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# An Assessment of Macroplastic Litter Surrounding Four Freshwater Lakes in Columbus, Georgia

Clara Ray

The United Nations Environment Programme identifies plastic pollution as a major environmental issue (Blettler, Ulla, Rabuffetti, & Garello, 2017). Despite this, researchers note a distinct lack of research regarding plastic pollution in the world's freshwater ecosystems (Blettler et al., 2017). The purpose of this study was to find the concentrations and characteristics of shoreline plastic pollution surrounding four public lakes in Columbus, Georgia. A plastic debris assessment was conducted per guidelines from the National Oceanic and Atmospheric Association (NOAA) (Lippiatt, Opfer, and Arthur 2013). The average concentration of macroplastic debris amongst the four sample lakes was 0.151 particles per m², and the primary functional use of this debris was foam food containers. Out of the four sample lakes, Cooper Creek Lake had the highest concentration of macroplastic debris with 0.41 items per m², or 205 items in an area of 500 m².

*Keywords:* plastic pollution, lakes, freshwater plastic, macroplastic, lakeshore

## Introduction

The world is currently in a period of mass plastic production referred to by some experts as 'The Plastic Age' (Wagner et al., 2014). The rise of plastics began in the mid-twentieth century due to the material's durability and wide array of uses (Ryan, 2015). Even though this new material allowed for an increase in global productivity, it did not come without consequences. It is estimated that 192 coastal countries produced 225 million tons of plastic waste in the year 2010 alone (Jambeck, 2015). Ultraviolet radiation from the sun causes plastic to photodegrade into smaller plastic particles, also known as microplastics ( 5 mm), which means that plastic pollution never completely cycles out of the environment naturally (Ryan, 2015). Approximately 4.8 to 12.7 million tons of plastic entered the oceans in the year 2010 (Jambeck, 2015). A lot of this marine plastic pollution originates on land, flowing through miles of freshwater systems before emptying into the ocean. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) reported that in 2010, 70-80% of marine plastic flowed into the ocean via freshwater rivers (GESAMP, 2015).

Due to the durable nature of plastic, the inorganic material can be detrimental to the health of aquatic ecosystems. Fish and aquatic birds can become entangled in plastic nets, which can lead to drowning or reduce their ability to feed (Sigler, 2014). A 2016 report by the United Nations indicated that over 220 marine species sampled had ingested microplastic debris (Smith, Love, Rochman, & Neff, 2018). Ingestion of plastic debris can cause internal damage and blockages, sometimes leading to the death of the organism (Sigler, 2014). However, large portions of plastic debris are not the only threat to aquatic health. Researchers at Johns Hopkins University's Department of Environmental Health and Engineering have determined that when aquatic organisms consume microplastic, the plastic bioaccumulates through the food chain and is then indirectly consumed by humans via seafood (Smith et al., 2018). Plastics of any size may have a negative impact on biodiversity and life in aquatic ecosystems if left unaddressed.

## Literature Review: Freshwater Plastic Pollution

Although marine pollution generally gains more public awareness, plastic debris is still prevalent in the world's freshwater lakes, rivers, and streams. A 2017 survey conducted by scientists at the National Institute of Limnology documented the concentration of plastic debris surrounding the floodplain lakes of the ninth largest river in the world, the Paraná (Blettler et al., 2017). The researchers sampled plastics along these lakes in the following sizes: microplastics ( 5 mm), mesoplastics (5 mm to 2.5 cm), and macroplastics ( 2.5 cm) based on the diameter of the plastic debris. These categories are a standardized way for researchers to compare plastic debris based on its size. The goal of the Paraná survey was to determine the spatial distribution of plastic debris along these lakes, as well as their characteristics and resin types. Bletter, Ulla, Rabuffetti, & Garello (2017) reported that an average of 217 macroplastic items were found at each 50 m by 5 m transect of shoreline, or a concentration of 0.868 macroplastics per $m^2$. Microplastic debris averaged at 704 fragments per $m^2$. The researchers noted that the concentration of debris found was "alarming" and plastic bags and food containers were the primary types of plastic pollutants (Bletter et al., 2017).

In the past decade, several studies have been conducted to quantify plastic pollution around the Laurentian Great Lakes, the largest bodies of freshwater on Earth. One study recorded the distribution and degradation of plastic along the beaches of Lake Huron (Zbyszewski & Corcoran, 2011). This survey sampled seven beaches surrounding Lake Huron and found an uneven distribution of plastic pollution among them. While no fragments were found at three of the beaches, a total of 3,209 plastic fragments of varying sizes, including macro and microplastics, were found among the other four. Those four beaches only had a combined surface area of 85 $m^2$, therefore approximately 37.753 pieces were collected per $m^2$. Zbyszewski and Corcoran (2011) reported that Lake Huron still had relatively fewer plastic fragments on its beaches when compared to marine environments. However, plastic pellets were comparatively more abundant around the lake per area than is typical of marine beach surveys. This illustrates the importance of conducting freshwater beach litter assessments to determine if certain types of plastic are more prevalent at each specific lake or stream. Following this study, researchers at the University of Michigan modeled the distribution and transport of plastic pollution inside all of the Great Lakes (Cable, D. Beletsky, R. Beletsky, Wigginton, Locke, & Duhaime, 2017). This study reported that plastic debris inside the lake was distributed most abundantly around coastlines and urban cities, further suggesting the importance of plastic assessments along lakeshores.

## Public Awareness and Responses

The large volume of plastic waste entering water systems is partially due to improper disposal. A comprehensive study on the sources of oceanic plastic determined that the majority of marine plastic originates on land (Jambeck et al., 2015). The United States only has one piece of federal legislation requiring the Environmental Protection Agency (EPA) to regulate solid waste disposal: the Resource Conservation and Recovery Act (RCRA) (Juon, 2018). The responsibility is mostly left to U.S. state and local governments to develop laws addressing plastic recycling in their area (Juon, 2018). According to Allen, Coumoul, and Lacorte (2019), increasing public engagement is crucial to developing cleanup and prevention methods for issues with little public visibility; the researchers cite freshwater microplastic pollution as an example of a topic that the public may be uneducated on. Engaging volunteers or non-scientists directly in pollution cleanup is known as the "citizen science approach." When average citizens are involved in or aware of litter cleanup projects, they are typically more motivated to address issues like pollution in their communities (Cepuritis, Ulme, & Graudina-Bombiza, 2017).

## Research Objectives

While researchers have begun to assess plastic pollution along some of the world's major lakes, such as the Laurentian Great Lakes and watersheds of the Paraná, the field of freshwater plastic pollution research is still limited. The goal of this research study was to conduct a standard shoreline macroplastic lit-

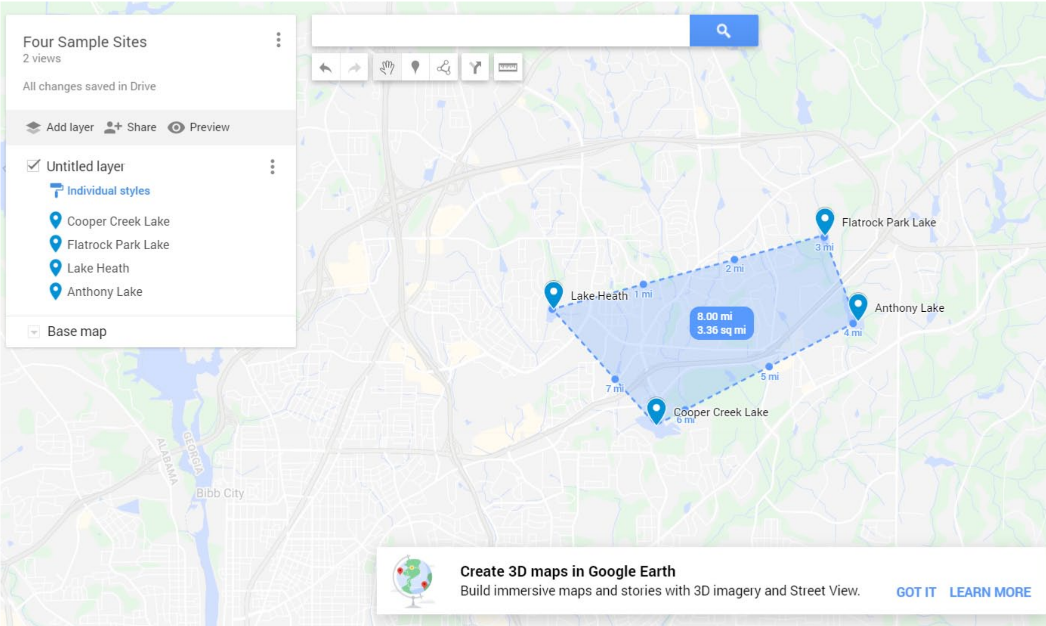


**Figure 1**
*All Four Sample Sites*

*Note:* This map showing all four sample lakes was generated online using the application *Google Maps* (2020). The area between the four lakes measured approximately 5.41 square kilometers (3.36 square miles). The perimeter of this area was approximately 12.87 square kilometers (8.00 square miles).

ter assessment along four public lakes in Columbus, Georgia. This observational study aimed to provide a more comprehensive understanding of the types and quantities of macroplastic litter surrounding some of the lakes in Columbus' environment. The sample lakes were Cooper Creek Lake (also referred to as Bull Creek Watershed Number Three), Flatrock Lake, Anthony Lake, and Lake Heath. Figure 1 below shows all four sample lakes and their proximity to one another.

The specific research objectives were to determine the following:

- Which of the four sample lakes had the highest concentration of shoreline plastic pollution?
- Which form of plastic pollution was most prevalent at each sampling location?
- What were the resin types of the plastic pollution based on the ASTM (American Society for Testing and Materials International) International Resin Identification Coding System?

## Methodology

The sampling sites for this study were Cooper Creek Lake, Flatrock Lake, Anthony Lake, and Lake Heath. Each of these are public lakes in Columbus, GA. Macroplastics (2.5cm) were chosen to represent the extent of plastic pollution at these lakesites because there is currently no standardized way to collect and measure microplastics ( 5 mm) in a water source. A lack of sampling standardization makes it difficult to compare microplastic content at different water sources (Mai, Bao, Shi, Wong, & Zeng, 2018). Furthermore, the equipment required to sample microplastics, such as a manta trawl and a density separation solution, were not readily available for this survey. This methodology was modified because according to the NOAA, quantifying macroplastic is a viable way to quantify plastic pollution, as it can easily be conducted and compared at multiple lake sites (Lippiatt et al., 2013).

### Sample-Site Analysis

The guidelines for collecting and analyzing the macroplastic particles was derived from NOAA Technical Memorandum NOS-OR&R-46, titled, "Marine Debris Monitoring Assessment" (Lippiatt et al., 2013). The methodology was slightly modified in the Blettler, Ulla, Rabuffetti, and Garello (2017) study for use on the shoreline of a freshwater lake. One of these modifications was the collection of macroplastic at only one time of day. In a marine environment, it would be necessary to sample at varying tidal levels, but Bletter et al. determined that this was not necessary during their study on lakes. This research study combined the recommended collection guidelines from Lippiatt, Opfer, and Arthur (2013) and the methodology used by Blettler, Ulla, Rabuffetti, and Garello (2017).

The NOAA recommends that at least one sampling site be selected that is 100 meters long and parallel to the shoreline (Lippiatt et al., 2013). For this research study, the shoreline of each lake was visually inspected to find the portion with the most visible plastic present. At each lake, this was typically the portion of the shoreline that was most accessible to people (such as being near a parking lot or restroom). The mobile application software *MilGPS* was used to measure a section of shoreline that was 100 meters in length. The application, found on the Apple App Store, uses satellite imaging to precisely measure selected distances in meters. The application was also used to provide satellite images of each sample lake. During the sampling process, plastic was not collected more than 5 meters from the shoreline. A meter stick was used on site to determine this distance. Flag markers were then placed in the soil at each corner of the transect.

### Macroplastic Sampling

Each sampling transect was visually inspected for macroplastic fragments. Plastic fragments were recorded on a data sheet and collected in a large garbage bag for further analysis in the lab. The plastic items were measured in the field to ensure that they were classifiable as a macroplastic. All visually identifiable plastics were collected, but plastics under 2.5 cm in diameter were not used as data in the survey since this research study specifically examined macroplastics. The sampling transects were surveyed multiple times to reduce the possibility of human error when visually collecting the macroplastics. Then, the materials were transferred to the lab for further analysis.

### Sample Analysis

First, each plastic item was washed, thoroughly dried, and counted. Then, the items were classified based on their functional origin and type. The following guidelines for sample classification were created in Technical Memorandum NOS-OR&R-46 (Lippiatt et al., 2013). Multiple fragments, that appeared to have once been one item, were counted as multiple pieces. If a fragment was identifiable as a specific item, such as a fragment of a drink bottle, it was counted as such if it was at least 50% of the original item. Any unidentifiable items were photographed next to a ruler for size reference and described based on physical appearance. The categories for functional origin included: beverage bottles, bags, food wrappers, other hard food containers/food service items, foam food containers, personal care product containers, fishing line, other (any item that does not fit into one of the categories were placed here and described), and unidentifiable. Similarly to the research study conducted by Bletter et al. (2017), each plastic item was then classified by type (hard plastic, film, line, or foam).

The plastic items were examined for their American Society for Testing and Materials (ASTM) Resin Identification Code (RIC), which were explained in the *D7611: Standard Practice for Coding Plastic Manufactured Articles for Resin Identification* manual (ASTM, 2016). This label is printed on plastic products to identify their resin type, and the varying labels with their corresponding resins can be found in Figure 2. The collected plastics with their RIC labels intact were sorted into additional categories based on their resin type. However, this was not possible for all fragments, as not all of them maintained their RIC label.

Finally, the macroplastic item concentration (number of debris items per m$^2$) per lake was calculated by dividing the number of items observed by the area of the sampling transect. The mean item concentration and standard deviation for all four lakes was calculated.

| Resin | Resin Indentification Code-Option A | Resin Indentification Code-Option B |
|---|---|---|
| Poly(ethylene terephthalate) | 1 PETE | 01 PET |
| High density polyethylene | 2 HDPE | 02 PE-HE |
| Poly(vinyl chloride) | 3 V | 03 PVC |
| Low density polyethylene | 4 LDPE | 04 PE-LD |
| Polypropylene | 5 PP | 05 PP |
| Polystyrene | 6 PS | 06 PS |
| Other resins | 7 OTHER | 07 O |

**Figure 2**

*Standard Resin Identification Codes*

*Note.* Published by the American Society for Testing and Materials in the *ASTM D7611: Standard Practice for Coding Plastic Manufactured Articles for Resin Identification* (2016).

# Findings

All four lakes were sampled on Sunday, February 9th, 2020, between the hours of 10:00 AM and 1:30 PM. Based on the NOAA's functional classifications created by Lippiatt, Opfer, and Arthur (2013), the following types of plastic were found at these sample lakes: beverage bottles, hard food containers, foam food containers, fishing line, personal care products, bags, and others. No "unidentifiable" macroplastics were found. According to NOAA guidelines, all macroplastics placed in the "other" category were described below when discussing the lake where they were located.

The primary type of plastic collected amongst the four lakes in Columbus was foam food containers, comprising 44% of all plastic collected. Foam beverage cups were the primary form of foam food containers found, but foam plates and containers were collected as well. Table 1, located below, shows the proportions in which each type of plastic was found. Overall, 302 pieces of macroplastic were collected in the sampling transects at each lake. The mean concentration of macroplastic was 0.151 particles per m$^2$, with a standard deviation of 0.177 particles per m$^2$. The standard deviation of this data being higher than the mean suggested that the data (concentrations of macroplastic) had a relatively high variability between the sample areas. Out of all 302 macroplastic collected, 103 pieces still had their RIC label intact. Amongst those plastic pieces, PETE, or polyethylene terephthalate, was the most common resin type documented.

The most polluted shoreline, according to the transect sampled, was Cooper Creek Lake. Approximately 67.9% of all plastic collected was recovered at this lake, and Cooper Creek had the highest concentration of macroplastic debris per m$^2$.

**Table 1**
Functional Use Categories and Resin Types

| Functional Use Category | Type | No. of Items | Resin | Percentage out of Total |
|---|---|---|---|---|
| Foam food containers | Foam | 133 | PS | 44% |
| Beverage Bottles | Hard | 96 | PETE, HDPE | 38.1% |
| Other hard food containers/food service items | Hard | 31 | PP | 10.3% |
| Bags | Film | 14 | _ | 4.6% |
| Food wrappers | Film | 12 | _ | 4.0% |
| Others | Hard | 10 | PP | 3.3% |
| Personal care product containers | Hard | 4 | _ | 1.3% |
| Fishing Line | Line | 2 | _ | 0.7% |
| Total | _ | 302 | _ | _ |

Note. The functional use categories are sorted by decreasing order of frequency. Resins within each "Resin" box are sorted by decreasing order of frequency. Dashes indicate that no data was present. Percentages may not add to 100% due to rounding. PETE = polyethylene terephthalate, PS = polystyrene, HDPE = high density polyethylene, PP = polypropylene.

## Anthony Lake

During a field survey of Anthony Lake, it was noted that the lake is surrounded by two residential neighborhoods and one apartment complex. The lake primarily serves as a watershed of Bull Creek and the Chattahoochee River, but it is also used for recreational fishing. The 100 meter sampling transect that was surveyed is shown in Figure 3 below. The concentration of macroplastic debris along the shoreline of Anthony Lake was 0.112 items per m$^2$. In total, 56 pieces of macroplastic were collected in the sampling transect at Anthony Lake. The primary type of plastic debris collected at Anthony Lake was beverage bottles, with 33 out of the 56 items being bottles. Out of all plastic debris collected, 23 pieces still had their Resin Identification Code (RIC) intact. The most common type of resin discarded along these lakes was Polyethylene Terephthalate (PETE). Five macroplastics were collected that did not fall under one of the fixed functional use categories, and were therefore placed in the "other" category. These macroplastics included two hard plastic chewing tobacco containers, two hard plastic toy balls, and one hard plastic pen cap. None of these items had an RIC label present.

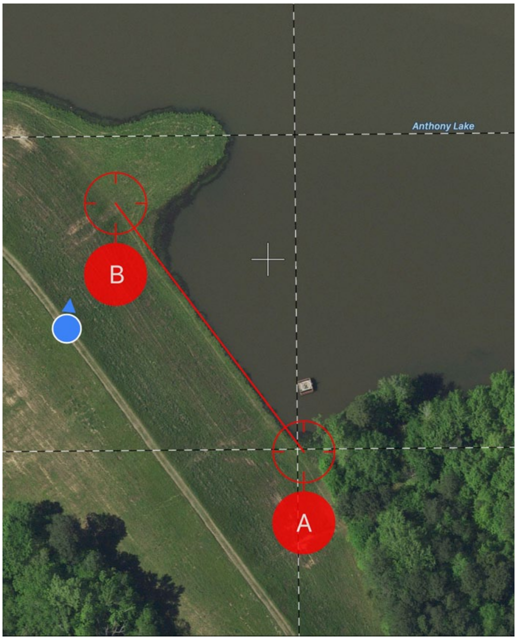


**Figure 3**
*Satellite image of Anthony Lake*

*Note.* The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

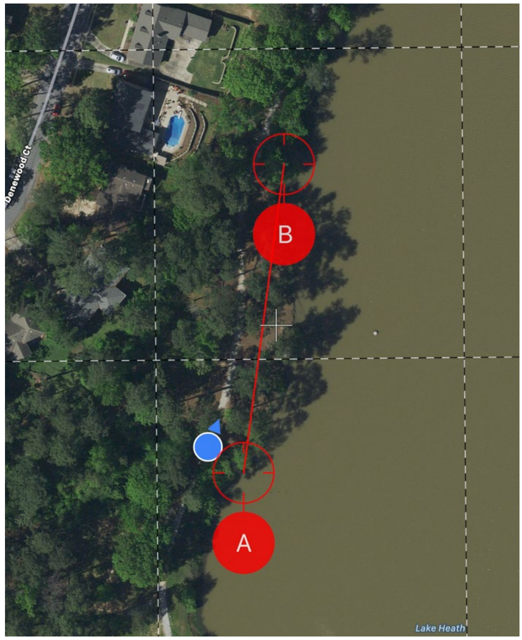


**Figure 4**
*Satellite image of Lake Heath*

*Note.* The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

### Lake Heath

Lake Heath is located inside Heath Park, which is surrounded by a residential neighborhood. A walking trail surrounds the entire lake, which makes the shoreline of the lake highly accessible to the public. Figure 4 below shows the 100 meter sampling transect parallel to the shoreline where plastic was collected. Lake Heath was the least polluted by macroplastic according to this debris assessment. Eight pieces of macroplastic were collected in the sampling transect at Lake Heath. When calculated, the concentration of macroplastic in this transect was 0.016 items per $m^2$. The primary functional use of this plastic was beverage bottles. The most common type of plastic resin found was PETE, according to the RIC label found on some of the plastic debris. One macroplastic item from Lake Heath was placed in the "other" category: a hard plastic pair of toy eyeglasses. The item did not have an RIC label present.

### Cooper Creek Lake

Cooper Creek Lake is located inside Cooper Creek Park. The lake primarily serves as a watershed for Bull Creek, also located in Columbus, GA. Cooper Creek Lake is alternatively named Bull Creek Watershed Number Three. The lake is also a recreational fishing location in Columbus, and the park features amenities inside it such as tennis courts and concessions. A total of 205 macroplastic items were collected in the sampling transect along Cooper Creek Lake. The image below, Figure 5, shows the portion of the shoreline that was sampled. The concentration of macroplastic debris was 0.41 items per $m^2$. At Cooper Creek Lake, four macroplastic items were placed in the "other" category. The "other" items included: one hard plastic chewing tobacco container, one hard plastic toy ball, and two hard plastic pill bottles. The two pill bottles were labeled as the resin type PP.

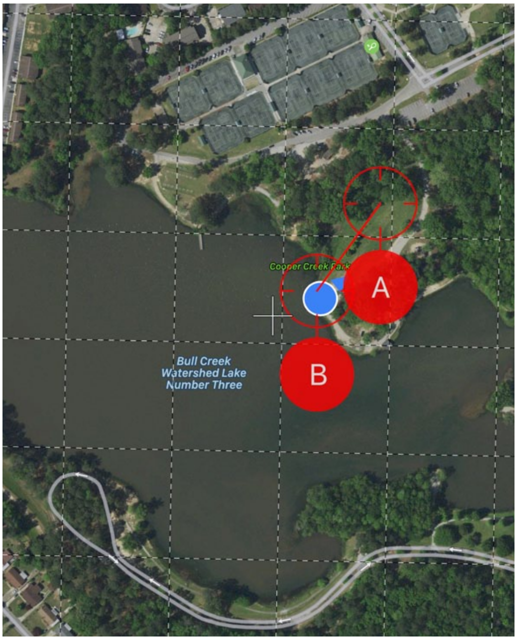


**Figure 5**
*Satellite image of Cooper Creek Lake*

*Note.* Cooper Creek Lake is also known as Bull Creek Watershed Number Three. The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

### Flatrock Lake

Flatrock Lake is located in Flatrock Park, one of the largest parks in Columbus according to the Columbus Parks and Recreation web page titled, "Parks" (n.d.). This was the only lakesite that was not within viewing distance of any residential homes or industries. A total of 33 pieces of macroplastic were collected in the following sampling transect along the shoreline of Flatrock Lake. The concentration of macroplastic debris was 0.066 items per m². No "other" macroplastic items were collected here.

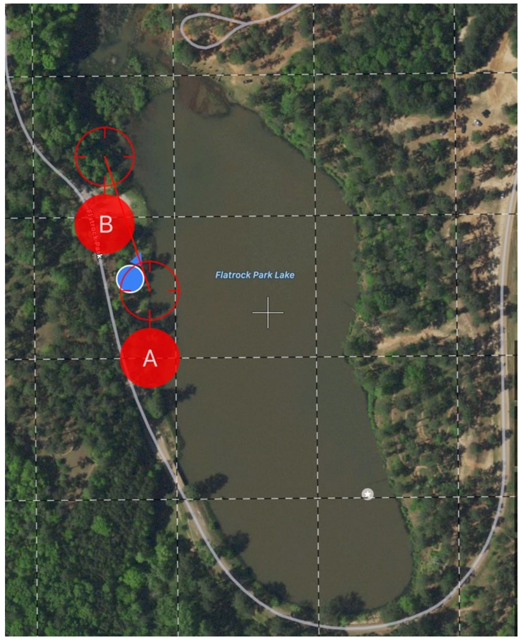


**Figure 6**
*Satellite image of Flatrock Park Lake*

*Note.* The red line from point A to B represents the sample transect. Image retrieved from the mobile software application *MilGPS* (2020).

## Discussion

### Limitations

Before discussing the results of this macroplastic assessment, the following limitations should be taken into consideration. There was opportunity for human error during the macroplastic collection process because plastics were visually removed from the sampling transect. There was room for human error once again during the process of counting the macroplastics collected at each lake. This type of error could have caused the collected number of macroplastics to differ from the true number of macroplastics in each transect. Although the NOAA guideline specifically requires the description of infrastructures and water sources surrounding the sample sites, it does not provide an explanation for the correlation between these features and the macroplastic concentrations (Lippiatt et al., 2013).

Furthermore, the findings about resin types were limited because not all macroplastic items had their Resin Identification Code (RIC) intact. This means that the primary resin type collected at each sample transect may be influenced by the durability of that resin, and not truly representative of the present quantities of each resin. Previous research studies have used a device called a FT-IR spectrophotometer to determine the resin type of all other plastic items, but this device was not available for this study (Bletter et al., 2017).

Because samples were only collected on one date, the weather, season, or one event may have influenced the concentration of macroplastics. The time constraints of this study meant that it was not possible to sample these lakes during both the summer and winter seasons. The human interference at these lakes could have had a varying impact during a different time of year. However, this study was merely observational and did not test that hypothesis. Specific figures regarding the level of human traffic were not available for these sample lakes, meaning that no concrete data about this could be provided.

Any correlations between variables were not implied to show a causational relationship. For example, if a lake with a recycling bin was proven to have a higher shoreline macroplastic concentration, this study does not prove that those two variables have a cause and effect relationship. The results of this assessment were also limited to the four lakes which they were conducted and may not be applied to any other lakes in the area. The limitations of this macroplastic assessment mean that these results should only be taken in context and applied to the areas sampled.

## Results in Context

The findings at these four sample lakes, including macroplastic concentration and primary type of plastic found, were then compared with previous studies at other lakes. The Bletter et al. (2017) research study was the most similar to this study because it assessed macroplastic along the shoreline of a freshwater lake. Bletter et al. (2017) also used the same methodology for collection that was used in this study, as recommended by Lippiatt et al. (2013). Surrounding their sample lake, the researchers collected an average of 0.868 macroplastics per $m^2$ amongst all sampling transects. The average concentration of macroplastic was lower at Columbus lakes, where it was 0.1510 particles per $m^2$. Bletter et al. (2017) found the following types of plastic most often (in descending order of abundance): food wrappers, bags, and foam food containers. This differed from the four Columbus lakes sampled where foam food containers were the most abundant type of macroplastic, followed by beverage bottles and other hard food containers.

### Resin Types

Each type of plastic resin has different physical properties and therefore different specific advantages. However, there was a commonality among all resin types found in the sampling transects: according to a web page published by the American Chemistry Council (n.d.), each resin type found in this study is primarily used for some type of food/beverage container. Four of the major seven types of plastic resin were represented in this study: Polyethylene Terephthalate (PETE), High Density Polyethylene (HDPE), Polystyrene (PS), and Polypropylene (PP), in decreasing order of frequency. The American Chemistry Council (n.d.), states that PETE is a relatively tough form of plastic, "...making it ideal for carbonated beverage applications and other food containers." This application is evident in the results of this study, as all PETE collected was in the form of a beverage container. Furthermore, the durable nature of PETE may have increased the frequency in which it was located at the sample lakeshores. HDPE is also primarily used for food packaging. Although it is more versatile than PETE, it does not create a barrier for gases, making it ineffective as a carbonated beverage container. Because it can be molded into a film, it is often used to package snack foods (American Chemistry Council, n.d.). All HDPE collected at the sample sites was formed into a non-carbonated beverage bottle. The American Chemistry council notes that PS and PP are both versatile types of plastic which are primarily used in packaging. PP may have been overestimated in this study compared to other resin types due to its noted resistance to water allowing it to persist in the lake environments. PS may be formed into foam or hard plastic. However, it is mainly used for foam food containers, which is supported by the results of this study.

### Recycling Systems

The Columbus Consolidated Government collects recyclable materials, including some plastics, from residencies via a curbside collection system. Besides residential collection, Columbus, Georgia has four recycling drop-off trailers, but only one is located at a public park (Columbus Recycling & Sustainability Center, n.d.). A recycling drop-off trailer is placed approximately 18 meters from the shoreline of Cooper Creek Lake. This was the only lake in the survey that was located near any type of container for recyclable waste. Despite the convenient location of this recycling drop-off container, Cooper Creek Lake still had the highest concentration of macroplastic debris of all sampled lakes. Normal waste disposal bins were located around the shoreline of each lake except for Anthony Lake. This was likely due to the fact that the other three lakes are located inside a public park, while Anthony Lake is not.

The primary functional use of macroplastic collected at the four sampling transects was foam food containers. The majority of these were foam beverage cups, but foam take-out containers and foam fragments were also collected in high frequency. This is concerning because Columbus' city recycling department does not recycle polystyrene or styrofoam (Columbus Recycling & Sustainability Center, n.d.). This provides another obstacle for citizens of Columbus who wish to recycle styrofoam waste. On the Columbus Recycling & Sustainability Center's webpage, it states that they do not recycle some other plastic items, including plastic bags, plastic toys and plastic straws.

## Conclusions

The results of this macroplastic assessment conducted on Cooper Creek Lake, Flatrock Lake, Anthony Lake, and Lake Heath have expanded the current knowledge about lakeshore pollution in Columbus, Georgia. The specific conclusions to each of the previously stated research questions were the following:

The sample lake with the highest shoreline macroplastic concentration was Cooper Creek Lake with a concentration of 0.41 items per $m^2$. The concentrations of macroplastic at the sample sites of each other lake were as follows: Anthony Lake (0.112 items per $m^2$), Flatrock Lake (0.066 items per $m^2$), and Lake Heath (0.016 items per $m^2$). The average concentration between the four lakes was 0.151 particles per $m^2$, with a standard deviation of 0.177 particles per $m^2$. In total, 302 macroplastic pieces were collected.

The dominant functional use of the macroplastic debris amongst the sample lakes was foam food containers.

According to the ASTM's Resin Identification Codes, the primary type of plastic resin located along these shorelines was PETE, or polyethylene terephthalate. Out of the seven main plastic resin types, PETE, PP, HDPE, and PS were found at the sampling sites (with their RIC label intact). The other types of plastic resin may have been located at the lakeshores; however, they were either unlabeled or their label was no longer present.

## Future Implications

When considering these conclusions, this study suggests that more plastic cleanup projects should be focused at these sample lakes, specifically at Cooper Creek Lake. One possible solution to this plastic debris would be the "citizen-science approach" suggested by researchers Cepuritis, Ulme, and Graudina-Bombiza in 2017. They argued that getting the public involved in environmental science projects would increase their knowledge and care for these issues. Using that logic, if the public were to engage in future macroplastic assessments, they would be able to clean up more plastic while simultaneously gaining awareness of the issue.

Considering that the lake with the highest concentration of macroplastic debris was the only one near a recycling receptacle, this evidence recommends further research to evaluate the effectiveness of Columbus' recycling system. As suggested previously in the study, the results of this macroplastic assessment could be used to make targeted recycling campaigns. For example, the city government, or even local restaurants, could make flyers encouraging the proper disposal of foam food containers. This research particularly highlights the issue of foam plastic debris in the environment. Between all four sampling transects, 133 pieces of foam were recovered, accounting for approximately 44% of all macroplastic particles. This type of plastic had no chance of being recycled by the city government's recycling system.

More macroplastic assessments should be conducted on lakes in the future in order to provide context for the concentrations of macroplastic found at these sample lakes. In the field of lakeshore pollution, it is still unclear when a concentration of macroplastic becomes a significant threat to the lake. Although the results of this study bridge a small gap in understanding in this field, the characteristics of macroplastic around Columbus' lakes, the lack of freshwater plastic research makes it difficult to place these results in context. As discussed previously, the results of this study are only directly comparable to the results of the Bletter et al. (2017) research. Furthermore, if another plastic assessment were to be conducted on these lakes in the future, mesoplastics and microplastics should be sampled as well. This would provide a more detailed extent of plastic pollution in these lakes because plastic degrades and becomes less visible to the public eye. This would also fill another gap in freshwater plastic research, as few studies have been published regarding microplastics in freshwater compared to marine environments (Blettler et al., 2017).

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