CIRCULARITY IN THE SOUTHEAST: OVERCOMING BARRIERS TO RURAL RECYCLING

by

SHELBY MENDEZ

(Under the Direction of Jenna Jambeck)

ABSTRACT

The United States is a major contributor to global plastic pollution, with rural communities disproportionately affected by environmental impacts. There are goals to increase recycling rates. Studies show that rural recycling is challenging because of low population densities, limited resources, and lack of economies of scale. Despite these barriers, there is a gap in rural recycling research and literature in the US. This project characterizes rural circularity by conducting a Circularity Assessment Protocol (CAP) in three rural communities within the US EPA Region 4: Tifton, Georgia; Cherokee County, North Carolina; and Georgetown County, South Carolina. The data from each CAP category was analyzed to identify opportunities to improve recycling as part of circularity. Findings compare circularity across the cohort and highlight shared challenges and opportunities to strengthen rural recycling and make it resilient.

INDEX WORDS: rural communities, rural recycling, recycling challenges, circularity, Southeast United States, EPA Region 4

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GLOSSARY

BMT	Billion Metric Tons
CAP	Circularity Assessment Protocol
CIL	Circularity Informatics Lab
C&D	Construction and Demolition
DRS	Deposit Return Scheme
EPA	Environmental Protection Agency (US)
EPS	Expanded Polystyrene Foam
EPR	Extended Producer Responsibility
FFP	Fibers and Flexible Plastics
FMCG	Fast-Moving Consumer Goods
FY	Fiscal Year
GEPD	Georgia Environmental Protection Division
HDPE	High-Density Polyethylene
MDT	Marine Debris Tracker
MT	Metric Tons
Mt	Million Metric Tons
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NMI	New Materials Institute
NC DEQ	North Carolina Department of Environmental Quality
NGO	Non-Governmental Organization

PAYT	Pay As You Throw
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
SC DHEC	South Carolina Department of Health and Environmental Control
SPLOST	Special Purpose Local Option Sales Tax
SWM	Solid Waste Management
SUP	Single-Use Plastic
TCTAC	Thriving Communities Technical Assistance Centers
UGA	University of Georgia

CHAPTER 1

INTRODUCTION

1.1 | Overview

Plastic pollution has been a growing issue since the 1970s when scholarly papers first reported plastic in the oceans (Jambeck et al., 2015). North America generates a disproportionate amount of waste, accounting for 14% of the world's waste while making up just 5% of the global population (Kaza et al., 2018). The United States has an estimated annual 0.14 to 0.41 million metric tons (Mt) of plastic waste illegally dumped and 0.84 Mt littered (Law et al., 2020). In addition, the US is ranked in the top 15 countries contributing to plastic entering the coastal environment (Jambeck et al., 2015; Law et al., 2020).

Due to this, the US Environmental Protection Agency (EPA) set a goal to increase recycling, including composting, a form of organic recycling, to 50% by 2030. As of 2018, the recycling rate was 32.1%, mechanical recycling was 23.6%, and composting was 8.5%. Plastic recycling is the lowest category at 8.7% (US EPA, 2020b). Recycling rates could be improved by expanding efforts in rural areas, which comprise 20.3% of the U.S. population but cover 87.4% of the nation’s land area (HSRA, n.d.).

Disadvantaged communities, such as rural areas, bear the greatest burden of the environmental impacts caused by mismanaged waste (Tunnell, 2008; UNEP & International Solid Waste Association, 2024; US EPA, 2021a). However, there is a lack of studies on rural recycling in the US. A World Bank report discussed the gap between rural and urban waste collection coverage for each region except for North America (Kaza et al., 2018).

This gap calls for further investigation to better understand the recycling challenges in rural areas and address the disproportionate environmental impacts of mismanaged waste. This research was conducted under the Circularity Informatics Lab (CIL) at the University of Georgia (UGA) and is funded by the US EPA. This project conducted CAPs in three rural communities in the US EPA Region 4: Tifton, Georgia; Cherokee County, North Carolina; and Georgetown County, South Carolina. This research aims to improve community health and resilience in the rural cohort by measuring circularity in the community, focusing on improving recycling rates as one component of circularity. The data and findings were shared with each community to understand the challenges faced by different spokes of the CAP and provide insights on how to improve recycling in their community. The general findings and lessons learned from the rural cohort CAPs will be shared through the CIL online portal at https://www.circularityinformatics.org/ and a virtual webinar to all interested parties and communities in Region 4. This will enable other rural communities to better understand their challenges and implement strategies to improve their recycling efforts. A cross-comparison of the rural communities was conducted to provide a broader understanding of the recycling challenges faced by rural areas within the region.

1.2 | Objectives and Aims

The objectives of this research were to:

1. *Characterize circularity within each rural community in the cohort using the CAP*

The CAP collects data from seven spokes that provide information to local, regional, or national decision-makers on circularity to reduce the leakage of waste into the environment and/or improve circular materials management (Figure 1).

Figure 1: Circularity Assessment Protocol Diagram
Reference: Jambeck et al., 2024

The spokes explore the following questions to measure circularity:

Input: What products are sold in the community, and where do they originate?

Community: What conversations are happening, and what are the stakeholders' attitudes and perceptions?

Product Design: What materials, formats, and innovations are found in products, particularly packaging?

Use: What are the community trends around the use and reuse of product types?

Collection: How much waste is generated, what does it comprise, and how is it disposed of? How much is collected, and what infrastructure exists?

End of Cycle: What is waste's fate once appropriately discarded? How is it treated?

Leakage: What waste ends up in the environment? Why and how is it getting there?

2. *Compare community circularity across the cohort*

The three rural communities are compared using the US Government's Climate & Economic Justice Screening Tool (CEJST), geographical location, levels of tourism, population size, and population density. The comparison aims to understand how the different components affect solid waste management (SWM). The rural communities were further analyzed by comparing and contrasting key results from each CAP spoke. The two comparisons highlight key challenges and opportunities unique to each community or shared that could benefit from regional collaboration. This analysis creates tailored and broad recommendations to improve the effectiveness of recycling programs in rural areas across the US EPA Region 4.

3. *Provide insights on how to increase rural recycling resilience across the cohort and region*

Analyzing data and understanding local practices, previous CAP experiences, and policies will provide insights. These insights will inform recommendations to improve the resilience of recycling programs in rural areas and broad recommendations to increase recycling rates across rural areas in Region 4.

1.3 | Thesis Organization

This thesis is organized in the following way for subsequent chapters. Chapter 2 is a literature review of current studies and reports on the current state of waste management, recycling in the US (including rural areas), and waste management in each of the three states where the three rural communities are located (Georgia, North Carolina, and South Carolina). Chapter 3 includes the methods used to conduct the CAP and how the cohort was compared and contrasted. Chapter 4 consists of CAP results for each community (sections 4.1, 4.2, and 4.3), explaining the key insights for each of the seven spokes, followed by opportunities to increase recycling as a component of circularity. Chapter 5 examines relationships between the three rural

communities, compares the CAP results for each spoke, and outlines general opportunities to increase recycling rates in rural communities. Lastly, Chapter 6 discusses key takeaways, future work to understand rural recycling better, and the broader impacts.

CHAPTER 2

BACKGROUND

2.1 | Current State of Waste Management

In 2020, the total global waste generated was 2.126 billion metric tons (BMT). 2050 waste generation estimates range from 3.4 to 3.8 BMT, with the largest increases in Sub-Saharan Africa, South, Central, and East Asia. The two main drivers for this exponential growth are gross domestic production and population growth (Kaza et al., 2018; UNEP & International Solid Waste Association, 2024). Approximately 40% of the world's waste is uncontrolled, open-dumped, or burned, primarily in lower-income countries in Africa and Asia. The next most common waste destination is a landfill (30%). Higher-income countries send more waste to waste-to-energy or recycling facilities (sometimes exported to lower-income countries) (Brooks et al., 2018). Waste composition also varies among countries' income levels. As income increases, the largest waste category shifts from food waste to dry recyclables (e.g., packaging). Despite this, the estimated global recycling rate is below 20% (Kaza et al., 2018; Lloyd's Register Foundation, 2024; UNEP & International Solid Waste Association, 2024).

Currently, the majority of waste in the US is landfilled, but this could be diverted through expanded recycling and composting efforts. A disproportionate amount of waste is generated in North America, producing 14% of waste despite only having 5% of the population (Kaza et al., 2018). The rate of municipal solid waste (MSW) generated in the US has increased exponentially due to the increase in population (Jambeck et al., 2015; US EPA, 2020b). The per capita generation has plateaued since the 1990s. As of 2018, 292.4 million tons of MSW were

generated. Half of the MSW was sent to landfills, and the remaining amount was either recycled, combusted with energy recovery, composted, or went through other food management pathways. The three largest categories of landfilled materials, over half the total waste generated, were paper/paperboard, food, and plastics (US EPA, 2020b). Diversion of these materials can occur through recycling or composting, decreasing the amount of waste landfilled throughout the US.

Federal policies have shaped SWM in the US, shifting from minimal federal guidelines to advocating for more sustainable practices over time. The Resource Conservation and Recovery Act of 1976 (RCRA) established modern US MSW management, creating the federal minimum guidelines only to the planning level. This shifted the day-to-day responsibilities to municipalities, causing waste to be managed differently throughout the country (Louis, 2004). The US EPA began shifting towards sustainable materials management in 2009. As a part of this, they set a goal to increase recycling, including composting, a form of organic recycling, to 50% by 2030. To help achieve this goal, the EPA released a three-part series on approaches and guidance on how to reach a circular economy for all. It focuses on the national recycling strategy, reducing food loss, recycling organics, and preventing plastic pollution. The goal is to divert as much of the generated waste from landfills to shift towards a circular economy by increasing composting and recycling rates (US EPA, 2024c).

Despite the US having a robust waste management system, it faces several challenges: cost and plastics. SWM is a costly infrastructure. The most expensive part is the collection of solid waste due to the transportation from collection to source separation (Lloyd's Register Foundation, 2024; UNEP & International Solid Waste Association, 2024). If a municipality lacks funding, it can struggle with adequately managing the waste generated in the community.

Plastics poses another challenge to the current US waste management system. Since the 1950s, the amount of virgin plastic produced worldwide has grown exponentially, reaching 8,300 BMT as of 2015. Out of the 6,300 BMT of plastic waste generated, the majority (79%) ended up in landfills or the natural environment. The remaining amount has been recycled (9%) or incinerated (12%) (Geyer et al., 2017). In 2018, the US generated 35.6 million tons of plastic, making it the third largest waste category. Only 8.7% of plastics were recycled, making it the lowest recycling rate of all waste categories. Most plastics (75.5%) were landfilled (US EPA, 2020b). There are also high amounts of mismanaged plastic waste in the US, estimated to be an annual amount of 0.14 to 0.41 Mt illegally dumped and another 0.84 Mt littered (Law et al., 2020). Community-science-based initiatives have collected data on leakage and found that about 75% of litter items were plastic. The most common leaked items included cigarette butts, food wrappers, and hard plastic fragments (National Academies of Sciences, Engineering, and Medicine, 2022).

Plastic pollution is a pressing issue for the US as it is a top contributor of plastic waste in oceans. Plastics do not decompose. Instead, they break down into smaller and smaller pieces, becoming micro- and nano-plastics, staying in the environment for long periods. They've been found in wildlife and are a threat to humans. Once plastics enter the ocean, they become widely distributed, and high-density materials sink, making them more challenging to recover (Ziani et al., 2023). The US contributes an estimated 0.04 to 0.11 Mt of plastic waste into the oceans. Despite the US being a high-income country with developed waste management infrastructure, it still had the 20th highest amount of plastic marine debris entering the ocean. It was also the top high-income country on the list (Jambeck et al., 2015).

2.2 | Recycling in the US

Recycling involves collecting, processing, and remanufacturing items, extending the resource's lifespan, and has grown in popularity over the past 65 years. In the 1960s, the US began curbside collection of metal and paper to recycle (NCSL, 2023). The first reported recycling rate in 1960 was 6.4% (US EPA, 2020b). The creation of the chasing recycling symbol in the 1970s, which was added to products deemed recyclable (NCSL, 2023), helped boost the recycling rate to 9.6% in 1980 (US EPA, 2020b). In the late 1990s, the US adopted single-stream curbside recycling, hoping to reduce collection costs compared to the then-dominant dual-stream (CRI, n.d.). However, it increased contamination in collected recyclables, making separation more difficult and expensive (Brooks et al., 2018; Law et al., 2020; National Academies of Sciences, Engineering, and Medicine, 2022). Despite these challenges, recycling rates rose, reaching 21.8% in 2000 and 23.6% in 2018. Paper/paperboard dominated the 69 MT of recycling in the US, followed by metals. There is an enormous potential to increase plastic recycling, as only 8.7% of the plastic generated is currently being recycled (US EPA, 2020b).

US recycling has decreased due to China’s import ban on plastic scraps intended for recycling. In North America, 55% of the waste stream is dry recyclables (National Academies of Sciences, Engineering, and Medicine, 2022), but the US recycling rate was 23.6% in 2018 (US EPA, 2020b). This is a 2.4% drop in the recycling rate from 2010 levels before import bans were in place (Brooks et al., 2018; US EPA, 2020b). The US depended on exporting recyclables, the second largest amount of plastics, to other countries like China as it was cheaper than domestic recycling. When the ban went into effect in 2018, it impacted the global waste management supply chain, causing countries to have to deal with the 111 Mt of displaced waste domestically

or find another country to export (Brooks et al., 2018). This shift to domestic recycling increased processing costs and decreased recycling rates.

The US could further maximize both the economic and environmental benefits of recycling by increasing rates. The 46 MT of recycled paper and paperboard, 67% of all recycled materials, resulted in a reduction of 155 MtCO2e, comparable to removing 33 million cars off the roads (US EPA, 2020b). Approximately 1.17 jobs are created for every 1,000 tons recycled, and wages and tax revenue are increased (US EPA, 2020a). A study found that recycling brings the US $35.6 billion of total annual benefits from gross value added to the economy, wages, material value capture, and greenhouse gas impact reduction (Eunomia Research & Consulting Inc, 2023).

There is a wide variety of commodity prices for recycled goods. The US average price of recyclables is $94 per ton. However, events can negatively impact the price, as seen with the 2018 China import ban and COVID-19, significantly decreasing the value of recycled goods. In 2021, a US material recovery facility (MRF) could get over $1,500 per ton for aluminum and natural high-density polyethylene (HDPE), while mixed paper had the lowest rates (SWANA, 2021). Over fifty percent of aluminum cans were recycled, representing one of the highest recycling rates and resulting in substantial profit. The predominant material recycled was paper, which constrains the potential profit margins due to its low market prices (US EPA, 2020b). Proper separation of recyclables is essential to maximize their value (Lloyd’s Register Foundation, 2024; UNEP & International Solid Waste Association, 2024).

2.2.1 | Composting

While composting is not the main focus of this study, it is essential to explore it, as composting is a form of waste management that includes some compostable and biodegradable plastics. It plays a role in circularity in waste management systems. Recycling and composting are the second most environmentally preferred methods in the EPA waste management hierarchy behind reuse and reduction (US EPA, 2024a). Composting happens at many different levels, from as small as in a backyard to as large as at an industrial level. Backyard composting primarily involves composting food waste and is intended for personal gardens. Community composting engages the local community and keeps compost and its benefits local. Municipal governments can also collect compost as part of their SWM program and compost it locally or at an industrial composting site that can manage high volumes of organic materials from a region (US EPA, 2024d). The Institute for Local Self-Reliance and US EPA provide several guides for individuals and communities to compost.

Composting rates in the US are low, which limits the wide range of benefits it can provide. In the US, the composting rate (8.5%) has increased eightfold from 4.2 MT in 1990 to 24.9 MT in 2018. However, this does not include backyard composting, which could increase this number. Food waste is the largest category that could increase the composting rate, as it has the third largest landfill rate (55.9%) while only 4.1% is composted. The highest composting rate is for yard trimmings (67%) (US EPA, 2020b). If the US increased the national composting rate, it would experience several benefits at a larger scale. It decreases the amount of methane emissions produced by the anaerobic digestion of organic waste, making landfills the third largest source of human-related methane emissions in the US. It also improves soil quality and

creates a carbon sink. Not only are there environmental benefits, but composting also increases jobs, environmental education, and healthy diets (ILSR, 2024).

2.2.2 | Recycling Challenges and Opportunities

The most popular form of recycling is the single-stream curbside pickup. This may not be the most economical choice as it increases collection costs, the costliest part of waste management (Lloyd's Register Foundation, 2024; National Academies of Sciences, Engineering, and Medicine, 2022; UNEP & International Solid Waste Association, 2024). There are issues with maximizing recovery value due to increased contamination from complex materials and wish-cycling, an act of hopeful recycling (Law et al., 2020; National Academies of Sciences, Engineering, and Medicine, 2022; Wright et al., 2014). Single-stream curbside pickup may not be the best option for all communities, but single- or separated-stream drop-off could be viable options. While single-stream curbside recycling presents challenges, addressing the accessibility and educational gaps in recycling programs could help improve overall participation and effectiveness. In the US today, about 75% of all households have access to recycling: curbside collection or drop-off locations. Single-family homes have 2.3 times more accessibility than multi-family homes; therefore, focusing on multi-family home recycling accessibility would increase recycling rates.

Despite the infrastructure available in the US, only 43% of people participate in recycling (The Recycling Partnership, 2024), which results in positive feelings (Abbott et al., 2014; Berglund, 2006). A 2022 survey found that 75% of people believe recycling makes a difference and is worth the effort. This lack of confidence may stem from only 17% of people feeling well-informed on what happens with their recycling after it leaves their home, further exacerbated by

75% of people not remembering the last time communication was received from the local recycling program (The Recycling Partnership, 2022). Increased communication and public education on recycling would increase confidence, leading to a higher recycling participation rate (Lloyd's Register Foundation, 2024; The Recycling Partnership, 2024; UNEP & International Solid Waste Association, 2024) and reducing leakage.

Leakage into the environment causes several health, environmental, and economic issues that outweigh the gains from recycling (Kaza et al., 2018; UNEP & International Solid Waste Association, 2024). This is exacerbated further by human behavior, with studies showing that people are more likely to litter in an already littered area than in a clean environment, and women are less likely to litter than men (Cialdini et al., 1990). The EPA's Escaped Trash Risk Map found that the average modeled litter density in the US is 46 items per transect, the average length of a city block (US EPA, 2024b). Current waste management fees do not include the marginal externality cost, which burdens community members by making them pay more taxes or deal with the environmental and health consequences (Ferrara & Missios, 2014; National Academies of Sciences, Engineering, and Medicine, 2022). The most expensive way to manage waste is through litter clean-ups (National Academies of Sciences, Engineering, and Medicine, 2022; Tunnell, 2008). US states and municipalities spend an average of $1.3 billion annually (National Academies of Sciences, Engineering, and Medicine, 2022). Addressing waste upstream by improving recycling systems would improve health and decrease costs.

2.2.3 | Rural Recycling

The environmental impacts associated with mismanaged waste are felt more by disadvantaged communities like rural communities (Tunnell, 2008; UNEP & International Solid

Waste Association, 2024; US EPA, 2021a). This is due to lower access to services and limited development opportunities compared to urban areas (Mihai et al., 2021). However, there is a lack of studies on rural recycling, with most resources being white papers. Global studies report the gap between rural and urban waste collection coverage for each world region except North America (Kaza et al., 2018). Six years later, a study mentioned a 20% household waste collection rate difference between rural and urban areas in North America, showing the opportunity to increase rural recycling rates (Lloyd's Register Foundation, 2024). This is still on a continent scale and not about the US. This warranted further exploration to better understand rural areas' recycling challenges and address the disproportionate environmental impacts of mismanaged waste.

The few rural studies discuss the unique recycling problems faced: a low quantity of recyclables, volatile recycling markets, and economies of scale. These non-metropolitan areas account for 20.3% of the U.S. population but span 87.4% of the nation's land area (HSRA, n.d.). According to the HSRA, the three communities studied—Tifton in Georgia, Georgetown County in South Carolina, and Cherokee County in North Carolina—with varying populations are considered rural (Table 1). The low population density leads to fewer recyclables being collected, making the curbside recycling method economically infeasible due to a lack of economies of scale. This may prompt alternative collection methods (Jakus et al., 1996; National Academies of Sciences, Engineering, and Medicine, 2022).

Table 1: July 2023 Population Estimates of Rural Communities
Reference: US Census Bureau, n.d.

Rural Community	Type of Community	Population
Tifton, Georgia	City	17,357
Cherokee County, North Carolina	County	29,959
Georgetown County, South Carolina	County	65,731

In addition to this, recycling markets are very volatile (The Recycling Partnership, 2024; UNEP & International Solid Waste Association, 2024). When the value of recovered materials falls below processing costs, it results in a loss of profit, often forcing rural communities to reduce the recycling services offered as they have limited public revenue (The Recycling Partnership, 2024; Tunnell, 2008). Economies of scale in recycling are achieved only at low recycling amounts, with the minimized cost occurring at 13,200 tons of recyclables per year, comparable to what 80,000 people generate (Bohm et al., 2010). Neighboring rural cities or counties can collaborate to increase the total quantity of recyclables, allowing them to leverage economies of scale. This is important because open burning or dumping rates increase when there is no curbside collection in rural areas (Tunnell, 2008).

There is no best form of collecting recyclables, as it depends on each community's needs and challenges (Lloyd’s Register Foundation, 2024; UNEP & International Solid Waste Association, 2024). Arguments against curbside collection in rural communities consist of long driveways decreasing the desire to place the recycling bin on the main road. Drop-off areas provide a social experience for citizens (Wright et al., 2014). On the other hand, curbside recycling promotes the social norm of recycling as it is visible to their neighbors (Abbott et al.,

2014). Drop-off areas burden residents due to increased time and effort (UNEP & International Solid Waste Association, 2024). Additionally, studies have found that the farther an individual travels to a drop-off area, the lower the recycling rate (Saphores et al., 2006; Sidique et al., 2010). However, rural residents may not view the distance as inconvenient if they also have to dispose of their household waste at the drop-off areas (Saphores et al., 2006).

2.3 | Waste Management in Georgia

The Georgia Environmental Protection Division (GEPD) regulates the state's waste management. The most recent waste characterization study was conducted in 2003-2004 when the population of Georgia was 8.6 million. The state's total MSW reported was 10.04 million lbs. The per capita MSW rate increased from 5.56 lbs/person/day in 1993 to 7.14 lbs/person/day. Figure 2 shows Georgia MSW's top categories, with paper and organics representing 67% together and plastics being the third largest category (15.8%) (Georgia Department of Community Affairs, 2005).

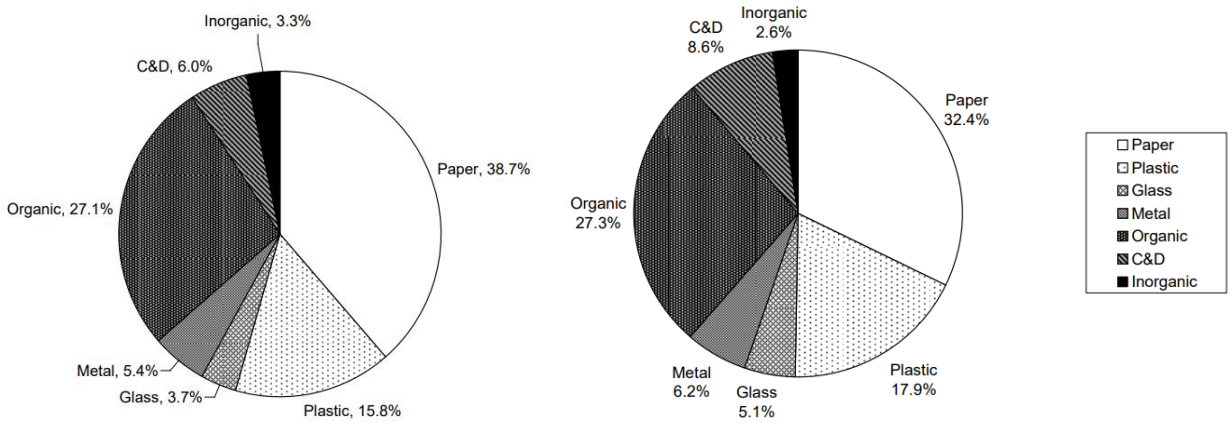


Figure 2: Georgia (left) and South Georgia Region (right) MSW Characterization
Reference: Georgia Department of Community Affairs, 2005

The City of Tifton represents the Georgia rural community for this work. The South Georgia region includes Tift County, where Tifton is located, and eight other counties. This comprises 214,520 people who generated 226,382 tons of MSW, accounting for 2% of Georgia's total MSW. The top three MSW categories were the same as the state data, but compared to the state data, South Georgia generates 6.3% less paper and produces 2.1% more plastic (Figure 1). The top three commonly recycled materials that were landfilled are corrugated cardboard, newspaper, and office paper. Other materials on this list were polyethylene terephthalate (PET) and HDPE bottles but at lower tonnage. The report has no information on the recycling rate for Georgia or the South Georgia region (Georgia Department of Community Affairs, 2005). Georgia has a large presence in the recycling industry. The Georgia paper industry recycles 8% of all paper in the U.S., and one-third of all plastic bottles recycled in North America are utilized in the carpet industry in Northwest Georgia (Georgia Department of Economic Development, n.d.).

Although the GEPD has published minimal information on recycling, reports from non-governmental organizations (NGO) and companies have provided some insights. The Recycling Partnership found that 62% of households have access to recycling, but only 19% of multi-family homes have access in Georgia, contributing to the 13% state-level recycling rate. 1.3 million tons of recyclables are lost to landfills (The Recycling Partnership, 2024). In a report for Ball Corporation, the recycling rate for packaging without fibers and flexible plastics (FFP) (PET, HDPE, rigid plastic #3-7, glass, aluminum, and steel cans) in Georgia was found to be 14%, ranking 31st in the US. The state recycling rate with FFP increased to 36% and increased the national ranking to 28. The highest recycling rate was for cardboard/paper packaging (52%),

and the lowest was for polypropylene (PP) (3%). This resulted in $100 million in material recovery (Eunomia Research & Consulting Inc, 2023).

2.4 | Waste Management in North Carolina

The North Carolina Department of Environmental Quality (NC DEQ) Division of Waste Management releases a yearly report outlining the state's SWM efforts, with the most recent for fiscal year (FY) 2022-2023. The total amount of MSW generated was 11.55 million tons. In Cherokee County, the rural area surveyed, less than 1% of the state's MSW is landfilled (NC Department of Environmental Quality, 2024). Almost half a million tons of MSW were exported to the surrounding states, so there is a possibility that Cherokee County exported waste, as it borders both Tennessee and Georgia (NC Department of Environmental Quality, 2024b).

In North Carolina, 404,083 tons of commonly recycled goods were processed. Plastic recycling accounts for only 2.2% (34,148 tons). Nearly all recycled plastics were HDPE and PET bottles (NC Department of Environmental Quality, 2024b). This is mainly due to House Bill 1465, passed in 2009, which bans the disposal of plastic bottles in landfills. However, only 30% of PET bottles are recycled (NC Department of Environmental Quality, n.d.).

North Carolina's single-stream collection system, which handles 75% of all recyclables, can recycle 266,221 tons after accounting for a 19% contamination rate. Mixed paper and cardboard represent the largest categories, making up half of the recovered commingled recyclables. The following largest categories are glass and contamination (37.4%), which incur processing costs (Figure 3). In the summer of 2023, aluminum ($1,340 per ton) and natural HDPE ($460 per ton) had the highest market values and have been for the last ten years. However, these materials comprise only 2.2% of the total weight of recyclables, which limits

potential profits. As a result, most MRFs charge a tipping fee, as the average blended material value of $51 per ton is insufficient to cover processing costs (NC Department of Environmental Quality, 2024b).

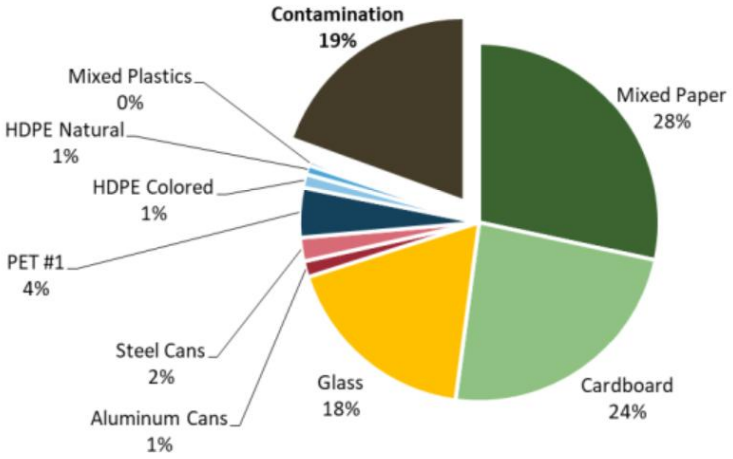


Figure 3: North Carolina Commingled Recyclable Characterization
Reference: NC Department of Environmental Quality, 2024b

Three hundred three local governments offer curbside pickup, serving 2.25 million people or 20% of North Carolina's population. In addition, composting programs have diverted 18,469 tons of food waste. Forty-four counties participate in unique initiatives to reduce waste generation, including 26 public reuse, 44 backyard composting, and 61 source reduction programs (NC Department of Environmental Quality, 2024b). The NC DEQ created a website to connect recyclable material generators to recycling companies: https://recyclingmarkets.deq.nc.gov/.

Although the NC DEQ has published information on recycling, reports from NGOs and companies have provided further insights. The Recycling Partnership found that a quarter of households do not have access to recycling, with multi-family households having only 15% accessibility, contributing to a 19% recycling rate and 1.3 million tons of recyclables lost to

landfills (The Recycling Partnership, 2024). In a report for Ball Corporation, the recycling rate for packaging without FFP is 17%, ranking 28th nationally. The state recycling rate with FFP increased to 50%, increasing the US ranking to 12th. The highest recycling rate was cardboard/paper packaging (72%), and the lowest was rigid plastics #3-7 (2%). This resulted in $113 million in material recovery (Eunomia Research & Consulting Inc, 2023). This is the highest recycling rate out of the three states.

2.5 | Waste Management in South Carolina

The South Carolina Department of Health and Environmental Control (SC DHEC) produces an annual report on the state's SWM. In FY 2023, 5.4 million tons of waste was generated. The average tipping fee in the state was $36/ton for Class II landfills and $43/ ton for Class III. The recycling rate includes composting and was 20.9%. Among recycled materials, metals accounted for the largest amount (25%), while plastics had one of the lowest recycling rates (2%). Georgetown County, the rural area surveyed, generated about 0.73% of South Carolina's MSW and 1.13% of the amount recycled (SC Department of Health and Environmental Control, 2023)

South Carolina has set goals to reduce MSW to 3.25 lbs/person/day by recycling at least 50% of its MSW (SC Department of Health and Environmental Control, 2023). To support recycling, the South Carolina government has invested $5.4 billion into the recycling industry between 2018 and 2022, resulting in a $13.6 billion total annual economic impact. This is due to 301 recycling businesses throughout the state. Georgetown County has only a glass bunker, but neighboring counties Florence and Charleston each have 14 and 29 recycling businesses, respectively (Recycling Market Development Advisory Council, 2022). As of 2018, plastic

manufacturing was the 10th largest employing job area in Georgetown County (Economic Leadership LLC, 2019). The SC DHEC created a website to connect recyclable material generators to recycling markets: https://www.recyclinginsc.com/directory/.

South Carolina's recycling is collected through 530 drop-off sites or 69 curbside programs (SC Department of Health and Environmental Control, 2023). However, the state faces issues with plastic bags stuck in sorting machines. Horry County, Georgetown's neighboring county, estimates fixing solid waste sorting machines from plastic bag damage to be $100k. Charleston County has stopped accepting plastic bags due to the damage they cause MRFs (Coastal Conservation League, 2017).

Several reports address Georgetown County's litter and SWM according to the Sustainable Development Goals supported by internships through the Georgetown RISE United Nations Youth Corps Initiatives. One of the 2022 reports, using Keep America Beautiful protocols, analyzed the county's yearly litter index and found hotspots at Andrews, Pawleys Island, and areas near rural highways (Figure 4). Andrews has more litter than Pawleys Island due to lower income, decreased use of private waste companies, and less tourism, which encourages a cleaner community. Most of the litter found was alcohol-related, such as bottles and packaging. Common litter items include take-out packaging, aluminum cans, plastic bottles, and tires. From 2021 to 2022, thirty county-organized cleanups resulted in 29,404 lbs of litter removed from the environment, resulting in less litter than the 2021 litter index (Rainwater, 2022). Due to Georgetown County's location on Winyah Bay and Atlantic Ocean, there is a greater risk that mismanaged waste, especially plastic, will end up in the ocean. Therefore, waste must be appropriately managed, and litter must be picked up to reduce the amount (Castleforte, 2022; UNEP & International Solid Waste Association, 2024).

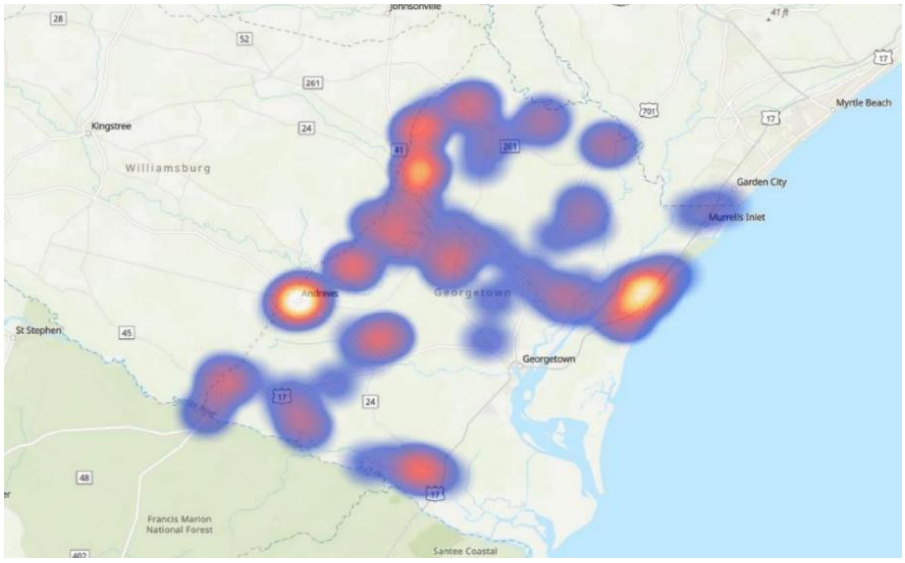


Figure 4: Georgetown County Litter Heat Map
Reference: Rainwater, 2022

Despite the large amount of information on recycling from the state and county levels, outside studies not affiliated with the municipal or state government find valuable insights. Multi-family households in South Carolina have only a 6% accessibility rate, contributing to a 15% recycling rate. 640k tons of recyclables are lost to landfills (The Recycling Partnership, 2024). According to a report for Ball Corporation, South Carolina's recycling rate for packaging without FFP is 6%, ranking it 46th in the US. The state recycling rate with FFP increased to 35%, increasing the national ranking to 30th. The highest recycling rate was for cardboard/paper packaging (56%), and the lowest was for PP (2%). This resulted in $43 million in material recovery (Eunomia Research & Consulting Inc, 2023).

CHAPTER 3

METHODS

The CAP is a standardized, systems-based methodology for community-level data collection and decision-making developed by the CIL at UGA in 2018. It uses a hub-and-spoke approach to evaluate how materials flow into, are consumed within, and exit a community, including their environmental impact. The CAP illustrates the relationships between influencers, drivers (e.g., policies), and its seven spokes, qualitative and quantitative data, providing a comprehensive view of circularity at the community level. This provides a snapshot in time of circularity in the community. It equips communities with the data needed to make informed decisions and policies by standardizing the quantification of circular materials management. As of January 2024, the CAP has been conducted in 56 communities across 16 countries (Jambeck et al., 2024; Maddalene et al., 2023).

Data was collected using the CAP methods in three rural communities: Tifton, Georgia; Cherokee County, North Carolina; and Georgetown County, South Carolina. While there was only a sample size of three rural communities, they were selected to represent a range of characteristics within EPA Region 4, providing a snapshot of the region's diverse recycling challenges. These communities did not have any pre-existing relationships before this study.

The process began with collaboratively deciding the area of study within the community. The following subsection describes this process, along with the methodology used to collect data for the seven spokes and how the EPA Region 4 rural communities were compared. CAP

fieldwork was conducted in September and November 2022 for Tifton, August 2022 and April 2023 for Cherokee County, and April to May 2023 for Georgetown County.

Some CAP results were compared to data from six other US city CAPs completed as a part of a project funded by the Walmart Foundation at the University of Georgia New Materials Institute (NMI): Athens, Georgia; Atlanta, Georgia; Blytheville, Arkansas; Cape Girardeau, Missouri; Minneapolis, Minnesota; and Vicksburg, Mississippi (New Materials Institute, 2024). This comparison was completed to contextualize the data collected in this study and to understand how it compares to other US cities. Four of the cities sponsored by Walmart Foundation are located in the Southeast US, Region 4 of USEPA (Athens, Atlanta, Blytheville, and Vicksburg), and four are also non-metro cities/smaller cities (Athens, Blytheville, Cape Girardeau, and Vicksburg). The six city CAPs sponsored by the Walmart Foundation are hereafter called the "Walmart Foundation cohort".

3.1 | Site Selection

For each rural community, a 10 km x 10 km area over the community center was identified in ArcMap to sample various locations randomly. The ambient population, or societal activity, was sorted into three tertiles: high, medium, and low. These classifications were done using the Oak Ridge National Laboratory's 2022 LandScan dataset, which provides the ambient population per raster cell at approximately 1 km spatial resolution. The dataset incorporates both nighttime, residential areas, and daytime, employment areas, population and census data. Supplementary spatial data to further refine the data include high resolution imagery (capturing light data at night), transportation infrastructure, lidar data (for building detection), and land use data from parcels. In addition, activity hubs such as academic institutions, prisons, shopping

malls, commercial areas, and cultural attractions are integrated into the model, contributing to more accurate estimates of daytime population distribution (Oak Ridge National Laboratory, n.d.).

From each of the three ambient population tertiles, three 1 km^2 areas were randomly selected from the National Oceanographic and Atmospheric Administration Sampling Tool for a total of nine areas for each rural community. Next, in each 1 km^2 area, three 200 m^2 sites were selected by the sampling tool as litter transect locations, totaling 27 litter transects (Maddalene et al., 2023). The only variation from the site selection process outlined above was for Georgetown County, South Carolina, where an additional three 1 km^2 areas were selected in Pawleys Island, one for each tertile. This is to better understand differences in circularity between coastal and mainland areas in the same county. Figures 5-8 represent the litter transects for the three rural communities plus Pawleys Island. The large squares represent the 1 km^2 population tertile area, and the smaller squares inside are the 200 m^2 sites where the litter transect occurs.

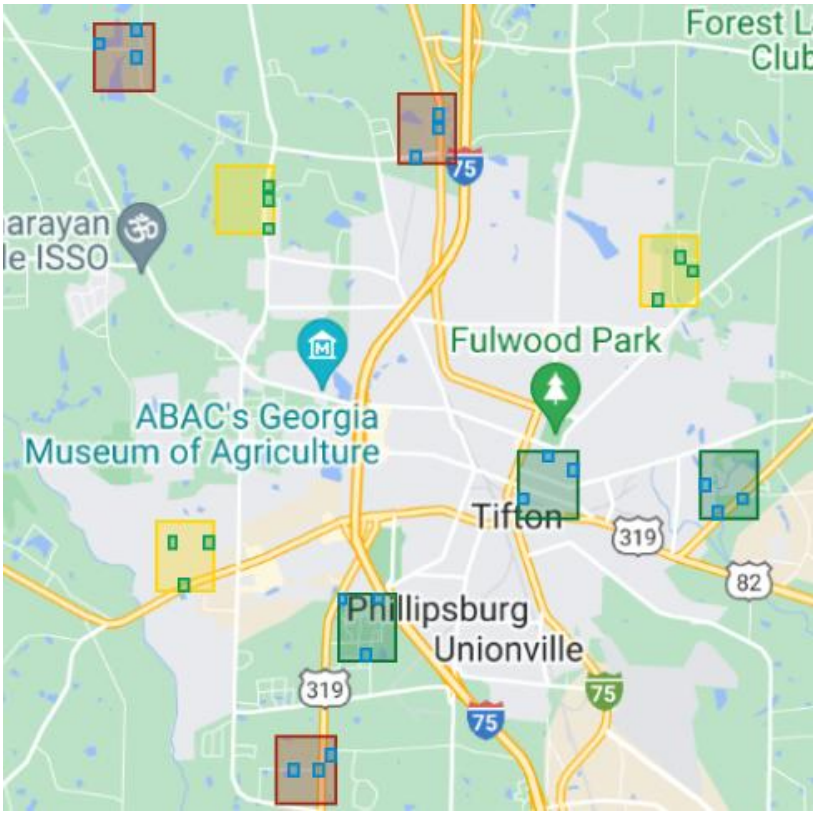


Figure 5: Population Tertiles and Survey Sites in Tifton, GA

Note: The green squares represent the high ambient population tertile, the yellow squares represent the medium ambient population tertile, and the red squares represent the low ambient population tertile.

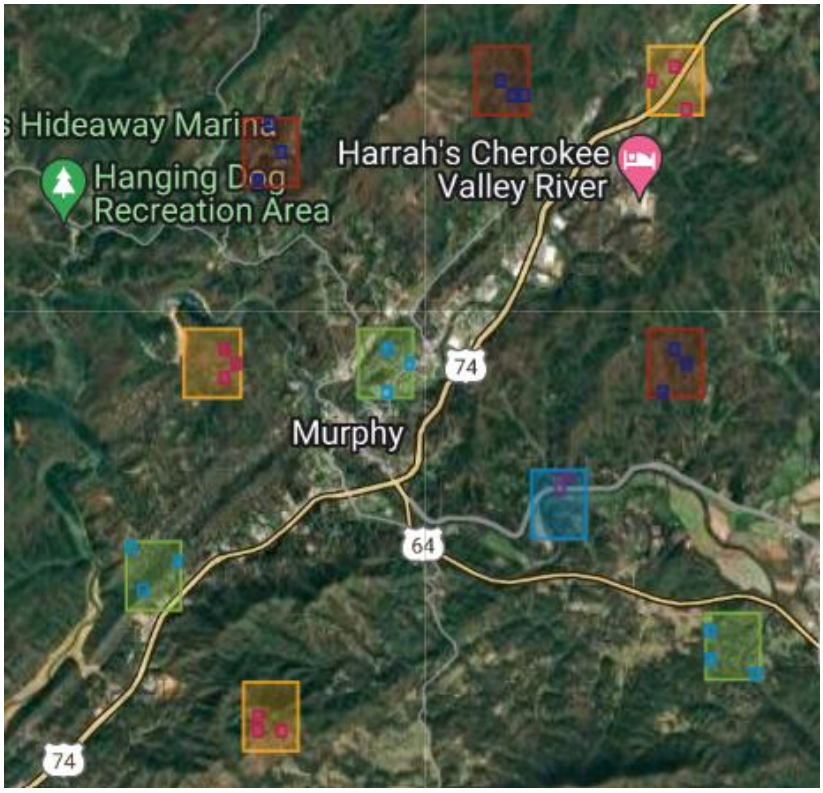


Figure 6: Population Tertiles and Survey Sites in Cherokee County, NC

Note: The green squares represent the high ambient population tertile, the orange squares represent the medium ambient population tertile, and the red squares represent the low ambient population tertile. The red square on the right could not be accessed, so the blue square replaced it.

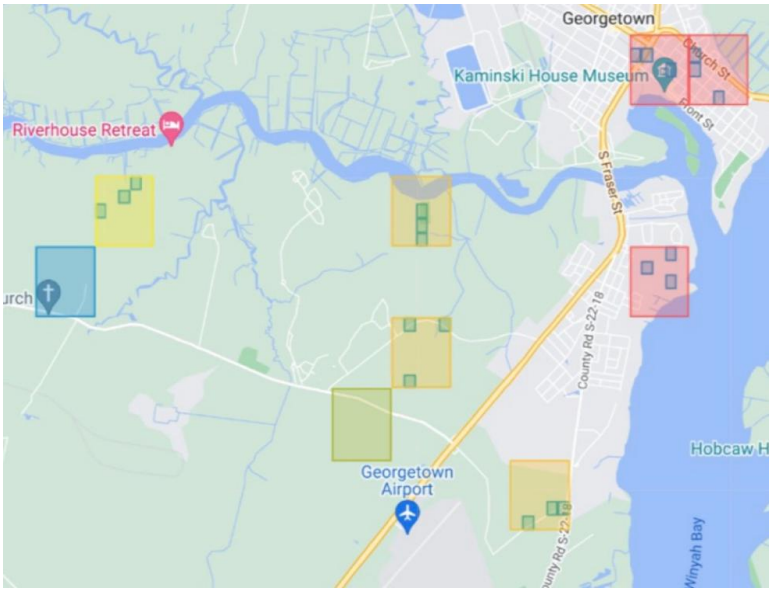


Figure 7: Population Tertiles and Survey Sites in Georgetown County, SC
Note: The red squares represent the high ambient population tertile, the orange squares represent the medium ambient population tertile, and the yellow, blue, and green squares (the three squares on the left) represent the low ambient population tertile.

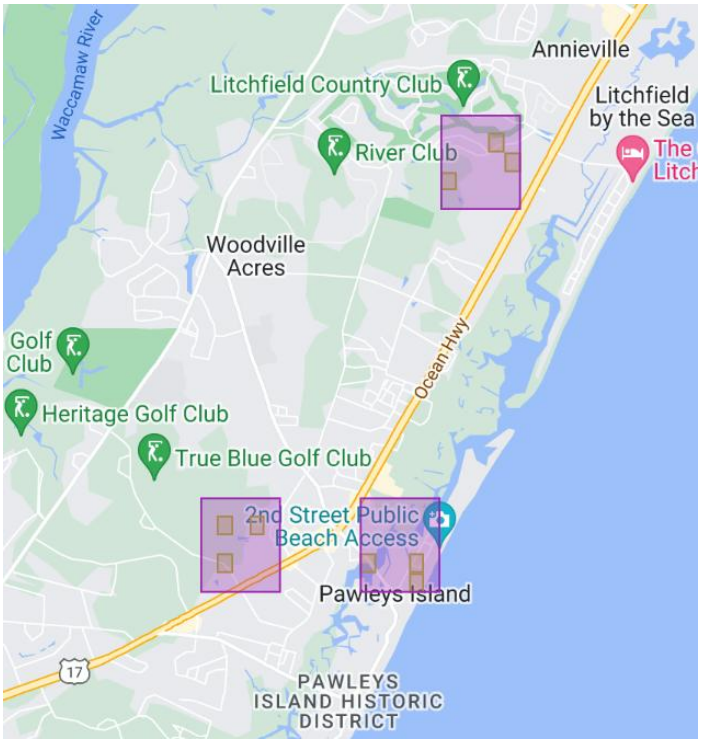


Figure 8: Population Tertiles and Survey Sites in Pawleys Island, SC
Note: The top square represents the high ambient population tertile, the bottom left square represents the medium ambient population tertile, and the bottom right square represents the low ambient population tertile.

3.2 | Input

The input section investigates the products sold in the community and where they originate. This was done by collecting samples of fast-moving consumer goods (FMCG) at three stores (grocery stores, convenience stores, pharmacies, etc.) within or as close as possible to the nine 1 km^2 transect areas to identify the types and sources of common plastic-packaged items entering each rural community (Maddalene et al., 2023). Due to the low population density of the rural communities, there were instances where there were less than three stores per transect area. The FMCG visually assessed in stores were beverages (soda or juices), chips, candy, usually found close to the checkout line, and tobacco products, if present. Common brands of each FMCG category were collected at each store, determined by shelf space or input from store employees, along with their packaging type and the parent company (Maddalene et al., 2023). Samples of identical brands were collected only once.

The locations of manufacturing and parent companies were identified based on packaging information and desktop research (Youngblood et al., 2022). At times, the manufacturing locations were challenging to locate, as the US is not required to identify them on packaging explicitly. The manufacturing locations are likely closer than the parent company locations, but they could not be found. As a result, the distances default to the parent companies. Distances from stores to the respective parent or manufacturing companies were calculated using ArcGIS (Youngblood et al., 2022).

3.3 | Community

The community section consists of semi-structured interviews and conversations with local stakeholders influencing recycling to gather attitudes and perceptions about recycling. The

insights enhance and contextualize the quantitative and qualitative data collected in the other CAP spokes (Maddalene et al., 2023). Stakeholders were identified through internet searches as having potential interest in, and influence on, waste management and plastic pollution in each city. Efforts were made to obtain interviews from a variety of stakeholder groups. However, due to the rural locations of the communities, the number of stakeholders was limited. The responses of those who participated in interviews were recorded and transcribed for coding and thematic analysis (Maddalene et al., 2023). There were 14 conversations with notes taken and two semi-structured interviews, one in Georgetown County and one in Cherokee County. Conversation notes and interview responses were used to contextualize the CAP results further.

3.4 | Product Design

The product design explores the materials found in products, particularly packaging, in two contexts: stores and restaurants. In each store selected as described in the input section, visual assessments of packaging material types of FMCG were conducted. Some of these products were purchased to measure plastic packaging and product weight using kitchen scales (Maddalene et al., 2023). The packaging and product weights were supplemented by a master list of other common FMCG's packaging and product weights bought from previous US CAPs.

The in-store packaging material type visual assessments also included staple goods commonly bought and stocked in stores. The staple goods assessed were detergent, greens, milk, eggs, oil, rice, and sugar, or as many were available. Food was purchased from up to three randomly selected restaurants, grocery delis, gas station to-go, or coffee shops at or near each 1 km^2 transect area, nine total, to sample to-go food packaging (Maddalene et al., 2023). There

were instances of some transects having less than three restaurants due to the low population in the rural communities.

3.5 | Use

The use section examines community trends in the use and reuse of product types. Data was gathered at each store, including brand name, packaging material, usage type, price, and quantity for single-use plastic (SUP) alternatives for household items, personal care products, and picnicware. The same information was collected for comparable SUP items to assess the cost differences via Excel. Additionally, a bag survey was carried out at both stores and restaurants to check for the availability of reusable bags and the cost.

3.6 | Collection and End of Cycle

The collection section investigates the volume and composition of waste generated and collected, disposal methods, and the current infrastructure in each rural community. Further analysis was done on buffer zones around the drop-off centers. Buffer zone distance was manipulated until approximately 90% of the ambient population was within the buffer zone. The ambient population data was pulled from the Oak Ridge National Laboratory's 2023 LandScan dataset, and the buffer zone analysis was done using ArcGIS. The end of cycle section examines the waste's fate after it has been adequately disposed of and its treatment. Information for this section was primarily gathered through visits to the SWM infrastructure and interviews with stakeholders. This was collected throughout several dates: Tifton, Georgia **(**September 2022), Cherokee County, North Carolina (August 2022), and Georgetown County, South Carolina

(April 2023). Further information was obtained through desktop research (Maddalene et al., 2023).

3.7 | Leakage

The leakage section explores what waste is leaking into the environment, why, and how it ends up there. As previously indicated in the site selection process, litter transects were conducted in the 27 transects across three population tertiles for each community (Figures 5-8). There were an additional nine transects for Pawleys Island. Transects were 100 m long and 1 m wide, following along the side of a road or pathway measured using a distance wheel. Within this distance, the type of litter and GPS coordinates were recorded for litter items >2.5 cm using the Site Assessment list in the Marine Debris Tracker (MDT) mobile application (Appendix A). If the litter item did not fit any specific category, it was labeled as "Other" with an accompanying description. (Maddalene et al., 2023). The MDT is a citizen science application that allows anyone with an Android or iPhone to track litter and marine debris at a larger scale with greater speed and efficiency (Jambeck & Johnsen, 2015). Data is open for public access at http://marinedebris.engr.uga.edu/.

Groups of trained undergraduate researchers at the University of Georgia's CIL collected the litter data. It is important to note that the litter data collected is a snapshot in time and is subject to change based on season, weather, etc. The data was collected during the following periods: Tifton, Georgia **(**November 12 - 13, 2022), Cherokee County, North Carolina (April 7 - 9, 2023), and Georgetown County, South Carolina (May 14 - 17, 2023).

3.8 | Rural Community Comparison

The three communities were compared following the CAP, and the subsequent data analysis was performed on each rural community. The rural communities are characterized by three distinct geographies gathered by the site visit. Levels of tourism within the communities were analyzed by researching the tourists' economic impact in US dollars. The US Census Bureau's geography estimates for 2020 were used to analyze the population density differences. In addition, the cities were compared across their ambient population density using the Oak Ridge National Laboratory's 2022 LandScan dataset. Further analysis utilized the US Government's CEJST, developed by the US Council on Environmental Quality, to identify burdened communities from the 2010 census tract boundaries. This tool categorizes the analysis into eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development (US Council for Environmental Quality, n.d.-a). The comparison of the three rural communities focused on how SWM is affected by several components, including geographical location, levels of tourism, population density, ambient population, and the CEJST.

CHAPTER 4

RESULTS

4.1 | Circularity Protocol Assessment in Tifton, Georgia

A CIL team conducted fieldwork for the Tifton CAP from November 12 to 13, 2022. The following sections detail the findings and discussions regarding the seven CAP spokes: Input, Community, Product Design, Use, Collection, End-of-Cycle, and Leakage, concluding with Opportunities. The CAP aims to assess circularity and improve recycling as part of broader circularity efforts in Tifton, Georgia.

4.1.1 | Input

The CIL team surveyed thirteen stores to collect and sample 446 fast-moving consumer goods, comprising 133 beverages, 229 candies, 63 chips, and 21 tobacco products. The top brands in Tifton consisted of the following:

- **Beverages**: Gatorade, Coca-Cola, and Mountain Dew
- **Candy**: Reese's, M&Ms, and Snickers
- **Chips**: Lays, Doritos, and Cheetos
- **Tobacco Products**: Marlboro, Newport, and L&M

Most FMCG were manufactured in the US at 93% (Figure 9), with local bottling facilities in Tifton for Coca-Cola and Albany for PepsiCo. A majority (82%) of the FMCG parent company locations are also domestic (Figure 10), with Pennsylvania, New York, Virginia, Georgia, and Texas being the top parent company states. The top three parent companies (Mars Inc, PepsiCo,

and The Hershey Company) sourced 33% of all the FMCG. Products originating from global parent companies (18%) were predominantly in Europe and North America. However, some products were sourced from Ecuador, Japan, Peru, South Korea, and Turkey (Figure 10).

Figure 9: Tifton Manufacturer Locations by FMCG Type Map

Figure 10: Tifton Parent Company Locations by FMCG Type Map

Tobacco products showed the farthest average distance from parent companies yet had the closest distance to manufacturers (Table 2). 41 FMCG were manufactured and/ or had a parent company location in Georgia, of which The Coca-Cola Company in Atlanta produced 73%. Candy had the lowest minimum distance to the parent company and manufacturer (30 km) in Ocilla, GA. The closest beverage parent company/ manufacturer (116 km) was also located in Georgia in Arlington.

Table 2: Distances between Tifton and Manufacturer and Parent Company Locations for FMCG

	*Length Store to Parent Company (km)			Length Store to Manufacturer (km)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Beverages	116	11,736	1,861	116	12,209	1,743
Candy	30	11,320	2,619	30	14,746	1,585
Chips	368	7,200	1,576	368	14,746	1,665
Tobacco Products	216	6,908	3,387	216	2,130	868

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

The states neighboring Georgia manufactured 9% of the sampled FMCG in Tifton (Table 3). North Carolina was the most popular state due to its tobacco industry, closely followed by Florida. PET was the primary beverage packaging material, but three manufacturers (Ingles Market Co., Milo's Tea Co., and Milkco Inc.) packaged them in HDPE. Both materials are recyclable and widely accepted.

Table 3: Products Manufactured in Neighboring States and Distributed in Tifton

Neighboring State	Manufacturer	Product Category	Main Packaging Type
Alabama	Golden Flake Snack Foods	Chips	Multilayer Plastic Film
	Milo's Tea Co.	Beverages	HDPE
	Nantze Springs	Beverages	PET

Florida	Anastasia Confections Inc	Candy	Multilayer Plastic Film
	Barberi International	Chips	Multilayer Plastic Film
	Costa del Sol	Chips	Multilayer Plastic Film
	De Mi Pais	Beverages	PET
	Natalie’s Juice Co.	Beverages	PET
	Polaris Trading Corp.	Chips	Multilayer Plastic Film
	Raindrops Enterprises LLC	Candy	Multilayer Plastic Film
	Swisher	Tobacco	Paperboard & plastic film
	Tropicana Manufacturing Co.	Beverage	PET
	Zephyrhills Public Water Supply	Beverage	PET
North Carolina	American Snuff Company	Tobacco	Paperboard & plastic film
	Food Lion LLC	Beverage	PET
	GoodMark Foods Inc	Chips	Multilayer Plastic Film
	Ingles Market Co.	Beverage	HDPE
	ITG Brands	Tobacco	Paperboard & plastic film
	Liggett Group	Tobacco	Paperboard & plastic film
	Milkco Inc	Beverage	HDPE
	Pepsi Bottling Group Inc	Beverage	PET

	RJ Reynolds Company	Tobacco	Paperboard & plastic film
	Snyder's Lance Inc	Chips	Multilayer Plastic Film
South Carolina	Deer Park	Beverage	PET
	Lowcountry Kettle	Chips	Multilayer Plastic Film
Tennessee	Charms LLC	Candy	Multilayer Plastic Film
	PepsiCo	Beverage	PET
	Standard Candy Co.	Candy	Multilayer Plastic Film

4.1.2 | Community

Eight key stakeholders shared their insights into the community's prevailing attitudes and perceptions about plastic waste and recycling (Table 4). Conversations were held with three stakeholders from academia, two from facilities management, one from the regional recycling center, and two from waste management companies. It is important to note that the information gathered from stakeholders is not exhaustive, as the rural nature of the communities limited the number of participants. The stakeholders provided insights into Tifton's recycling system, highlighting strong community interest and significant challenges: past mismanagement, lack of resources and facilities, and high contamination. Addressing these issues through education, policy changes, and infrastructure improvements is key to rebuilding trust and improving their recycling system. The following insights are presented as closely as possible to the notes taken during stakeholder conversations.

Table 4: Stakeholder Groups and Number of Stakeholders in Tifton

Stakeholder Group	Number of Stakeholders
Academia	3
Facilities Management	2
Regional Recycling Center	1
Waste Management Company	2

An academic stakeholder provided insight into Tifton's recycling history. In the 1990s, a progressive city council initiated recycling. Another push for recycling came from a progressive mayor. A facilities management stakeholder highlighted a shift in the relationship between Tifton and Tift County. In the past, there was a strong working relationship in which they collaborated with representatives from both the county and city boards. However, disagreements on splitting Special Purpose Local Option Sales Tax (SPLOST) money, a 1% sales tax that funds capital projects, resulted in a turf war between the city and county and, ultimately, lawsuits. As a result, collaboration to decrease costs and increase the volume of recyclables is unlikely.

Despite the political challenges, waste management companies have observed that many Tifton residents enjoy recycling. Academics also highlighted the city's many environmental activists, and the UGA Tifton campus participated actively when there was a recycling drop-off. While some in the community want to recycle, the community's trust in recycling has been damaged. An academic stakeholder shared that a past waste management company was dishonest and dumped recyclables in the trash.

Recycling in Tifton faces economic and facility challenges. A facilities management stakeholder noted that the market for recyclables has collapsed, and there is a need for funding

and space to recycle more efficiently. Waste management companies shared that it is challenging to recycle economically because the low landfill tipping prices ($42/ ton) compete with the much higher recycling costs ($120/ ton). Additionally, Tifton lacks key facilities, such as a MRF or a transfer station, making transportation a major hurdle. Due to its rural location far from major cities, baled plastic must be hauled to Tallahassee, FL, 90 miles away, as it is the closest location. Colleges, a top employment sector in Tifton, would be willing to participate in recycling if they didn't have the burden of hauling recyclables themselves.

A waste management company stakeholder shared that single-stream recycling is great in philosophy due to its less space and convenience to residents. Still, it doesn't work on a human level because people contaminate it. They estimated that approximately 80% of the recycling is trash. This is particularly challenging with plastic. If it is not clean, it must go to another recycler. An academic stakeholder shared that many people are unwilling to work to sort their recycling properly, as seen with the campus cardboard recycling contaminated with Styrofoam. Thirty years ago, inmate labor was used to sort recycling to reduce contamination and keep costs low. This practice is no longer present in the community, possibly due to ethical concerns, particularly around fairness, consent, and the potential exploitation of a vulnerable population.

Tifton's large agricultural sector is also affected by the recycling system. Farmers are reluctant to take plastic mulch or liners to the landfill and instead store them in their fields. These plastics are exposed to weathering and can fragment and run off if it rains. Plastic can get entangled during tilling and in cotton-picking tractors, ending up in the threads of the tractor's threads, shared an academic stakeholder.

One way to address plastic pollution and increase recycling rates is through community education. A facilities management stakeholder believes it has been too long since recycling was

a main option in SWM, so the campus and community need to be re-educated. An emphasis on why and how to recycle and the value of the land that is lost by sending all waste to the landfill is important to encourage the public to recycle. Waste management companies shared that education must start at a young age in school. Recycling was previously part of the school curriculum, but stakeholders reported it no longer exists.

Waste management stakeholders suggested several policy changes to improve recycling in Tifton. The city could give residents smaller trash cans to increase recycling rates. It also needs to enforce clean recyclables or give waste management the power to do so. Finally, recycling could be incentivized. This could be a tax incentive for higher levels of recycled materials advertised on TV, the internet, and paper pamphlets when residents sign up for waste services.

Ultimately, Tifton's recycling system has been influenced by ongoing conflicts among city and county officials, community interests, and systemic challenges. While many residents and institutions support recycling, past situations have weakened public confidence, including lack of resources and facilities, as well as contamination issues, and decreased recycling rates. Furthermore, the city's agricultural sector faces specific challenges related to plastic waste. Education and awareness campaigns are crucial to improve recycling rates, alongside policy changes that encourage better waste management practices. Tifton can rebuild trust and establish a more sustainable city and efficient recycling system by educating the public, enforcing clean recycling, and offering incentives.

4.1.3 | Product Design

The CIL team analyzed 349 FMCG products and their packaging across 25 stores in Tifton. Beverages had the highest product and packaging mass compared to chips and candy (Table 5). This may be attributed to the high density of PET, a common packaging material for plastic bottles and beverages. Beverages had the highest packaging-to-product ratio (0.06), and candy and chips were close behind at 0.05. Thus, candy and chips produce the lowest packaging waste per product unit among the three categories. For comparison, samples taken in six US cities, known as the Walmart Foundation cohort, showed that the average chip packaging weight was 4.99 g, higher than the Tifton value (3.91 g). The average product weight was also higher at 80.1 g than Tifton's value (74.8 g) (New Materials Institute, 2024).

In this study, cigarette products were not purchased since they typically come in a standard size. Our previous findings indicate an average of approximately 10 g of plastic packaging for every 15 g of product. This relatively high packaging-to-product ratio of 0.67 is likely influenced by the cellulose acetate filters in cigarette butts, which usually weigh around one gram each.

Table 5: Average Weight of Products and their Plastic Packaging for FMCG in Tifton

Category	Product Count	Average Quantity of product (g or ml)	Average Weight of packaging (g)	Packaging-to-Product Ratio
Beverage	111	528	34	0.06
Candy	181	63.5	3.13	0.05
Chips	57	74.8	3.91	0.05

The majority of chips, candy, greens, and rice were packaged in multilayer plastic film, and eggs were packaged in expanded polystyrene (EPS), commonly known as Styrofoam (Figure 11). These materials cannot be recycled and can easily leave the waste stream. In contrast, certain items primarily used recyclable packaging materials. Beverages and oil products were packaged in PET, milk and detergent in HDPE, and sugar in paper. The following material types for oil packaging were steel, tin, or other metal and glass (10% each), all of which are alternatives that can be recycled.

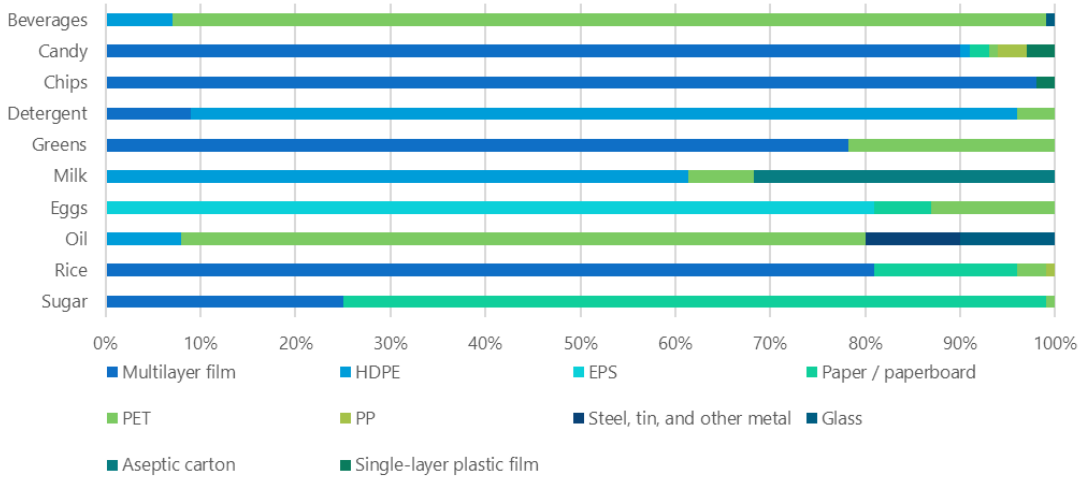


Figure 11: Material Breakdown of FMCG and Staple Goods in Tifton

The CIL team surveyed 24 restaurants in Tifton to identify the to-go items offered. PP was the primary material for straws, utensils, and cold cup lids (Figure 11). EPS was the primary material for cold cups and tied with polystyrene (PS) for food containers. Bags are primarily made of soft HDPE, which can escape the waste stream. PP, EPS, PS, and soft HDPE are not widely recycled. The only to-go item primarily composed of recyclable materials was the sauce container lids, of which 50% were made from PET. Other items were made out of some recyclable materials. Bags (40%) and food containers (8%) were made of paper, while cold cup

lids (23%) and sauce containers (9%) were produced from HDPE. The most common recyclable material was PET, which included food containers (12%), cold cups (13%), cold cup lids (18%), and sauce containers (9%). There were no to-go items made from alternative materials.

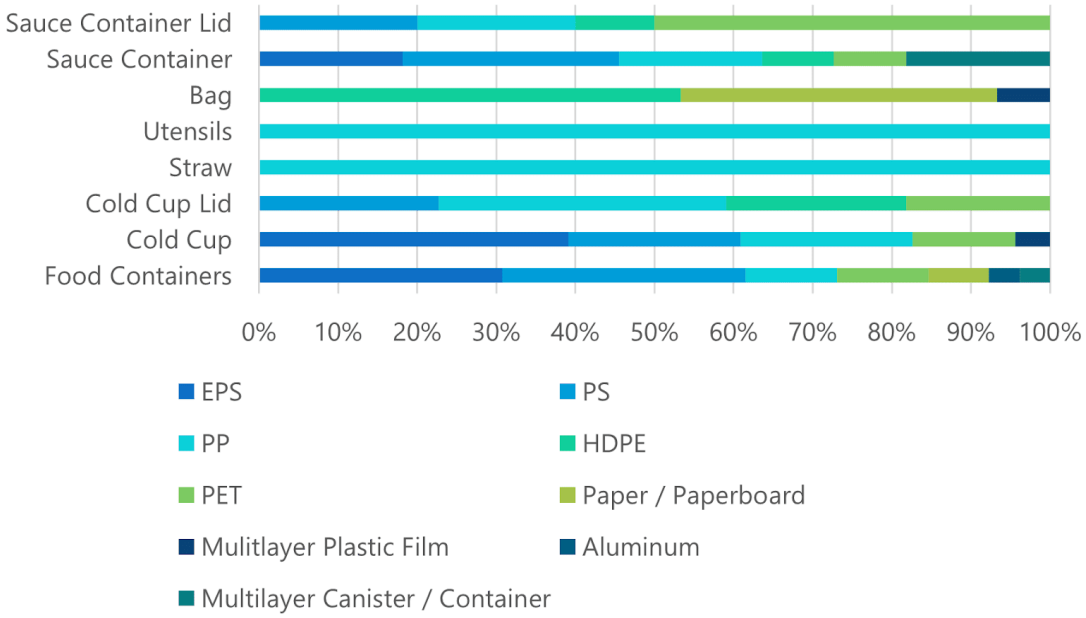


Figure 12: Material Breakdown of Restaurant To-Go Items in Tifton

4.1.4 | Use

All 25 stores surveyed in Tifton provided single-use plastic bags. Reusable bags, cloth and non-woven laminated PP, were offered at 27% of stores (Figure 13) for an average cost of $2.43. None of the stores provided paper bags for free or at a reduced price.

Figure 13: Example of Reusable Bags Sold in Tifton Stores

Tifton sold household and picnicware alternatives in 32% of its stores. Compostable products were the most popular alternative use type (67%), followed by reusable products (19%) (Figure 14). Many of these items can only be commercially composted, but Tifton has no infrastructure for this.

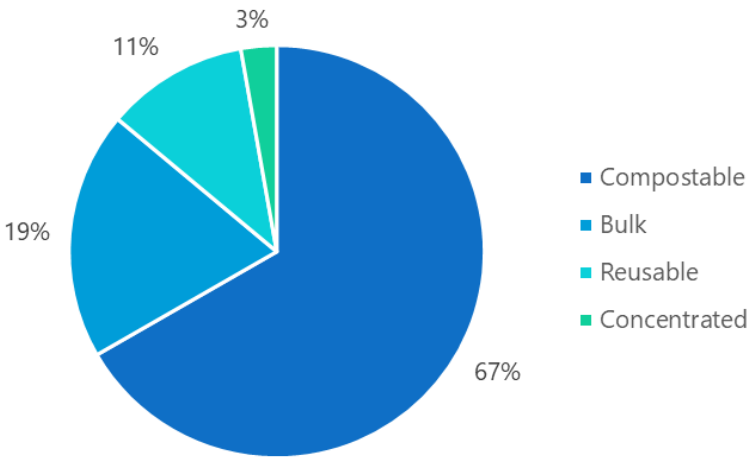


Figure 14: Tifton Alternative Use Type Breakdown

A limited number of alternative household products were available, with only bulk laundry detergent having more than one option (Table 6). Half of the alternatives were sold in bulk and were less expensive (-77% to -12%) than their comparable SUP competitor. The Tifton stores only offered one concentrated alternative, but it was the most expensive household alternative: 74% more than their comparable SUP item.

Table 6: Tifton Alternative Household Products Available

Product	Alternative Material(s) Found	Cost Difference for Alternative (n)
Dish Soap	Bulk	-12% (1)
Hand Soap	Bulk	-77% (1)
Large Trash Bags (33 gallons)	Compostable	56% (1)
Laundry Detergent	Bulk	-26% (2)
	Concentrated	74% (1)
Tall Trash Bags (13 gallons)	Compostable	-44% (1)
Wet Wipes	Compostable	17% (1)

Most picnicware alternatives were compostable (75%), and compostable plates were the most common (Figure 15, Table 7). Reusables were the costliest alternative, ranging from 4,390% more for straws with a breakeven point at 50 uses compared to a SUP item to 22,300% more for sandwich bags, which require 224 uses to break even. However, some consumers may

not reuse these items enough to reach the breakeven point, ultimately making them a more expensive option. All bulk alternatives were less expensive than their comparable SUP item.

Figure 15: Examples of Compostable Picnicware Items in Tifton Stores
Note: Left to right: Hefty plates, Nature's Promise Utensils, and Complete Home cups

Table 7: Tifton Alternative Picnicware Items Available

Product	Alternative Material(s) Found	Cost Difference for Alternative (n)
Bowls	Compostable	25% (2)
Cups	Bulk	-25% (2)
	Compostable	82% (3)
	Reusable	7,410% (2)
Plates	Compostable	155% (9)
Sandwich Bag	Bulk	-53% (1)

	Reusable	22,300% (1)
Straws	Compostable	158% (5)
	Reusable	4,390% (1)
Utensils	Compostable	-2% (2)

Nearly a third (32%) of Tifton stores offered alternatives of varying material types (Figure 16), but none were personal care items. Among all usage types, bulk items were the only option that cost less than comparable SUP products (243% less). In contrast, reusable items were on average 420 times more expensive and required an average of 106 uses to break even. The large availability of compostable items (67%) costs, on average, 26 times more than SUP items. Despite concentrated alternatives being more economical, only one option was available. The presence of alternatives to plastic signifies that Tifton is actively working to diminish its dependence on single-use plastics.

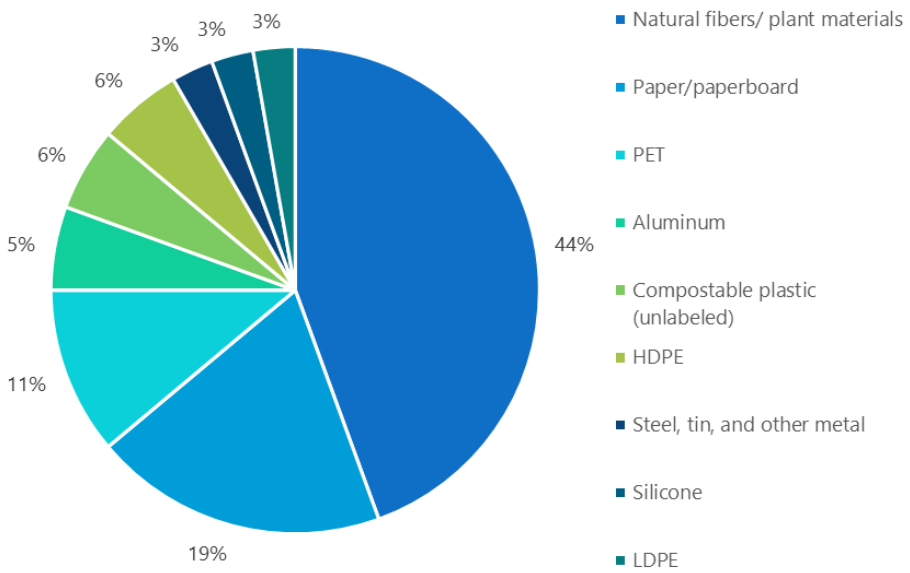


Figure 16: Tifton Alternative Material Type Breakdown

4.1.5 | Collection

The City of Tifton has a separate trash and recycling system from Tift County. In 2021, the City of Tifton transitioned to Ryland Environmental for a five-year locked-in price of $19.33/ month. This price includes weekly curbside household waste (Figure 17), yard waste, bulk items, and biweekly recycling pickup (Miller, 2020). Due to inflation, the City agreed to increase the monthly cost by $1, a 5.7% increase (Cobb, 2024).

Figure 17: Tifton Trash Bins

The site visit and stakeholder conversations conducted in the second half of 2022 indicated that Ryland Environmental no longer collects recyclables through curbside. Despite the city having curbside recycling pickup for over 30 years, there was a shift to single-stream drop-off at Ryland Environmental's headquarters in Tifton during business hours only (Figure 18). This happened because the MRF in Cordele, the closest one approximately 40 miles away, closed down, and although Tifton is close to processors, it lacks a transfer station. This made managing the recyclables collected curbside costly due to increased transportation.

Figure 18: Tifton Single-Stream Recycling Drop-off

Laminated flyers (Figure 19) were placed on the bin, outlining what recyclables are accepted (cardboard, paper, plastic bottles, and cans) and which ones are not (plastic bags, food waste, glass, and Styrofoam). A waste management company shared that glass has not been collected since 2017 because it contaminates single-stream recycling. Also, the nearest location that accepts glass is south of Atlanta, over 150 miles away, which makes it too far to haul.

Figure 19: Recycling Flyer at Tifton Drop-off Center

The recycling drop-off location was analyzed using the city's ambient population (Figure 20). In a buffer zone 3 km from the convenience centers, 29% of the population is in the zone. Increasing the distance to 4 km covers more of the population (63%). This indicates that the singular drop-off location is out of the way (more than 4 km) for 37% of the population, resulting in decreased collection rates.

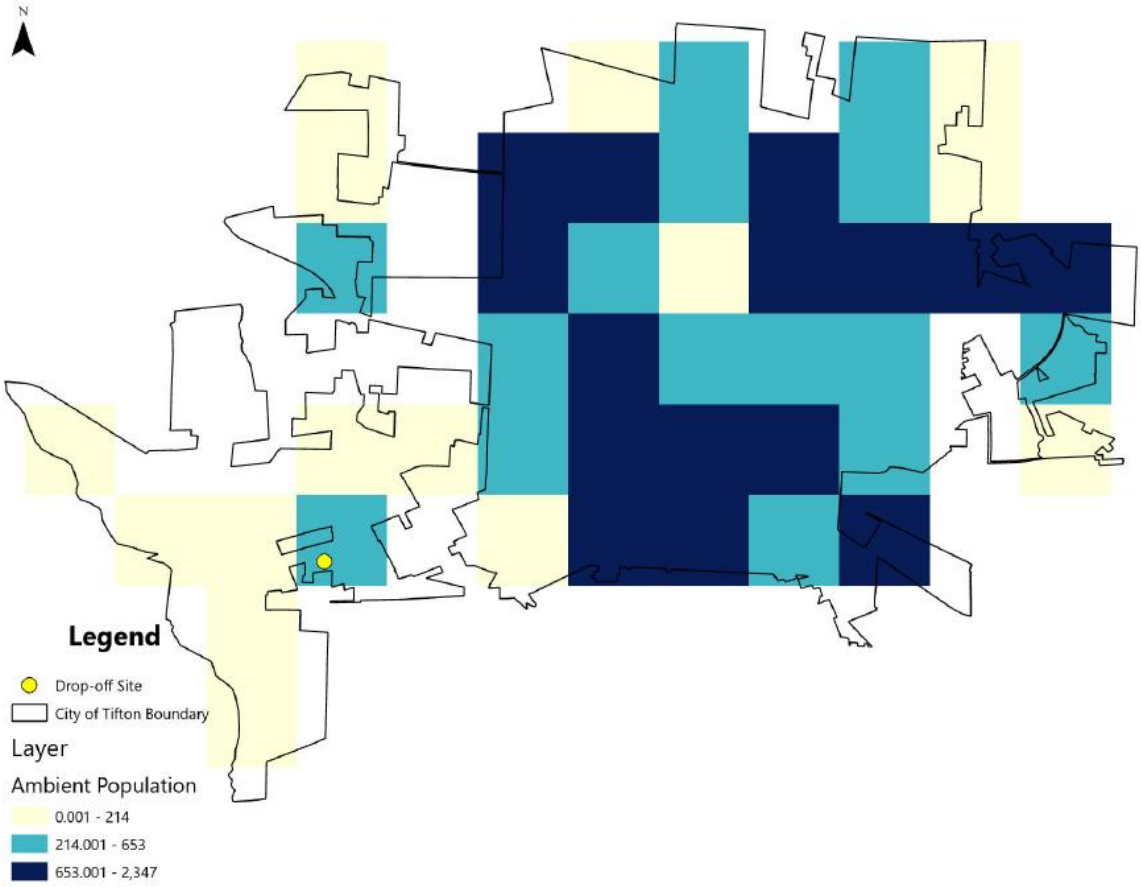


Figure 20: Tifton Map of Ambient Population with Drop-off Location

According to a waste management company stakeholder, contamination is a major issue with single-stream collection. They speculate that only 10% of people recycle correctly, and 80% is trash, resulting in limited recyclables. Additionally, the facilities management stakeholder shared that public awareness of the drop-off location is low, further reducing collection rates.

4.1.6 | End of Cycle

From 2022 to 2023, the City of Tifton disposed of 65,004 tons of MSW and 8,467 tons of wood waste. The MSW is sent to the Tifton-Tift County Landfill. An expansion project will add 10 acres to the landfill, which is projected to be completed by 2027 or 2028 (City of Tifton, 2023). Without expansion, the landfill will be full by 2027 (Cobb, 2023). The collected wood

waste is taken to the inert landfill that accepts concrete and bricks, construction & demolition (C&D) materials. Both landfills are open Monday through Saturday (City of Tifton, n.d.).

Tifton recycled 89 tons of metal and 17 tons of tires (City of Tifton, 2023). However, no information is available on plastic recycling, which may indicate that plastic recycling is minimal or not formally tracked. This may be due to Tifton's lack of a MRF. Waste management stakeholders believe there will never be enough recyclables to build one in the city. As a result, recyclables are sent to the closest MRFs in Columbus, GA (126 miles) and Tallahassee, FL (90 miles). The Recycling Partnership's US Residential MRF Map reveals a gap in MRFs in South Georgia, with the southernmost MRF in Savannah (The Recycling Partnership, n.d.).

Waste management stakeholders shared that the cost to landfill is $42 per ton of waste, while the cost to send recyclables to a MRF is $120 per ton. This higher cost also includes a fee for contamination, a large problem that recycling faces. Recycling costs about 3 times more than landfilling, making it a less economical option. A facilities management stakeholder emphasized that recycling is not just an environmental effort in rural communities but must also be financially viable. They explained that profitability is key to vendors' willingness to engage in recycling programs.

4.1.7 | Leakage

The CIL team recorded 2,464 litter items across the 27 litter transects in Tifton. The litter density in the transects ranged from 0.08 to 4.86 items/m^2, with an average of 0.91 items/m^2 (Figure 21). This is higher than the US-modeled average of 0.47 items/m^2 (US EPA, 2024b) and higher than three of the six cities in the Walmart Foundation cohort (New Materials Institute, 2024).

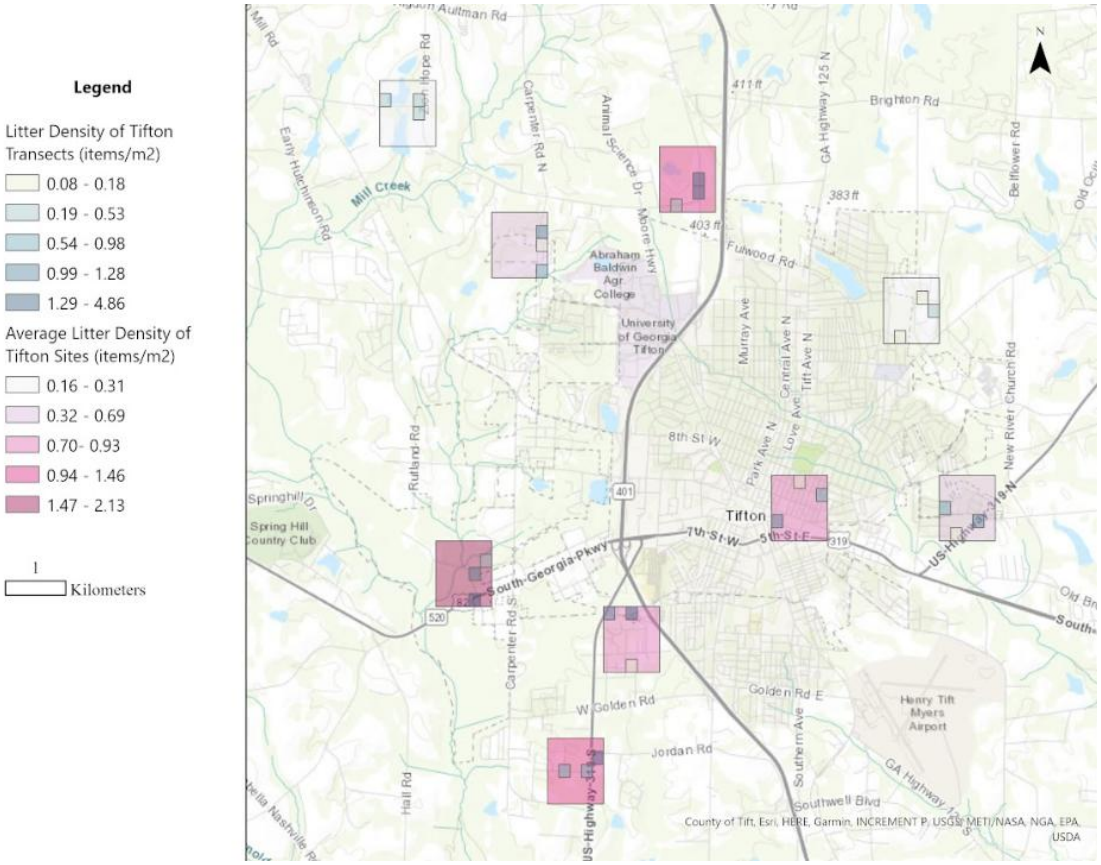


Figure 21: Map of Litter Densities in Tifton

More than half (57%) of the litter consisted of tobacco products (29%) and plastic fragments (28%) (Figure 22). Tobacco products have little to no recycling options, and plastic fragments show that plastics leak into the environment and degrade. A portion of the litter surveyed (20%) can be recycled if collected: paper (10%), metal (6%), and glass (4%).

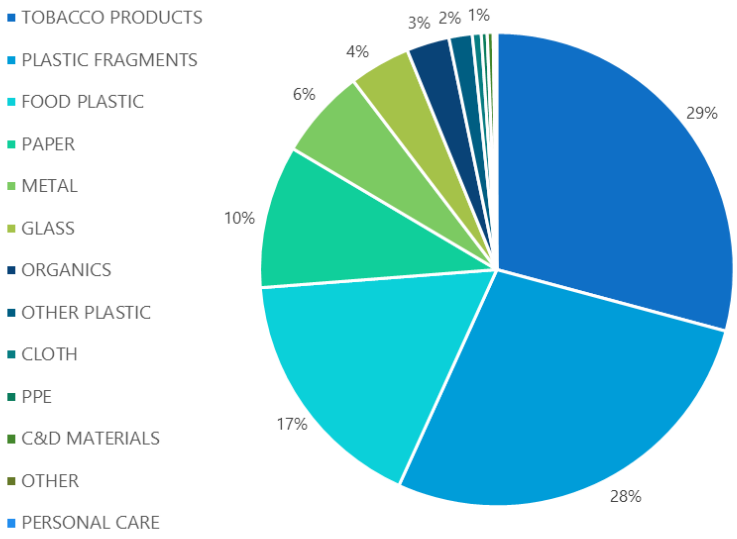


Figure 22: Tifton Litter Survey Material Breakdown

Cigarettes comprise 35% of the top 10 litter items (Figure 23), and no local recycling market exists. This resembles the Walmart Foundation cohort, where 83% of the cities also had cigarettes as the top litter item (New Materials Institute, 2024). Fragments such as film, hard plastic, foam, glass or ceramic, and other fragments dominated the top litter items (39%), emphasizing the shortcomings of current waste management and recycling systems in effectively capturing them. Two items in the top litter can be recycled: paper and aluminum/tin cans. Other organic waste came in the 10th most common litter item spot, which can be composted. Improving recycling collection would reduce the quantity of these items that escape into the environment (Figure 24).

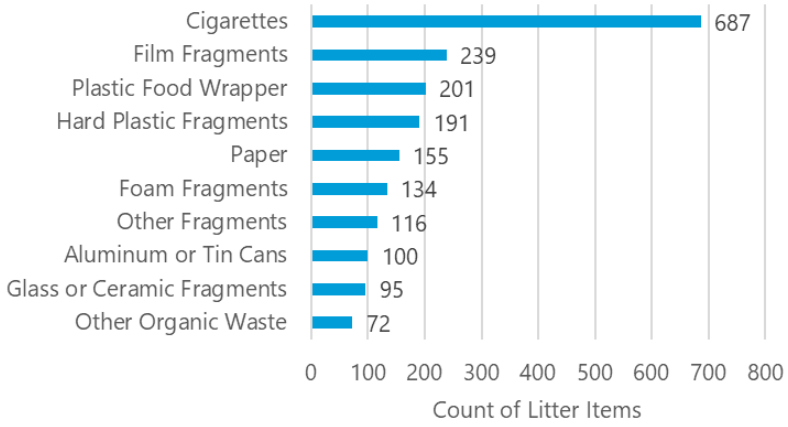


Figure 23: Tifton Litter Survey Top Litter Items by Count

Figure 24: Example of Litter in Tifton

4.1.8 | Opportunities

According to the CAP findings, the following opportunities are recommended to improve circularity, especially to increase recycling rates in Tifton. These opportunities correspond to the seven spokes of the CAP model and are categorized based on their potential to reduce plastic waste in Tifton for each spoke. The county can assess the feasibility and cost-effectiveness of the

proposed opportunities. Strategically combining these opportunities could result in a more significant impact.

INPUT

Of the FMCG surveyed, 93% had manufacturers in the US, and 82% had domestic parent company locations. Nine percent of the FMCG in Cherokee County were manufactured in neighboring states. PepsiCo, a top parent company, has a local bottling facility in Albany, GA. The Coca-Cola Company dominates the products with manufacturers and/or parent company locations in Georgia (73%) and has a bottling facility in Tifton. Aluminum and tin cans were among the top items found in the litter data.

- Facilitate voluntary extended producer responsibility (EPR) schemes with nearby parent companies and manufacturers.
- Leverage reuse, refill, and deposit return schemes (DRS) with local bottling companies (ex. Coca-Cola).

COMMUNITY

Eight conversations were held with key stakeholders in Tifton. These conversations highlighted the community's challenges with past mismanagement, a lack of resources and facilities, and contamination. These have led to inefficiencies and a lack of public trust in the system.

- Leverage the large institutional presence that is interested in supporting recycling throughout campus and the city.
- Educate farmers on the benefits of recycling rather than storing plastic waste on-site. The Natural Resources Conservation Service could help do this.
- Re-integrate recycling into the school curriculum.

- Allowing waste management companies to speak at schools or share videos on current recycling practices after materials are dropped off could help increase public trust in the system.
- Provide incentives for high recycling (tax incentive) or non-contamination (i.e., a discount at a store or restaurant that offers alternatives).

PRODUCT DESIGN

Five FMCG and staple goods were packaged in multilayer film or EPS in the 25 stores surveyed. In restaurants, PP and EPS were the top packaging materials. Sauce container lids were the only to-go item mainly packaged in recyclable material, PET. The packaging-to-product ratio was highest for beverages (0.06).

- Shift towards easier-to-recycle materials like PET, HDPE, and paper/ paperboard.
    - Incorporate discussion on egg packaging, a large Georgia industry, into the local agricultural-based university curriculum.
- Educate store owners and the public to purchase items/packaging that are locally recyclable.
- Improve product delivery efficiency by shifting towards minimal packaging design and/or increasing product quantities.

USE

32% of Tifton stores offered alternatives, but no alternative personal items were found. Despite no composting infrastructure, most alternatives (67%) were compostable. Bulk items were the only alternative use type less expensive than comparable SUP products (243% less). Reusable items cost the most, averaging 420 times more. There is a lack of concentrated items. Reusable bags are offered at 54% of stores.

- Educate store owners on the benefits and popularity of alternative personal care items.
- Provide more bulk and concentrated products that tend to be less expensive than single-use products.
- To support local businesses, the city could highlight efforts by local businesses to reduce plastic use.
- Promote the use of reusable bags.
- Promote only upon request policy at restaurants (straws, utensils, and bags).

COLLECTION

Weekly trash pickup occurs, but recycling must be brought to the single-stream drop-off center. Four categories of recyclables were collected (cardboard, plastic, paper, and aluminum cans). The drop-off location is outside a 4km buffer for 37% of the population. There is low public awareness of the drop-off location. Contamination is an issue with single-stream recycling.

- Place more recycling drop-off areas throughout the city.
- Consider source-separated collection.
- Glass products could be accepted at the drop-off center. It can be used for roadbeds or fill in the local community.
- Consider changing the City's waste management company contract to one that has higher recycling success rates.
- Place a banner and increase signage to increase awareness of the drop-off center.
- Provide pop-up locations to collect recyclables and educate the public on how and where to recycle.

- Educate the public to recycle the most profitable materials: aluminum, natural HDPE, & PET.
- Inform community members about local businesses that accept source-separated film plastic.
- Push private haulers to separate recycling from waste (e.g., smaller trash cans, free days to recycle the most profitable recyclables). Pay-as-you-throw (PAYT) systems incentivize residents to throw away less trash and recycle.
- Monitor (e.g., cameras) the drop-off center and contact residents who recycle incorrectly.

END OF CYCLE

The Tifton-Tift County landfill is being expanded by 10 acres. Yard waste, concrete, and bricks are sent to the inert landfill. There is no MRF in Tifton. The closest ones are in Columbus, GA, or Tallahassee, FL. Recycling costs about 3 times more than landfilling, including a contamination fee.

- With a switch to a multi-stream drop-off center, recyclables can be sold directly to processors.
- Coordinate with nearby counties to build a new MRF and reach economies of scale.
- To decrease the price difference between landfilling and recycling, use outside sources for grant writing support, like US EPA's Regional Thriving Communities Technical Assistance Centers (TCTAC) Southeast Program, REACT4, at https://www.react4.org/.
- Invest in composting infrastructure as yard waste is collected and compostable alternatives are available. The end market is farmers in Tifton.

LEAKAGE

Tifton's average litter density is 0.91 items/m^2. Cigarettes were the top litter item, followed by film fragments. Paper and aluminum or tin cans were also top litter items in Tifton's litter survey.

- Address upstream some of the top littered items (tobacco items) with additional policies and public campaigns.
- With continued litter monitoring, the County can identify gaps in convenience centers.
- Place yard signs or road signs throughout the county to remind people not to litter.
- Place trash cans and recycling bins at entrances of recreational areas (tourism/shopping centers/ parks).

4.2 | Circularity Assessment Protocol in Cherokee County, North Carolina

A CIL team conducted fieldwork for the Cherokee County CAP from April 7 to 9, 2023. Subsequent sections detail the findings and discussions regarding the seven CAP spokes: Input, Community, Product Design, Use, Collection, End-of-Cycle, and Leakage, concluding with Opportunities. The CAP aims to assess circularity and enhance recycling as part of the broader circularity efforts in Cherokee County, North Carolina.

4.2.1 | Input

The CIL team surveyed thirteen stores to collect and sample 414 fast-moving consumer goods, comprising 116 beverages, 163 candies, 127 chips, and 8 tobacco products. The top brands in Cherokee County consisted of the following:

- **Beverages**: Coca-Cola, Pepsi, Gatorade, and Mountain Dew

- **Candy**: M&Ms, Reese's, and Hershey's
- **Chips**: Lays, Doritos, and Cheetos
- **Tobacco Products**: Marlboro, Newport, and L&M

Nearly all FMCG were manufactured domestically, at 96% (Figure 25). There are local PepsiCo bottling facilities throughout North Carolina, and Coca-Cola bottling facilities are located in nearby cities in Tennessee and Georgia. Most (89%) of the FMCG had domestic parent company locations. The top parent company states were Pennsylvania, New York, Virginia, Georgia, and Texas. The top three parent companies, The Hershey Company, PepsiCo, and The Coca-Cola Company, sourced 40% of the FMCG in Cherokee County. While a few products originate from global parent companies (11%), they were predominantly from Europe and North America. However, some were sourced from Japan and Turkey (Figure 26).

Figure 25: Cherokee County Manufacturer Locations by FMCG Category Map

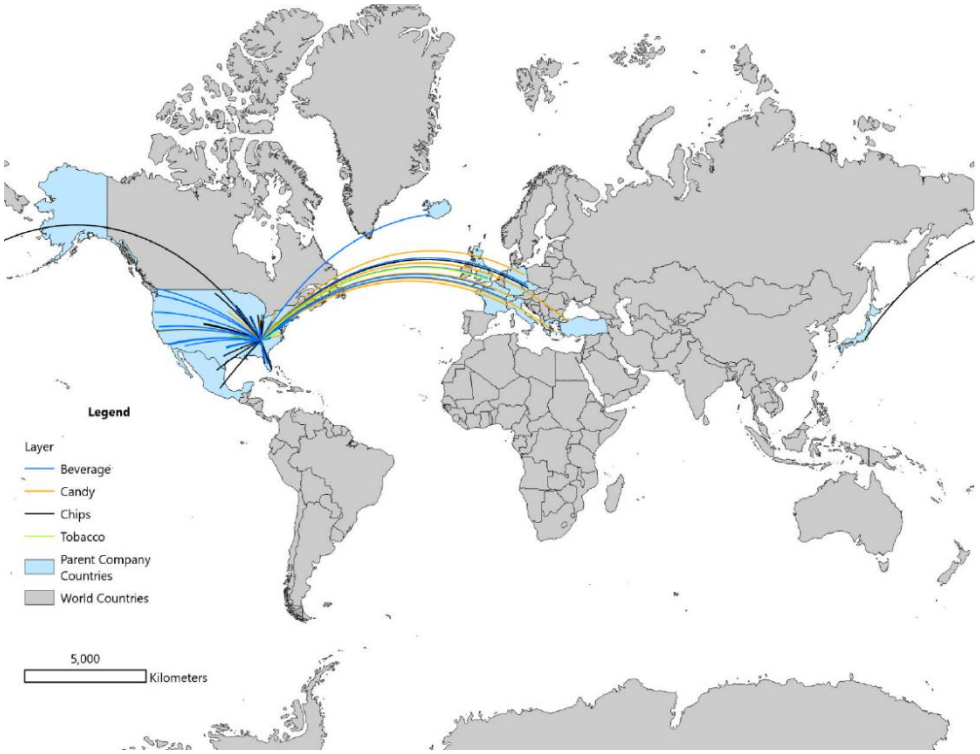


Figure 26: Cherokee County Parent Company Locations by FMCG Category Map

Tobacco products had the greatest average distance from parent companies while maintaining the shortest distance to manufacturers (Table 8). There were 23 products with a manufacturer and/ or parent company located in North Carolina. This can be seen in the minimum distance for the parent company for beverages, 147 km, located in Asheville, NC. Cherokee County's unique location allows several minimum distances to be in nearby states. For parent company locations, chips and candy have a minimum distance of 95 km and 275 km, respectively, for nearby Tennessee locations. The minimum manufacturer distances for chips (154 km) and candy (439 km) are in Georgia and Kentucky, respectively.

Table 8: Distances between Cherokee County and Manufacturer and Parent Company Locations for FMCG

	*Length Store to Parent Company (km)			Length Store to Manufacturer (km)		
	Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
Beverages	147	7,656	1,527	61	11,826	1,711
Candy	275	9,160	2,240	439	14,337	1,326
Chips	95	10,950	1,311	154	7,716	1,184
Tobacco Products	653	6,658	3,749	363	1,984	924

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

The states neighboring North Carolina manufactured 8% of the sampled FMCG in Cherokee County (Table 9). The majority were from Georgia due to the popularity of Coca-Cola products. While most beverages were packaged in PET, Mayfield Dairy Farms packaged them in HDPE.

Table 9: Products Manufactured in Neighboring States and Distributed in Cherokee County

Neighboring State	Manufacturer	Product Category	Main Packaging Type
Georgia	Deep River Snacks	Chips	Multilayer Plastic Film
	good2grow	Beverage	PET
	The Coca-Cola Company	Beverage	PET
South Carolina	Deer Park Spring Water	Beverage	PET

Tennessee	Brim’s Snack Foods	Chips	Multilayer Plastic Film
	Charms LLC	Candy	Paper / Paperboard
	Mayfield Dairy Farms	Beverage	HDPE
	PepsiCo Inc	Beverage	PET
Virginia	Bottling Group LLC	Beverage	PET
	Mars Inc	Candy	Multilayer Plastic Film
	Nestle USA Inc	Beverage	PET
	Sweet Smiles Candy	Candy	Multilayer Plastic Film

4.2.2 | Community

Three key stakeholders shared the community's attitudes and perceptions about plastic waste and recycling (Table 10). Cherokee County consisted of conversations with two recycling center employees and a semi-structured interview with an educator. Stakeholders highlighted challenges to recycling, like low collection rates, political obstacles, and illegal dumping. Limited resources further hinder waste management efforts. To address these issues, they suggest incentives for recycling, statewide funding support, and shifting towards biodegradable packaging. Insights from stakeholder conversations are presented as closely as possible to the notes taken.

Table 10: Stakeholder Groups and Number of Stakeholders in Cherokee County

Stakeholder Group	Number of Stakeholders
Educator	1
Recycling Center	2

All stakeholders identified pollution as a major issue. A recycling center employee shared that some private properties accumulate waste outside, where solid waste ordinance laws can't be enforced. Another stakeholder expressed concerns about plastic pollution:

"… it appears to go away. It just breaks down into tiny little pieces and becomes microplastic." - **Educator**

"Since endeavoring to work in this material, I have paid more attention to plastic, discarded plastic in general… Everything you buy now is sheathed in plastic, whether it's an apple or a pound of butter, or everything comes in a pouch or a shrink wrap." - **Educator**

" [My post-consumer recycled plastic art] is like a biome in the ocean of some sort of these creatures, and that sort of has a nexus with the idea of how plastics are affecting the environment." - **Educator**

Stakeholders highlighted several barriers to recycling in Cherokee County. There is low participation due to inconvenience. A recycling center employee shared that people don't recycle as much cardboard because it is easier to throw it away. Another interviewee pointed out that there is a lack of recycling bins where materials are commonly used:

"That's where the bottle gets emptied and discarded. They're not going to take it home and put it in their recycling at home." - **Educator**

Political and logistical challenges further limit recycling efforts. According to the recycling center employees, nearby counties have attempted to collaborate. Clay County and Graham County had intended to share costs, but they no longer communicate, and political issues hinder most counties from cooperating. Within Cherokee County, several convenience centers are located near areas where people can be aggressive, creating safety concerns.

Illegal dumping and tire disposal are costly, which is another frustration for recycling center employees. Many residents believe their taxes cover bulky waste disposal, such as mattresses, but the centers are only funded for MSW. While 99% of residents understand what can be recycled, non-residents contribute the most contamination. It is also harder to fine them, reducing the revenue stream. As for tires, the NC DEQ only allows Western North Carolina counties to use one tire disposal company, US Tire, to receive money back from the Scrap Tire Disposal Account Fund Grant Application. However, they only received an average of 10% of the requested funds. This causes Cherokee County to continuously pay about $25,000 to $30,000 every 6 months out of pocket to dispose of tires.

Stakeholders also identified a need for more funding and staff to improve recycling education and outreach. One stakeholder summarized the challenge:

"…the problem with rural recycling is it's spread so thin." - **Educator**

Despite these challenges, stakeholders offered ideas to improve recycling. One interviewee suggested using incentives:

"You're going to do a lot better with a carrot [incentive] than with a stick [punishment]." - **Educator**

"Okay, so at the grocery store, have 'em get some kind of modest discount or something for free, or you brought some plastics in, brought your detergent bottle back." - **Educator**

Recycling center employees expressed interest in a statewide fee that would create a reimbursement fee for waste management. Another stakeholder mentioned changing packaging:

"I'd like to see packaging made out of more biodegradable materials [rather than plastic]." - **Educator**

Beyond recycling, stakeholders noted that yard waste is accepted at the landfill, but only one person brings it. Most residents burn their yard waste, which could be composted. However, Cherokee County lacks a composting facility.

Stakeholders see pollution as a major issue and have identified multiple barriers to effective recycling in Cherokee County, such as low recycling collection rates, political obstacles, safety concerns, illegal dumping, and tire disposal. Resource limitations further impede outreach and educational efforts. Despite these obstacles, stakeholders suggested several solutions: incentives for recycling, statewide funding support, and a transition to biodegradable

packaging. Furthermore, implementing composting infrastructure could effectively tackle the amount of yard waste burned.

4.2.3 | Product Design

The CIL team analyzed 368 FMCG products and their packaging across the 13 stores in Cherokee County. Beverages had the highest product and packaging mass compared to chips and candy (Table 11). This may be due to the high density of PET, a typical packaging material for plastic bottles and beverages. Beverages and chips had the highest packaging-to-product ratio (0.06), while candy had the lowest (0.04). Therefore, beverages and chips generate the most packaging waste per product unit out of the three categories. For comparison, samples taken throughout the Walmart Foundation cohort showed that the average packaging weight for candy was 4.22 g, whereas the Cherokee County value was lower (2.66 g). The average product weight was 63.5 g, lower than Cherokee County's value (65.4 g) (New Materials Institute, 2024).

In this study, cigarette products were not purchased as they come in standard sizes. Our earlier research shows about 10 g of plastic packaging for every 15 g product. This high packaging-to-product ratio of 0.67 is probably affected by the cellulose acetate filters in cigarette butts, which generally weigh nearly one gram each.

Table 11: Average Weight of Products and their Plastic Packaging for FMCG in Cherokee County

Category	Product Count	Average Quantity of product (g or ml)	Average Weight of packaging (g)	Packaging-to-Product Ratio
Beverage	98	526	30.6	0.06
Candy	150	65.4	2.66	0.04
Chips	120	73.7	4.12	0.06

The packaging type was documented for the FMCG and staple goods. The majority of chips, candy, greens, and rice were packaged in multilayer plastic film, and eggs were packaged in EPS (Figure 27). These materials are not recyclable and can easily escape the waste stream. A Cherokee County educator noticed the change in egg packaging from paper to EPS, even with locally produced eggs, and how Cherokee County can push for a sustainable change:

"Most of my concerns are their [egg producers] changing the packaging from recycled paper egg cartons. Right now, you buy eggs that also come in a Styrofoam egg carton, or they come in PET cartons…. Could you get the Cherokee County Egg Producers Association to establish a policy that says we're going to advocate that all of our members to be good members of good standing will use nothing that isn't paper cartons?" **- Educator**

Several items were mainly packaged in recyclable materials. Beverages and oil were packaged in PET, milk and detergent were in HDPE, and sugar was in paper. The second largest beverage packaging material was aluminum (17%), which can be infinitely recycled and has high profits.

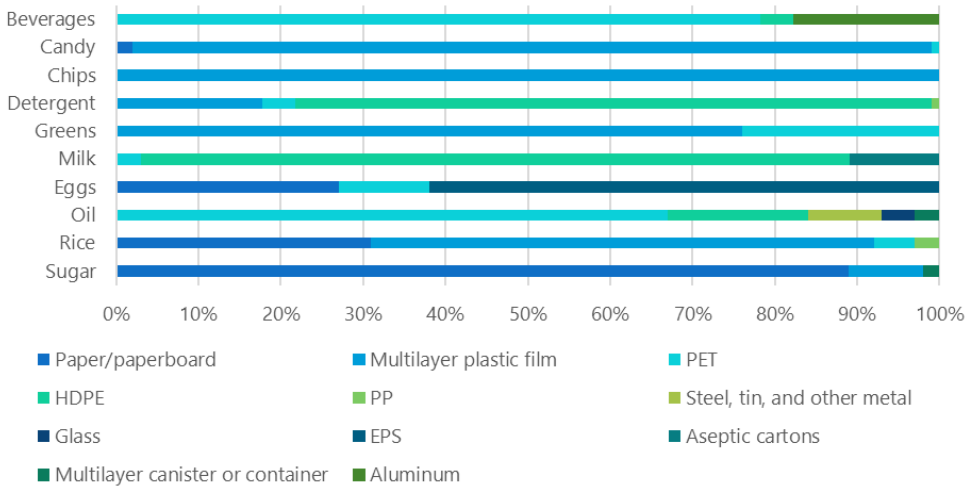


Figure 27: Material Breakdown of FMCG and Staple Goods in Cherokee County

The CIL team surveyed 16 restaurants in Cherokee County to understand what to-go items were handed out at restaurants. PS was the main material for food containers, cold cups, and cold cup lids (Figure 28). PP was the main material for straws and utensils. Sauce containers were evenly split between PP and PS as the most common material. Bags are primarily made of soft HDPE, which can escape the waste stream. PS, PP, and soft HDPE are not widely recycled. The only to-go item mainly made of recyclable material was the sauce container lids, where 71% were made of PET. Other items were made out of some recyclable materials, with 38% of food containers, 30% of bags made out of paper, and 14% of food containers made of aluminum. Food containers were also made from natural fiber and plant materials (5%), an alternative material.

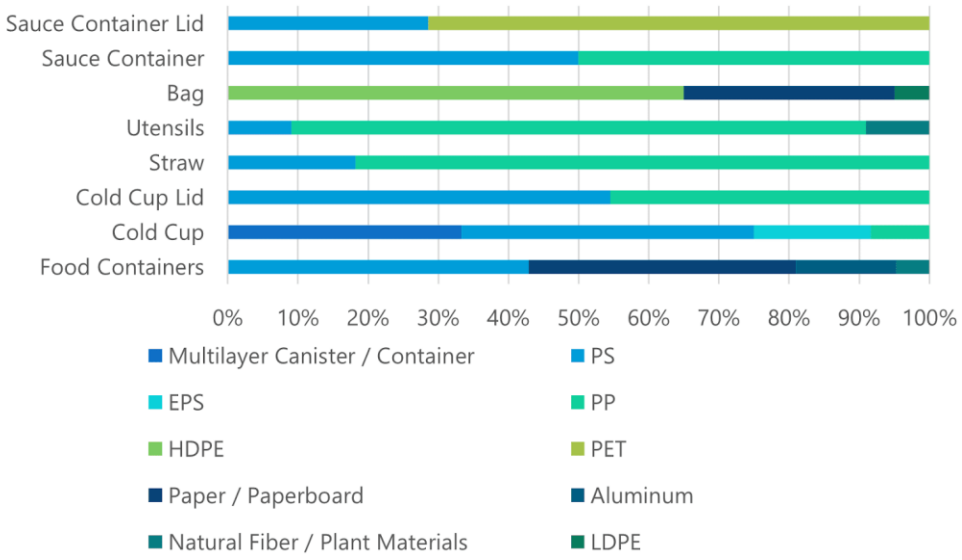


Figure 28: Material Breakdown of Restaurant To-Go Items in Cherokee County

4.2.4 | Use

In the 13 stores surveyed in Cherokee County, all but one provided single-use plastic bags. Reusable bags, cloth and non-woven (laminated and non-laminated) PP, were offered at 54% of stores (Figure 29) for an average cost of $1.31. Free paper bags were provided by 15% of the stores.

Figure 29: Example of Reusable Bags Sold in Cherokee County Stores

Cherokee County sold household and picnicware alternatives to SUPs at 46% of the stores. Compostable products were the most popular alternative use type (68%), followed by reusable products (22%) (Figure 30). Many of these items can only be commercially composted, but Cherokee County has no infrastructure for this.

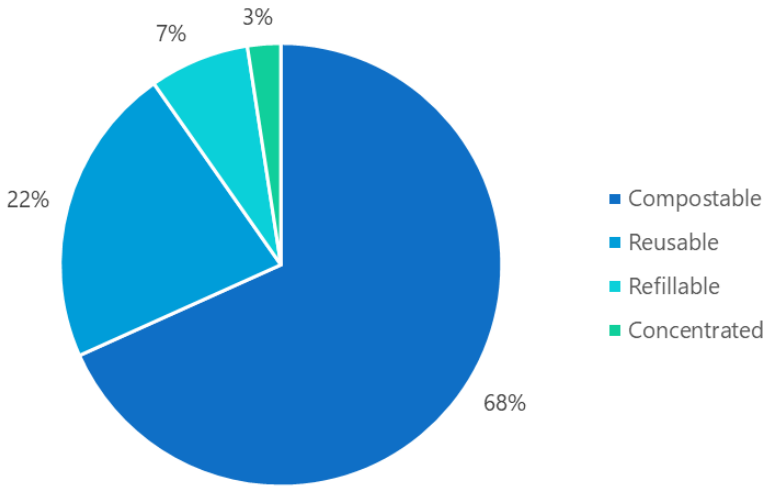


Figure 30: Cherokee County Alternative Use Type Breakdown

Compostable trash bags were the most popular household alternative but were also the most expensive at 133% more than their SUP (Table 12). Refillable products (hand soap and household cleaner) were less expensive (18%) than their single-use plastic competitors. Laundry detergent was the only concentrated alternative option found in Cherokee County (Figure 31).

Table 12: Cherokee County Alternative Household Items Available

Product	Alternative Material(s) Found	Cost Difference for Alternative (n)
Hand Soap	Refillable	-18% (2)
Household Cleaner	Refillable	-18% (1)
Laundry Detergent	Concentrated	109% (1)
Trash Bags (13 gallons)	Compostable	133% (3)

Figure 31: Examples of Alternative Household Products in Cherokee County Stores
Note: Left to right: Mrs. Meyers refillable hand soap and Clean Cult concentrated laundry detergent

Although there were considerably more picnicware options than household alternatives, only compostable or reusable types were available (Figure 32). Compostable plates were the stores' most common alternative (12) (Table 13). Reusable sandwich bags were the most expensive alternative, costing 18,780% more than the comparable SUP items and requiring 189 uses to break even. No alternatives were found for picnicware items that were less costly than comparable SUPs.

Figure 32: Examples of Alternative Picnicware Items in Cherokee County Stores
Note: Left to right: Hefty compostable bowls, Stasher reusable sandwich bags, and Repurpose compostable straws

Table 13: Cherokee County Alternative Picnicware Items Available

Product	Alternative Material(s) Found	Cost Difference for Alternative (n)
Bowls	Compostable	91% (6)
Plates	Compostable	138% (12)
Sandwich Bags	Reusable	18,780% (7)
Straws	Compostable	271% (4)
	Reusable	9,711% (2)
Utensils	Compostable	143% (3)

While nearly half (46%) of Cherokee County stores offered alternatives made of various materials (Figure 33), none were personal care items. Among all the usage types, refillable items were the only option less costly than comparable SUP products (18% less), while reusable items cost 168 times more. The large availability of compostable items averaged 2.46 times more than

SUP items. There is a lack of bulk and concentrated items that tend to be more economical options. The availability of plastic alternatives indicates that Cherokee County is making efforts to reduce its reliance on single-use plastics.

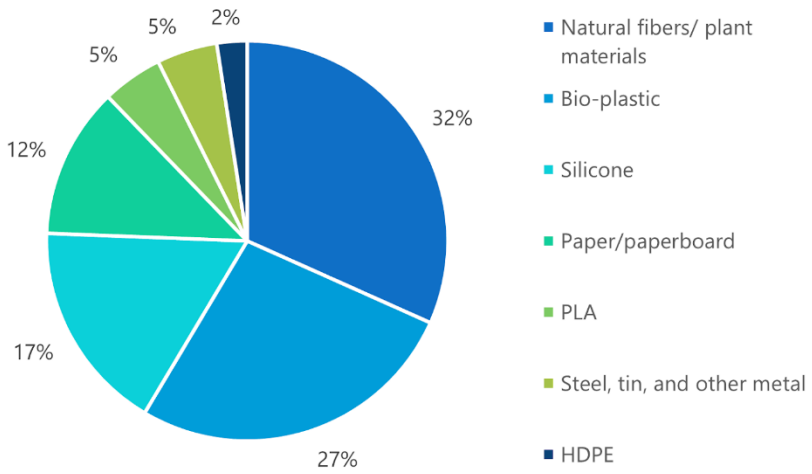


Figure 33: Cherokee County Alternative Material Breakdown

4.2.5 | Collection

Cherokee County does not provide curbside trash or recycling pickup. Instead, it is collected through 10 controlled-access, source-separated convenience centers (Figure 34). Three locations are open 24/7, while the remaining are open Monday through Saturday for at least six hours daily (Cherokee County NC, n.d.-a). According to a recycling center employee, these are the only convenience centers open 24/7 in the state. Also, most of these locations have swap shops, allowing any items dropped off to be reused or repurposed by another resident.

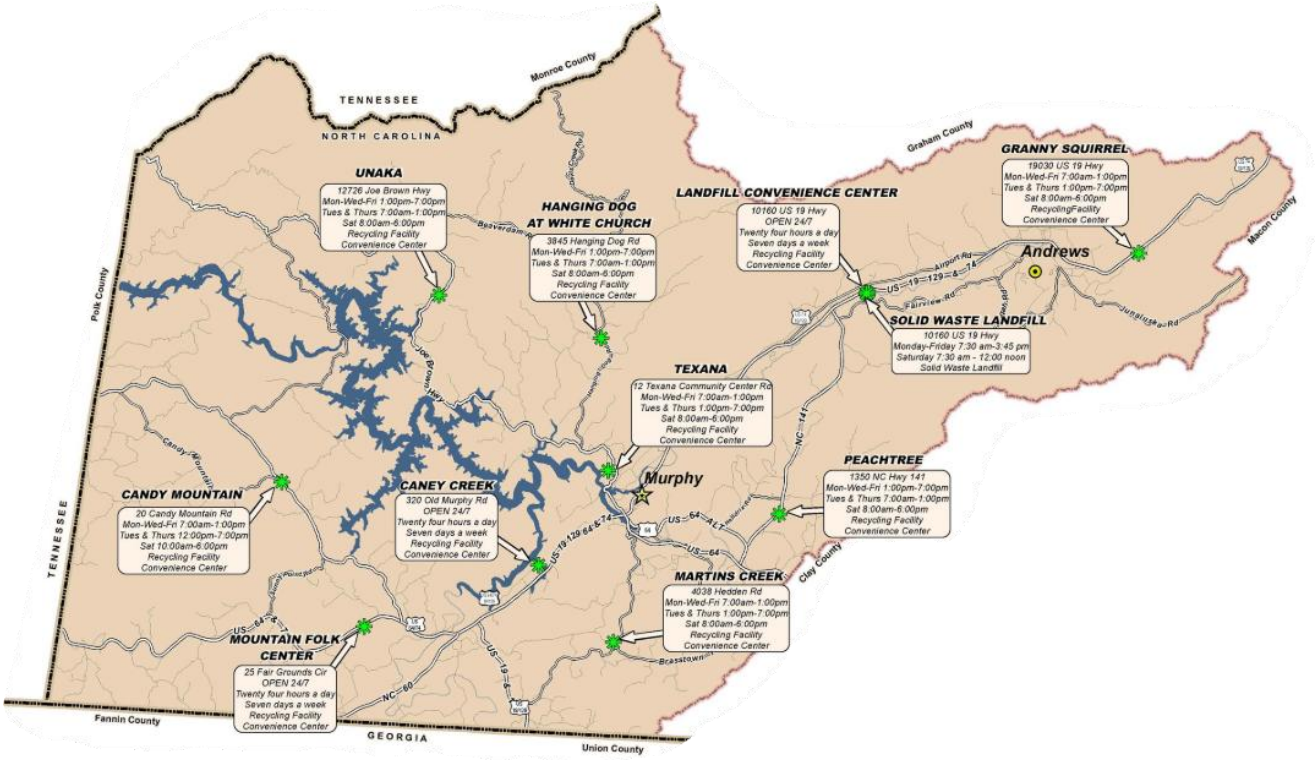
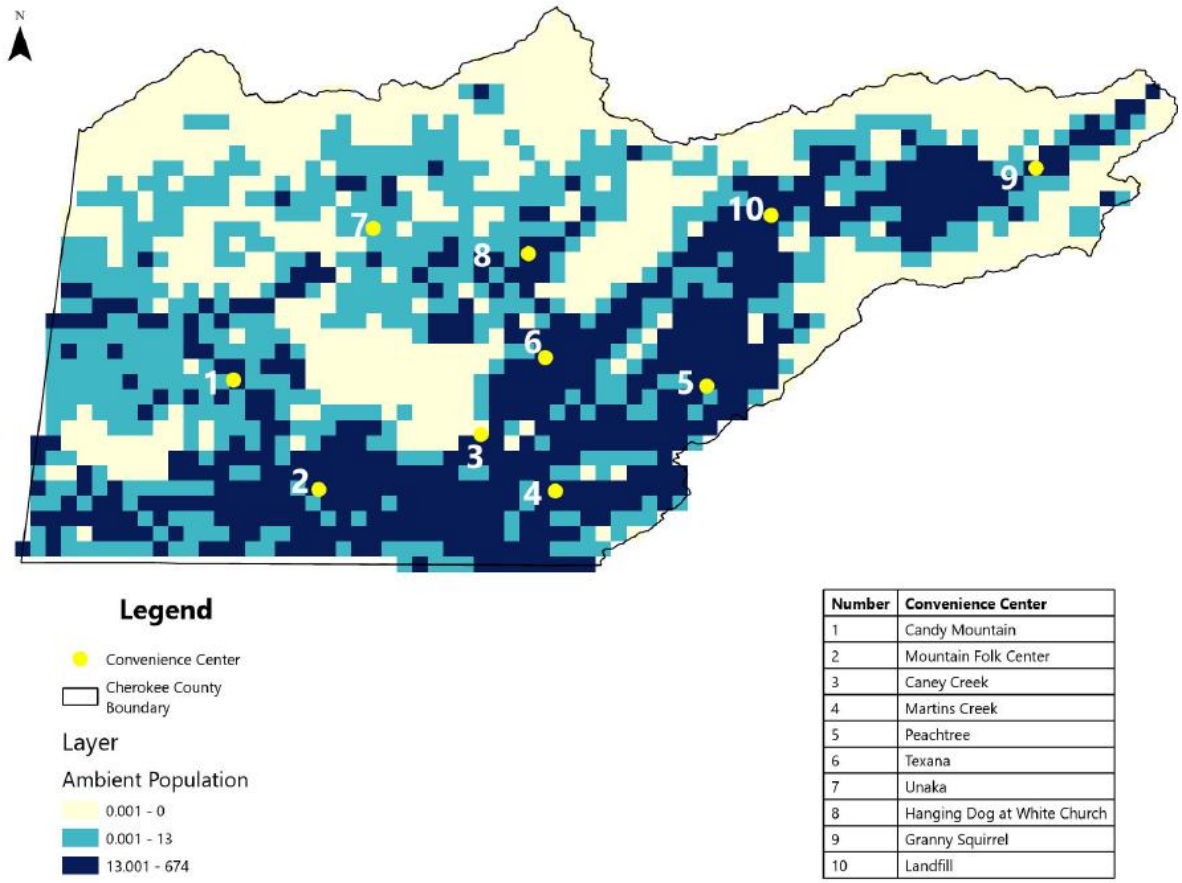


Figure 34: Cherokee County Convenience Centers
Reference: Cherokee County NC, n.d.-a

The convenience center locations were analyzed using the county's ambient population (Figure 35). In a buffer zone 5 km from the convenience centers, 80% of the population is in the zone. When the distance was increased to 6 km, nearly the entire population (92%) was covered. This indicates that the convenience centers are strategically positioned across Cherokee County.



Number	Convenience Center
1	Candy Mountain
2	Mountain Folk Center
3	Caney Creek
4	Martins Creek
5	Peachtree
6	Texana
7	Unaka
8	Hanging Dog at White Church
9	Granny Squirrel
10	Landfill

Figure 35: Cherokee County Map of Ambient Population with Convenience Center Locations

There is a 20.1-times difference in the tonnage of recyclables and MSW collected in Cherokee County (Table 14). Despite the significantly higher amount of MSW, it is 1.68 times less expensive to manage than recyclables. The higher cost of managing recyclables puts pressure on ensuring they are sold at the highest price possible to minimize lost money. Cherokee County has two unique ways to minimize this price differential: baling methods and surveillance.

Table 14: Cherokee County Collection Costs in FY24
Reference: Recycling Center Employee Conversation

Type of Waste	Amount Collected (Tons)	Total Cost ($)	Cost/Ton Managed ($/Ton)
MSW	18,000	388,400	21.6
Recyclables	894	654,500	36.4

The recyclables collected at the convenience centers are baled on-site (Figure 36). This compaction increases the amount of recyclables that can be stored and minimizes the number of trips to the respective outlets.

Figure 36: Cherokee County Baled Recyclables
Note: Left to right: plastics and aluminum/tin

The recycling center employees shared some rules and explained why they were in place (Figure 37). All visitors must show their convenience center access card to prove their residency since they are tax-funded. Additionally, all waste and recycling must be disposed of properly. Video surveillance is continuously monitored, and notices and fines are issued to visitors who do not comply with the rules. Illegal dumping and maintaining a clean stream are significant challenges that video surveillance helps to address. Some people believe they can illegally dump

waste at convenience centers because they pay taxes to throw away their waste. However, contamination decreases the cost of the recyclables being sold.

Figure 37: Cherokee County Convenience Center Rules

The workers also expressed the need to replace or repair dumpsters at the convenience centers due to wear and tear over time (Figure 38). However, there is a lack of money. There are grants available at the state level for new dumpsters if there are none in the area, but they do not cover repairs or replacements.

Figure 38: Convenience Center Dumpsters in Cherokee County
Note: Left to right: source-separated recycling and household trash

4.2.6 | End of Cycle

The items collected from the convenience centers are either disposed of in landfills or processed for recycling. The Cherokee County MSW Landfill, which opened in 1998 and is operated by the county, has approximately 40 years of space left (NC Department of Environmental Quality, 2024a). According to a recycling center employee, 143 tons of yard waste were disposed of in the landfill, which is approximately 1% of the yearly tonnage that ends up in the landfill due to the lack of composting infrastructure. Bagged household trash and appliance disposal are covered in the $75 yearly fee per household. All other waste and all waste for businesses cost $4 per 100 lbs or $80/ton (Cherokee County NC, n.d.-b).

There is no MRF in Cherokee County. Instead, recycling center employees directly broker materials to processors, making recycling cost-neutral. They shared that 660 tons of recyclables were recycled from July 2023 to June 2024 (Table 15). The largest category was cardboard (432 tons), and the lowest was aluminum (22.3 tons).

Table 15: Cherokee County July 2023 - June 2024 Recycling Statistics
Reference: Recycling Center Employee Conversation

Recyclable	Quantity Recycled (tons)
Cardboard	432
Glass	142
Plastic	63.6
Aluminum	22.3
Total	**660**

Every recyclable has a different outlet (Table 16). The community has found a local use for recycled glass in roadbeds or as fill. Instead of using gravel, it offsets the cost by about $20 per ton. According to recycling center employees, aluminum can bring up to $7,000 per truck, the highest value among all recyclables.

Table 16: Cherokee County Recyclables' Outlet
Reference: Recycling Center Employee Conversation

Recyclable	Outlet	Location
Glass	Roadbed / Fill	Cherokee County, NC
Plastic	Sonoco Recycling	Asheville, NC
Cardboard	Jackson Paper Manufacturing	Sylva, NC
Aluminum	Regional Recyclers	Regional

There are large costs associated with several items Cherokee County collects. The A recycling center interviewee shared that cathode ray tube TVs cost $7,000 - $8,000 per 53' tractor-trailer load to dispose of safely. It is a diminishing problem as less is collected, averaging one load per year. However, tires pose another large monetary challenge. Cherokee County must

use US Tire, the only Western North Carolina tire disposal company approved by the NC DEQ, to receive state reimbursement, considerably less than disposal costs. According to a recycling center employee, this results in a $25,000 to $30,000 shortfall every six months that the county must cover with property taxes. The current system forces residents to pay twice, once at the point of sale and again through taxes, while failing to account for tourism-related tire waste. Due to the unfair and inefficient funding model, a convenience center worker would like a better way to dispose of tires.

Employees at the convenience center have reported that no initiatives are currently focused on waste reduction. Limited funding and staffing hinder investment in these programs.

4.2.7 | Leakage

The CIL team recorded 603 litter items across the 27 litter transects in Cherokee County. The litter density in the transects ranged from 0.00 to 0.84 items/m^2, with an average of 0.24 items/m^2 (Figure 39). This is lower than the US-modeled average of 0.47 items/m^2 (US EPA, 2024b) and lower than all the cities in the Walmart Foundation cohort (New Materials Institute, 2024).

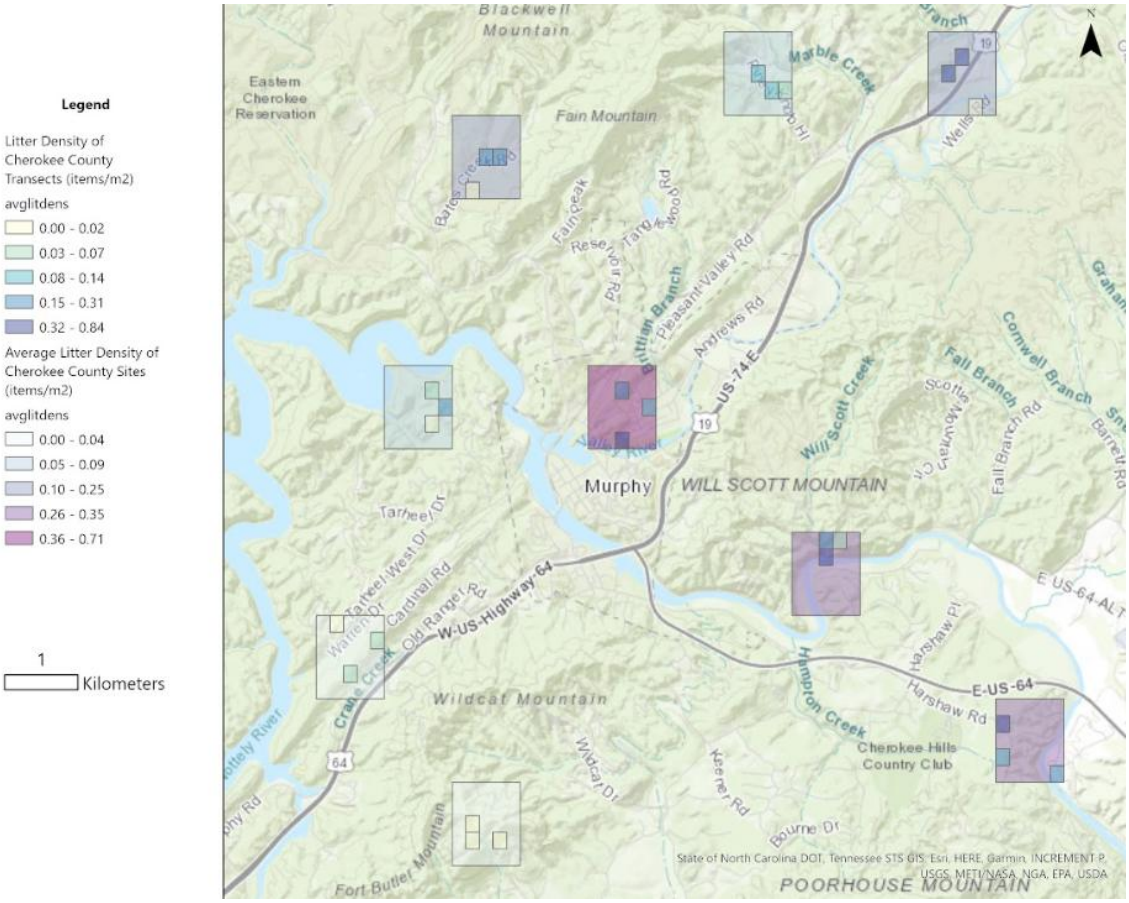


Figure 39: Map of Litter Densities in Cherokee County

Three materials dominated the litter survey, representing nearly 75% of all the litter: tobacco products (26%), food-related plastic packaging (25%), and plastic fragments (22%) (Figure 40). These three materials have limited to no recycling capabilities. The remaining quarter of materials found in the litter survey can be recycled if collected: metal (12%), paper (7%), and glass (5%).

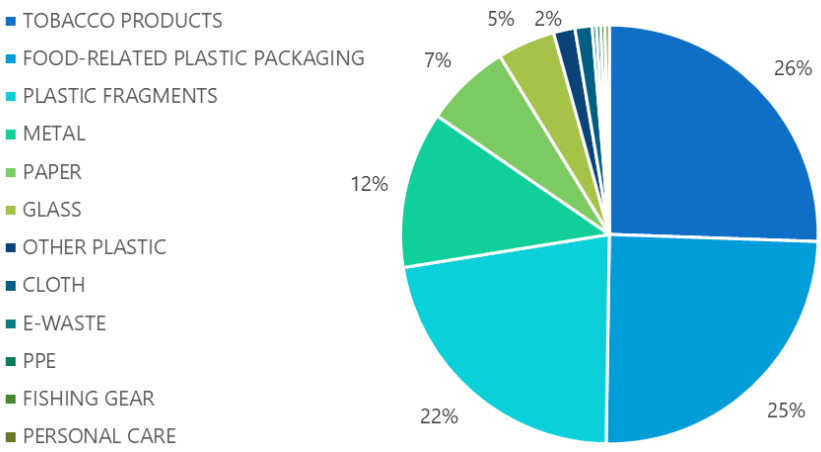


Figure 40: Cherokee County Litter Survey Material Breakdown

Cigarettes are the most common item on the list of the top 10 litter items (Figure 41), and there is currently no local recycling market. This is similar to the Walmart Foundation cohort, where 83% of the cities also listed cigarettes as the top litter item (New Materials Institute, 2024). Fragments such as film, hard plastic, glass or ceramic, and foam dominated the top litter items, highlighting that existing waste management and recycling systems are inadequate in capturing them. Two items could be recycled in the top litter: paper and aluminum/tin cans. Improving recycling collection would reduce the quantity of these items that escape into the environment (Figure 42).

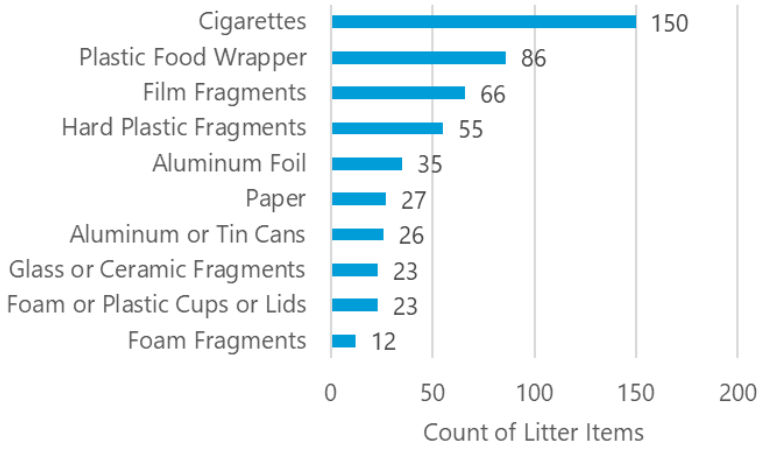


Figure 41: Cherokee County Litter Survey Top Litter Items by Count

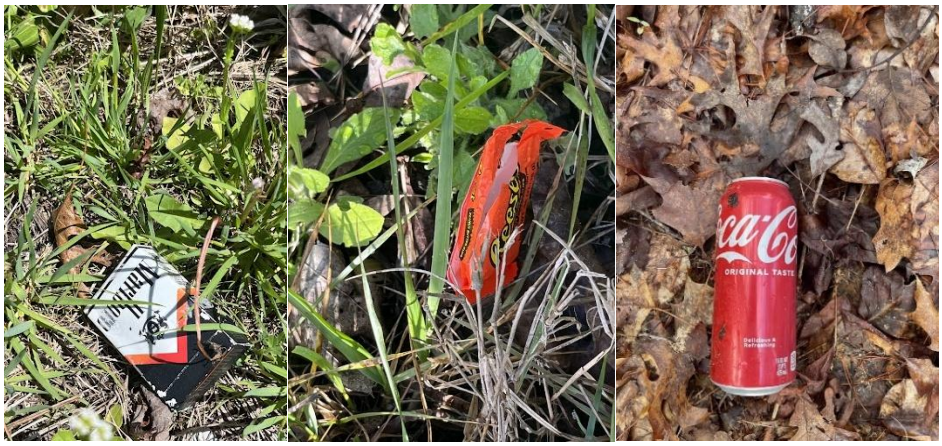


Figure 42: Example of Litter in Cherokee County

Note: Left to right: Marlboro cigarette pack, Reese's plastic wrapper, and Coca-Cola aluminum can

Despite Cherokee County's relatively low litter density, recycling center employees shared that littering occurs on private properties where solid waste ordinances can not be enforced (Figure 43). Mismanaged waste has negative environmental and health impacts.

Figure 43: Mismanaged Waste on Cherokee County Private Property

4.2.8 | Opportunities

Based on the CAP findings, the following opportunities are suggested to expand and improve circularity, specifically targeting increased recycling rates in Cherokee County. These opportunities fall into the seven spokes of the CAP model and are organized by their potential impact on reducing plastic waste in Cherokee County for each spoke. The county has the discretion to evaluate the feasibility and cost-effectiveness of the recommended opportunities. Combining opportunities strategically may lead to a greater impact.

INPUT

Of the FMCG surveyed, 96% had domestic manufacturers, and 89% had domestic parent company locations. The neighboring states manufactured 8% of the FMCG in Cherokee County. The top parent companies had local bottling locations, with PepsiCo throughout North Carolina and Coca-Cola in Cleveland, TN, and Jasper, GA. Aluminum and tin cans were among the top items found in the litter data.

- Facilitate voluntary EPR schemes with nearby parent companies and manufacturers.
- Leverage reuse, refill, and DRS with local bottling companies.

COMMUNITY

Two conversations and one semi-structured interview were conducted in Cherokee County. The stakeholders provided insights on barriers to recycling, such as low collection rates, political obstacles, safety concerns, illegal dumping, and limited resources. They also highlighted several ways to improve recycling.

- Place recycling bins where recyclables are emptied outside the household (i.e., laundromats).
- Scan IDs to ensure that only residents use the convenience centers. This will also make it easier to track violators who are illegally dumping.
- Engage in conversations with nearby manufacturers on shifting to biodegradable packaging.
- Provide incentives for correctly recycling (i.e., a discount at a store/restaurant that offers alternatives).
- Work with nearby counties or organizations to discuss with the North Carolina government to increase financial support for recycling.

PRODUCT DESIGN

Five FMCG and staple goods were packaged in multilayer film or EPS in the thirteen stores surveyed. In restaurants, PP and PS were the top packaging materials. There is a lack of recyclable packaging, with sauce container lids being the only takeout item mainly packaged in PET. The packaging-to-product ratio was highest for beverages and chips (0.06).

- Shift towards easier-to-recycle materials like PET, HDPE, and paper/ paperboard.

    - Engage with the Cherokee County Egg Producers Association and Dutt & Wagner to shift from EPS to paper pulp or PET egg packaging.
- Educate store owners and the public to purchase items/packaging that are locally recyclable.
- Improve product delivery efficiency by shifting towards minimal packaging design and/or increasing product quantities.

USE

46% of Cherokee County stores sold alternatives, but none sold alternative personal items. Despite no composting infrastructure, most alternatives (68%) were compostable. Refillable items were the only less costly alternative than comparable SUP products (18% less). Reusable items cost the most, averaging 168 times more. There is a lack of bulk and concentrated items. Reusable bags are offered at 54% of stores.

- Tourism and long-term stays bring a less price-sensitive group that could use reuse or refill alternatives.
- Educate store owners on alternative personal care items and how they can appeal to nature enthusiasts who hike in Cherokee County.
- Provide more bulk and concentrated products that tend to be less expensive than single-use products.
- To support local businesses, the city could highlight efforts by local businesses to reduce plastic use.
- Promote the use of reusable bags.
- Promote only upon request policy at restaurants (straws, utensils, and bags).

COLLECTION

Trash and recycling are collected through 10 drop-off convenience centers in Cherokee County. Four categories of recyclables were collected (cardboard, plastic, paper, and aluminum), with aluminum being the least collected recyclable (22.3 tons). A convenience center access card for county residents must be shown upon entrance, and video surveillance ensures that no illegal dumping occurs. Fines and citations are given to those who don't follow the rules. Dumpsters collecting waste/recyclables or holding bailed materials are old and broken.

- Educate the public to recycle the most profitable materials: aluminum, natural HDPE, & PET.
- Inform community members about local businesses that accept source-separated film plastic.
- Consider further source-separated collection.
- Provide pop-up locations to collect recyclables and educate the public on how and where to recycle.
- Allow non-county residents, like tourists, to utilize convenience centers for a fee to collect money to replace or repair dumpsters.
- Push private haulers to separate recycling from waste (e.g., smaller trash cans, free days to recycle the most profitable recyclables). PAYT systems incentivize residents to throw away less trash and recycle.

END OF CYCLE

There is no MRF in Cherokee County. Instead, the materials are brokered directly to regional processors, making recycling cost-neutral. Aluminum is the highest-value material sold. Tire

disposal results in a $30,000 deficit every six months. Insufficient funding and staffing hinder investment in waste reduction programs, and no composting infrastructure is available.

- Work with nearby counties to increase the supply of recyclables to reach economies of scale.
- Continue to compile deficit data from Western NC counties to advocate for a state policy change on tire disposal and/or form partnerships with private companies that use recycled tire materials.
- Invest in composting infrastructure as compostable alternatives are present.
- Consider utilizing volunteers and/or incarcerated individuals as a low-cost workforce to support the development of waste reduction programs, including education and awareness initiatives.
- Use outside sources for grant writing support for waste reduction programs like US EPA's Regional TCTAC Southeast Program, REACT4, at https://www.react4.org/.

LEAKAGE

Cherokee County's average litter density is 0.24 items/m^2. Half of the litter consisted of tobacco products (26%) and food-related plastic packaging (25%). Aluminum or tin cans and paper were the top litter items in Cherokee County's litter survey.

- Addressing upstream some of the top littered items (cigarettes) with additional policies and public campaigns
- The city could identify possible gaps in the convenience center locations and/or hours with continued litter monitoring.
- Place yard signs or road signs throughout the county to remind people not to litter.

- Place trash cans and recycling bins at entrances of recreational areas (tourism/shopping centers/ parks).
- Partner with the John C Campbell Folk School to hold a trash art-making competition to increase littering and plastic waste awareness. Share winners in the newspaper.

4.3 | Circularity Protocol Assessment in Georgetown County, South Carolina

A team from CIL conducted fieldwork for the Georgetown County CAP from May 14 to 17, 2023. The following sections present the results and discussions of the seven CAP spokes: Input, Community, Product Design, Use, Collection, End of Cycle, and Leakage, followed by Opportunities. Data was also collected in Pawleys Island, a coastal town, to gain insights between the coastal and inland areas of Georgetown County. The purpose of the CAP is to measure circularity and improve recycling as a component of circularity within Georgetown County, South Carolina.

4.3.1 | Input

The CIL team surveyed twenty stores in Georgetown County to obtain samples of 269 fast-moving consumer goods, comprising 111 beverages, 97 candies, 38 chips, and 23 tobacco products. In Pawleys Island, the CIL team surveyed nine stores. The same brands were found between inland and coastal Georgetown County, but there were some differences in the top brands (Table 17). At least two top brands were the same for all the FMCG in both areas but were in different orders.

Table 17: Top FMCG Brands found in Georgetown County and Pawleys Island

FMCG Category	Georgetown County Top Brands	Pawleys Island Top Brands
Beverages	1. Coca-Cola 2. Gatorade 3. Mountain Dew	1. Coca-Cola 2. Dasani 3. Gatorade / Sprite
Candy	1. Reese's 2. M&Ms 3. Hershey's	1. Hershey's 2. Reese's 3. M&Ms
Chips	1. Lays 2. Doritos 3. Cheetos	1. Lays 2. Takis 3. Doritos
Tobacco*	1. Marlboro 2. Newport 3. Pall Mall / Swisher Sweets	1. Marlboro 2. Newport 3. L&M

*Note: The top brands for tobacco were only identified and not purchased.

Due to the similarity of brands in Georgetown County's inland and coastal regions, the distance to manufacturer and parent company locations for FMCG was only calculated for the inland area. Most FMCG were domestically manufactured at 93% (Figure 44), with local bottling facilities in South Carolina for PepsiCo and Coca-Cola. Most (83%) of the FMCG parent company locations are also domestic, with New York, Pennsylvania, Virginia, Texas, and Georgia being the top parent company states. A quarter of the FMCG came from the top three parent companies: PepsiCo, The Hershey Company, and The Coca-Cola Company. Products originating from global parent companies (17%) were predominantly in Europe and North America. However, a few were sourced from Australia, Japan, and Turkey (Figure 45).

Figure 44: Georgetown County Manufacturer Locations by FMCG Category Map

Figure 45: Georgetown County Parent Company Locations by FMCG Category Map

Tobacco products had the highest average distance to parent companies yet maintained the lowest average distance to manufacturers (Table 18). Two products were manufactured and/or had a parent company location in South Carolina. The beverage minimum distance for manufacturers is 161 km, and the chip minimum distance for manufacturers and parent company locations is 93 km, representing the in-state locations of Chesterfield County and Charleston, respectively.

Table 18: Distances between Georgetown County and Manufacturer and Parent Company Locations for FMCG

	*Length Store to Parent Company (km)			Length Store to Manufacturer (km)		
	Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
Beverages	246	16,004	1,878	161	16,004	2,020
Candy	461	11,353	2,735	461	14,549	2,239
Chips	93	3,589	1,164	93	15,837	2,216
Tobacco Products	278	11,353	2,929	278	2,451	672

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

The neighboring states of South Carolina manufactured 8% of the FMCG sampled in Georgetown County, dominated by The Coca-Cola Company in Atlanta, Georgia (Table 19). Beverages and tobacco were the most common products. North Carolina manufactures 39% of all the surveyed tobacco.

Table 19: FMCG Manufactured in Neighboring States and Distributed in Georgetown County

Neighboring State	Manufacturer	Product Category	Main Packaging Type
Georgia	The Coca-Cola Company	Beverage	PET
	Biolyte	Beverage	PET
	good2grow	Beverage	PET
	Lemon Perfect Company	Beverage	PET
	Tum-e Yummies	Beverage	PET
North Carolina	Brooklyn Bottling	Beverage	PET
	Carolina Beverage Corporation	Beverage	PET
	Cheyenne International	Tobacco	Paperboard & plastic film
	Food Lion, LLC	Beverage	PET
	GoodMark Foods Inc	Chips	Multilayer Plastic Film
	ITG Brands	Tobacco	Paperboard & plastic film
	John Boy & Billy Inc	Beverage	PET
	Liggett Group	Tobacco	Paperboard & plastic film
	OhFresh Brands	Beverage	PET
	Pepsi Bottling Group Inc	Beverage	PET
	RJ Reynolds Company	Tobacco	Paperboard & plastic film
	Snyder’s Lance Inc	Chips	Multilayer Plastic Film

4.3.2 | Community

Five key stakeholders shared the community's attitudes and perceptions about plastic waste and recycling (Table 20). One semi-structured interview was conducted with an NGO, and conversations were held with three government employees and another NGO. The conversation notes and interview responses gave insights into Georgetown County's SWM issues, which include limited funding, outdated recycling infrastructure, and low accessibility to recycling bins. Progress includes litter hotspot mapping, daily collection programs with opportunities for stronger recycling policies, NGO collaborations, composting programs, and targeting tourist rentals for better waste management. Insights from stakeholder conversations are presented as closely as possible to the notes taken.

Table 20: Stakeholder Groups and Number of Stakeholders in Georgetown County

Stakeholder Group	Number of Stakeholders
Government Employees	3
NGO	2

Overall, all stakeholders saw litter in the environment as a major problem. Government employees noted that many empty roads have high litter counts (Figure 46), as low-population areas tend to have higher litter counts because of their limited collection capacity.

"And there's this joke … South Carolina must have the cleanest cars because the trash is all over the roads. So this is definitely something of concern." - **NGO**

Figure 46: Example of Litter Along Rural Road in Georgetown County

A way to address the high levels of littering would be to increase recycling. However, stakeholders identified several challenges. An NGO stakeholder mentioned the low amount of recyclables collected, constrained by limited accessibility to recycling bins. People are littering because there is no trash can or recycling bin present. Government employees are frustrated by the lack of support for writing and implementing grants. They also mentioned that there is limited staff, which inhibits the efficiency of the MRF. One interviewee mentioned the limited amount of money available:

"So the biggest challenge for Georgetown County is funding. They do not have a very large tax revenue, and they have a very limited budget. They are strapped for cash." - **NGO**

While recent local environmental regulations have seen few updates, the Georgetown County government has begun taking measures. For example, they launched a litter program that operates daily and has collected 65,000 pounds of waste from the environment, sending it to the landfill over the past two years. Another initiative has been the Georgetown RISE program, detailed below:

"... the Department of Public Works, their environmental services department … worked with interns through the same program that we have, the Georgetown RISE Program, to do litter inventories, sort of mapping hotspots around the county. And so they have maps showing hotspots of litter, including Andrews and the North Santee area and South Santee." - **NGO**

Stakeholders presented diverse perspectives and recommendations regarding opportunities to increase recycling in Georgetown County. The first point brought up was passing policies:

"...There should be a requirement to have recycling at events …So there needs to be a policy change there through ordinance language to require recycling at these big events because they produce a ton of waste." - **NGO**

"[We must] work with officials on enforceable litter laws….A high fine does not stop anyone from breaking the law. Law enforcement are more amenable to writing a ticket if it's a smaller fee, [such as when the] structure is by poundage." - **NGO**

Another identified opportunity was working with NGOs to make a change:

"For Palmetto Pride … working with Winah Rivers Alliance for Education around boat landings to try to reduce litter and pollution around our waterways [has] had some success. They've put out the fishing line receptacles to try to reduce plastic getting into the river." - **NGO**

Plastic packaging is problematic, and changing packaging in stores and restaurants was an opportunity identified by several stakeholders:

"[I would want to see] goals and objectives come forward to ban single-use plastics starting with plastic bags transitioning to [reusable bags] or bringing in containers as well. That would be huge for all the restaurants to move away from Styrofoam and plastic containers. " - **NGO**

Messaging was identified as a key way to increase awareness and make tourists and locals care about waste entering the environment. One NGO mentioned that while traditional news advertisements reach many people, they do not necessarily reach people who litter. Many outreach opportunities exist, including expanding to new media, using existing groups, and wildlife messaging:

"The city of North Myrtle Beach is using the tourist bureau to spread awareness for the plastic bag ordinance, and they were even giving out reusable plastic bags… as marketing… I feel very confident that the Georgetown Chamber could do that as well.." - **NGO**

"I find that if you relate it back, because so many people in South Carolina are hunters or fishers, and they care about wildlife in the sense of a resource. And so if you can message litter and plastic as impacting your resources, people are really going to care more about it…" - **NGO**

Other opportunities mentioned by interviewees included composting and targeting tourist rentals to increase the amount of recyclables collected:

"We've talked about doing a composting program since Charleston County and Horry County both use a company called Smart Recycling to pick up composting. Horry County is using it for the school system, and then Coastal Carolina University uses it for the school system." - **NGO**

"One [opportunity] that has come up with my friend group [is] talking about recycling for the hotels and the rental properties - trying to [get them to] have recycling dumpsters. So a lot of them have trash dumpsters where if you rent a house for a week, you're supposed to take out your trash, but they don't necessarily have recycling dumpsters for people." - **NGO**

Stakeholders in Georgetown County identified litter in the environment as a significant issue, made worse by inadequate historical funding and insufficient infrastructure for recycling. They highlighted barriers to improving recycling, including limited funding and outdated facilities. Low accessibility to recycling bins hinders efforts to increase the collection of recyclables. However, the county is making progress by mapping litter hotspots and implementing daily litter collection programs. The NGOs made many recommendations, including passing policies to enforce recycling and litter reduction, collaborating with NGOs for

targeted initiatives, promoting packaging changes in businesses and restaurants, and leveraging wildlife-focused messaging to increase awareness. Additional opportunities lie in implementing composting programs and targeting tourist rentals to improve waste management.

4.3.3 | Product Design

The packaging and product mass of 99 FMCG were analyzed within the twenty stores surveyed in Georgetown County. Beverages had the highest product and packaging mass compared to chips and candy (Table 21). This may be due to the high density of PET, a typical packaging material for plastic bottles and beverage liquids. Chips had the highest packaging-to-product ratio (0.07), while candy had the lowest (0.03). Therefore, chips generate the most packaging waste per product unit out of the three categories. For comparison, samples taken throughout the Walmart Foundation cohort showed that the average packaging weight for beverages was 31.1 mL, and the average product weight was 538 mL. The Georgetown County values for beverages and chips were lower than those of the Walmart Foundation cohort (New Materials Institute, 2024).

In this study, cigarette products were not purchased. This is because they usually come in a standard size. Our previous findings indicate an average of approximately 10g of plastic packaging for every 15g product. This relatively high ratio of product to packaging, 0.67, is likely influenced by the cellulose acetate filters in cigarette butts, which typically weigh close to one gram each.

Table 21: Average Weight of Products and their Plastic Packaging for FMCG in Georgetown County

Category	Product Count	Average Quantity of Product (g or ml)	Average Weight of Packaging (g)	Packaging-to-Product Ratio
Beverage	41	547	29.9	0.05
Candy	27	76.6	1.96	0.03
Chips	31	59.2	4.37	0.07

For each FMCG surveyed, the packaging type was documented, as was the packaging type for staple goods. The majority of chips, candy, greens, and rice were packaged in multilayer plastic film, and eggs were packaged in EPS (Figure 47). These materials are not recyclable and can easily escape the waste stream. Several items were mainly packaged in recyclable materials. Beverages and oil were in PET, while most milk, shampoo, and detergent were packaged in HDPE and sugar in paper. There were no significant differences in the packaging type for FMCG and staple goods in Pawleys Island.

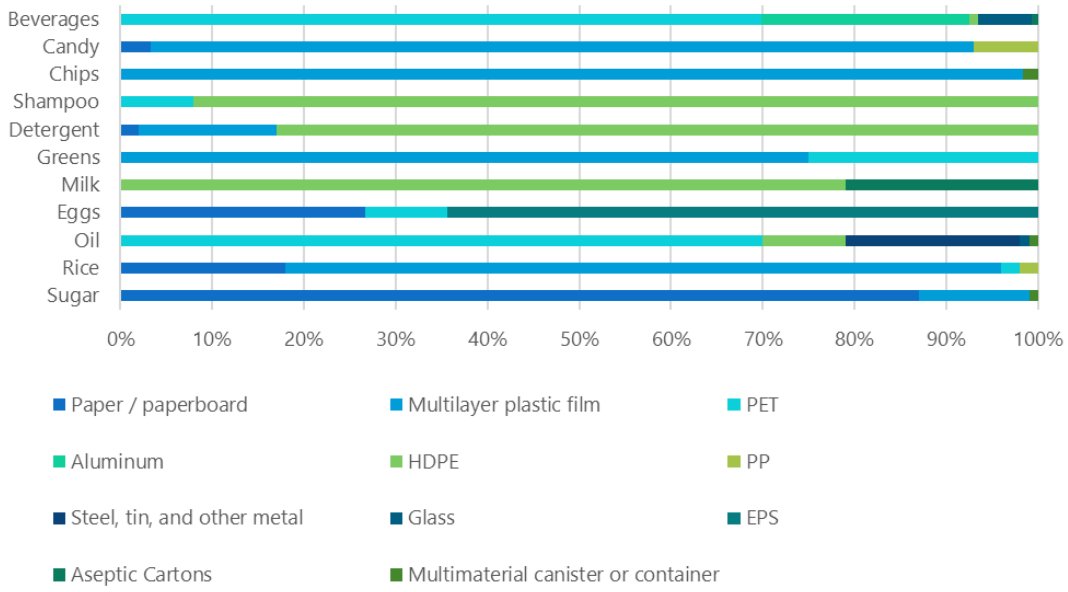


Figure 47: Material Breakdown of FMCG and Staple Goods in Georgetown County

The CIL team surveyed 18 restaurants in Georgetown County to understand the to-go items handed out at restaurants. Most food containers and cold cups were made of EPS, commonly known as Styrofoam, which is not recyclable (Figure 48). All utensils and most straws were made of PP. Only 25% of food containers and 16% of cold cups were packed in recyclable materials. Some items were packaged in alternative materials, with 5% of food containers made from natural fibers and plant materials and 7% of compostable plastic straws.

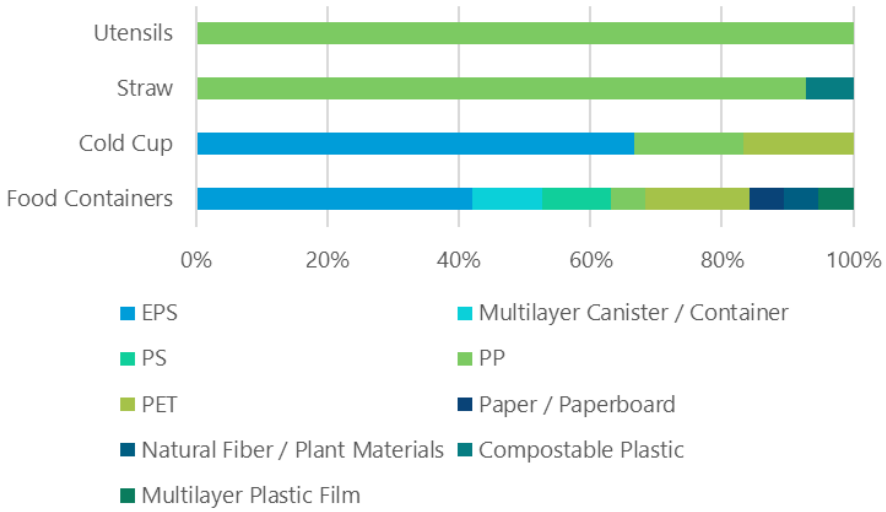


Figure 48: Material Breakdown of Restaurant To-Go Items in Georgetown County

While the material packaging in stores was similar, the material breakdown for restaurant to-go items in Pawleys Island was different. The CIL team surveyed eight restaurants. Similarly, most food containers and cold cups were made of EPS. However, the number of items packaged in recyclable materials differed: 12.5% of food containers and 33% of cold cups. More items were packaged in alternative materials, with a quarter of the utensils made from natural fibers or

plant materials (Figure 49). The higher rate of to-go items packaged in alternative materials may be due to the proximity to the beach and tourists visiting from more affluent areas.

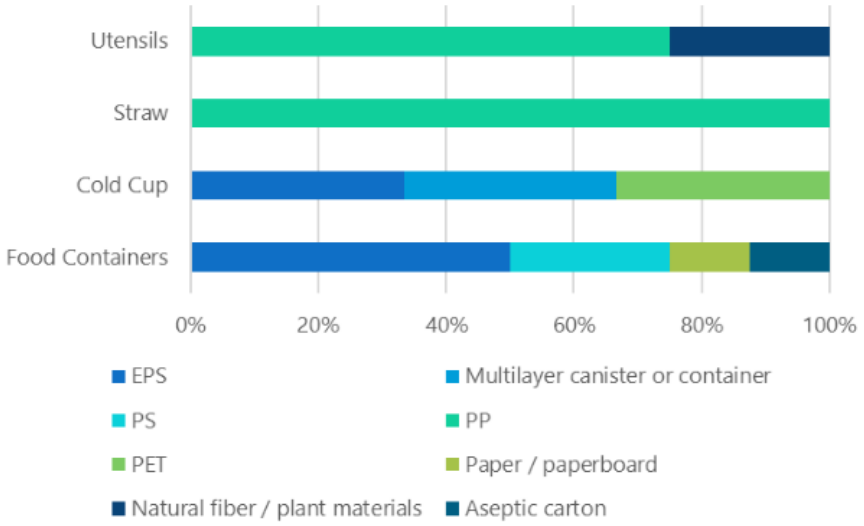


Figure 49: Material Breakdown of Restaurant To-Go Items in Pawleys Island

4.3.4 | Use

In the same survey of twenty stores in Georgetown County, all but one provided single-use plastic bags. A quarter of the stores offered non-woven PP or cloth reusable bags (Figure 50), with an average cost of $5.64, including a $23 fabric bag. The average cost of reusable bags is $1.31 without the fabric bag. The survey of nine stores in Pawleys Island found a higher rate of reusable bags offered (60%). The average cost of thick plastic reusable bags was slightly higher at $2.14. The coastal stores did not provide paper bags.

Figure 50: Example of Reusable Bags Sold in Georgetown County Stores

The trend for a higher rate of alternatives in Pawleys Island remained true when looking at the survey of alternatives in household items, personal care products, and picnicware. About 67% of the coastal stores had alternatives to SUPs, while only 35% of the inland stores had alternatives. In both areas, compostable products were the most popular alternative use type (Figure 51). Many of these items are only commercially compostable. Despite this, there is no composting infrastructure in Georgetown County. The second most popular use type in the inland area was bulk, while Pawleys Island was refillable. Stores may offer fewer bulk items because of the limited time tourists visit.

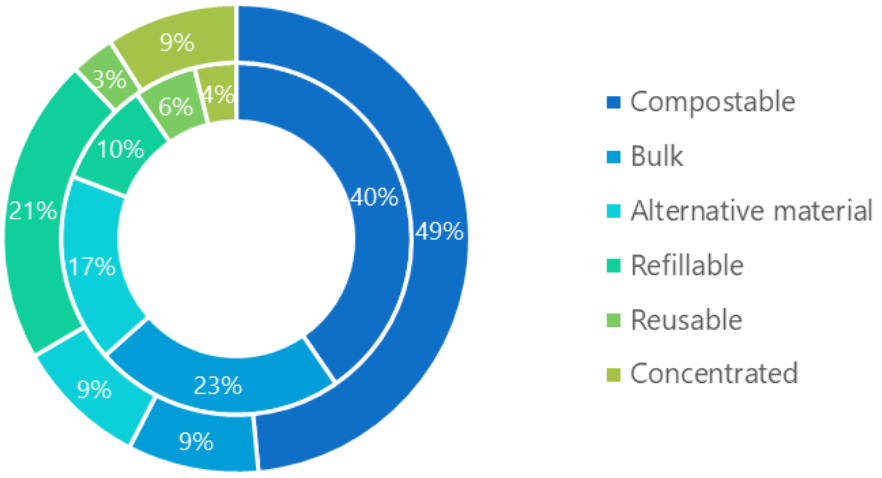


Figure 51: Georgetown County Alternative Use Type Breakdown
Note: The inner ring represents inland, and the outer ring represents coastal Georgetown County.

The price difference between alternatives and SUPs was compared to better understand the economics of buying alternatives in both inland Georgetown County and coastal Pawleys Island. When looking at alternative household products, buying hand soap in bulk was the most popular alternative found and was also less costly than its SUP counterpart in both areas. This remained true for all bulk household products: dish soap and cleaner. The costliest alternative was in Pawleys Island, where the one sample of hand soap made of alternative materials was 13,503% more expensive than its single-use plastic competitor. Across both areas, a refillable household cleaner was the costliest alternative (Table 22).

Table 22: Inland and Coastal Georgetown County Alternative Household Products Available

Product	Alternative Material(s) Found	Inland Cost Difference for Alternative (n)	Coastal Cost Difference for Alternative (n)
Cleaning Wipes	Compostable	25% (1)	-
Dish Soap	Alternative Material	-	38% (1)
	Bulk	-35% (2)	-
	Refillable	-	9% (1)
Hand Soap	Alternative Material	-40% (1)	13,500% (1)
	Bulk	-41% (9)	-13% (1)
	Refillable	351% (1)	-20% (5)
Household Cleaner	Alternative Material	-23% (1)	-
	Bulk	-	- 93% (1)
	Concentrated	-28% (1)	2,097% (3)
	Refillable	64% (2)	3,183% (1)
Laundry Detergent	Alternative Material	-28% (1)	51% (1)
	Refillable	-93% (1)	-
Small Trash Bags	Compostable	109% (1)	-

Inland Georgetown County offered more alternative picnicware items than Pawleys Island. Compostable products were the most popular and were the only alternative material available for bowls and utensils (Figure 52). Despite this, they ranged from 32% to 1,470% more expensive than their comparable SUP competitor. Reusable sandwich bags were the costliest alternative in both areas, costing 11,340% more with a 115-use break even in inland Georgetown County and 14,550% more with a 147-use break even in Pawleys Island. No alternatives were found for picnicware items that were less expensive than their comparable single-use product (Table 23).

Figure 52: Examples of Compostable Picnicware Items in Georgetown County Stores
Note: Left to right: Repurpose cups, Good & Smart plates, and Total Home utensils

Table 23: Inland and Coastal Georgetown County Alternative Picnicware Items Available

Product	Alternative Material(s) Found	Inland Cost Difference for Alternative (n)	Coastal Cost Difference for Alternative (n)
Bowls	Compostable	140% (5)	32% (4)
Cups	Alternative Material	1,822% (2)	-
	Compostable	208% (2)	111% (2)

	Refillable	2,978% (1)	-
Plates	Compostable	219% (8)	103% (5)
	Reusable	2,204% (1)	-
Sandwich Bags	Reusable	11,340% (1)	14,550% (1)
Straws	Alternative Material	200% (1)	-
	Compostable	1,472% (1)	98% (2)
	Reusable	29,140% (1)	-
Utensils	Compostable	174% (3)	123% (3)

The final alternative group examined consisted of personal care products. None were located in Pawleys Island stores, but some were found in inland stores. The scarce selection of alternative personal care products in Georgetown County suggests that this option is beginning to emerge in the market. All the alternatives (body wash, deodorant, toothbrush, and toothpaste) were less expensive than their comparable SUP competitors. The bulk body wash sample was identified as the least expensive option surveyed, costing 47% less than the SUP body wash (Table 24).

Table 24: Inland and Coastal Georgetown County Alternative Personal Care Items Available

Product	Alternative Material(s) Found	Inland Cost Difference for Alternative (n)	Coastal Cost Difference for Alternative (n)
Body Wash	Bulk	- 47% (1)	-
Deodorant	Alternative Material	-19 (1)	-
Toothbrush	Alternative Material	-12 (2)	-
Toothpaste	Concentrated	-31 (1)	-

Georgetown County had more alternative items across all categories, but they were located at fewer stores than Pawleys Island. Inland stores offered about 75% more bulk items, 67% more alternative materials, and 24% more compostable products. Refillable products were the only alternative item more prevalent, 28% more, in coastal stores. The top three material types for alternatives in inland stores can be composted (47%) (Figure 53). In contrast, only the top material in Pawleys Island, natural fibers/plant materials (28%), is compostable, while the next two materials are recyclable (Figure 54).

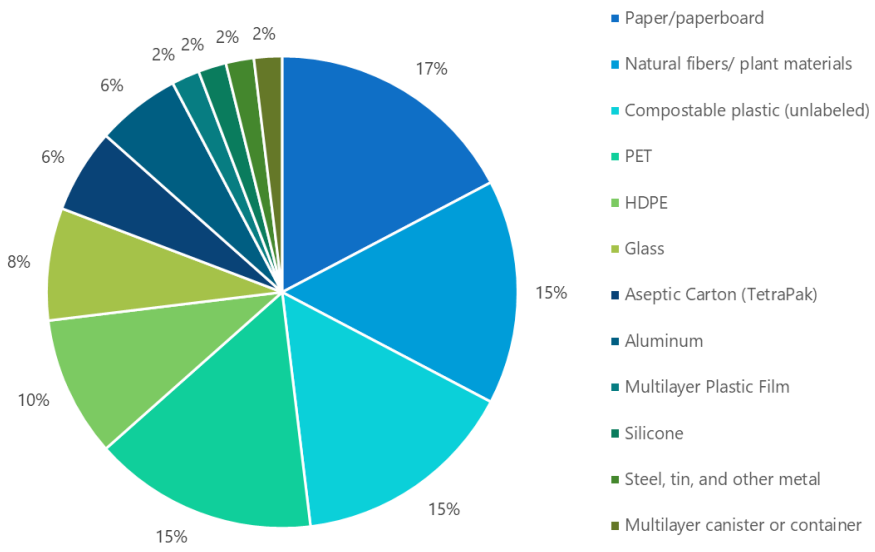


Figure 53: Georgetown County Alternative Material Type Breakdown

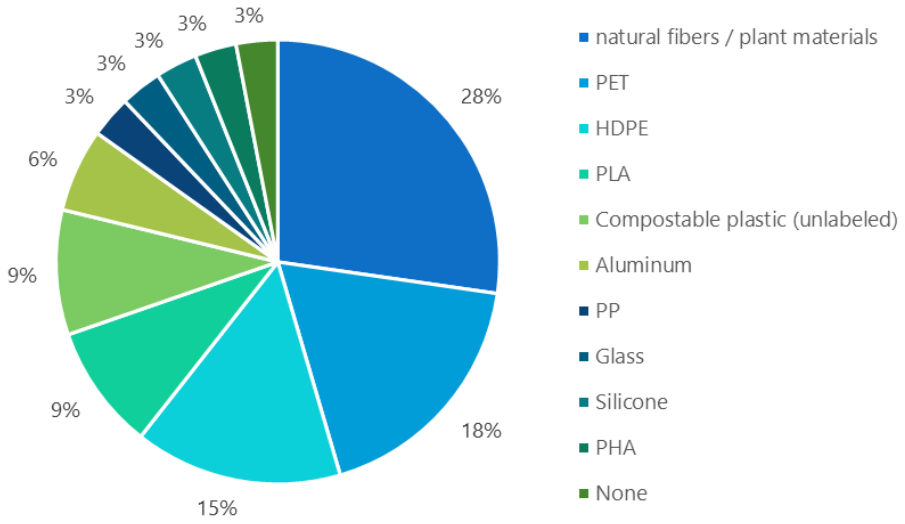


Figure 54: Pawleys Island Alternative Material Type Breakdown

In both areas, bulk items were less costly than comparable single-use plastic products, and reusable items cost 427 times more. Concentrated items in inland stores were also more affordable. Tourism and long-term stays in Pawleys Island attract a less price-sensitive group that may place a high value on environmental conservation, positioning them as strong candidates for embracing reuse and refill alternative. The growing availability of plastic

alternatives shows that Georgetown County is taking steps to move away from single-use plastics.

4.3.5 | Collection

The County of Georgetown does not provide curbside trash pickup. Instead, multi-stream drop-off is available at 15 manned convenience centers throughout the county for residential trash and recyclables (Figure 55). Three convenience centers have swap shops, allowing residents to repurpose, reuse, or donate unwanted items, diverting items from landfills (Georgetown County, n.d.-b).

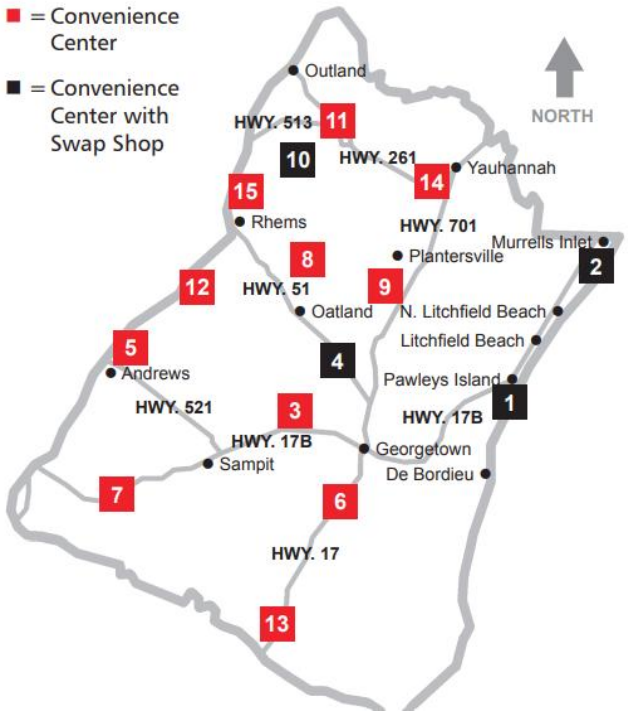


Figure 55: Map of Georgetown County Convenience Centers
Reference: Georgetown County, n.d.-a

Various recyclables are accepted (Figure 56) and separated into containers at the centers: plastic, glass, newspaper, cardboard (Figure 57). By the end of 2024, receptacles were placed to collect plastic films, including grocery bags, produce bags, Ziplock bags, etc. There is a

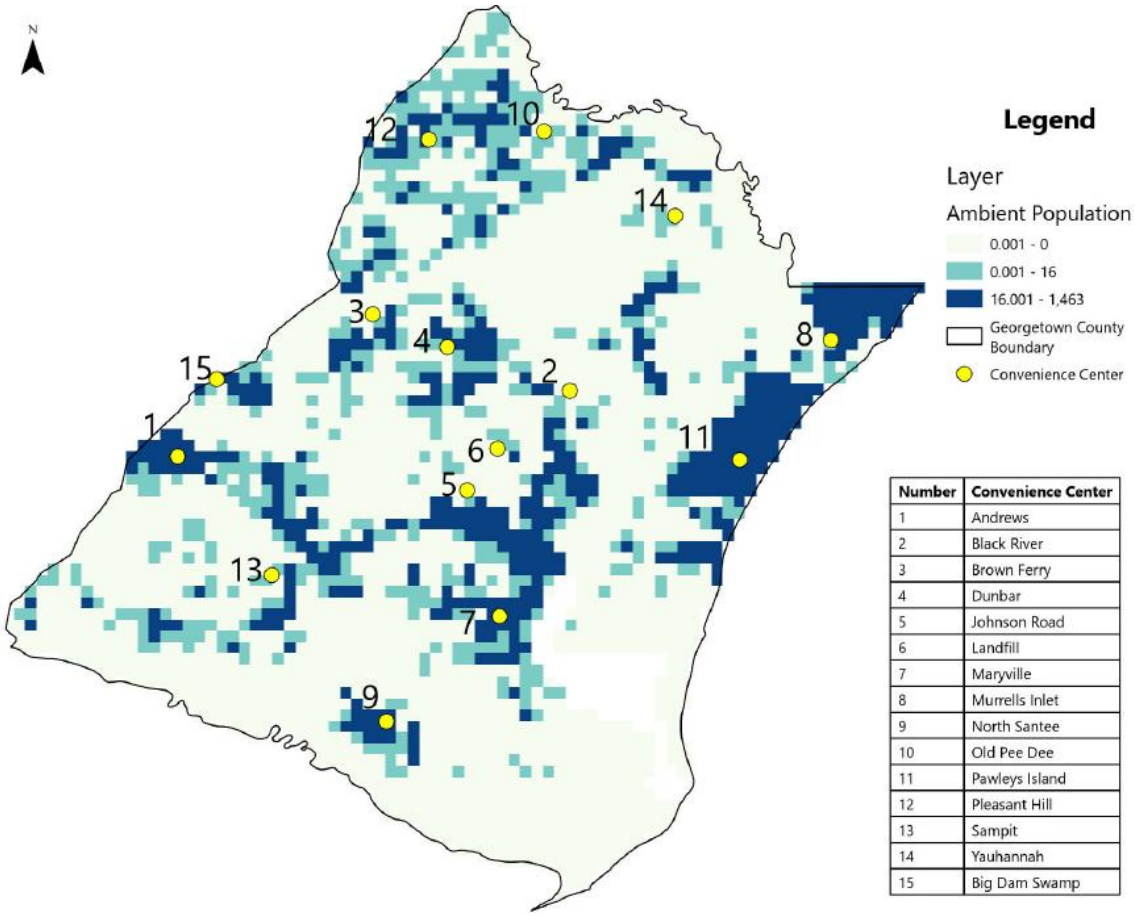
commercial recycling program that collects paper and cardboard weekly. However, a limited number of businesses can participate (Georgetown County, n.d.-b).

Figure 56: List of Acceptable Recyclables at Georgetown Convenience Centers
Reference: Georgetown County, n.d.-c

Figure 57: Georgetown County Convenience Center

The convenience center locations were analyzed using ambient population (Figure 58). 71% of the ambient population is within the convenience centers' 5 km buffer zone. If the

distance is increased to 6 km, nearly all the population is covered, at 93%. This shows that the convenience centers are well-located throughout Georgetown County.



Number	Convenience Center
1	Andrews
2	Black River
3	Brown Ferry
4	Dunbar
5	Johnson Road
6	Landfill
7	Maryville
8	Murrells Inlet
9	North Santee
10	Old Pee Dee
11	Pawleys Island
12	Pleasant Hill
13	Sampit
14	Yauhannah
15	Big Dam Swamp

Figure 58: Map of Ambient Population with Convenience Center Locations in Georgetown County

Issues with recycling collection limit the amount collected and recycled. One stakeholder mentioned that city and county recycling is not consistent. Confusion may arise regarding trash and recycling standards throughout the county since Georgetown City and Andrews offer separate curbside trash pickup for those within the city limits. Another issue is a gap in groups utilizing the convenience centers, decreasing the amount of recyclables collected. A stakeholder highlights a gap in recyclables collected at rentals or long-term stay locations:

"I think it's an obstacle because a lot of the rentals or hotels do not have recycling pickup. So that's a challenge with the tourists, especially during the summer, but the tourist season is all year now. So that's been an identified challenge … it's the rare tourist that's going to Google recycling centers and take their recycling to one of the centers that's not on the beach." – **NGO**

4.3.6 | End of Cycle

The items collected from the convenience centers are either landfilled or recycled. In FY23, Georgetown County generated 52,600 tons of MSW, of which 39,800 tons were disposed of at the Class III landfill. It received a total of 1.3 million tons and has an estimated 23.3 years of space available. The Class II C&D landfill received 27,600 tons and has 18 years of space left (SC Department of Health and Environmental Control, 2023). The tipping fee at each landfill is $45 per ton (Georgetown County Environmental Services, n.d.).

Georgetown County recycled 12,800 tons of MSW in FY23, a 24% recycling rate that includes organics (Table 25). The largest category was organics (61%), which consisted of yard trimmings turned into mulch. The recycling rate without organics was 11.2%. Metal, mainly mixed scrap metal, and paper, mainly cardboard, were the next largest amounts recycled. They received the largest amounts from non-residential sources. Plastics were the lowest category (145,06 tons), mainly HDPE and PET.

Table 25: Georgetown County Recycling Data in Tons in FY23
Reference: SC Department of Health and Environmental Control, 2023

Commodities	Residential	Commercial/ Institutional	Industrial (office/ packaging)	Total
Glass	202	0.27	0.00	**202**
Metal	594	2.88	842	**1,440**
Paper	635	705	67.6	**1,410**
Plastic	46.1	0.43	98.4	**145**
Organics	7,800	11.5	0.00	**7,810**
Banned*	847	217	43.5	**1,100**
Miscellaneous	53.1	7.99	412	**473**
Commingled	135	18	110	**263**
Total	**10,300**	**963**	**1,570**	**12,800**

*Banned refers to items that can not be disposed of in landfills and must be recycled per SC laws (appliances, electronics, lead-acid batteries, used motor oil, and whole tires)

There are issues with recycling in Georgetown County. The MRF's infrastructure is outdated and undersized for community needs (Figure 59). Government employees discussed the need for more staff and investment in balers to make the MRF more efficient. An interviewee mentioned the significant investments required:

"I forget the estimate that the county administrator gave, but I want to say it was like five to $8 million that it's going to take to improve the MRF …. it's over 30 years old. So getting newer technology, reducing the amount of hand sorting that they need to do and helping to increase their ability to recycle." - **NGO**

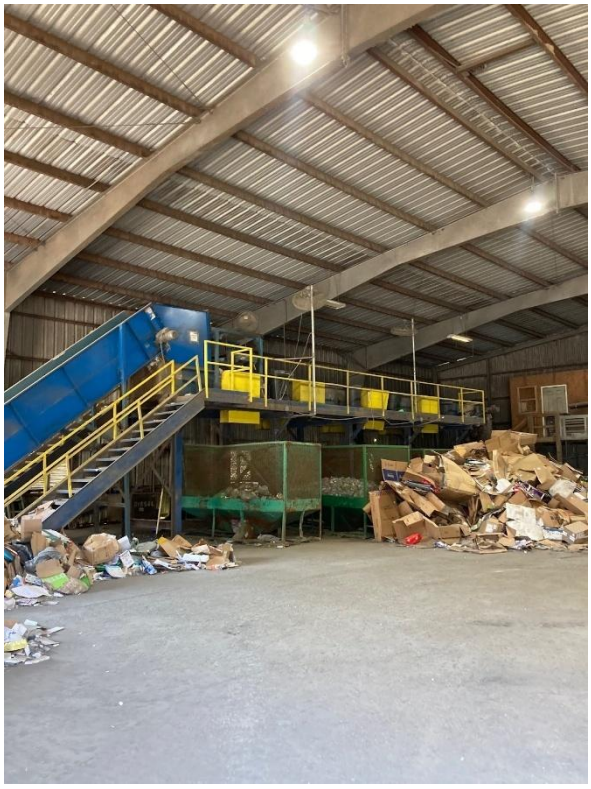


Figure 59: Georgetown County MRF Sorting Line

The MRF's age and lack of upgrades lead to significant downtime, resulting in a backup of recyclables that accumulate (Figure 60). This makes the MRF inefficient.

Figure 60: Pile of Backed-Up Unsorted Recyclables at Georgetown County MRF

Composting is another end-of-cycle pathway that diverts food and yard waste. However, Georgetown County does not have commercial compost infrastructure. According to a government employee, commercial composting was available about 15 years ago but stopped because it was not profitable.

4.3.7 | Leakage

The CIL team recorded 2,460 litter items across the 27 litter transects in Georgetown County. The litter density in the transects ranged from 0.06 to 2.96 items/m^2, with an average of 0.91 items/m^2 (Figure 61). This is higher than the US-modeled average of 0.47 items/m^2 (US EPA, 2024b) and higher than three of the six cities in the Walmart Foundation cohort (New Materials Institute, 2024).

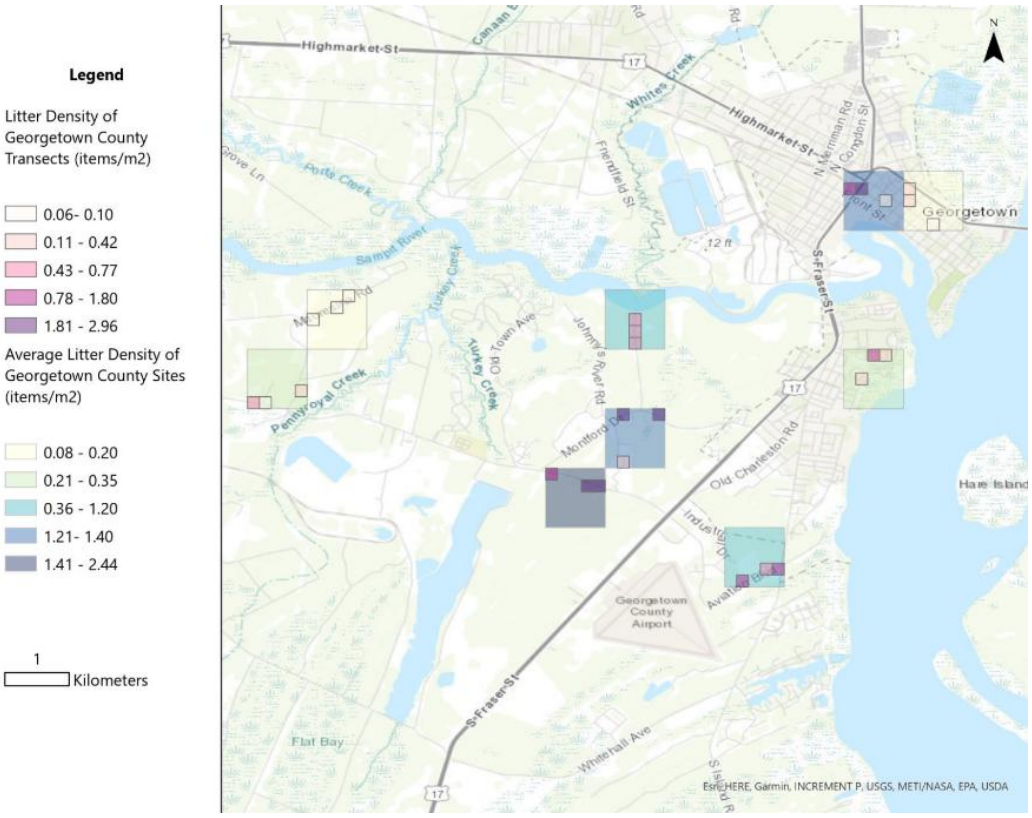


Figure 61: Map of Litter Densities in Georgetown County

Over half of the surveyed items were plastic fragments (30%) and tobacco products (23%) (Figure 62). Both of these materials have limited to no recycling capabilities. The next top material found in the litter survey was food-related plastic packaging (15%), contributing to a high amount of plastic pollution in the environment. About 25% of the materials were paper (12%) and metal (12%), both recyclable.

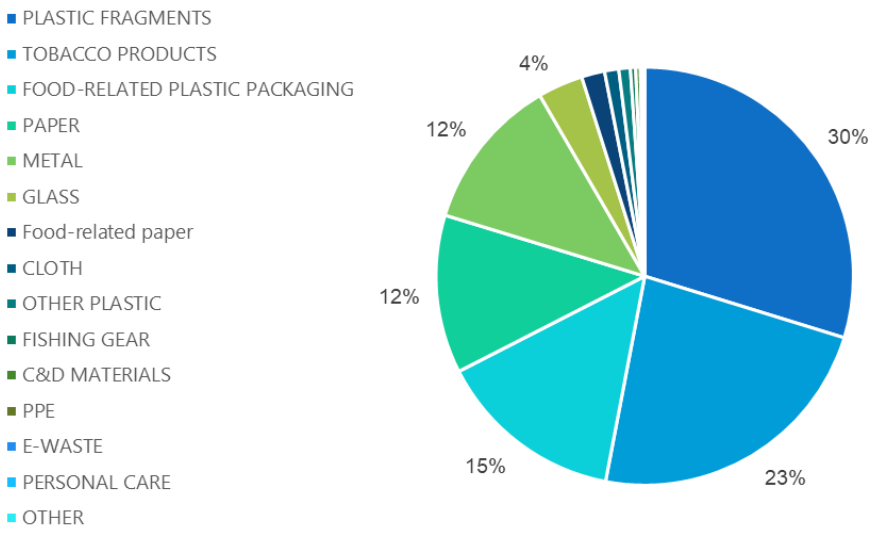


Figure 62: Georgetown County Litter Survey Material Breakdown

The top 10 litter items (Figure 63) were led by cigarettes, for which no local recycling market exists. The most common litter items were fragments (hard plastic, film, paper, foam, glass/ceramic, and metal), indicating that current waste management and recycling systems are failing to capture these items. Some items could be recycled in the top litter items: aluminum or tin cans and plastic bottles (Figure 64). Improving recycling collection would decrease the number of these items that leak into the environment.

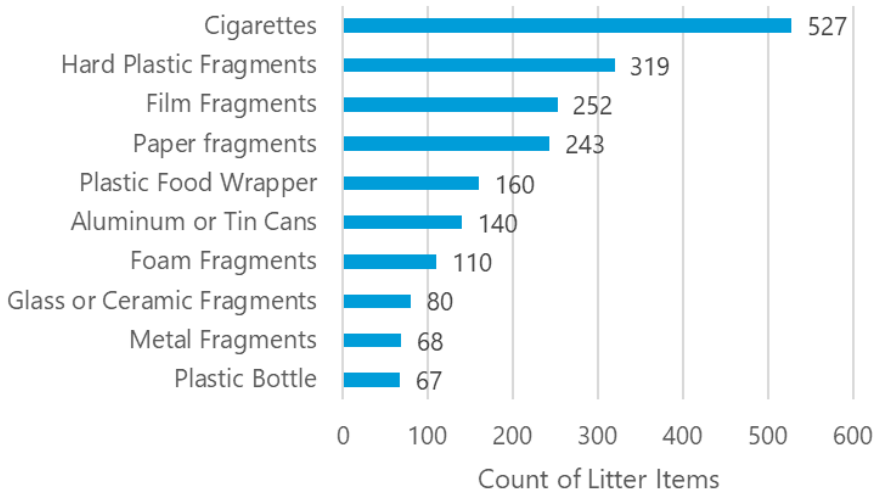


Figure 63: Georgetown County Litter Survey Top Litter Items by Count

Figure 64: Examples of Top Litter Items Leaked into the Environment
Note: Left to right: L&M cigarette pack, Arizona aluminum can, and Sunkist plastic bottle

There has been some progress in reducing the leakage of cigarettes, the top litter item. According to an NGO, Keep America Beautiful and Altria have installed close to 500 cigarette receptacles and have seen a 50% reduction in cigarettes in the litter.

Pawleys Island has a different story. Across the nine litter transects, 345 litter items were recorded. The litter density ranged from 0.29 items/m² to 0.46 items/m², with an average of 0.38 items/m² (Figure 65). This is lower than both the US-modeled average and Georgetown County.

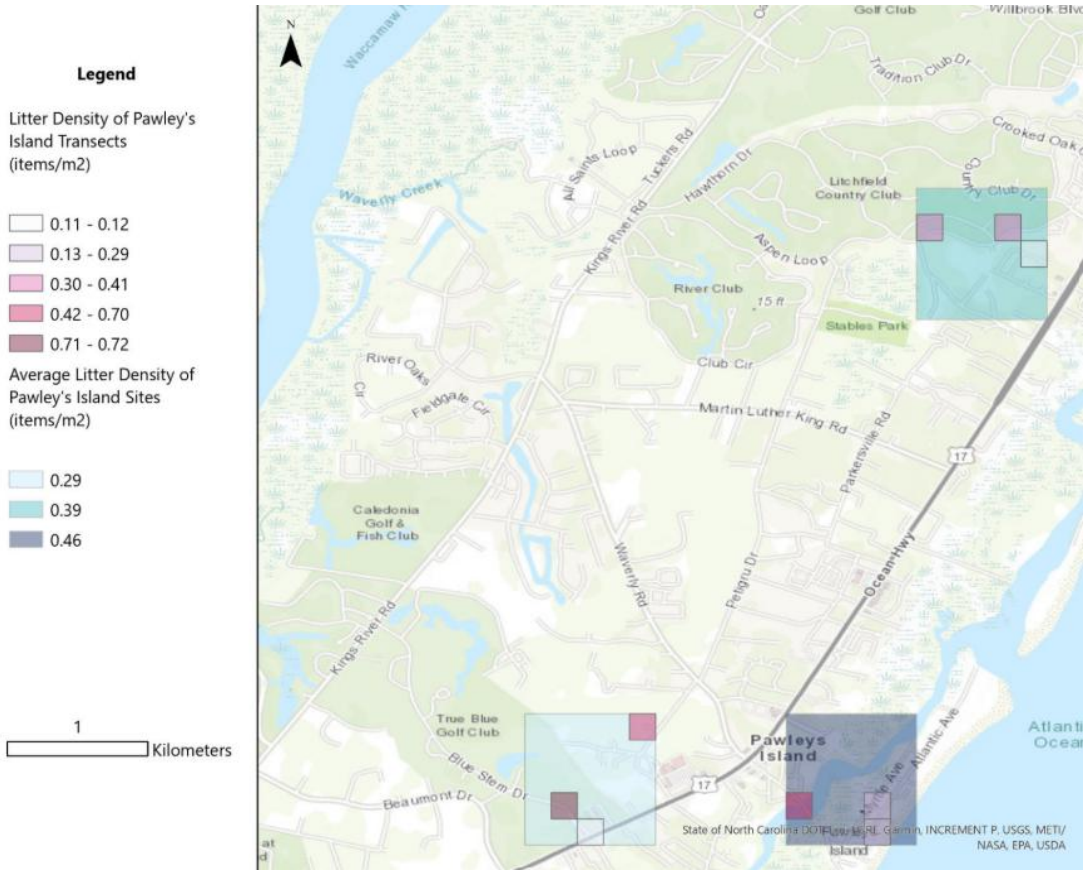


Figure 65: Map of Litter Densities in Pawleys Island

Almost half of the litter was tobacco products (48%), while plastic fragments accounted for 26% (Figure 66). This is more tobacco products than the inland area.

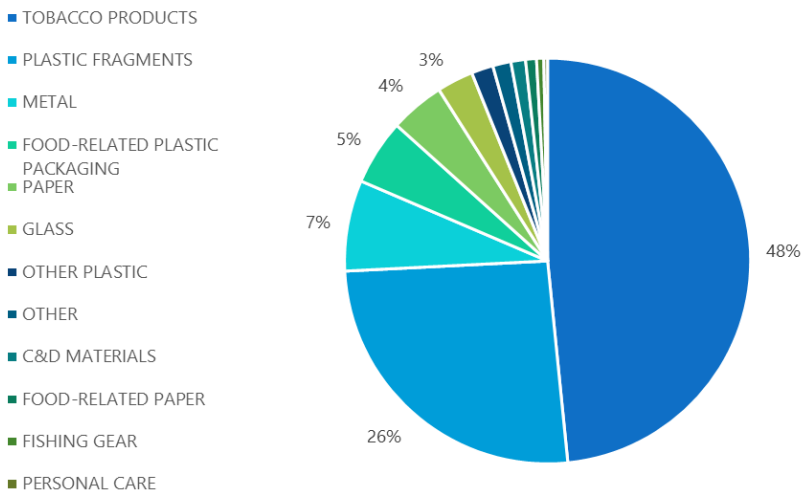


Figure 66: Pawleys Island Litter Survey Material Breakdown

Cigarettes dominated Pawleys Island's top 10 litter items, and fragments were also popular. Plastic food wrappers, aluminum foil, and popsicles or lollipop sticks were the remaining items (Figure 67), indicating the presence of tourists socializing in the area. There were no recyclables in the top litter items.

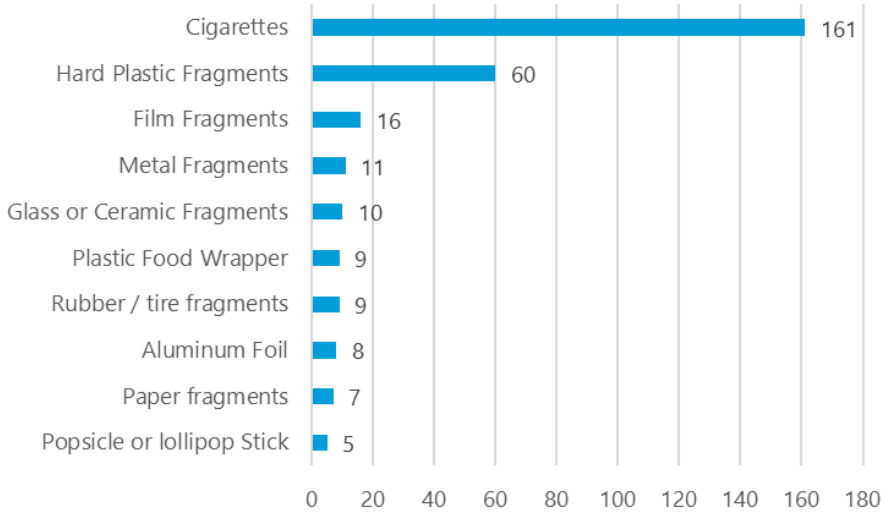


Figure 67: Pawleys Island Litter Survey Top Litter Items by Count

Pawleys Island had a lower litter density than Georgetown County. This may be due to the proximity to the ocean, which makes people care more about keeping the environment clean. Cigarettes were the top litter item in both areas. This resembles the Walmart Foundation cohort, where five of the six cities identified cigarettes as the leading litter item (New Materials Institute, 2024). Recyclables were present in Georgetown County's litter surveys, but none were found in Pawleys Island. Clearly, there are stark differences in the litter found in the environment between inland and coastal areas.

4.3.8 | Opportunities

The following opportunities are recommended to expand and enhance circularity, specifically aimed at increasing recycling rates in Georgetown County, based on the findings of the CAP. These opportunities are categorized according to the CAP model's seven spokes and listed based on the potential impact of reducing plastic waste in Georgetown County within each spoke. It is up to the county's discretion to assess the feasibility and cost-effectiveness of the recommended opportunities. A more substantial impact on Georgetown County's circularity, specifically recycling, may be seen if opportunities are strategically combined.

INPUT

93% of FMCG manufacturers and 83% of FMCG parent company locations were domestic to the US. South Carolina's neighboring states manufactured 8% of the FMCG surveyed. PepsiCo and The Coca-Cola Company were the top parent companies, with local bottling locations in North Myrtle Beach and Bishopville, respectively. Plastic bottles were among the top items found in the litter data for the inland area.

- Facilitate voluntary EPR schemes with nearby parent companies and manufacturers.

- Leverage reuse, refill, and DRS with local bottling companies.
- Invest in water refill stations in government buildings and parks.

COMMUNITY

Four conversations and one semi-structured interview were conducted with two different stakeholder groups. The participants provided insights on barriers to recycling, including lack of funding, old infrastructure, and accessibility challenges. They highlighted areas that could increase recycling rates.

- Work alongside NGOs that have initiatives to decrease the amount of litter in the environment.
- Work on passing policy addressing litter or increasing recycling rates.
- Expand education to social media.
- Utilize wildlife messaging to connect with the public.
- Use outside sources for grant writing support, such as the US EPA's Regional TCTAC Southeast Program, REACT4, at https://www.react4.org/.
- Visit K-12 locations to educate students and hand out brochures, trash art contests, etc.

PRODUCT DESIGN

Twenty stores were surveyed, and five FMCG and staple goods were mainly packaged in multilayer film or EPS. In restaurants, EPS was the most popular packaging material for food containers and cold cups in the inland and coastal areas. The packaging-to-product ratio was highest for chips (0.07).

- Shift towards easier-to-recycle materials like PET, HDPE, and paper/ paperboard.
- Educate store owners and the public to purchase items/packaging that are locally recyclable.

- Improve product delivery efficiency by shifting towards minimal packaging design and/or increasing product quantities.

USE

85 alternative materials were found in the inland and coastal stores. Georgetown County had more alternative items but was located at fewer stores than Pawleys Island. Bulk items were less costly, while reusable items cost 140 times more. Compostable products were the most popular alternative (44%), but no commercial composting infrastructure was available. Pawleys Island had more stores offering reusable bags (60%) than Georgetown County (25%).

- Tourism and long-term stays bring a less price-sensitive group that could use reuse or refill alternatives.
- Invest in reusable foodware in schools to reduce waste (VYTAL reuse available in 2025 w/HQ in Atlanta).
- To support local businesses, the city could highlight efforts by local businesses to reduce plastic use.
- Promote the use of reusable bags.
- Promote only upon request policy at restaurants (straws, utensils, and bags).
- Increase awareness of existing commercial recycling programs.

COLLECTION

Trash and recycling are collected through 15 drop-off convenience centers throughout Georgetown County. A 6 km buffer zone around convenience centers indicates that 93% of the ambient population is covered. However, recycling collected from tourist areas is low.

- Educate the public to recycle aluminum and natural HDPE as they are the most profitable recyclable items.

- Expand awareness of convenience centers in tourist areas to address the gap in recyclables collected.
- Provide pop-up locations to collect recyclables and educate the public on how and where to recycle.
- Push for private haulers to separate recycling from waste (e.g. smaller trash cans, free days to recycle the most profitable recyclables). PAYT systems incentivize residents to throw away less trash and recycle.

END OF CYCLE

The MRF is outdated and undersized for community needs. Significant investment is needed to update the infrastructure and increase staff. A backup of recyclables at the MRF is typical. There is no composting infrastructure available.

- Work with nearby counties to increase the supply of recyclables to reach economies of scale.
- Invest in composting infrastructure as compostable alternatives are present.
- Invest in updating MRF for more efficient processing.
- Utilize volunteers and/or incarcerated individuals to help with tasks at the MRF.

LEAKAGE

Georgetown County's average litter density is higher (0.91 items/m^2) than Pawleys Island (0.38 items/m^2). The top litter item for both areas is cigarettes. In Georgetown County's litter survey, aluminum or tin cans and plastic bottles were in the top litter items list.

- Addressing some of the top littered items (tobacco items) with additional policies and public campaigns upstream.

- Place trash & recycling bins according to CAP litter surveys or annual leakage data reports.
- Place yard signs or road signs throughout the county to remind people not to litter.
- With continued litter monitoring, the County can identify gaps in convenience centers.
- Place trash cans and recycling bins at entrances of recreational areas (tourism/shopping centers/ parks).

CHAPTER 5

RELATIONSHIPS BETWEEN RURAL COMMUNITIES

5.1 | Rural Community Comparison

The three rural communities were compared to examine how SWM is affected across several components, including geography, levels of tourism, population density, ambient population, and the US Government's CEJST (Table 26).

Table 26: Summary of Rural Community Comparison

Community	Geography	Tourism Economic Impact ($USD million) in (year)	Population Density (people/km^2)	Max Ambient Population (people/km^2 over 24 hours)	Population Living in Disadvantaged Areas (%)
Tifton	Agricultural	93 (2022)	3,470	2,440	45
Cherokee County	Mountainous	101 (2023)	163	674	100
Georgetown County*	Coastal	380 (FY23)	201	1,460	69

*Note: Georgetown County represents both inland and coastal (Pawleys Island) data

The three rural communities have distinct geographies. Tifton is agricultural, with many row crops: peanuts, cotton, tobacco, and pecans. Cherokee County is mountainous, located at the southern tip of the Great Smoky Mountains. Georgetown County is coastal, located on the Atlantic Ocean between Myrtle Beach in the north and Charleston in the south. These

geographies lend to unique economic and cultural identities that affect the type of waste produced.

The geography highlights that each community has different types and amounts of tourists who impact the town economically. Tifton thrives on agricultural-related overnight stays from conferences, trade shows, and events associated with the several state commissions and associations, UGA, and the Abraham Baldwin Agricultural College in Tift County. It also benefits from the I-75 traffic (Boyd, 2019). This leads to the lowest tourist economic impact of $93 million in 2022 for Tifton (UGA Extension, 2024). Cherokee County is mainly known for outdoor tourism. The area has many hiking trails and nature getaways that attract nature lovers looking to relax. Cherokee County's total tourist economic impact was $101 million for 2023 (Economic Development Partnership of North Carolina, 2024). Finally, Georgetown County is big on fishing and coastal tourism as it is situated along the Hammock Coast, one of South Carolina's top tourist destinations. It attracts visitors throughout the year and generates over $380 million annually, representing the highest economic impact from tourism in the rural cohort (Georgetown County, 2023). Ultimately, proximity to nature increases tourist levels. This increase in tourism can lead to a higher volume of waste produced and mismanaged waste, as tourists may care less about areas that are not their home. If there are not many bins placed throughout the community and awareness of recycling rules, recyclables may be sent to landfills or can escape into the environment.

Population density is another way that the three rural communities can be compared. Each community has a different population size and area. This is particularly true for Tifton, the only city in the rural cohort. Tifton has the highest population density (3,470 people/km^2) due to the city's small area (US Census Bureau, n.d.). The community with the lowest population

density is Cherokee County (163 people/km^2). It is nearly half of Georgetown County's area but not far behind its population density of 201 people/km^2. A high population density makes it easier to collect trash and recyclables curbside, but transportation costs rise with lower population densities.

Ambient population density represents the number of people actively moving through an area for a set time period, in this case, 24 hours. This was calculated using the Oak Ridge National Laboratory's 2022 LandScan dataset. It combines census data on daytime and nighttime population data with supplementary spatial data such as high-resolution imagery, transportation infrastructure, lidar, land use data, and activity hubs (Oak Ridge National Laboratory, n.d.). Cherokee County has the lowest max ambient population density (674 people/km^2), followed by Georgetown County (1,460 people/km^2). Tifton has the highest max ambient population density (2,440 people/km^2). A low ambient population density means fewer people are in an area over 24 hours. It is important to consider as it affects how much foot traffic a drop-off recycling center will have. Placing them in the higher ambient population density is the most convenient for residents.

The final comparison used the US Government's CEJST (US Council for Environmental Quality, n.d.-b) to assess the extent of community disadvantage and the locations of SWM facilities. In Tifton, 45% of the population lives in a disadvantaged area (50%) (Figure 68). This is the lowest percentage in the rural cohort. The disadvantaged areas of Tifton and Tift County are found in the southern half. This may be due to historical zoning practices. It is important to note that the Tifton census tracts are not exclusive and include some of the Tift County population. The inert landfill is in a disadvantaged area of Tifton. The MSW Tifton-Tift County

landfill is in a disadvantaged area of Tift County. The recycling drop-off center is located in the other disadvantaged areas in Tifton.

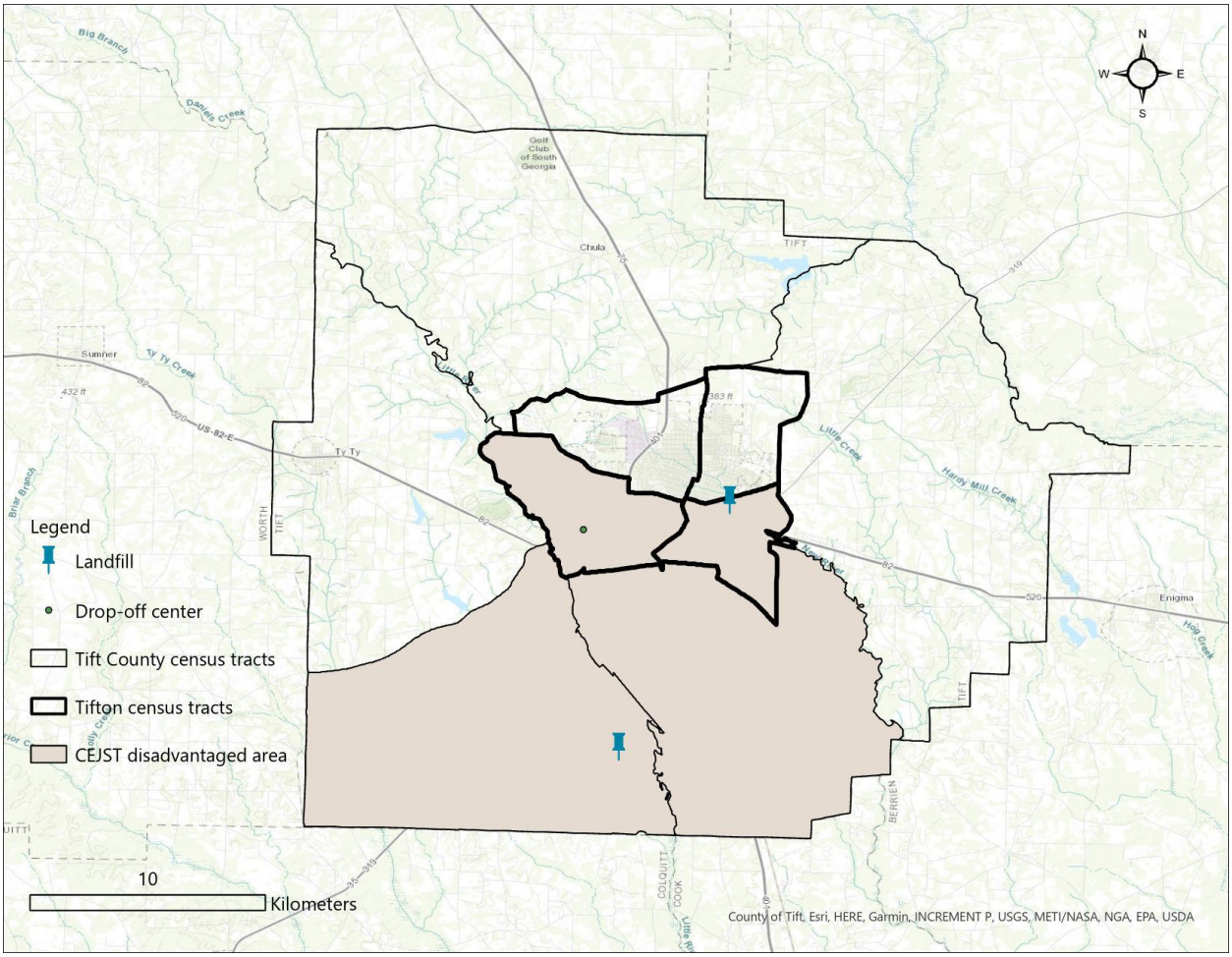


Figure 68: Tifton SWM facilities mapped along with CEJST disadvantaged areas

Cherokee County is classified as a disadvantaged area (Figure 69). Therefore, all 10 convenience centers and landfills are situated within this disadvantaged region, which has the highest percentage of the population residing in such an area.

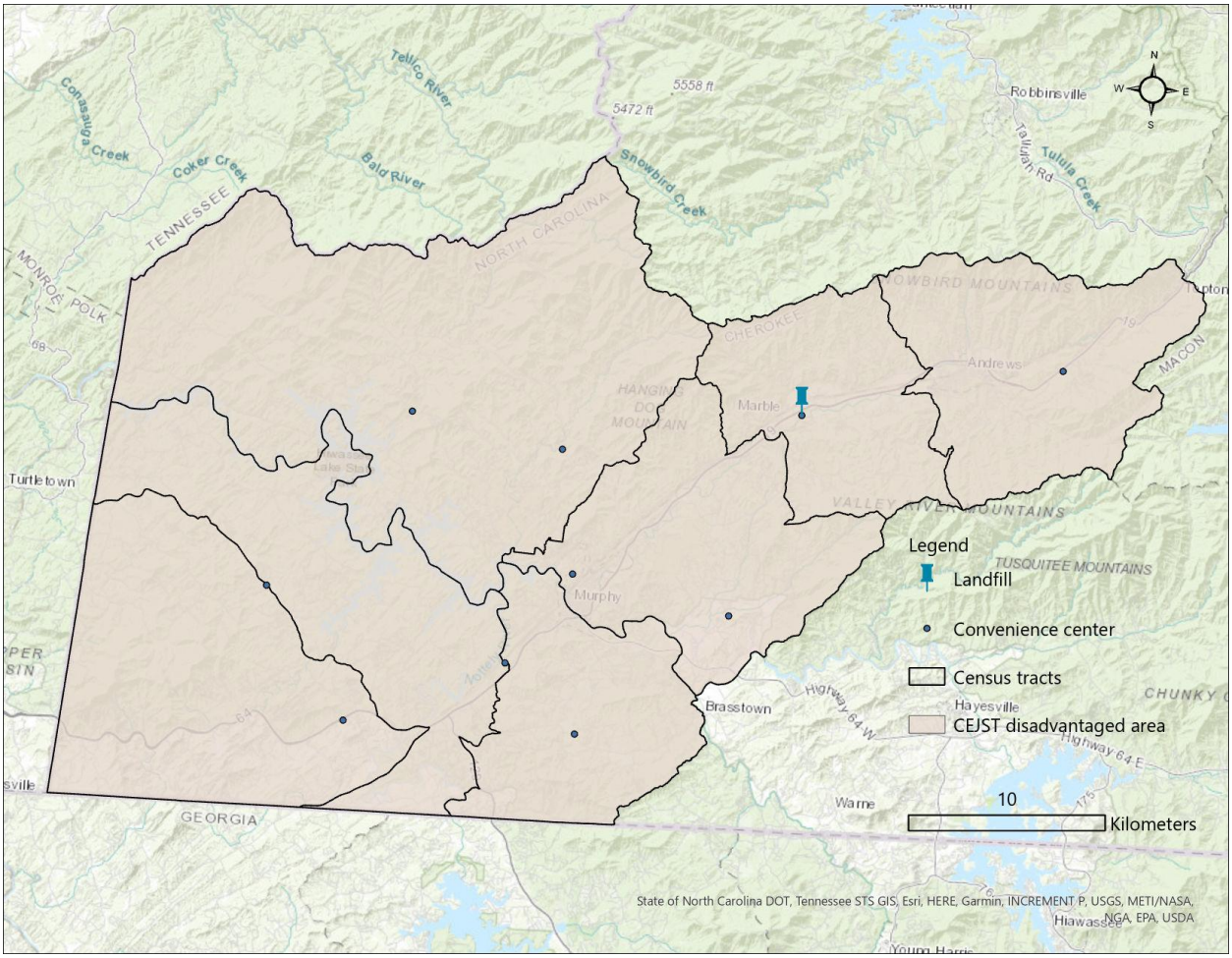


Figure 69: Cherokee County SWM facilities mapped along with CEJST disadvantaged areas

In Georgetown County, 69% of the population lives in disadvantaged areas (71%) (Figure 70). Pawleys Island, the City of Georgetown, and other coastal areas are not disadvantaged. Most (93%) of the convenience centers are in disadvantaged areas. The convenience center, which is not in a disadvantaged area, is close to Pawleys Island, a large tourist area, and borders a disadvantaged census tract serving both communities. The Georgetown County landfill is in a disadvantaged area in the middle of the County.

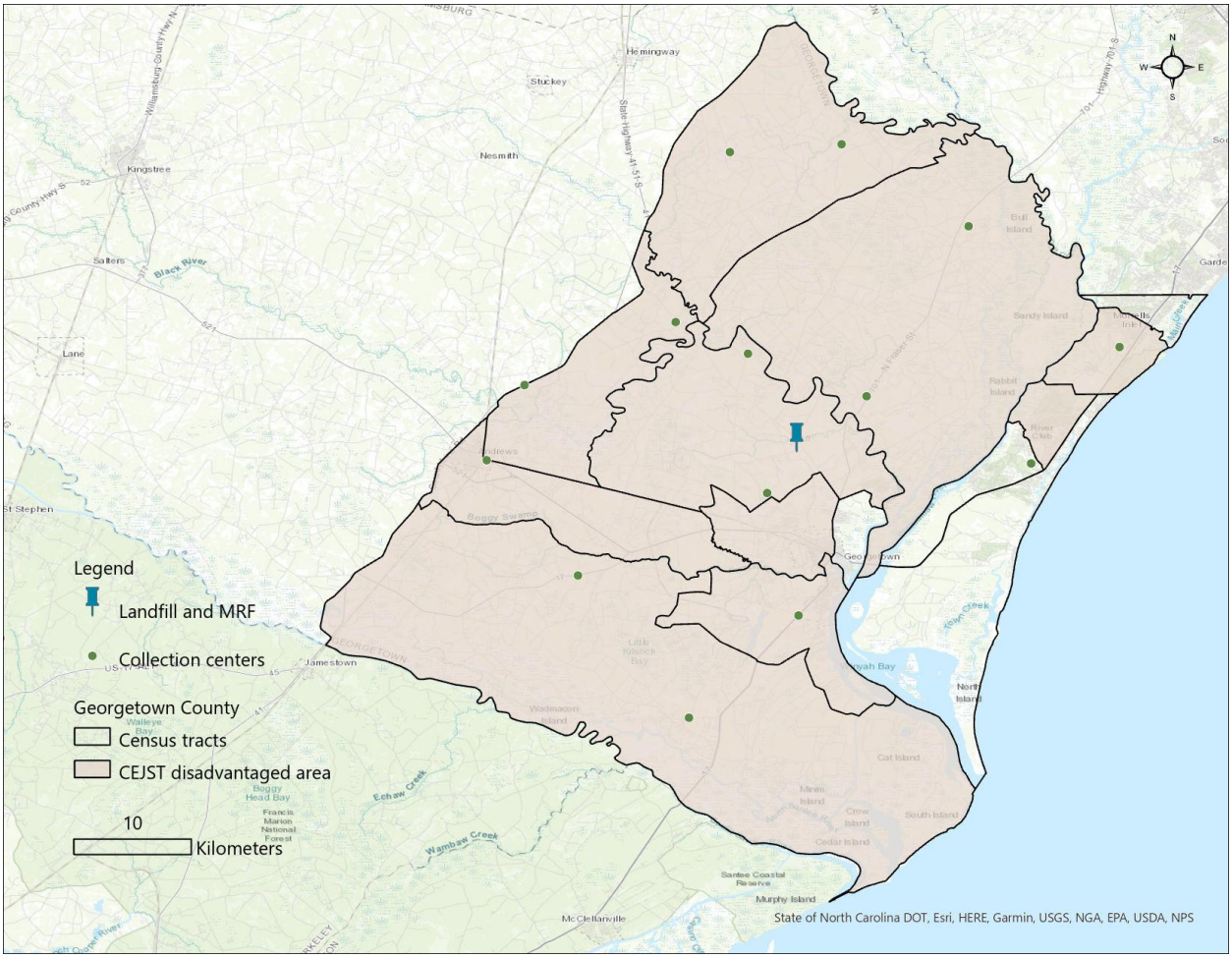


Figure 70: Georgetown County SWM facilities mapped along with CEJST disadvantaged areas

All convenience centers except one were situated in CEJST disadvantaged areas. There are several benefits to having the centers in disadvantaged areas. It shows that the community is taking steps towards environmental justice, giving communities that often lack resources access to recycling. It mitigates the environmental impacts of mismanaged waste, disproportionately affecting disadvantaged communities. This also improves public health since pollution is reduced. However, all the landfills were in CEJST disadvantaged areas due to low land prices, less political resistance, and industrial zoning. This contributes to environmental racism and exposes the disadvantaged areas to air and water pollution and health risks. Addressing these disparities requires continued efforts to ensure that waste management infrastructure (landfills

and recycling convenience centers) is distributed more equitably to reduce environmental burdens on disadvantaged communities.

In conclusion, the three rural communities were compared across various components: geography, levels of tourism, population density, ambient population, and the US Government's CEJST. Each component highlighted an important lesson on effective SWM. Each community has a distinct geography that affects its waste generation. The geography also affected the level of tourism, with Georgetown County's beaches having a tourist economic impact about 3.8 times larger than the other rural communities. This can cause an increase in waste production and mismanagement. Tifton had the highest population density, making it easier to have curbside collection. Georgetown and Cherokee County were significantly lower, which means increased transportation during collection, creating inefficiencies. Tifton also had the highest maximum ambient population density. This indicates higher foot traffic in the area, an important aspect to consider when placing the recycling convenience centers. Finally, most (96%) of the convenience centers were in CEJST disadvantaged areas, increasing availability, but the landfills that pollute the air and water were also there. Understanding the relationships between the components and SWM will allow for more effective recycling systems in rural communities.

5.2 | Circularity Assessment Protocol Spoke Comparison

The three rural communities are compared based on data collected for each CAP spoke. Pawleys Island was included only when there was a significant difference between inland and coastal Georgetown County. The following subsections outline the similarities and differences in the CAP results for each spoke across the three communities, allowing for broad

recommendations to be made for rural communities within US EPA Region 4, should there be shared findings across the rural cohort.

5.2.1 | Input

The majority of manufacturers and parent companies are domestic (Table 27). Nearly 10% of manufacturers were in neighboring states. PepsiCo and The Hershey Company are the top parent companies in all three communities. The Coca-Cola Company and Mars Inc. are the other top parent communities. There are local bottling companies for Pepsi and Coca-Cola products near each community.

Table 27: Rural Community Input Comparison

Rural Community	Domestic Manufacturers (%)	% of Manufacturers in Neighboring States	Domestic Parent Companies (%)	Top Parent Companies
Tifton	93	9	82	1. Mars Inc. 2. PepsiCo 3. The Hershey Company
Cherokee County	96	8	89	1. The Hershey Company 2. PepsiCo 3. The Coca-Cola Company
Georgetown County	93	8	83	1. PepsiCo 2. The Hershey Company 3. The Coca-Cola Company

These shared findings highlight several opportunities that rural communities could implement. NGOs could help facilitate voluntary EPR schemes with nearby parent companies and manufacturers. They could also leverage reuse, refill, and DRS with local bottling companies. Leveraging these nearby locations to reduce the flow of single-use plastic through the community and minimizing leakage into the environment is a step towards circularity in rural communities. According to Georgetown County's leakage data, plastic bottles ranked among the top litter items, highlighting the opportunity to invest in water refill stations in government buildings and parks. This can be implemented in any rural community to decrease the amount of plastic water bottles sold.

5.2.2 | Community

Conversations and interviews with key stakeholders in the three rural communities provided insights on key barriers and solutions. The three communities face littering issues throughout the community. Their shared recycling challenges are due to limited access to resources and facilities and low collection rates. Stakeholders emphasized education, policy changes, and incentives as essential strategies to improve recycling. However, each area has distinct challenges. Cherokee County struggles with political obstacles, safety concerns, illegal dumping, and tire disposal. Tifton deals with public distrust, contamination issues, and conflicts between city and county officials. Georgetown County, on the other hand, highlights historical underfunding and limited accessibility to recycling bins.

Despite these differences, stakeholders agree on the need for system-wide improvements to create a more effective recycling system. Government employees, who influence policy, funding, and regulation, along with waste management companies, which can implement

recycling practices, tend to have the most influence on increasing recycling. NGOs also play a key role by mobilizing grassroots initiatives and advocating for systemic change.

While each community will have unique opportunities based on input from its community members, the general shared opportunities highlighted by stakeholders in the rural cohort could also help increase recycling rates and decrease littering in other rural communities across the US EPA Region 4. Examples of opportunities include educating the public on the consequences of littering and the benefits of recycling, especially in school curricula, and making recycling more convenient by increasing the supply of recyclables collected or public bins. Additionally, they could also provide incentives for recycling. Residents who recycle a large amount could receive a tax incentive, or stores and restaurants that offer alternative packaging materials could receive a discount. Areas with mismanaged waste or illegal dumping could increase lighting, monitoring, and signage to decrease the amount littered in the future. NGOs and volunteering groups can help with clean-ups in the area. Rural areas could utilize outside sources for grant writing support, like US EPA's Regional TCTAC Southeast Program, REACT4, at https://www.react4.org/, to increase funding available in the community. A wider variety of opportunities based on the conversations and unique to each rural community is outlined in each community's opportunity section in Chapter 4.

5.2.3 | Product Design

Across the three communities, beverages and/or chips had the highest packaging-to-product ratio (Table 28). The highest was in Georgetown County (0.07) for chips. This makes product delivery inefficient as a higher proportion of the weight is packaging that gets discarded (Youngblood et al., 2022). Additionally, smaller product sizes lead to more frequent purchases

and are cheaper per unit than larger sizes. However, these smaller packages frequently incur a "poverty tax," meaning the cost per quantity is higher, generating more packaging waste per quantity of product.

The top packaging type in stores for FMCG and staple goods was multilayer film as it was the main packaging for chips, candy, greens, and rice. This can easily escape the waste stream since it is lightweight. The top material type for restaurant to-go items ranged from PP to EPS and PS, which are not easy to recycle. Alternative materials are present in the to-go items as seen in Cherokee and Georgetown County, where 5% of food containers were made from natural fibers/ plant materials. There were compostable straws (7%) as well in Georgetown County. The largest percentage was in Pawleys Island, where 25% of utensils were made from natural fibers/ plant materials, while none were found in Tifton.

Table 28: Rural Community Product Design Comparison

Rural Community	Highest Packaging-to-Product Ratio (FMCG)	Top Packaging Type in Stores	Top Material Type for To-Go Items	Alternative Material(s) Present for To-Go Items
Tifton	0.06 (Beverages)	Multilayer Film	PP	n/a
Cherokee County	0.06 (Beverages & Chips)	Multilayer Film	PS	Natural fibers/ plant materials
Georgetown County	0.07 (Chips)	Multilayer Film	EPS / PP	Natural fibers/ plant materials & compostable
Pawleys Island	-	-	PP	Natural fibers/ plant materials

The data from the product design spoke highlighted several opportunities that rural communities could implement. There could be discussions on the economic impact of improving

product delivery efficiency by shifting towards minimal packaging design and/or increasing product quantities with nearby manufacturers/parent companies. Local groups could educate store owners and the public about purchasing locally recyclable items. Nonprofits and universities could initiate discussions to promote using more easily recyclable materials like PET, HDPE, paper/paperboard, and alternative materials. The egg industry in Georgia and North Carolina produces the top 10 largest amounts in the country (US Department of Agriculture, 2025). Therefore, a unique opportunity exists to shift egg packaging, mainly EPS, to biodegradable paper pulp or recyclable PET for rural communities in these states. Increasing awareness of conscious packaging decisions in rural communities is context-specific and varies depending on the industries present in each community. For example, in Tifton, an opportunity was to utilize the presence of an agriculture-focused university to address this topic in their curriculums, extension programs, or outreach. Cherokee County could converse with the Cherokee County Egg Producer Association and local egg producer, Dutt & Wagner.

5.2.4 | Use

Pawleys Island had the highest percentage of stores selling reusable bags (60%), while inland Georgetown County had the lowest (25%) (Table 29). The average cost of reusable bags ranged from $1.31 to $5.64. Cloth bags were more expensive than non-woven PP bags, significantly increasing the Georgetown County average price. The most common alternative use type was compostable, highest in Cherokee County (68%) and Tifton (67%) because there was less variety of alternatives available. In most communities, bulk items were the least expensive alternative to their comparable SUP products. Concentrated items were another affordable alternative. In all the communities, reusable products were the most expensive alternative use

type. Their design to be reused makes them more robust, increasing their up-front cost, but over time, the price per use makes it more economical. There is a lack of alternative personal care items in all locations except Georgetown County.

Table 29: Rural Community Use Comparison

Rural Community	% of Stores Selling Reusable Bags	Average Cost of Reusable Bags ($)	% of Stores Selling Alternatives	Most Common Alternative Use Type (%)	Least Expensive Alternative Use Type (%)	Most Expensive Alternative Use Type (%)
Tifton	27	2.43	32	Compostable (67)	Bulk (-243)	Reusable (41,900)
Cherokee County	54	1.31	46	Compostable (68)	Refillable (-18)	Reusable (16,800)
Georgetown County	25	5.64	35	Compostable (40)	Bulk (-41)	Reusable (14,200)
Pawleys Island	60	2.14	67	Compostable (49)	Bulk (-53)	Reusable (14,500)

The shared findings indicate that rural communities throughout EPA Region 4 have several opportunities that could encourage plastic reduction within the community. Stores could offer more bulk and concentrated products, which tend to be less expensive than SUP products. The community could advertise on social media, online, or in the newspaper to highlight local businesses that offer alternatives. The communities could also promote reusable bags and an only-upon-request policy for utensils, straws, and bags at restaurants. Personal care alternatives could be promoted with messaging that appeals to nature-loving tourists, especially in areas with a strong ecotourism presence. A less price-sensitive market exists in communities with a high

volume of tourists and long-term stays, making them more likely to purchase reusable and refillable alternatives. Increasing their availability in stores could decrease SUP item sales.

5.2.5 | Collection

Cherokee and Georgetown counties collect their trash and recycle it similarly using drop-off convenience centers around the county, 10 and 15, respectively (Table 30). These are well-located throughout the county, with more than 90% of each county within a 6 km buffer zone of a convenience center. Tifton has a different story. Trash is collected curbside, while recycling must be dropped off at the single convenience center. It is within a 4 km buffer zone for 63% of the community.

Table 30: Rural Community Collection Comparison

Rural Community	Trash/ Recycling Collection	Number of Convenience Centers	% of Population within Buffer Zone* around Convenience Centers
Tifton	Trash: Curbside Recycling: Drop-off	1	63
Cherokee County	Drop-off	10	92
Georgetown County	Drop-off	15	93

*Cherokee County and Georgetown County use a 6 km buffer zone. Tifton uses a 4 km buffer zone since it is smaller in size.

Each community had its method for collecting household waste and recyclables, presenting various opportunities. Since collection methods are context-specific, these opportunities vary based on each rural community's unique situation. The public could be educated to recycle aluminum and natural HDPE, as they are the most profitable recyclables.

Pop-up locations could be provided to collect recyclables and educate the public on how and where to recycle. Private haulers used by some of the community members could be incentivized to separate recyclables from waste. This could be done by implementing PAYT systems to divert waste from landfills and provide smaller trash cans. Single-stream recycling collection could be changed to source-separated collection. Also, community members could be informed about local businesses that accept separated plastic films, which easily escape waste streams.

Opportunities unique to certain rural communities, but potentially relevant to others with similar collection systems, are outlined. Georgetown County could expand awareness of convenience centers to tourist areas to address the gap in recyclables collected. Cherokee County could allow non-county residents, like tourists, to utilize convenience centers for a fee to collect money to replace or repair dumpsters. Tifton could place more recycling drop-off areas throughout the city to increase the population within the buffer zone and place signage to increase location awareness. They could also accept glass products that can be used for roadbeds or fill in the local community.

5.2.6 | End of Cycle

Each rural community operates a MSW landfill (Table 31). Tifton and Georgetown County also have a C&D landfill. Each community handles their recyclables differently. Tifton does not have a MRF, so it transports recyclables to the nearest MRFs, which are about 100 miles away. Cherokee County also lacks a MRF. However, it brokers materials directly to processors, skipping the MRF step. Georgetown County has a MRF, but it is outdated and undersized. Tifton recorded the lowest recycling rate, while Georgetown County had the highest.

Tifton's low recycling rate may be due to the limited number and awareness of the drop-off center. None of the locations have composting infrastructure.

Table 31: Rural Community End of Cycle Comparison

Rural Community	Landfill (s)	MRF Present	Recycling Rate (%)*	Composting Infrastructure
Tifton	MSW and C&D	No, hauls to nearest MRFs (~100 miles)	0.19	No
Cherokee County	MSW	No, but directly brokers materials to processors	3.66	No
Georgetown County	MSW and C&D	Yes	11.2	No

*The recycling rate does not include organics.
**The Tifton recycling amount is predicted to be 125 tons. Limited information is available, and it is only reported that 89 tons of metal and 17 tons of tires were recycled (City of Tifton, 2023).

There are a variety of opportunities for the end of cycle that rural communities throughout the US EPA Region 4 could implement. Investments in compostable infrastructure could be made, especially as there has been a rise in the popularity of compostable alternatives. They could also collaborate with nearby counties to reach economies of scale. As previously mentioned, outside sources for grant writing support, like REACT4, to implement waste reduction or education programs and to decrease the price difference between landfilling and recycling. Volunteers and/or incarcerated people to help with tasks at the drop-off center and/or MRF. While utilizing incarcerated individuals for labor can reduce costs and offer valuable work experience, it raises ethical concerns, particularly regarding fairness, consent, and the potential exploitation of vulnerable populations. Improvements to outdated and undersized recycling

infrastructure could be made to increase the number of recyclables processed. Finally, if recyclables are collected in a multi-stream drop-off center, a rural community could sell recyclables directly to processors, cutting out the MRF, which most rural areas lack. There could be coordination between nearby counties to build a MRF if there is a gap in the recycling infrastructure in the area.

5.2.7 | Leakage

Tifton and Georgetown County have the highest average litter density (0.91 items/m^2), while Cherokee County has the lowest (0.24 items/m^2) (Table 32). Pawleys Island, the coastal area of Georgetown County, has a litter density 2.4 times lower than inland Georgetown County. All the communities surveyed had tobacco products and plastic fragments in the top litter materials, with cigarettes as the top litter item. Recyclables were present in the litter surveys in all locations except Pawleys Island. They all had aluminum/tin cans and paper or plastic bottles in the top litter list.

Table 32: Rural Community Leakage Comparison

Rural Community	Average Litter Density (items/m^2)	Top Litter Materials	Top Litter Item	Recyclables in Top Litter Items List
Tifton	0.91	1. Tobacco Products 2. Plastic Fragments 3. Food Plastic	Cigarettes	Paper & Aluminum/Tin Cans
Cherokee County	0.24	1. Tobacco Products 2. Food-related Plastic Packaging	Cigarettes	Paper & Aluminum/Tin Cans

		3. Plastic Fragments		
Georgetown County	0.91	1. Plastic Fragments 2. Tobacco Products 3. Plastic Fragments	Cigarettes	Aluminum/ Tin Cans & Plastic Bottles
Pawleys Island	0.38	1. Tobacco Products 2. Plastic Fragments 3. Metal	Cigarettes	n/a

The three rural communities' leakage data highlighted opportunities that could be implemented throughout the US EPA Region 4. Rural communities could address the top littered item, cigarettes, with additional policies and public campaigns upstream. Cigarette collection bins could be installed throughout the area. The communities could identify gaps in convenience center locations with continued litter monitoring. Yard or road signs could be placed throughout the community to remind people not to litter. Also, trash cans and recycling bins could be placed at the entrances of recreational areas (tourism/shopping centers/ parks) to capture the litter and recyclables entering the environment.

CHAPTER 6

DISCUSSION AND FUTURE WORK

6.1 | Discussion

There is a lack of studies on rural waste management in the US, so it is imperative to explore the challenges that rural recycling faces. Additionally, rural areas are a key part of increasing the nation's recycling rate. Increasing the recycling rate is more efficient than addressing the subsequent impacts of landfilling or leakage. Our goal was to examine rural recycling in three communities in the Southeast US, EPA Region 4, to better understand their challenges.

In this report on overcoming barriers to rural recycling, the aim was to accomplish three goals: (1) characterize circularity within each rural community in the cohort using the CAP, (2) compare community circularity across the cohort, and (3) provide insights on how to increase rural recycling resilience across the cohort and region.

The first objective, to characterize circularity within the three rural communities, was accomplished. The CAP fieldwork, conducted from August 2022 to May 2023, was followed by data analysis, which generated key findings and opportunities. This was shared with the rural communities and will be publicly available. Our next goal, to compare community circularity across the cohort, was completed in Chapter 5. This allows readers and rural communities to see the similarities and differences in circularity between the cities. Finally, opportunities were recommended to increase rural recycling resilience in the cohort based on similar challenges observed in the region. It is up to the community's discretion which opportunities they pursue

based on their perspective on feasibility and cost-effectiveness. Strategically combining opportunities might result in a larger impact. It is important to note that while there have been some recent federal changes, currently grant opportunities still remain an option for these cities.

Collaboration is essential to overcome barriers to recycling. Research shows that working together yields greater benefits than individual efforts (Lasker et al., 2001), and successful collaboration requires not only coming together but staying and growing together (Savage et al., 2023). Rural communities often have limited funds and staff, so partnerships with stakeholders like NGOs, volunteer groups, and local universities are helpful for long-term success. Strengthening these collaborative efforts to implement opportunities outlined in this work can improve the resilience and effectiveness of rural recycling programs. Rural communities throughout the region can use the key findings and opportunities to improve their recycling programs.

6.2 | Future Work

The US EPA Region 4 includes eight states and six tribes, encompassing 66.9 million people, representing 20% of the US population (US EPA, 2021b). This work focused on two rural counties and one rural city in three states (Georgia, North Carolina, and South Carolina) in Region 4, a small sample size. Each rural community has its own unique situation and findings. Common opportunities were pulled from the data of the three rural communities. This is the beginning of understanding the challenges that rural recycling faces in Region 4.

While these three locations in Region 4 represent the rural areas of the region, opportunities can be applied elsewhere in the region, more cities may want site-specific CAPs. The CIL is finalizing data collection and training for CAPs into online portals as a part of a

National Science Foundation project. The online data portal will allow rural communities to find cities with similar characteristics and explore relevant opportunities. The shared data and lessons learned can inform and support local and state-level interventions. The CIL's current data dashboard includes Urban Ocean cities and can be found here: https://www.circularityinformatics.org/interactive-data.

This study could be expanded by revisiting certain spokes to collect data and observe change over time. For example, the leakage data can be recollected in different seasons to assess tourism's impact. Additionally, if certain policies are passed or changes are made, impacted CAP spokes can be redone to assess the effectiveness of the change (e.g., a plastic bag ban should mean they are no longer in stores). Leakage data should not be collected during or right after a rain event, as the rain can wash away litter on the ground, as was the case for Cherokee County.

6.3 | Broader Impacts

This research helps to address the gap in US rural recycling research and literature. It allows for a better understanding of rural recycling challenges that communities in Southeast US, EPA Region 4, face. This is especially important because it targets improvements in disadvantaged areas like rural communities that disproportionately experience the environmental effects of mismanaged waste (Tunnell, 2008; UNEP & International Solid Waste Association, 2024; US EPA, 2021a). The majority of the rural community populations live in a CEJST-classified disadvantaged area.

The US EPA set a goal to increase recycling, including composting, to 50% by 2030 (US EPA, 2024c). However, the 2018 recycling rate was 32.1%, comprised of 23.6% mechanical recycling and 8.5% composting (US EPA, 2020b). Rural areas comprise 20.3% of the U.S.

population yet cover 87.4% of the nation's land area (HSRA, n.d.). Focusing on this large potential can contribute to the US EPA's goal of increasing recycling.

Throughout the project, each rural community's solid waste management contact has had access to the data and key findings. They've been involved in meetings to discuss the initial opportunities and provide feedback. Georgetown County already used the data to apply for further US EPA grants. Cherokee County plans to use some opportunities presented as ideas to apply for state-level recycling grants to increase the amount collected. The EPA grant that this project was funded by also set aside a small amount of money for the rural communities to use to address their recycling infrastructure. Georgetown County paid for recycling education field trips at the MRF. Cherokee County is placing an LED digital readout sign at the landfill entrance to notify the public about Cherokee County Recycling, Landfill, and Solid Waste Department hours, news, and events. The CAP empowers communities and informs decision-making. In the future, the data can be used for policy and decision-making in waste management or plastic pollution interventions specific to each community. The data, key findings, and opportunities will be publicly available, allowing other rural communities in the region and throughout the US to access and implement some of the opportunities if they face similar challenges. This will allow rural communities throughout the US to have a more resilient recycling system, a component of circularity, and implement other circularity solutions.

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APPENDICES

Appendix A: Full List of Litter Items and Associated Material Categories from the Site Assessment List in MDT

Material	Items
C&D Materials	Aggregate and Brick
	Bolts, Nails, and Screws
	Building Materials
	Lumber
	Other C&D
Cloth	Clothing
	Fabric Pieces
	Other Cloth
E-Waste	Batteries
	E-Waste Fragments
	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
	Metal Bottle Caps or Tabs
	Metal Fragments
	Other Metal
Organic Waste	Food Waste
	Other Organic Waste
Other	Other
Other Plastic Products	Bulk Bags
	Flip Flops
	Other Plastic
	Plastic String, Tape, or Packing Straps
	Rubber Bands
	Tires
Paper	Coated Paperboard

	Corrugated Cardboard
	Multi-material Paper Box
	Noncoated Paper Food Wrapper
	Other Paper
	Paper
	Receipts
Personal Care Products	Blister Pack
	Cotton Buds
	Other Personal Care Product
	Personal Care Product Sachet
	Shampoo or Other HDPE Container
	Toothbrushes
	Toothpaste or Other Product Tube
Plastic Food Products	Foam or Plastic Cups or Lids
	Other Food-Related Plastic
	Other Plastic Bag
	Plastic Bottle
	Plastic Bottle Cap
	Plastic Food Wrapper

	Plastic Grocery Bag
	Plastic Utensils
	Straws
	Street Food Bowl
	Styrofoam Container
Plastic Fragments	Film Fragments
	Foam Fragments
	Hard Plastic Fragments
	Other Fragments
PPE	Associated PPE Packaging
	Disinfected Wipes
	Disposable Gloves
	Face Mask Packaging
	Face Masks
	Face Shield
	Hair Nets
	Hospital Shoe Covers
	Other PPE
Tobacco Products	Cigarette Packaging

	Cigarettes
	Other Tobacco Product
	Tobacco Sachets