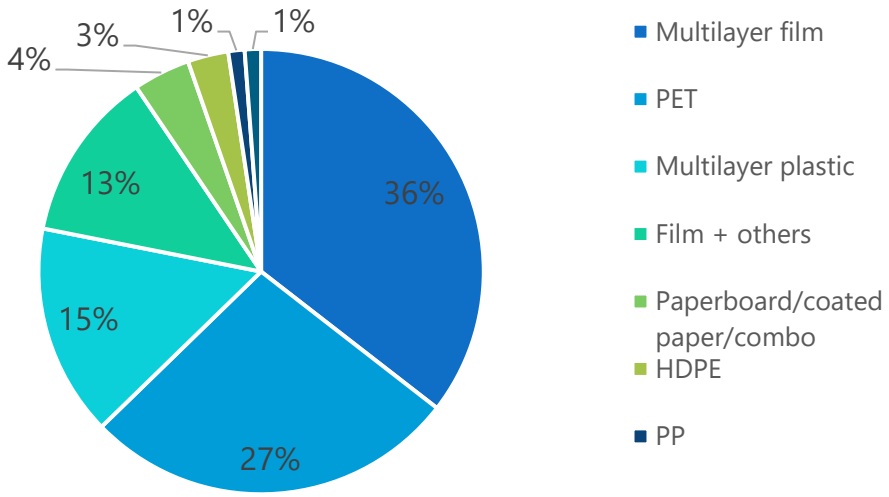


Figure 7: Material breakdown of top convenience items in Vicksburg



In addition to surveying convenience and grocery stores, the CIL team surveyed restaurants in each of the nine 1 km^2 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

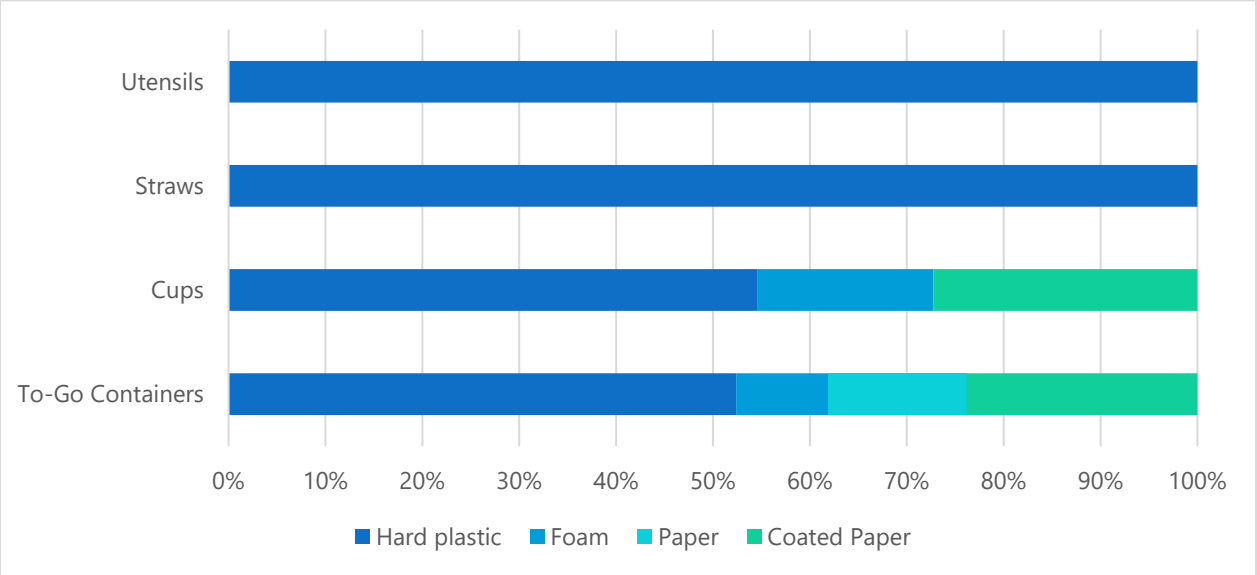
straws. Twelve food vendors were sampled across the transects, of which five were national fast-food chains, three were full-service sit-down restaurants, two were American fast-casual chains, and two were local café and bakery vendors. Across these vendors, 54 takeout items were collected such as cups, straws, utensils, bags, etc. 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 or two material types. For example, all seven straws obtained were made of polypropylene, while all eight bags were made of either HDPE or paper. By material type, 70% of the items were made of plastic, with the most common type being polypropylene 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 8 summarize the items by product type and material.

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)	Hard plastic	11
	Foam	2
	Paper	3
	Aluminum	0
	Coated Paper	5
	Aluminum-lined paper	0
Cups	Coated Paper	3
	Hard Plastic	6
	Foam	2
Straws	Paper	0
	Hard Plastic	7
Utensils	Hard Plastic	6
	Wood	0

There are some state level funding opportunities that may be useful for targeting product design and development as well as recycling equipment, support structures, and demonstration projects through the Mississippi Department of Environmental Quality (MDEQ) Incentive Recycling and Research Grants. These grants are open to research institutions and private recycling companies, as well as cities, counties, and regional solid waste authorities (MDEQ 2023).

Figure 8: Material breakdown of to-go items surveyed in Vicksburg, MS



Use

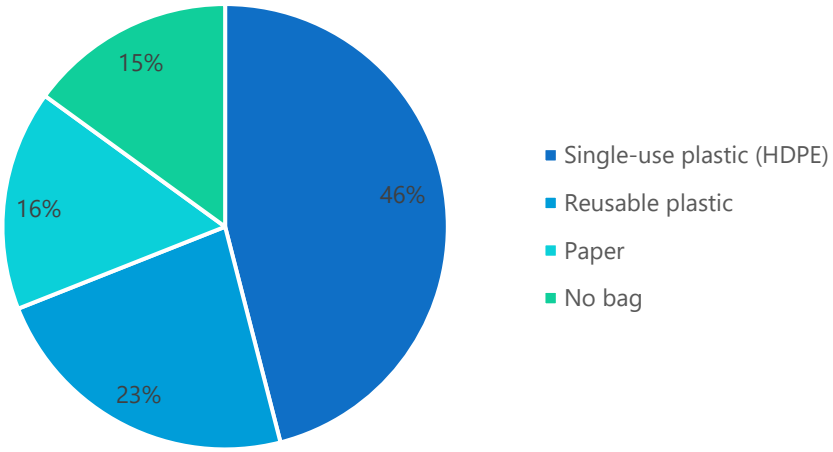
Throughout the transects, the CIL team surveyed what types of bags business provided at check-out. A total of 26 bags were assessed across twenty businesses consisting of 12 food vendors and eight retail stores. Across the food vendors, eight (67%) offered take out bags of which 50% were paper and 50% were HDPE. Additionally, none of the vendors offered compostable plastic bags. Similarly, the team surveyed eight retail stores consisting of seven grocery stores and one pharmacy. At all locations goods plastic retail bags were provided to customers at no additional cost. Of these plastic bags, 100% were made of HDPE, and all but one of the plastic bags were labeled with information about how to dispose of them. Specifically, three of the bags were labeled with the standard arrows that universally represent 'recyclable'. Four of the bags were labeled with information for how to recycle as shown in Figure 9, which shows a plastic retail bag labeled with the words 'Please return to participating store for recycling'. While this label does provide some direction to customers regarding disposal options, it may be superfluous if customers have limited awareness of which stores are participating.

Figure 9: Example of plastic bag from convenience store in Vicksburg (Photo Credit: CIL)

Alternative options for plastic bags were not common among the businesses surveyed. Most bags offered by businesses were typical HDPE bags. Alternatives included reusable plastic bags (23%), paper bags (16%), or no bags offered at all (15%) (Figure 10). As mentioned above, only 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). While five of the eight surveyed retail stores provided reusable bags as alternatives to the single-use plastic retail bags, all the alternative options were made of plastic. Most alternative retail bags were comprised of woven polypropylene and ranged from $0.74 to $3.98 USD depending on size. Additionally, one store

provided an insulated plastic tote option priced at $5.00 USD. Notably, the three stores that did not provide any alternative bag options were local retailers, two of which were a small grocery and one of which was a pharmacy, suggesting that the decision to provide alternatives may be cost-prohibitive for smaller, independent retailers.

Figure 10: Material breakdown of bags surveyed from convenience and grocery stores



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, stainless steel reusable straws were $0.92 USD each compared to single-use polystyrene straws that cost $0.01 USD. Similarly, items labeled as compostable were a typically more expensive alternative to disposable and recyclable items. For example, compostable bamboo plates were nearly 12 times more expensive than their cheapest single-use polystyrene 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, polystyrene and extended polystyrene plates, and polystyrene cutlery (Table 5), all of 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.

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 made of natural and organic material 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. 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: Price per count of items sold in stores by product, material type, and disposability

Material	Reusable	Compostable	Recyclable	Disposable
Baggies				
EVA	$2.99			
PP			$0.09	$0.07
Silicone	$9.34			
Cups				
Aluminum	$0.62			
EPS				$0.08
Not specified				
Plastic (not specified)				$0.11
PP			$0.11	
PS			$0.17	
Cutlery				
PLA		$0.13		
PS			$0.05	
Plates				
Bamboo		$0.48		
Coated paper		$0.08		$0.11
EPS				$0.05
Fiber		$0.17		
Paper				$0.06
Plant based		$0.16		
Plastic (not specified)				$0.17
PS			$0.35	$0.04
Sugarcane & bamboo		$0.18		
Sugarcane fiber		$0.16		
Straws				
Bio based		$0.07		
Paper			$0.08	$0.12
PP				$0.01
Stainless steel	$0.92			
Trash bags				
LDPE				$0.25
Not specified		$0.58		
PP				$0.23
Recycled plastic		$0.13		
Utensils				
PP				$0.33
Wood		$0.16		
Cup/lid combination				
Plant based		$0.61		
Average	**$3.46**	**$0.24**	**$0.14**	**$0.13**

One common approach to reducing plastic consumption is through policy efforts that disincentivize their use such as plastic bans or fees. Along with 14 other states in the USA, Mississippi introduced the state's Anti-Microbead Act through House Bill 618 in 2015, which prohibits the sale and manufacture of plastic microbeads used primarily in personal care products. However, the law excludes over-the-counter drugs in its ban (Mississippi State Legislature 2015). Policies related to other single-use plastic items are lagging in the state. While several states and cities in the US have implemented bag bans largely via local ordinances (Wagner 2017), one study found that Mississippi had the lowest probability of enacting a plastic bag ban of any other US state, largely due to economic and educational characteristics of the state (Li and Zhao 2017).

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'. Along with Arizona, Florida, Michigan, Wisconsin, Idaho, Minnesota, Missouri, Indiana, and Iowa, Mississippi has incorporated the outlaw of plastic bag bans (UNEP 2018). In 2018, the governor of Mississippi signed State Senate Bill 2570 into law which effectively prohibits local governments like that of Vicksburg from instating bans or fees on plastic bags, paper cups, or other containers distributed by retailers or food vendors (Mississippi State Legislature 2022b). 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. Despite being limited through governance, the implementation of product bans or fees could still be carried out by private businesses in Vicksburg. 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 2019, the state of Mississippi generated 3.1 million metric tons of waste (MDEQ 2020), however, it is likely that some of this waste was imported. For example, in 2013, an estimated 24% of waste managed in Mississippi was imported from other states and countries (The Environmental Research & Education Foundation 2016). The average Mississippi resident generates an estimated 2.3 kilograms of waste per person per day (American Society of Civil Engineers 2020), which is only slightly higher than the national waste generation rate (2.2 kilogram per person per day; Kaza et al. (2018)). Waste material characterization data (i.e., percentage of plastics, metals, glass, etc.) were not readily accessible for Vicksburg, Warren County, or the State of Mississippi at the time of writing this report. However, by applying the US national average plastic waste composition rate of 12% (EPA 2020), an estimated 372,000 metric tons of plastic waste were generated in the state in 2019.

Nearly 100% of waste is collected in the USA, with many cities mandating 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. In Vicksburg, waste collection is provided to households within the city limits via Waste Management LLC. While the contract for Vicksburg's waste management system operates on a bid, Waste Management has been the primary supplier of waste services for over 25 years, and as of 2013, the company has been the only permitted solid waste hauler for Warren County (Dane Lovell 2022). Residential waste is collected via curbside containers issued by the city which currently cost $16.50 per single-family household. Multi-family properties with three or less apartments may purchase additional containers as well (City of Vicksburg 2023) (Figure 11). Service fees are determined by the mayor and are posted in resident and businesses' water bills. Collection occurs twice a week except for in downtown, which is only picked up once a week (Dane Lovell 2022).

Figure 11: Waste Management collection truck and residential bin in Vicksburg (Photo Credit: CIL)

In addition to curbside pickup, there are also some waste drop off points in the city and the surrounding county including waste receptacles and larger waste facilities like private landfills or processors. In some of the mixed commercial zones of the city (e.g., downtown), the city provides receptacles. Additionally, some private businesses including large retailers and grocery stores like Walmart and Kroger provide item-specific waste receptacles primarily plastic bags and flexible plastics (Figure 12).

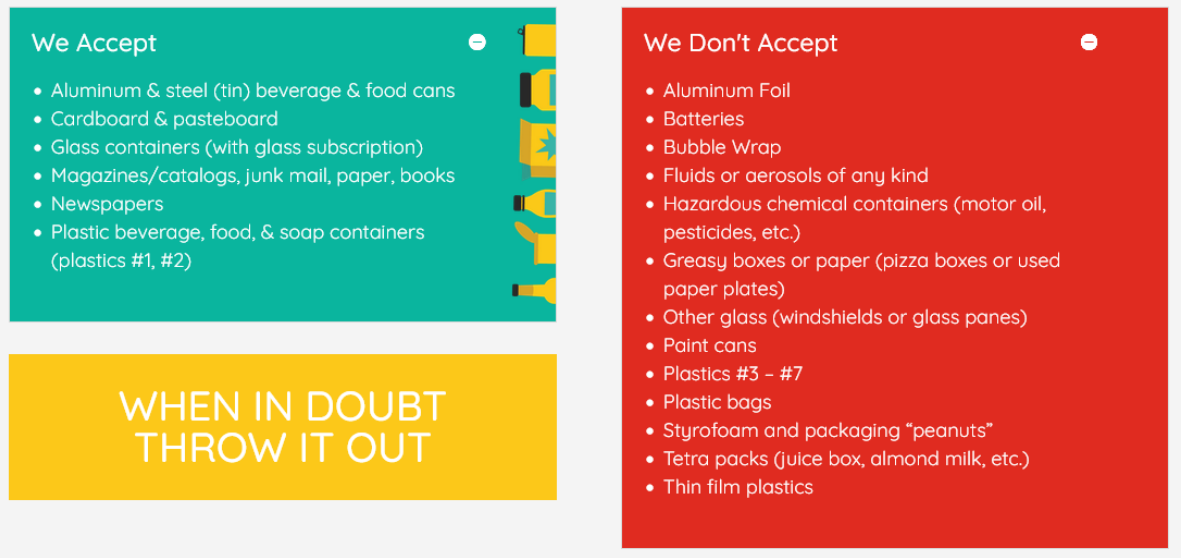
Figure 12: Common public waste receptacles in Vicksburg (Photo Credit: CIL)

For recyclable waste in the city, recycling services are provided to households and businesses. However, access to this service varies from neighborhood to neighborhood and data detailing coverage are unavailable. Segregated household waste is picked up by Waste Management LLC within the Vicksburg city limits. Through Waste Management's requirements, recycling in Vicksburg includes cleaned plastic bottles and containers, plastic food and beverage containers, as well as cans, paper and cardboard. Plastic bags, plastic wrap and film, and wax- or plastic-coated cups, plastic lids, polystyrene foam and plastic items are not permitted in the recycling stream for Vicksburg (Waste Management 2023). As such, efforts to target reduction in these items may help to reduce the generation of those plastic wastes that cannot be recycled. For example, awareness campaigns can encourage 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 alternative options to suit their needs.

For those residents outside of the city limits who may not be eligible for waste services provided by the city, one option for recycling collection is through a subscription service offered by a private company

called Recyclops, which provides collection and disposal services for recyclable products in areas that lack access to recycling services throughout the USA. Through Recyclops, residents can sign up for company-branded bags which are placed on the curb once they are filled with recyclables and picked up by local Recyclops employees for $12 per month per home. Participating residents do not have to segregate individual product types, but they are asked to place plastic items, cans, small cardboard & paper into blue bags provided by Recyclops and glass items into yellow bags. Although the base subscription service collects some plastic like polyethylene terephthalate (PET) bottles and high density polyethylene (HDPE) that is often used for food and personal care containers, the service does not collect remaining plastics #3 through #7, which includes plastics commonly used for food storage like polypropylene (PP) and low density polyethylene (LDPE) which is commonly used in film plastic applications (Figure 13). Once participating households' bags are collected, the company then hauls the bags to FV Recycling, which is located 50 miles east of Vicksburg in Jackson, Mississippi (Recyclops 2022).

Figure 13: Summary of accepted recyclables through Recyclops (Courtesy: www.recyclops.com)



Finally, the county has held some targeted waste collection events. For example, in March of 2022, the county hosted the Warren County Hazardous Waste Day during which the county's Board of Supervisors held a public event at the Sherman Avenue Elementary School in Vicksburg. On this day, the Board hired waste management vendors to assist collection and disposal and encouraged residents to drop off household hazardous waste items that are not suitable for regular recycling such as batteries, used motor oil, and antifreeze. Although items accepted at the event were not common single-use plastics, items like computer equipment, televisions, and tires were taken. Further, the total mass or count of items collected at the event are not available, but over 780 vehicles attended similar events in the past in Vicksburg (Guizerix 2022), suggesting that events such as these may be both well-advertised and popular among the public. In contrast, there have been efforts to provide and advance recycling efforts in Vicksburg.

There may be grant opportunities that Vicksburg can tap into to target improvement of waste collection throughout the community. The state has utilized financial resources from trust funds like the Environmental Protection Trust Fund, which supports solid waste collection in the state through a sustainable source of funding (American Society of Civil Engineers 2020). There are also several state-

assisted opportunities. For example, through the Mississippi Department of Environmental Quality (MDEQ), cities, counties, and regional solid waste authorities, private companies, and research institutions can apply to grants ranging from assistance with collection sites and recycling programs, identification of collection sites, funding for transportation costs

and waste storage facilities for waste tire cleanups, and collection, treatment, and storage of hazardous waste (MDEQ 2023). In the past, the city of Vicksburg has been awarded two grants since 2007 through MDEQ funding outlets totaling $75,000. The first grant ($25,000) supplied funding to purchase recycling containers and recycling program support. More recently, a $50,000 grant was awarded to the city that supported the establishment of drop-off sites located at four elementary schools throughout the community. The funding also aided enforcement by supporting security at these sites to prevent violations of the recycling ordinance. Further, the grant funded a paper shredder and a mobile recycling trailer for MIDD-West Industries, the latter of which was set up for collecting plastics (e.g., plastic bottles) as well as other products at events (City of Vicksburg 2019). Additionally, there are some public-private partnerships that provide financial assistance for waste collection. For example, Keep America Beautiful (KAB) has partnered with major beverage manufacturers like Coca-Cola, Dr. Pepper, and Snapple to provide grants like the Park Recycling Bin Grant program which provides annually awarded grant resources that expand recycling opportunities in public parks and beaches (Keep America Beautiful 2018).

End of Cycle

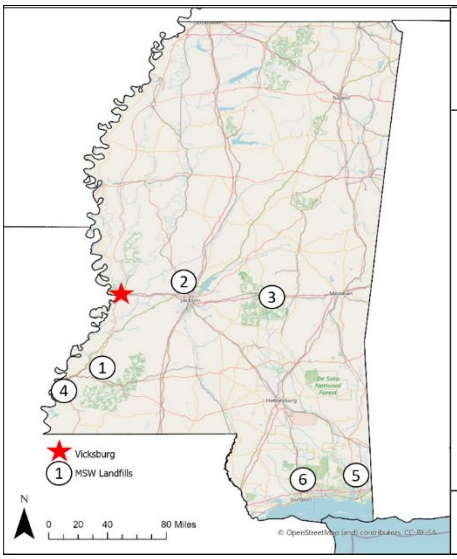
Add in https://vicksburgnews.com/vicksburg-introduces-solid-waste-ordinance-amendments/

Waste facilities in Mississippi are owned and operated by private entities rather than the state, though some are publicly owned but operated privately (American Society of Civil Engineers 2020). Mississippi has historically had one of the highest rates of waste disposal via landfilling in the US (The Environmental Research & Education Foundation 2016), and this reliance on permanent waste storage is still mirrored at the local level in Vicksburg. For end-of-cycle management of plastic waste following collection, there are several facility types that accept waste from Vicksburg and Warren County including municipal solid waste landfills, commercial rubbish sites, industrial processing facilities, waste tire processing collection, and commercial and industrial disposal facilities.

Municipal Solid Waste Landfills

An adequate volume of waste is needed to justify the establishment and investment in local waste management infrastructure. With a population of only 21,600 people as of 2020 (US Census Bureau 2020), Vicksburg must rely on multi-step collection, transportation, and disposal of waste. There are several deposit outlets for waste generated in Warren County according to the MDEQ. In the State of Mississippi, municipal solid waste (MSW) landfills are designated for nonhazardous household, commercial, industrial, and special waste (e.g., asbestos, medical, etc.). As of 2019, there were 19 MSW landfills in Mississippi, though no MSW landfill was located within Warren County. However, in the same year, about 13,500 metric tons (12,200 US tons) of municipal solid waste were exported from Warren County to six municipal landfills throughout central and southern Mississippi for disposal. On average these landfills were 183 kilometers (114 miles) from Vicksburg via driving routes generated by Google Maps (Figure 14). Given that there is no municipal landfill in Vicksburg or Warren County, it is ideal that waste generated by the city is deposited in the nearest landfills available that meet required state regulations. The largest quantity of waste was sent to Riverbend Environmental Services landfill, which is the second closest landfill to Vicksburg and operated by a private corporation of the same name (MDEQ 2020). In contrast, the smallest quantity (1.1 metric tons) was sent to the landfill the furthest away from the city.

Figure 14: Map of municipal solid waste landfills that received solid waste from Warren County in 2019 (Data source: MDEQ (2020))



No.	Facility name	Metric tons	Distance from Vicksburg (mi)
1	Riverbend Environmental Services Landfill	11,358	48
2	Little Dixie Landfill	1,972	42
3	Clearview Environmental Control Facility	99.2	98.1
4	Plantation Oaks Landfill	13.2	85.3
5	MacLand Disposal Center Inc.	12.1	218
6	Leflore County Municipal Solid Waste Landfill	1.10	193
Total		13,456	684

Class I and II Rubbish Sites

According to the Mississippi Department of Environmental Quality, these Class I sites accept the following solid waste categories which are a subset of municipal solid wastes that include non-putrescible (non-organic) waste including the following (MDEQ 2020):

- Construction and demolition debris
- Brick, mortar, concrete, stone, and asphalt
- Cardboard
- Natural vegetation
- Appliances which have had the motor removed (except refrigerators and air conditioners)
- Furniture
- Plastic, glass, crockery, and metal (except containers)
- Sawdust, wood shavings, and wood chips

In 2019, the two Class I rubbish sites in Warren County accepted about 24,500 metric tons of waste, while the Vicksburg Warren County Landfill received 152 metric tons from out of state. The Vicksburg Warren County Landfill sits on ten acres, yet its operable life is running out of time, with an estimated five years remaining as of 2019 (reflecting approximately one year life remaining at the time of writing). Fortunately, Warren County Waste Control facility has ample life remaining (50 years as of 2019) (Table 6). However, one significant challenge throughout Mississippi is the management of landfill closures, which requires that operators cover landfills with 24 inches of earthen material and are responsible for post-closure monitoring for 30 years. However, municipalities in Mississippi generally cover costs of landfill closures, despite many communities lacking financial resources to do so (American Society of Civil Engineers 2020).

Table 6: Class I Rubbish Facilities in Warren County as of 2019 (Data source: MDEQ (2020))

Facility name	Owner	Acres	Total waste received (tons/year)	Out of state received %	Est. life remaining	
					(years)	(acres)
Warren County Landfill Rubbish Site	Vicksburg Warren County Landfill	10	24,20210	0.62	5	3
Warren County Waste Control	River City Roll-Offs LLC	23	580	0	50	86
Total		**33**	**24,782**	**0.62**	**55**	**89**

In addition to Class I Rubbish sites, there are also four Class II Rubbish facilities in Warren County (Table 7). Class II facilities are non-commercial disposal facilities that accept non-hazardous industrial and institutional waste. Unlike MSW landfills and Class I Rubbish facilities, these Class II facilities are generally owned and operated by the institutions that generate the waste. Together, these sites accepted 32,800 metric tons (36,100 US tons) in 2019, with most waste generated and disposed of at International Paper's Vicksburg Mill.

Table 7: Class II Rubbish Facilities in Warren County as of 2019 (Data source: MDEQ (2020))

Facility name	Owner	Type	Acreage	Total waste received (tons/year)	Est. life remaining	
					(years)	(acres)
Cappaert Landfill	Cappaert Mfd. Housing Inc.	Landfill	37	43	20	35
IP Vicksburg Mill AMU	International Paper	Landfill	6	35,630	23	--
USACE Waterways Rubbish Site	USACE Waterways Exp. Station	Class II Rubbish facility	2	42	6	--
Vicksburg Forest Products Rubbish Site	Vicksburg Forest Products, LLC	Class II Rubbish facility	20	438	69	12
Total			**65**	**36,153**		

Transfer stations

In addition to waste disposal sites, there are two active municipal solid waste transfer stations in Warren County. Transfer stations can provide communities that do not have appropriate sites or sufficient populations to support the establishment of local waste management infrastructure like municipal landfills that collect household waste. Transfer stations can be used to temporarily store and then transfer waste to more appropriate facilities further away. Per the MDEQ Status Report on Solid Waste Management Facilities and Activities, transfer stations are defined as the following:

> *"Fixed facilities primarily used for the purpose of transferring solid waste from one solid waste transportation vehicle to another. Typically, municipal solid wastes or other wastes are unloaded from smaller, local collection vehicles and temporarily stored while the wastes are reloaded onto a larger, long-distance transport vehicle for shipment to a landfill or other appropriate solid waste management facility. By combining loads of waste material in this manner, local communities and waste management companies can reduce transportation costs. Transfer stations may also serve as local community drop off and collection points for other solid wastes and recyclable materials."*

The two transfer stations in Warren County are owned and operated by Riverbend Environmental Services LLC (MDEQ 2020), which operates the landfill in Fayette, Mississippi that accepted the largest mass of municipal waste in 2019 (Table 8). Similarly, the Vicksburg Transfer Station is owned by Waste Management of Mississippi, Inc. (MDEQ 2020), which operates the Clearview Environmental Control

Facility located in Lake, Mississippi, and accepted the third largest mass of waste from Warren County in 2019 (Table 8).

Table 8: Transfer stations in Warren County as of 2019 (Data source: MDEQ (2020))

Facility name	Owner	Total waste received (tons/year)	Out of state received %
Riverbend Transfer Station	Riverbend Environmental Services, LLC*	10,304	--
Vicksburg Transfer Station	Waste Management of Mississippi, Inc.	40,493	4.2
Total		50,797	4.2

*Acquired by Green Meadow Sustainable Solutions as of 2021 (Waste360 2021)

Recycling

Given the high reliance on landfilling throughout Mississippi and Vicksburg, the state has some of the lowest recycling rates in the country, with only 4% of MSW in the state being recycled in 2013. This low rate is similar to other states in the US that have smaller and/or remote populations such as Montana, Idaho, and Wyoming (The Environmental Research & Education Foundation 2016). The Recycling Partnership and Resource Recycling, Inc. have an online map of residential materials recovery facilities (MRFs) (https://recyclingpartnership.org/residential-mrfs/). The map is made up of the US locations of "Commingled Residential MRF as being a facility that accepts recyclables separated from trash and then brought in for processing as either single stream or dual stream materials to be sorted into individual commodities and sold to market" and shows no MRFs located in the entire state of Mississippi. The State of Mississippi defines *processing facilities* as those that, "sort, shred, grind, bale, treat or otherwise process solid wastes to facilitate recycling, reuse, or disposal," but do not include sites that receive and manage only pre-sorted recyclable components of solid waste or waste tire processors (MDEQ 2020). As of 2022, thirteen *processing facilities* (as opposed to MRFs as defined previously) were located across Mississippi, with MIDD-West Industries being the only one located in Vicksburg (MDEQ 2022, https://www.mdeq.ms.gov/wp-content/uploads/2022/03/MRFs-and-Recycling-Centers-in-MS-and-Neighboring-States-2022.pdf). MIDD-West operates as a non-profit organization that provides a range of employment and skill development opportunities to local community members with mental and/or physical disabilities and has provided drop-off/collection services for the city and baling of paper and plastics for recycling (Surratt 2015). COVID-19 forced MIDD-West to close to protect the health and safety of their employees (Parker 2020, Figure 15), highlighting a major challenge to the operations of waste management services for the community. The NGO was able to reopen collection operations in May of 2022, limited to collection in public schools for #1 and #2 plastics (i.e., PET and HDPE) only. As of the writing of this report, also located in Vicksburg is a privately owned scrap metal recycling facility called Big Recycling (Dane Lovell 2022, Figure 16).

Figure 15: MIDD-West Industry collection bins closed due to Covid-19 (Courtesy: Thomas Parker, Vicksburg Daily News)

In March of 2022, the governor of Mississippi signed House Bill 1135 into law, which was aimed at expanding recycling in the state by reclassifying chemical recycling as a manufacturing process (Mississippi State Legislature 2022a). Proponents of the law boast the economic benefits of the bill that may result from investments in recycling infrastructure and job creation. However, some environmental groups argue that laws like this one create gaps in solid waste regulation among private manufacturing companies, use energy-intensive processes that ultimately are burned for energy rather than recycled products, produce air pollution and more hazardous waste, and contribute to ongoing social justice issues with a disproportionate amount of low-income and communities of color housing these plants throughout the US (NRDC 2022). With the bill having recently been passed, it is uncertain how it will impact the state or the community of Vicksburg.

Figure 16: Scrap metal recycling facility (Big Recycling) in Vicksburg (Courtesy: CIL)

Composting

In 2017, there were 15 composting facilities throughout Mississippi, yet none of these are dedicated to materials found in municipal solid waste (Biocycle 2017). As of 2019, there were 11 active composting facilities throughout the state, with two inactive composting facilities in Hinds County, which is adjacent to Vicksburg. As such, there are no active commercial composting sites in Vicksburg or Warren County. However, according to a representative from the Vicksburg Public Utilities office, there is some backyard composting activity in the community at the household level (Dane Lovell 2022). While industrial composters can be useful for processing compostable plastic items, introducing those products in the waste stream (e.g., compostable plastic cups or bags) requires public education efforts, as these items are frequently confused with recyclable plastic items. Because compostable plastics are not equivalent to traditional plastic items that are able to be mechanically recycled, compostable items ultimately contaminate the recycling stream when they are incorrectly sorted.

With the lack of access to a municipal or commercial composting program in Warren County, the county and the city of Vicksburg have an opportunity (although resources needed) to create a residential composting program for their residents. 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, mass of organic waste to be collected, GHG Reduction from the program, and area required to create a composting facility for the organic waste (Table 9). 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.

Table 9: 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

Vicksburg and Warren County				
	Households Covered[2]	**Mass (Tons)**	**GHG Reduction (MTCO2E)**	**Area Required (Acres)[3]**
County-Curbside[1] (50-100%)	22,086	6,827 - 13,654	2,712 - 5,424	2.48 - 4.95
City Curbside* (50-100%)	10,841	3,351 - 6,702	1,331 - 2,662	1.22 - 2.43
City Drop-off (25-50%)	10,841	2,234 - 4,468	887 - 1,775	0.81 - 1.62

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

[2]number of households based on the 2020 census

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

In order 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 10.

Table 10: 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: 62,997 tons
Total Refuse for City Calculations: 30,922.3 tons
Using East South 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)

*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%2020050726.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 11). Those costs and the associated assumptions made in order to calculate the costs can be found in Table 12.

Table 11: 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	$145,000
Equipment Costs	$1,253,586
O&M Costs	$60,000
Fuel Costs	$0
Processing Costs	$23,458
Other Costs	$0
Total	$1,482,044
Summary of Annual Revenues/Savings of Residential SSO Collection Program:	
Fuel Savings*	$0
Mulch/Compost Revenues**	$0
Mulch/Compost Savings	$30,000
Disposal Cost Avoidance	$142,440
Other Revenues and Savings	$0
Total	$172,440
Estimated Monthly Net Costs per Household	
Monthly Cost per Household (Includes all Households in Community)	$10.07
Monthly Cost per Household with Access to Residential SSO Collection Program	$10.07
Monthly Cost per Participating Household	$14.38

Table 12: 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
Will yard waste be collected with the curbside compost program	Yes
Composition of Refuse Materials Targeted by Program Disposed by Community:[1]	
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 of organics	75%
Number of households served on single route	700
Routes per week	11
Number of vehicles	2
Carts, estimated number assumes purchase of an extra 10% of carts for replacements	11,925
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	$30,000
Jobs created:	
One Crew Leader	$45,000
Two Truck Drivers	$35,000 each
One Public Education Officer	$30,000

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)[2]	1,000
Cost per cubic yard of mulch/compost	$30
Disposal Cost Avoidance per ton[3]	$30.36
Will the city sell the mulch/compost created	No

[1]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

[2]Estimated using current number of public buildings/land in Vicksburg, MS

[3]Based on average tipping fee for Mississippi found here: https://erefdn.org/product/analysis-msw-landfill-tipping-fees-2/

Funding Opportunities

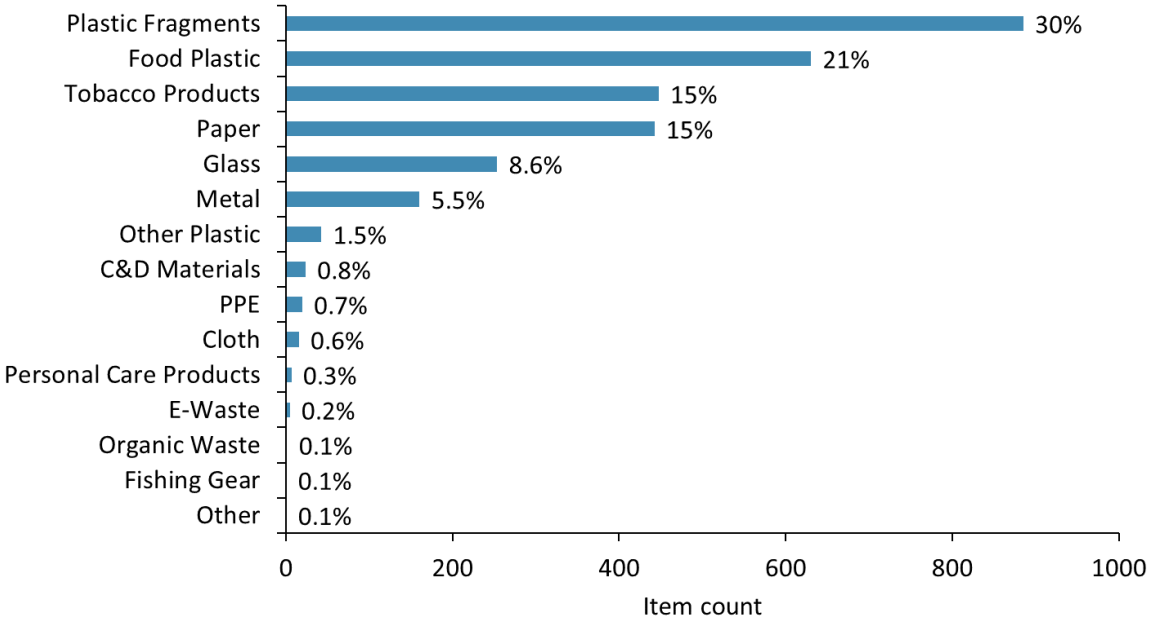
There are several potential funding outlets for targeting end-of-life management in Vicksburg. For example, the state of Mississippi provides several funding opportunities that target solid waste assistance through public grants ranging from cleaning up illegal dump sites, employing enforcement officers, developing collection programs for hard to recycle goods like appliances and furniture, and research and planning programs (MDEQ 2023). The state also uses financial resources from trust funds like the Mississippi Non-Hazardous Solid Waste Corrective Action Trust Program, which creates a federal assisted funding system for landfill and site owners to take over closed or abandoned MSW facilities through emergency actions, preventive or corrective actions for contaminant release, and post-closure monitoring and management activities (American Society of Civil Engineers 2020, MDEQ 2023). Additionally, there are some resources beyond Mississippi that provide funding and resources to communities. For example, The Recycling Partnership is a national NGO that broadly aims to improve community recycling systems through investment, support for EPR efforts, encouraging the design of circular packaging, etc. (Recycling Partnership 2023). There are also federally funded programs focused on rural waste management such as the Solid Waste Management Grants supplied through the US Department of Agriculture, which provides funding for organizations including public bodies, nonprofits, federally recognized tribes, and academic institutions, who then provide technical assistance and/or training for solid waste management planning and site operations to communities with populations of less than 10,000 people (USDA 2022). While Vicksburg may not be directly eligible due to its population size, other communities in Warren County that rely on the waste infrastructure provided by Vicksburg may benefit from these types of funds.

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 Vicksburg. 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 aggregated across the three population groupings.

In total, 2,957 litter items were recorded across twenty-seven 100 m^2 transects in nine different square kilometer areas sampled in July 2022. Across all surveyed transects, plastic fragments were the most prevalent litter item by item type, representing 30% of all items recorded (Figure 17). The second largest category was food plastic (21%) followed by tobacco products (15%), paper (15%), glass (8.6%), and metal (5.5%). The remaining categories represented 5% 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 54% of the total items.

Figure 17: Count and percentage of all surveyed littered material for Vicksburg, MS



By individual product types, cigarettes and plastic film fragments were the most recorded items with each making up 14% of the total count (Table 13). These values align with other cleanup events in Mississippi, including the 2022 International Coastal Cleanup, in which cigarettes were the most commonly documented item (20%) followed by food wrappers (10%) (Ocean Conservancy 2022). Common food packaging, like candy wrappers and chip packets, have low packaging-to-product ratios (Figure 5), which are generally less valuable for recycling compared to plastic bottles made of PET, which only comprised 1.4% of the litter recorded in Vicksburg, suggesting that there may be effective collection of plastic beverage bottles for disposal or recycling currently in the community.

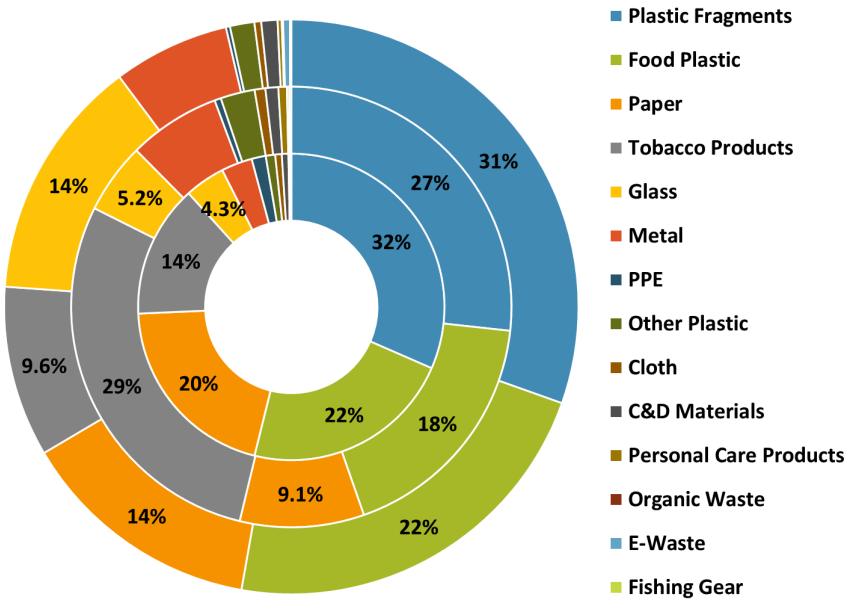
Table 13: Count and percentage of total transect count of debris items by item type

Item Type	Count	Percent of total
Cigarettes	424	14%
Film Fragments	423	14%
Hard Plastic Fragments	345	12%
Plastic Food Wrapper	340	11%
Paper	317	11%
Glass or Ceramic Fragments	240	8.1%
Foam Fragments	119	4.0%
Straws	81	2.7%
Foam or Plastic Cups or Lids	74	2.5%
Other Paper	73	2.5%
Aluminum or Tin Cans	50	1.7%
Plastic Bottle Cap	50	1.7%
Plastic Bottle	41	1.4%
Plastic String/ Tape/ or Packing Straps	40	1.4%
Metal Bottle Caps or Tabs	40	1.4%
Aluminum Foil	38	1.3%
Metal Fragments	25	0.8%
Cigarette Packaging	16	0.5%
Glass Bottle	15	0.5%
Coated Paperboard	15	0.5%
Total (top 20)	**2766**	**94%**

When examining the litter characterization based on the population count, some similarities and distinctions can be seen between the three groups. The high and low population count areas followed a similar pattern to the compiled litter data shown in (Figure 18), with plastic fragments being the most common material type of litter items and making up about a third of litter in each area. In the middle population count area, plastic fragments still made up nearly a third of the litter profile but were second to tobacco products, which were the most prevalent item there.

Comparatively, tobacco product litter made up only 9.6% and 14% of litter in the high and low population count areas, respectively. Other distinctions include a high proportion of glass (14%) in the upper population count, which was nearly three times of that seen in the middle and lower population areas. Similarly, the largest proportion of paper litter items was recorded in the lower population count area (20%), followed by the upper (14%) and middle population (9.1%). 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 population count area could suggest high tobacco use or a lack of infrastructure for proper disposal in comparison to that of the upper and lower areas. Similarly, the large proportion of plastic fragments in all three areas is notable given the challenges related to collecting, managing, sorting, and disposing or recycling those items given their size.

Figure 18. Composition of surveyed litter items for Vicksburg across the high (outer), middle, and lower (inner) population areas in Vicksburg, MS



When aggregated across all surveys, Vicksburg has an average litter density of 1.1 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 lower population count areas, while the lowest litter density was found in the middle population count areas, mirroring a similar pattern that can be seen in other US cities. While this area had the highest average density, it also had the most variation in litter density across the transects and ranged from 0.11-4.53 items per square meter.

Compared to other cities in the USA, Vicksburg has lower average litter density than those commonly seen in larger cities. However, variation across the three population groups follows similar patterns in other cities. For example, like Vicksburg, 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 (Table 14). Litter density may be lower in the middle and upper population count areas due to increased access to waste infrastructure (e.g., receptacles), more frequent waste collection and cleaning, and increased likelihood of enforcement of litter fines given that litter is only prosecutable within the corporate limits of the city according to the local Code 1959, § 10-39(a). In contrast, the low population area may have less infrastructure to support disposal of common items and the nature of being more remote may lend greater opportunities for illegal dumping and littering. Additionally, less uniformity of land use and activity in low population areas may contribute to more variation in litter abundance.

Table 14: Top litter items, total item count, total plastic composition, and litter densities for population tertiles in Vicksburg

Population tertile	Top five litter items by product type	Total item count (n)	Total plastic composition (%)	Mean litter density (count/m^2)
Upper (199 - 1,234 persons/sq km)	1. Plastic fragments 2. Food plastic 3. Paper 4. Tobacco products 5. Glass	1008	70	1.12
Middle (38 - 199 persons/sq km)	1. Tobacco products 2. Plastic fragments 3. Food plastic 4. Paper 5. Metal	636	77	0.71
Lower (0 - 38 persons/sq km)	1. Plastic fragments 2. Food plastic 3. Paper 4. Glass 5. Tobacco products	1313	64	1.46

Across all transects, cigarettes were the most documented items, yet they were only the top item in the middle population areas, comprising 27% of the transect count compared to 18% and 14% in the high and low population areas, respectively. In contrast, the high population area had more film fragments (18%) and paper (15%) and the middle population area had more hard plastic fragments (14%) and film fragments (13%). The composition of the top five items was similar across all three population areas, with all three seeing higher quantities of plastic fragments, cigarettes, food wrappers, and paper. The low population area was the only category in which glass fragments were in the top five, making up 13% of those transects (Table 15). The variation in items seen across the three population groups may be driven by the abundance and types of activity in each category as well as the access and proximity to waste management infrastructure. For example, in the high population areas, there may be increased access to waste receptacles and more frequent street cleaning. In the low population areas, transect data may reflect litter that is purposely or accidentally released from vehicles, and with less pickup and collection, have a longer exposure to the elements, leading to fragmentation over time.

Table 15: 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		
Film Fragments	184	18
Paper	155	15
Plastic Food Wrapper	146	14
Cigarettes	129	13
Hard Plastic Fragments	70	6.9
Middle		
Cigarettes	175	27
Hard Plastic Fragments	86	13
Film Fragments	66	10
Plastic Food Wrapper	64	9.9
Paper	52	8.1
Low		
Hard Plastic Fragments	189	14
Film Fragments	173	13
Glass or Ceramic Fragments	168	13
Plastic Food Wrapper	130	9.8
Cigarettes	120	9.1

There was some evidence of illegal dumping observed in Vicksburg during the CAP surveys (Figure 19). Illegal dumping is not isolated to Vicksburg, or Mississippi, but is a pressing challenge throughout the USA. Despite widespread access to waste and recycling collection throughout the USA, it is estimated that 0.14-0.41 million metric tons of plastic waste are illegally dumped throughout the country annually (Law 2020). Compounding the environmental and aesthetic impacts illegal dumping contributes, it can also be a costly endeavor for municipalities to clean up and prevent (Kaza et al. 2018). For example, the cities of Sacramento, California, Austin, Texas, and Fort Worth, Texas budget $40,000, $70,000, and $90,000, respectively, to raise awareness about illegal dumping (Waste360 2023). While the current budget

allocated for preventing and managing illegal dumping in Vicksburg is unavailable, the city can address the issue through investment in bulk waste collection infrastructure (e.g., bulk waste dumpsters) and the continuation of programs (e.g., education campaigns, free dump coupons, and neighborhood drop-off events) which may help to directly address problems in the community associated with the harmful practice.

Figure 19: Example of illegal dumping in Vicksburg (Courtesy: CIL)

While microplastic pollution is difficult to capture in waste management infrastructure due to its size, there is evidence of high concentrations of microplastics in both the Yazoo and Mississippi Rivers in Vicksburg. A recent study collected and analyzed water samples in both the Yazoo and Mississippi River locations adjacent to Vicksburg, finding that these locations had some of the highest concentrations of microplastics, with between 17 and 78 particles per liter in the Yazoo during the spring and 71-151 particles per liter in the Mississippi during the summer (Table 16). Most of the microplastics documented (>60%) were between ~30–90 µm and consisted primarily of plastic fragments (~85%), followed by fibers (~8%) and beads (~7%), with polyester, polyethylene, polypropylene, and polyacrylate as the primary microplastic types (Scircle et al. 2020). Prevention of microplastic pollution can be managed through upstream interventions such as improved waste collection, proper disposal, and litter clean up in the environment through community efforts and stormwater trapping systems.

Table 16: Mean microplastic concentration and riverine loads (> 30 micrometers) in the Yazoo and Mississippi River Vicksburg in 2019 (Scircle et al. 2020). Note that flow data were unavailable for the Yazoo load values)

	Spring (flooding)			Summer (post-flooding)		
River	**# samples**	**Mean (range) particles per liter**	**Load (count per 10^{12}/day)**	**# samples**	**Mean (range) particles per liter**	**Load (count per 10^{12}/day)**
Yazoo	4	45 (17-78)	--	2	73 (28-118)	--
Mississippi	3	18 (4-30)	64.3	3	103 (71-151)	307

Given the proximity to the Mississippi River and the public visibility lent to Vicksburg by it being located near a major US Interstate (I-20), there are some efforts in Vicksburg and Warren County to enforce prevention laws and provide service areas that are suffering from unmanaged litter and dumping. Littering is considered a misdemeanor in Vicksburg, and punishment ranges from a $50 to $1,000 fine or imprisonment in the city jail for no more than 90 days (City of Vicksburg 2022). Litter enforcement is challenging given the difficulty in generating sufficient evidence combined with a focus on higher priority civil needs that require more active monitoring (e.g., crimes, traffic accidents, etc.). To help encourage local participation in litter prevention enforcement, a $100 incentivization reward was recently offered to residents who report litterers in the community (Hadaway 2019). For cleaning up waste that has already reached the environment, Vicksburg supplies vacuum trucks to clean out storm drains. Additionally, there are some clean-up events that have focused on litter such as the Vicksburg Community Clean-Up Day. There are also several opportunities for property owners, cities, counties, and regional solid waste authorities to apply for funding assistance with illegal dump cleanups and prevention programs, local solid waste enforcement officers, public education programs, and illegal waste tire abatement (MDEQ 2023).

Opportunities

CIL found the following opportunities to expand and enhance circularity in Vicksburg based on the findings of this report. These opportunities are categorized based on the seven spokes of the CAP model. Stakeholder engagement with the partners of this project should take place 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 on end-of-life management, product design, alternative materials and alternative product delivery systems. Vicksburg could lead community

initiatives toward working with top local brands and producers that operate locations proximal to the community and Mississippi, with a particular focus on beverage and chip packaging.

- Explore resources and potential local industry partnerships that may be available for effective development, implementation, and enforcement of EPR Guidelines and rules that result from those guidelines. In addition, the city should be involved to the extent possible in crafting EPR Guidelines at the city and national levels to ensure that they can be effectively implemented at the local level.

Community

- The geographic location of Vicksburg lends access to industry, commerce, transportation and economic activity. There may be potential for public-private partnerships in Vicksburg that encourage innovation and collaboration among businesses, employers, and community stakeholders to invest and develop waste reduction strategies, waste collection and disposal infrastructure, and litter prevention.
- Many education and awareness programs in Vicksburg are described via news and media outlets. The city could benefit from improved documentation of when and where community events are happening, as well as their intended outcomes, to help gauge what works for Vicksburg community members and better inform strategies for future education efforts.
- There also may be opportunities to further collaborate across Warren County as well as state-wide clean up and beautification initiatives like Keep America Beautiful, the Mississippi Inland Clean Up Initiative, and broader Mississippi River clean up events.

Product Design

- Plastic alternatives in the form of bio-based, biodegradable, and compostable plastics are likely to continue gaining momentum in Vicksburg 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.
- There are funding opportunities that can be used to target innovative product design strategies and delivery systems through the MDEQ Incentive Recycling and Research Grants program, which is open to communities, recycling companies, and research entities.

Use

- Despite some items such as plastic bags being labeled with information about material type and general disposal guidelines, there is limited information about disposal locations specific to Vicksburg, which may negate the efforts at labeling items in the first place if consumers are

receiving insufficient information. This lack of information may present an opportunity for discussions and collaborations with manufacturers for improved labeling, as well as collaborations with the businesses providing these items to also share resources and locations for disposal.

- Although state legislation in Mississippi currently prohibits local governments from implementing bans or fees on common single-use plastics, there are opportunities for local businesses to implement policies that encourage or incentivize customers to bring their own reusable containers for carrying out items from food and retail vendors.
- Currently few businesses offer alternatives to plastic retail bags, which typically consist of paper or other reusable plastic options. Notably, local businesses were the least likely to offer alternatives, with many opting to use traditional plastic retail bags. There may be opportunities for local businesses to explore alternative cost-effective options or systems that encourage customers to bring their own bags by providing a discount to their purchase.
- To support and encourage local businesses, the city could highlight those that choose to switch to alternative modes of product delivery systems and designs or encourage customers to reuse or bring their own. Doing so may increase buy-in from local community members and businesses that could ultimately encourage positive policy outcomes.
- Any alternatives that are introduced in light of the ban on bans needs to be readily and easily reused or have a viable disposal option within the context of Vicksburg.

Collection

- Waste sorting generally falls to individuals and households, and while some information is available to the public regarding what types of materials are accepted in the Waste Management recycling stream, that information may be too broad. For example, there is no guidance on how to sort plastic cutlery, which are generally not recyclable due to their size, weight, and shape. Aggregated and consistent sorting information informed by the different recycling entities (i.e., Waste Management, MIDD-West industries, etc.) should be provided to residents and community members.
- Comprehensive monitoring of the different collection models (e.g., repeated litter transects or waste bin overflow assessments) would be useful to help evaluate what may or may not be effective for maximizing collection. Potential local partners such as Vicksburg Solid Waste Department, the Department of Commerce, or the Vicksburg Beautification Committee could partner with local organizations to collaborate on maximizing efficient data collection and monitoring capabilities.
- Currently, there is no publicly available data regarding the composition of waste collected. Generating this data and making it publicly accessible, both in Vicksburg and beyond, can improve intervention strategies and decision-making around waste management infrastructure and systems of management.
- At present, there is no geospatial data on locations of public waste receptacles or drop-off locations. Making that data available to the public can help to inform community members'

accessibility to waste infrastructure as well as identify areas that need improved collection infrastructure.

End of Cycle

- Landfilling is the most prominent form of waste management in Vicksburg and throughout Mississippi. 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 Vicksburg develops its own comprehensive approach to improving plastic waste management.
- Continue to support and expand recycling in Vicksburg, recognizing and acknowledging the limited opportunities for collecting and disposing of plastics. Expand recycling efforts to include #3-#7 plastics through bin placements for specific items or develop programs to collect hard-to-recycle materials. Given that the main recycling facility is operated by a local (MIDD-West Industries), the city should continue exploring ways to support existing efforts, including through policies, and resources, providing assistance for safe working conditions, efficient collection and transportation options, and integration with other programs like Recyclops and The Recycling Partnership.
- 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.
- Given the collection of captured debris from stormwater drains and street vacuuming, there may be opportunities to initiate monitoring of litter quantities, types, and characteristics ending up in the built environment.
- There may be several opportunities for public education initiatives. Given the prevalence of tobacco-related litter in the middle 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.

- Illegal dumping appears to be a challenge in Vicksburg. However, the city is making efforts to mitigate the issue. Continued monitoring of illegal dumping occurrences as well as encouragement for reporting may help to identify hot spots in the community that can be targeted for prevention. Additionally, having a plan to manage waste from frequent or recurring events and providing outlets for the collection of difficult-to-recycle materials that are often illegally dumped.
- Plastic fragments are a significant challenge in terms of leakage, but upstream efforts that prevent items from reaching the environment where they have the opportunity to fragment may be effective.

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

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

Figure A1. Litter density by transect in the high, mid, and low population areas.

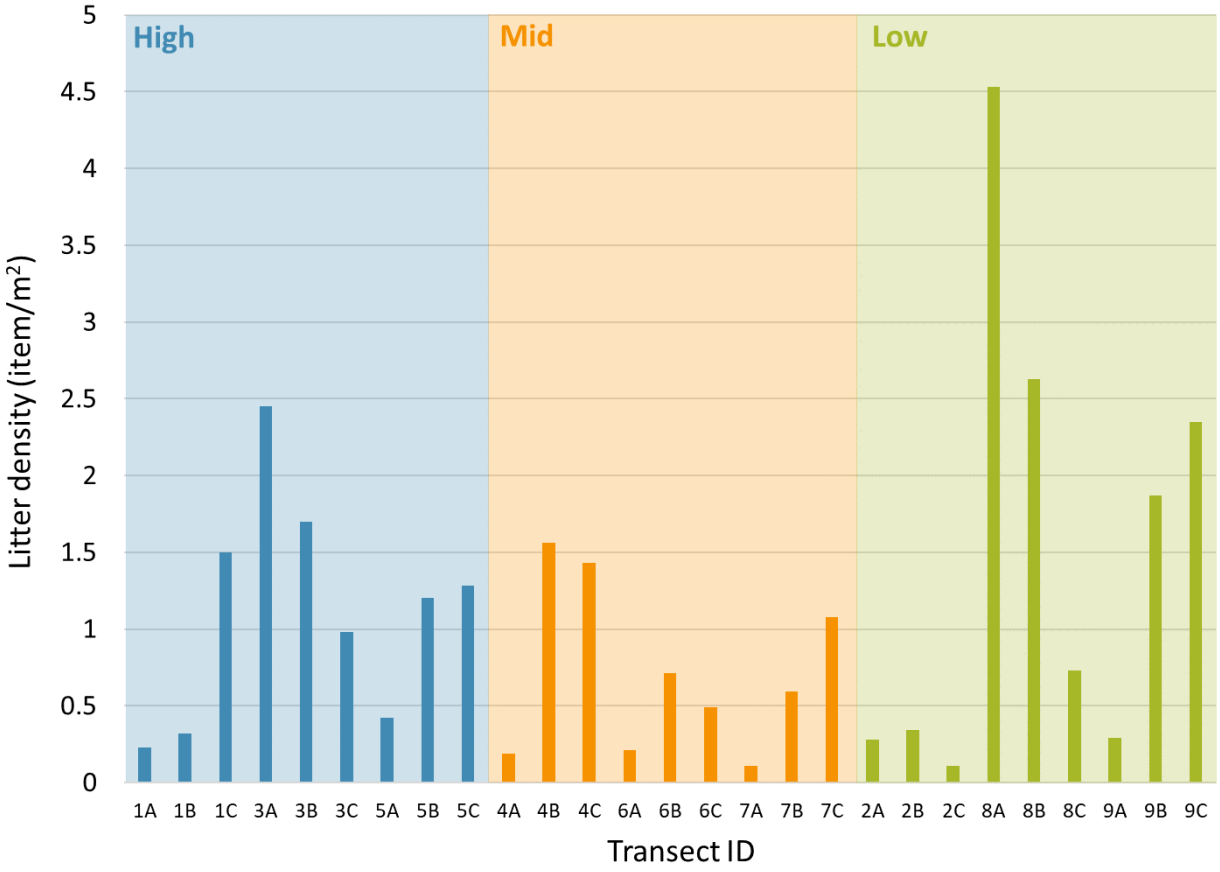


Table A2: Full table of manufacturers of top convenience products

Manufacturer	Manufacturing Location
American Foods LLC	Methuen, Massachusetts, USA
American Licorice Company	Laporte, Indiana, USA
Andes Candies	Delava, Wisconsin, USA
Annabelle Candy	Hayward, California, USA
atkinson candy	Lufkin, Texas, USA
August Storck USA	Chicago, Illinois, USA
BA Sports Nutrition LLC	New York, New York, USA
Bai Brands, LLC	Plano, Texas, USA

Barcel	Coppell, Texas, USA
Bazooka Candy Brands	Thailand
Bazooka Companies, Inc.	New York, New York, USA
Better Made Special	Detroit, Michigan, USA
Borden Dairy Company	Dallas, Texas, USA
Brimhall Foods Company, Inc.	Bartlett, Tennessee, USA
Brown Candy Corporation	Macon, Georgia, USA
Bug Juice International, Inc	Brighton, Michigan, USA
Campbell Soup Company	Camden, New Jersey, USA
Candy Dynamics Inc.	Pakistan
Charms LLC	Covington, Tennessee, USA
Circle K Stores Inc	Temp, Arizona, USA
Citrus World Inc	Lake Wales, Florida, USA
Community Coffee	Baton Rouge, Louisiana, USA
Concord Confections	Toronto, Canada
Core Nutrition	Frisco, Texas, USA
CVS Pharmacy Inc	Woonsocket, Rhode Island, USA
Danone	White Plains, New York, USA
Dole Food Company	Thousand Oaks, California, USA
Dr. Pepper/7-Up Inc	Plano, Texas, USA Frisco, Texas, USA
Essentia Water LLC	Bothell, Washington, USA
Fa!rlife	Coopersville, Michigan, USA
Ferrara	Franklin Park, Illinois, USA
Ferrara Candy Company	Chicago, Illinois, USA
Ferrero U.S.A., Inc.	Parsippany, New Jersey, USA
Ferrero	Warsaw, Poland

Ford Gum and Machine Company	Akron, New York, USA Guangdong, China
Fox Ledge Inc	Honesdale, Pennsylvania, USA
Frankford Candy LLC	Philadelphia, Pennsylvania, USA
Frito-Lay, Inc.	Plano, Texas, USA
Galerie	Mexico
Ghiardelli Chocolate Company	San Leandro, California, USA
Glacéau	Atlanta, Georgia, USA
Goetze Candy Co	Baltimore, Maryland, USA
Golden Flake Snack Foods Inc.	Birmingham, Alabama, USA
good2grow, LLC	Atlanta, Georgia, USA
GoodMark Foods, Inc.	Raleigh, North Carolina, USA
Haribo of America, Inc	Rosemont, Illinois, USA
Herr's	Nottingham, Pennsylvania, USA
Hint, Inc	San Francisco, California, USA
HP Food LLC	Lynnfield, Massachusetts, USA
La Joya Wraps and Snack Products	Monterey, Nueva Leon, Mexico
Laboratorios PISA, S.A. De C.V.	Tlajomulco De Zuniga, Jalisco, Mexico
Lemon Perfect Company	Atlanta, Georgia, USA
Mars Wrigley Confectionary US, LLC	Hackettstown, New Jersey, USA
Mederer USA	De Plaines, Illinois, USA
Naked Juice	Irvine, California, USA
Nestle USA, Inc.	Rosslyn, Arlington, Virginia, USA
Ocean Spray Cranberries Inc	Lakeville-Middleborough, Massachusetts, USA
PepsiCo	Purchase, New York, USA
Perfetti Van Melle USA	Erlanger, Kentucky, USA

Perrier	Vergèze, France
Popcorners	Middletown, New York, USA
Pringles Manufacturing Co	Jackson, Tennessee, USA
Quest Nutrition LLC	El Segundo, California, USA
RAP SNACKS Inc	Miami, Florida, USA
RawNature5 Corp	Los Angeles, California, USA
Red Diamond Inc	Moody, Alabama, USA
Russel Stover Chocolates LLC	Kansas City, Michigan, USA
Shamrock Farms Dairy	Phoenix, Arizona, USA
Snak-King Corp.	Los Angeles, California, USA
Snapple Beverage Co	Frisco, Texas, USA
Snyder's-Lance, Inc.	Charlotte, North Carolina, USA
Spangler Candy Company	Bryan, Ohio, USA
Star Brands North America	White Plains, New York, USA
TFCC, Inc.	Thailand
The Coca-Cola Company	Atlanta, Georgia, USA
The Gatorade Co	Chicago, Illinois, USA
The Hershey Company	Hanover, Pennsylvania, USA; Hershey, Pennsylvania, USA; Monterrey, Mexico
The Willy Wonka Candy Company	Queretaro, Mexico
Tootsie Roll Industries, LLC	Chicago, Illinois, USA
Topps	Scranton, Pennsylvania, USA
Topps Company/The Bazooka Candy Brands	New York, New York, USA
Unix Packaging LLC	Montebello, California, USA
Utz Qualtiy Foods	Hanover, Pennsylvania, USA
Wise Foods, Inc.	Berwick, Pennsylvania, USA

Wrigley Company	Yorkville, Illinois, USA
Zapp's Potato Chips	Hanover, Pennsylvania, USA

Table A3: Full table of Parent Companies of top convenience products

Parent Company	Parent Company Location
Alimentation Couche-Tard	Laval, Canada
American Foods LLC	Methuen, Massachusetts, USA
American Licorice Company	Bend, Oregon, USA
Andes Candies	Delava, Wisconsin, USA
Annabelle Candy	Hayward, California, USA
Arca Continental	Monterrey, Mexico
Atkinson Candy Company	Lufkin, Texas, USA
August Storck KG	Berlin, Germany
Better Made Snack Foods	Detroit, Michigan, USA
Bimbo	Mexico City, Mexico
Borden Dairy Company	Dallas, Texas, USA
Brimhall Foods Company, Inc.	Bartlett, Tennessee, USA
Brown Candy Corporation	Macon, Georgia, USA
Bug Juice International, Inc	Brighton, Michigan, USA
Cab Enterprises	Houston, Texas, USA
Campbell Soup Company	Camden, New Jersey, USA
Candy Dynamics	Indianapolis, Illinois, USA
Citrus World Inc	Lake Wales, Florida, USA
Community Coffee	Baton Rouge, Louisiana, USA
Conagra Brands, Inc.	Chicago, Illinois, USA
CVS Pharmacy Inc	Woonsocket, Rhode Island, USA

Danone	Paris, France
Disney Company	Burbank, California, USA
Ferrara Candy Company	Chicago, Illinois, USA
Ferraro Group	Alba, Italy
Ford Gum and Machine Company	Akron, New York, USA
Frankford Candy LLC	Philadelphia, Pennsylvania, USA
Galerie	Hebron, Kentucky, USA
Ghiardelli Chocolate Company	San Leandro, California, USA
Goetze Candy Co	Baltimore, Maryland, USA
good2grow, LLC	Atlanta, Georgia, USA
Haribo	Bonn, Germany
Harvest Hill Beverage Company	Stamford, Connecticut, USA
Herr Foods Inc.	Nottingham, Pennsylvania, USA
Hershey Company	Hershey, Pennsylvania, USA
Hint, Inc	San Francisco, California, USA
Kellogg's	Battle Creek, Michigan, USA
Keurig Dr. Pepper	Frisco, Texas, USA
Koia	Los Angeles, California, USA
La Joya Wraps and Snack Products	Monterey, Nueva Leon, Mexico
Lemon Perfect Company	Atlanta, Georgia, USA
Mars Inc	McLean, Virginia, USA
Mederer Group	Furth, Germany
Nam Holdings, LLC	Los Angeles, California, USA
National Beverage Company	Warren, Michigan, USA
Nestle	Vevey, Switzerland
Ocean Spray Cranberries Inc	Lakeville-Middleborough, Massachusetts, USA

PepsiCo, Inc.	Purchase, New York, USA
Perfetti Van Melle	Breda, Netherlands
Rap Snacks	Miami, Florida, USA
Red Diamond Inc	Moody, Alabama, USA
Russel Stover Chocolates LLC	Kansas City, Missouri, USA
Shamrock Foods Company	Phoenix, Arizona, USA
Simply Good Foods Co	Denver, Colorado, USA
Snak-King Corp.	Los Angeles, California, USA
Spangler Candy Company	Bryan, Ohio, USA
Talking Rain Beverage Company	Preston, Washington, USA
The Coca-Cola Company	Atlanta, Georgia, USA
The Foreign Candy Company, Inc.	Hull, Iowa, USA
The Hershey Company	Hershey, Pennsylvania, USA
The Topps Company, Inc.	New York, New York, USA
Tootsie Roll Industries, LLC	Chicago, Illinois, USA
Viacom International Inc	New York City, New York, USA
Yildiz Holding	Istanbul, Turkey

Social Media Analysis

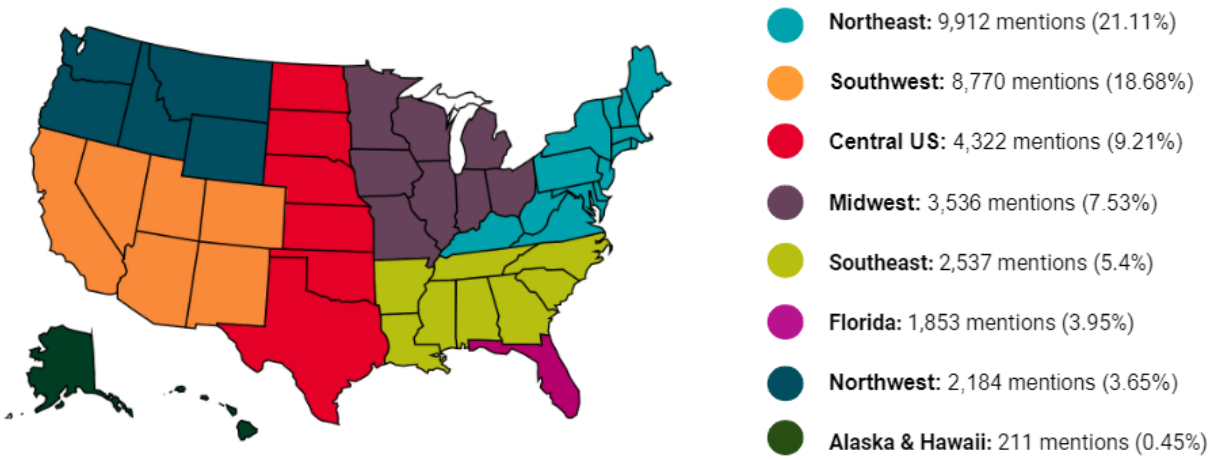
Education, infrastructure, and information transparency once again make an appearance in the community through our social media analysis. Through the data found in this analysis it is important to remark that information transparency plays a significant role in negative posts, those that usually include the criticism of a product, brand, or company. In this sense, people have negative feelings about the confusion around compostable and biodegradable items, the latter of which is sometimes used for greenwashing. Moreover, greenwashing creates a lot of distrust in potentially eco-friendly alternatives, making clearer labels and information transparency about the end-of-cycle of materials a crucial component of education. Education in the form of social media outreach has been present for a while, however, despite the clarifying bits of information in platforms, it's not always easy for users to refer to Twitter or Instagram to find information unless they already follow a specific educational account. These educational posts along with hopeful posts on infrastructure and composting count towards the positive or uplifting feelings demonstrated by the social media community. Some other posts give instructions on what to do with small and big contaminants of composting (from fruit stickers to sauce cups), or address the confusion about what is appropriate for what type of composting (home or industrial) and guide people on what what type of composting should be used for a certain product and what to do with it in the case of lack of infrastructure. In general, positive feelings posts highlight education initiatives or infrastructure/materials development while negative posts focus on the lack of information transparency that creates confusion and distrust, which is consistent with interviews and the general themes of stakeholders' concerns. Overall, between the lack of industrial composting facilities and citizens' confusion in how to dispose of plastic alternatives, the widespread introduction and use of compostables needs a responsible approach that includes addressing education, infrastructure, information transparency, and economics.

From July 1st, 2021, to August 31st, 2021, the Social Media Engagement and Evaluation (SEE Suite) group at University of Georgia's Grady College of Journalism and Mass Communication conducted a Compostable Plastics & Bioplastics Social Media Analysis using Bandwatch to aid in our understanding of consumer access and awareness of compostable and biodegradable plastics. SEE Suite sought to address three questions:

8. Are people aware of and purchasing biodegradable plastic alternatives?
9. Do people have access to compostable/biodegradable plastics in their community?
10. What types of composting systems would people like to see in their communities?

A geographic analysis of responses is shown below:

Figure A2: Geographic Analysis by Region



Twitter Conversations & Mentions

Conversations related to the awareness of and purchasing of biodegradable plastic alternatives that were analyzed on Twitter varied by region. 3.7% of the conversations related to biodegradable plastics were from the Southeast, while 7.5% of these conversations were from the Midwest. In contrast, 31% of biodegradable plastic conversations came from the Northeast and the Southwest, which indicates the regional awareness of plastic alternatives is higher in these areas than in the Southeast and Midwest. Tweets based on terms such as buy, own, purchase, use etc. captured 13.36% of the dataset, yet these conversations mostly discussed purchasing straws made from bioplastics, biodegradable/compostable straws, and reusable bags. Overall, purchasing patterns were difficult to gauge based on Twitter conversations.

Compostable/biodegradable plastics are widely available at grocery stores such as Walmart, Food Lion, Save A Lot, Kroger, Publix, etc., as well as at online retailers such as Amazon. However, compostable and biodegradable products are more expensive on average when compared to plastic, which can limit accessibility.

SEE Suite's search for specific methods of composting, ("warm composting," "hot composting," "vermicomposting,"etc.), only pulled ~6 mentions, which is very low compared to the almost 700 mentions from the total query. Data suggested that people are more focused on if composting is happening, as opposed to what type of composting. When using broader terms such as "composting infrastructure" and "composting systems," they found that industrial composting centers were desired among a niche group of people.

Industrial Composting

About half of those concerned with industrial composting came mostly from individuals with related professional experience, while the other half originated from nonprofits and professional/trade organizations such as Closed Loop Partners, Industrial Packaging, Nature Works, and the Plastics Industry Association. Most of these conversations revolved around the heat differences between home composting and industrial composting. Other conversations consisted of consumers purchasing biodegradable plastics with the intention of home composting, only to realize that the purchased items had to be sent to industrial composting, while other Tweets were from companies highlighting biodegradable plastics that can be home composted.

Home Composting

Home composting Twitter conversations tended to be broader, and had roughly equal representation from individuals, nonprofits, and companies. 25% of these conversations yielded no insights relating to how to live a more sustainable life or what activities to do to celebrate Earth Day. In contrast, insightful conversations tended to revolve around what items should and should not be added to home composts. A significant number of conversations were about how biodegradable plastics and stickers should not go into one's home compost. Overlapping conversations between Tweets about industrial composting and Tweets about home composting tended to share that industrial facilities are much hotter and that biodegradable plastic products must be sent to an industrial facility. Again, Tweets from companies highlighted products that can be home composted.

Greenwashing

About half of the Twitter conversations on greenwashing within the compostable/biodegradable plastics space came from individual users, while the other half came from media outlets, companies, nonprofits, and trade/professional organizations. Most of these Tweets focused on how biodegradable/compostable plastics/bioplastics are greenwashing, yet they rarely are explicit about sharing why. Conversations also focused on buzzwords that are typically used to convince consumers that a product is more environmentally friendly than it actually is, such as "plant-based," "biodegradable," "all natural," and "compostable." Although less common, conversations about how to avoid greenwashing typically bring up product labeling and certification, such as the USDA Certified Biobased label. Interestingly, there were a few instances where brands such as Exxon, Coca Cola Company, Unilever, and EcoTools were called out for explicit greenwashing.

Aside from the major themes related to industrial composting, home composting, and greenwashing, additional themes that emerged related to Packaging & Products, the Environment, Circular Economy, Purchasing Compostable/Biodegradable Plastics, and Research, Innovation, & Design.

- Packaging & Products: related to the materials used in packaging, as well as consumer products
    - Total Mentions: 9,997; 21.31% of all mentions
- The Environment: mentioned ecological systems from which bioplastics primarily benefit, such as oceans and plants
    - Total Mentions: 9,480; 20.19% of all mentions
- Circular Economy: primarily mentioned topics of recycling, composting, and reusing plastics
    - Total Mentions: 6,618; 14.11% of all mentions

- Purchasing Compostable/Biodegradable Plastics: related to the purchasing of biodegradable plastics instead of other plastic that is more environmentally harmful
    - Total Mentions: 6,266; 13.36% of all mentions
- Research, Innovation, & Design: focused mainly on research related to bioplastics and the market, as well as new forms of compostable and biodegradable technology
    - Total Mentions: 5,025; 11.1% of all mentions

Individual conversations related to these themes are shown on a timeline below:

Figure A3: Timeline of Conversations, July 1, 2021 - September 30, 2021

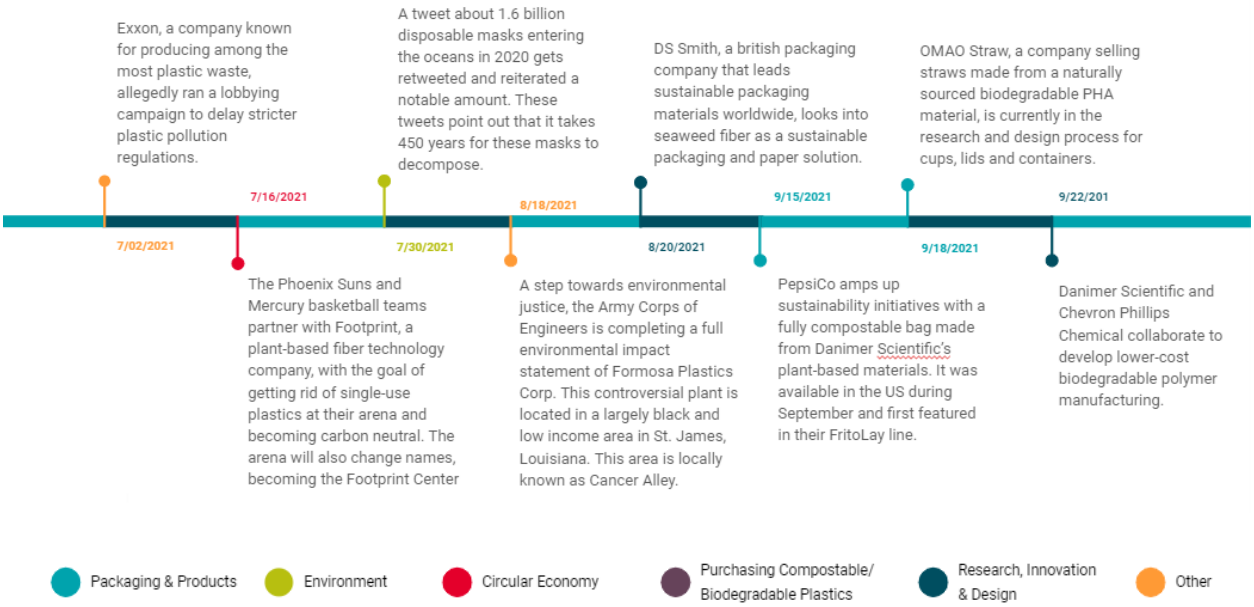


Figure A4: Timeline of Conversations, October 1, 2021 - December 31, 2021

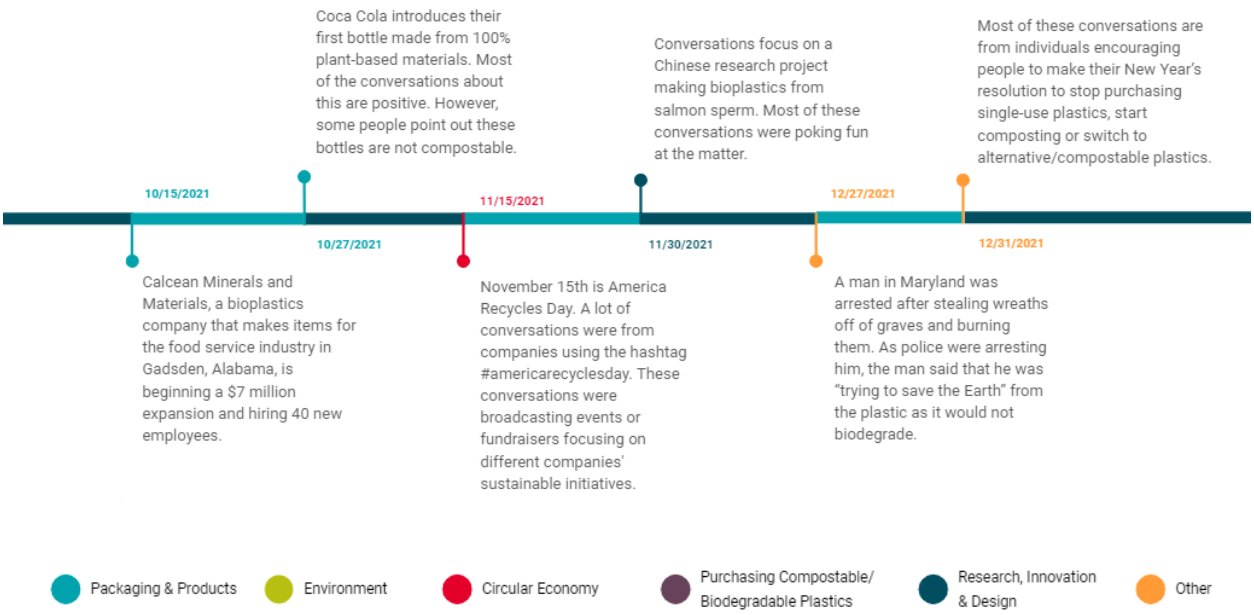


Figure A5: Timeline of Conversations, January 1, 2022 - March 31, 2022

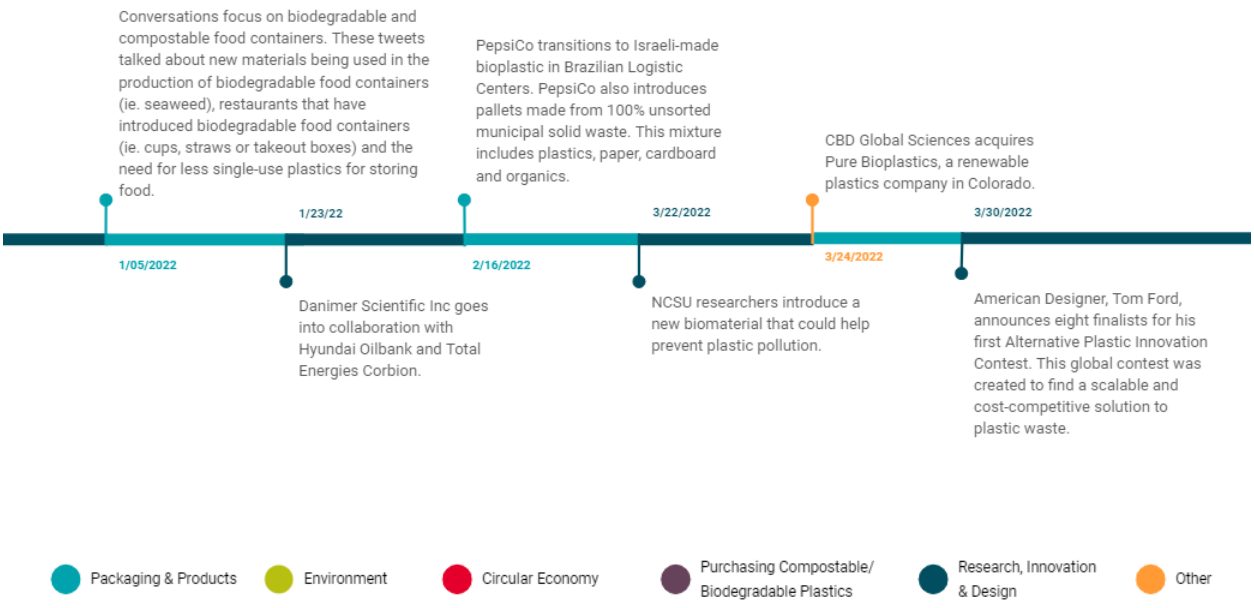


Figure A6: Timeline of Conversations, April 1, 2022 - June 30, 2022

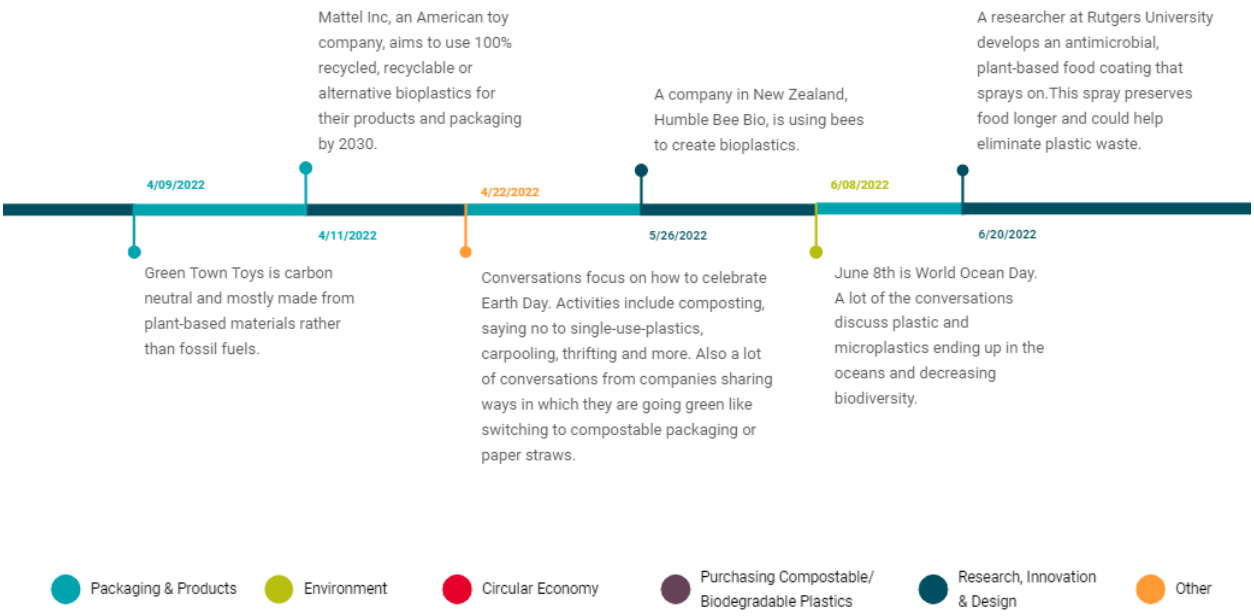
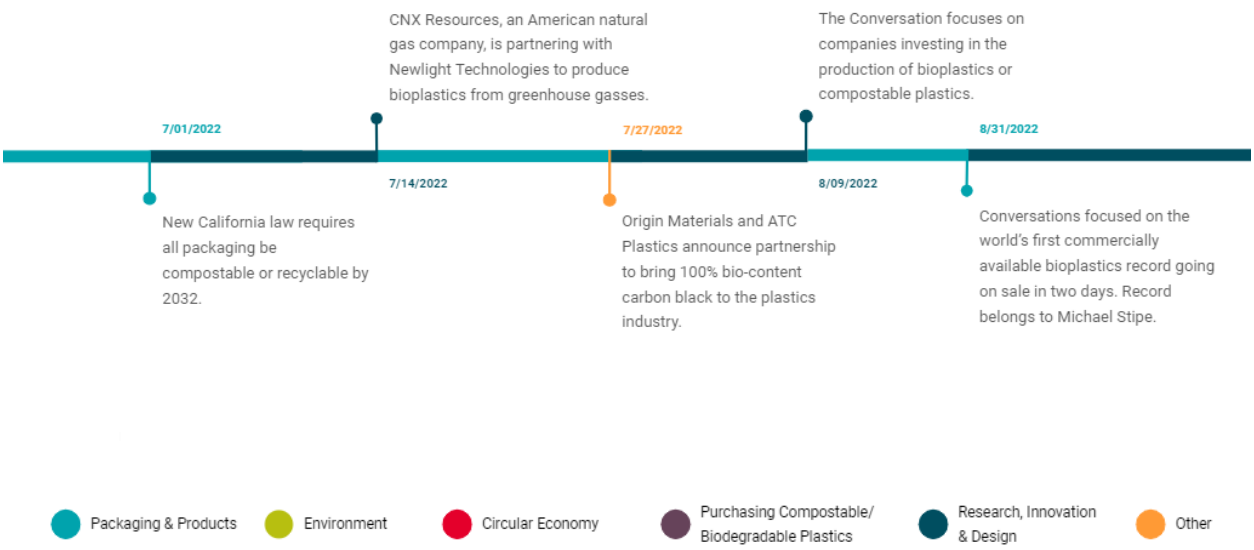


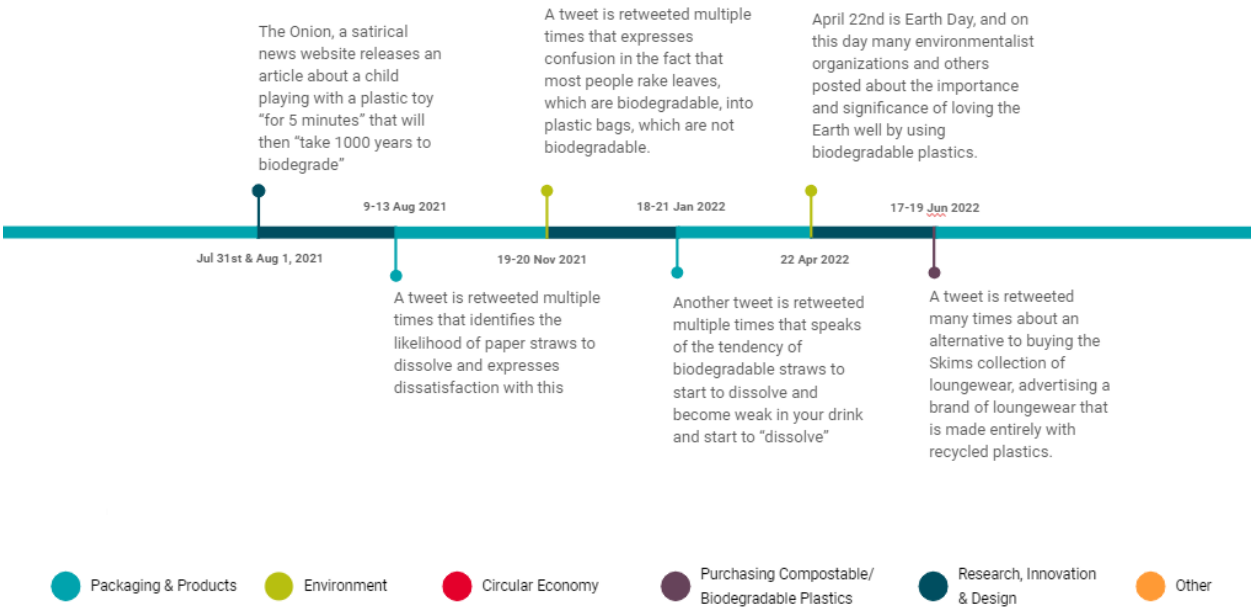
Figure A7: Timeline of Conversations, July 1, 2022 - August 31, 2022



Insights from the Southeast

Insights from the Southeast include both Tweets from the Southeast, and Tweets about the Southeast. Unique trending topics include "plastic pollution" (2,374 mentions) and "ban single use plastics" (104 mentions). "Plastic pollution" Tweets mostly described the environmental harm that plastics cause, as well as ways to combat this problem. Although a more narrow topic, "ban single-use plastics" examined the idea of single-use plastic bans in the South, which is increasingly gaining traction in the region.

Figure A8: Conversations from the Southeast; June, 2021 - July 31, 2022



Instagram Conversations & Mentions

While conversations about plastics, biodegradable and compostable materials, and related topics did happen on Instagram, Instagram's platform is mostly used as a way to sell alternative products. From Instagram, three main topics emerged, with total mentions of 140,753 and a total reach of 206,270,463. These topics are listed below:

- "Plastic Free July": @plasticfreejuly creates most of the posts mentioning this topic. Plastic Free July encourages people to stop consuming single-use plastics as part of their larger goal of ending plastic pollution globally. The nonprofit Let's Be Plastic Free mentioned the Plastic Free July Campaign in their popular yearly campaigns, while other nonprofits mentioned it when talking about actions to curb plastic pollution, such as composting. Companies mention Plastic Free July when promoting products that are packaged in compostable or biodegradable materials.
    - 6,657 mentions; 9,888,269 reach
- "Plastic Pollution": most of the mentions of plastic pollution come from nonprofits and companies. Nonprofits primarily mention plastic pollution when talking about community events such as beach cleanups, as well as other actions that curb plastic pollution. Companies tend to mention plastic pollution when discussing sustainability initiatives that resulted in less plastic pollution (such as turning waste into a bioplastic) or when discussing biodegradable packaging. Other posts related to environmental degradation, primarily in aquatic ecosystems. About 25% of these posts also mention Plastic Free July.
    - 4,629 mentions; 29,817,854 reach
- "Plant Based": here, "plant based" was used in multiple contexts, as this is the broadest topic. Food and restaurants described as being organic or plant forward consisted of the most common usage for the phrase; these conversations tended to mention biodegradable or compostable

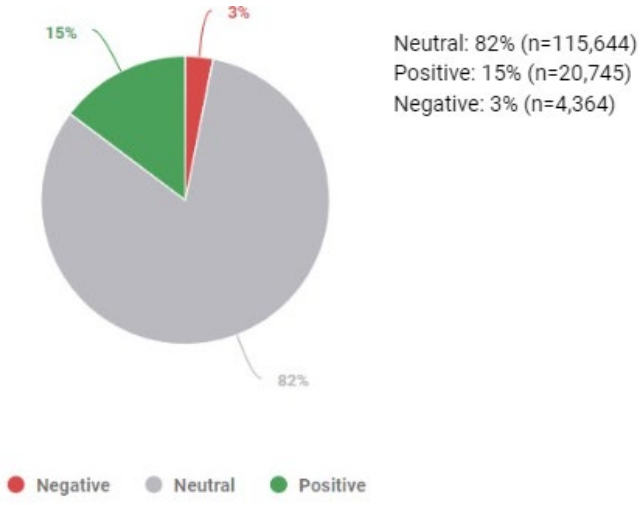
packaging. There were also many cleaning products and beauty products that were plant based. Posts from the two topics above -- "Plastic Free July" and "Plastic Pollution" -- tended to be evenly split between companies and nonprofits, with a few individuals chiming in. However, this topic mostly consisted of companies displaying and promoting different products.

- 13,585 mentions; 19,868,364 reach

Beauty and household products were a theme that was more specific to Instagram, consisting of 15.8% of the conversation, with 22,181 mentions and a total reach of 21,746,642. The eco-friendliness of everyday household and beauty products has been a prevalent topic of discussion in recent years. Conversations within this theme tend to be brands advertising their eco-friendly products on Instagram, due to Instagram's large marketplace and advertising platform. Other discussions urged consumers to not choose the "wrong products" by describing how those products are resulting in environmental harm.

Although posts sometimes had to mention the negative to promote positives, sentiment in Instagram posts tended to be neutral (82%), while positive posts (15%) outweighed the negative posts (3%).

Figure A9: Overview of Sentiment



While positive conversations were broad, they tended to come from companies and nonprofits. Companies had positive conversations when promoting new products, new partnerships, or anniversaries of important innovation milestones. Nonprofits were a part of many positive conversations when highlighting increasingly sustainable companies or successful events. Other posts from nonprofits and influencers relate to the impact that composting has on health and the environment. The top positive post in this dataset combined innovation and plastic is 4ocean's plastic guitar, shown below.

Figure A10: Top Positive Post - 4ocean Plastic Guitar

4ocean A guitar made from recovered ocean plastic 🎸

Last year, our good friend @Burlsart joined us for a day on the water cleaning up trash in Boca Raton, FL. The goal? Collect ocean plastic that Burls can turn into an epic guitar!

Due to its durability, Burls chose to use recovered HDPE and polypropylene plastic for the body of the guitar. And if you take a close look at the neck, you'll notice it's made up of plastic straws 👀

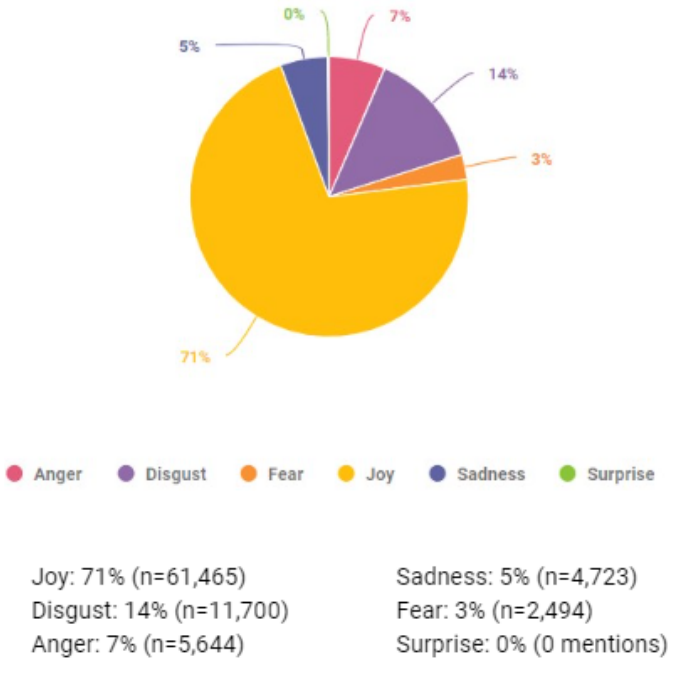
To check out a YouTube video on how Burls made this rad guitar, visit the link in our bio!

Negative conversations were also broad, but tended to bring up topics related to environmental harm, plastic pollution, and waste, as well as how these topics related to environmental justice issues and human health outcome. Some posts mention a lack of industrial composting facilities or people not sorting items correctly in waste or recycling bins. The top negative post was @get.waste.ed's post where they used a picture of Colgate's biodegradable packaging wrapped in plastic to promote their own line of bamboo toothbrushes.

Figure A11: Top Negative Post - Get.waste.ed and Colgate

While Brandwatch only categorized 61.12% of our dataset based on emotion, the emotions shown in Instagram posts tended to be overwhelmingly positive.

Figure A12: Overview of Emotions



Conversations portraying joy were mostly from nonprofits expressing excitement about upcoming events and celebrations. Other conversations from individuals, companies, and nonprofits invoked discussions on

the beauty of nature while homing in on the importance of limiting plastic waste by purchasing products in compostable packaging or by composting. Other companies shared excitement about new compostable packaging or bioplastic products. Conversations portraying disgust tend to focus on fossil fuel, petroleum, and fishing industries, as well as pollution and plastic waste. Conversations that portray anger tend to be from individuals who express their irritation with a lack of global environmental policies, detailing how arduous legal and legislative processes are and how big companies should take more accountability by participating in sustainability initiatives, changing their packaging, etc.

Overall, interest in biodegradable and compostable materials, concern over plastics, and other related materials seems to be growing on platforms like Twitter and Instagram. While individuals do participate in these interrelated conversations on both Twitter and Instagram, nonprofits, companies, and even some professionals in this space seem to be leading the discourse. While Twitter conversations tended to be more closely related to discourse about these topics, Instagram's visual nature provided more of an opportunity to promote alternative products.