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Mapping the Impact of A Trailway System on the Amount of Trash Present Within Two

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Mapping the Impact of A Trailway System on the Amount of Trash Present Within Two Watersheds of Lynchburg City, Virginia

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Senior Honors Project

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ABSTRACT

Transportation of debris within water systems is a prominent occurrence which has been linked to natural and artificial processes including wind, rain, and littering. This pilot study established methods to determine if a trail system is a good implementation to achieve recreation and connectivity goals laid out in the City of Lynchburg's *Tyreeanna & Pleasant Valley Neighborhood Plan*. Blackwater Creek watershed, which contains an established trail system, and Fishing Creek watershed, containing a non-established trail system, were the two locations where this study's methods were conducted. Use of the Virginia GIS Open Access Portal was essential in delineating the boundary lines of the watersheds, pinpointing study sites, and determining recreation access currently available in each watershed. Typical debris found included glass bottles, snack wrappers, tattered clothing, household decor, along with larger items such as couch cushions and traffic cones. Based on the collection results, both the presence of signage, distinguishing the greenway as protected, and the absence of nearby businesses to the waterway helped reduce trash accumulation in Blackwater Creek. With these findings I recommend that recreation development in the Tyreanna and Pleasant Valley section of the City of Lynchburg include signage displaying fines for littering, adding trash collection receptacles, and establishing city operated and protected parks.

Key Words: Fishing Creek (Lynchburg VA), litter, GIS, rivers and streams, greenway trails

1 | INTRODUCTION

Flowing water is a known transporter of pollutants and debris which eventually lead to a reservoir, bay, or ocean (Lebreton et al. 2017; NOAA 2021). This transportation occurs in many forms including runoff, along permeable and impervious surfaces, and through connecting waterways such as small streams (NOAA 2021). Multiple research publications reviewing waste in waterways refer specifically to the ocean; there are minimal studies focusing on smaller systems that are freshwater (Blettler et al. 2018). Specifically, a study conducted by Blettler et al. (2018) found that nearly 90% of publications relate to marine environments while less than 15% concern freshwater ones. The exact reason for the lack of broader research into waste and its management within river, creek, and stream waterways is unclear but could be attributed to their smaller size in comparison to the ocean (Blettler at al. 2018). As a result of the lack of research, investigation into whether freshwater systems are experiencing pollution issues, and what type of pollution is accumulating, must occur so that mitigation can be implemented.

Along with limited freshwater publications, much of the waste discussed in conducted research centers around plastic oriented debris. Plastic contributes to a lot of the waste laying or floating around in areas, but all types of aquatic trash are harmful to plants and animals along with humans and water quality health (EPA 2015). In terms of plastic waste, recreational areas and higher plastic densities go hand in hand (Tasseron et al. 2020). A litter examination done by Keep America Beautiful (2009) found that the composition of both small and large debris in recreational areas consists not of plastic but rather mainly of smoking products, confections and food-related items. A research study conducted by Shafer et al. (2000) determined that visitors who frequent greenways are concerned about pollution, the amount of natural area present, and accessibility as quality of their enjoyment while visiting recreation areas, but people do not believe they are what results in pollution spread. Despite this conclusion, pedestrians have been found to account for a total of 98.5% of debris accumulation resulting in them being the number one contributor of litter (Keep America Beautiful 2009). Although it has been concluded that recreational areas such as greenways tend to accumulate debris which could deter visitors, there are obvious other factors and benefits that influence the persistent use of these activity centered areas.

By definition, greenways are openspace connectors providing the opportunity to view riparian environments, improve residents' quality of life, and are important for urban sustainable development (Guglielmino 1997; Palardy et al. 2018). Coming into fruition in the early 1950's, the expression 'greenways' was originally developed to describe city based recreational trails for local, non-motorized, resident oriented use (Greenways Poland Association 2014); today they are most commonly referred to as trailways. Trails provide community members with activities away from the hustle and bustle of city life such as access to under-visited destinations, transportation to neighborhoods and businesses, and adventures through adjacent trail segments (Hayes and MacLeod 2008; Shafer et al. 2000).

All forms of greenways impart social, environmental, cultural, and economic facets to residents which is why trailways have grown to be experience based areas that people visit on a consistent basis (Hayes & MacLeod 2008). While trailways supply a multitude of benefits to city occupants, the riparian areas which trails are being established within are being disturbed by visitors. Upon development, the stream and its surrounding characteristics, watercourses [ie. flood plains and streambanks] and flora, become susceptible to disease and harmful modifications as a result of human foot traffic and waste left out from land-based human activities (USDA 1996; EPA 2015). Litter is known to breed bacteria which spreads disease to plants or humans, is harmful towards ecosystems by interfering with plant growth, and introduces non-native species to areas during its travel (United States Environmental Protection Agency 2015). Based on the benefits and disadvantages stated above, it can be concluded that greenways likely help reduce trash when people feel motivated to clean the area, but they may also be a source of trash, depending on the land usage. As a result, analysis of trail access points and trash accumulation in these areas must be conducted to determine whether people are more inclined to clean up or create debris accumulation.

Utilizing the Geographic Information Systems (GIS) Mapping process makes data management and analysis easier when researching trail access and trash accumulation. GIS allows researchers to organize data by creating visualizations in the form of maps, assisting in the understanding of geographic details of the world around us. States have their own online parcel viewer containing local data in tables which can be converted to a visually represented point on a map. Since this study was conducted in Virginia, the Virginia GIS Open Access Portal (2021) was used to obtain specific data layers to assist in this research. GIS descriptive statistics concerning current recreation (including trail) and park access points were initially obtained. Descriptive statistics display these key areas to examine as they have been found to contribute significantly towards trash accumulation. From this data, three study sites were then pinpointed along Blackwater Creek and Fishing Creek to conduct physical debris collection. Surveying quantities and types of items typically found at these areas was performed to determine where recreational development helped or hindered trash spread. From the data obtained we aimed to gain a better understanding of a trail system's influence on the amount of trash present within a watershed and what areas within Fishing Creek would benefit from recreation development.

As a thriving and continually growing community, the City of Lynchburg has developed multiple projects outlining future upgrades to improve the city with respect to residential and recreation use. Plans include the *Comprehensive Plan 2013-2030*, The *Downtown 2040 Master Plan*, and the *Tyreeanna/Pleasant Valley Neighborhood Plan*. Initiatives outlined in these plans encompass providing access to paved trails, extending connectivity between distanced areas of the city, and identifying locations available for future recreation implementation (Planning Commission 2019 & 2022). Methods of this research, GIS mapping and data collection, assisted in determining whether implementation of a recreational greenway (trail system) within Fishing Creek watershed would be a worthwhile investment. Trail way development within Fishing Creek would increase neighborhood connectivity and recreational access as laid out in the *Tyreeanna & Pleasant Valley Neighborhood Plan* development. As well, the presence of the trail development could potentially provide reduction of litter spread and an increase of outdoor activity opportunities for residents within an underutilized area of the City of Lynchburg.

2 | METHODS

2.1 | Study areas

Measuring around 49.5 Sq. Mi. The City of Lynchburg is located at the heart of Virginia and contains a population of roughly 79,000 residents (United States Census Bureau 2020). Lynchburg is described as a growing region due to its rich history and multitude of activities throughout the city for community members to get involved in (Lynchburg Planning Commission 2019). The city’s prominent land use consists of agriculture, urban and industrial establishments. There is approximately 27,000 acres of land available with 644 acres dedicated for public parks yet most development has remained within the Blackwater Creek watershed, not extending into the north-east section where Fishing Creek watershed is (Lynchburg Planning Commission 2019). One key natural recreation feature currently present that residents and tourists frequent is the James River which flows across the Lynchburg landscape. A tributary of the Chesapeake Bay, the largest estuary in the U.S. and one which serves a population of over 17 million people, the James River plays a role in the continual flow of water to the Northern Atlantic Ocean (Yonkos et al. 2014). Both of the watersheds, Blackwater Creek and Fishing Creek, are feeders to the James River. All water that flows from the two creeks into the James River will eventually make its way to the Chesapeake Bay and ultimately the ocean.

Blackwater Creek is the largest creek in the City of Lynchburg (Figure 1) totalling an area of 31.8 Sq. Mi. (Virginia GIS Portal 2021). Based on Lynchburg City's total population, the Blackwater Creek watershed serves around 50,750 people. Its drainage area consists mostly of central, southern, and western sections of the city with some dominance in the northern part of Lynchburg. Upstream connecting waterways include Ivy Creek and College Lake. The surrounding area of the creek is dominated by residential housing, business development, and outdoor recreation such as parks and the entire Blackwater Creek Natural Area. A heavily used recreation area within the Blackwater Creek watershed is the paved James River Heritage trail, also known as the Blackwater Creek trail, that follows beside Blackwater Creek from Old Forest Road to the James River. The trail is not a straight walk as there are multiple offshoot unpaved trails leading to other sections of the city. Built in the 1980's, this trail is well established with historical signage, mile markers, and trailheads for users to have an immersive experience. Other attractive factors of the trail include bathrooms, handicap access, and its cleanliness which can be attributed to cleanup efforts. A multitude of other recreational areas are present in the watershed as well. Organizations such as VA Department of Environmental Quality, City of Lynchburg Parks and Recreation, City of Lynchburg Water resources and more have implemented these cleanups so that visitors of the trailway can enjoy their time without being surrounded by waste and other debris.

Fishing Creek watershed makes up 6.8 Sq. Mi. (Figure 1), roughly a quarter of Blackwater Creek's size (Virginia GIS Portal 2021). Containing nearly 11,000 people who live within it, the watershed drains sections of the east-central and south areas of Lynchburg City ultimately connecting to the James River. The creek begins near the intersection of Mayflower Drive and Young Place, but there are no known upstream waterways that feed into Fishing Creek. The surrounding area is dominated by industrial businesses with residential housing along the stretch of the creek. Additionally, the middle section of the creek follows beside the Lynchburg Expressway. Keep America Beautiful (2009) found that pedestrians contribute nearly 18% of litter found along roadways and highways making Fishing Creek more susceptible to litter. Only one recreational area is identified within the Fishing Creek watershed signifying the lack of natural immersion opportunities for residents within the area.

2.2 | GIS summaries

Use of the Virginia GIS Open Access Portal (2021) was essential in delineating the boundary lines of the Blackwater Creek watershed and Fishing Creek watershed and determining access to recreational activities. The boundary line of Blackwater Creek watershed was quickly delineated as Dr. Perault had partially done so in a previous lab course and other studies had created an outline while further researching the area (Blackwater Creek Planning Committee 2008). A readily available Fishing Creek watershed boundary line had not been created, requiring Dr. Perault and myself to establish its boundary on our own. After delineating the boundary line for Blackwater Creek watershed we used the ‘Stream Centerline’ data and our knowledge of water flow in and around the area of Fishing Creek to create its watershed boundary line.

Considering that the information from the Virginia GIS Open Access Portal (2021) for the watersheds extends outside of city limits, the consistency of data from surrounding counties to be used for comparison statistics was a concern. Due to this determination, data outside of the city was not pertinent to the study as the focus of this research is to aid City of Lynchburg officials in the *Tyreanna & Pleasant Valley Neighborhood Plan*. This resulted in the need for the out of boundary information to be removed from the data we used to complete this research. Using the ‘clip’ function in ArcGIS 10.1 (as depicted in Figure 2), both the Blackwater and Fishing Creek watersheds within the boundaries of the City of Lynchburg were delineated (Figure 1).

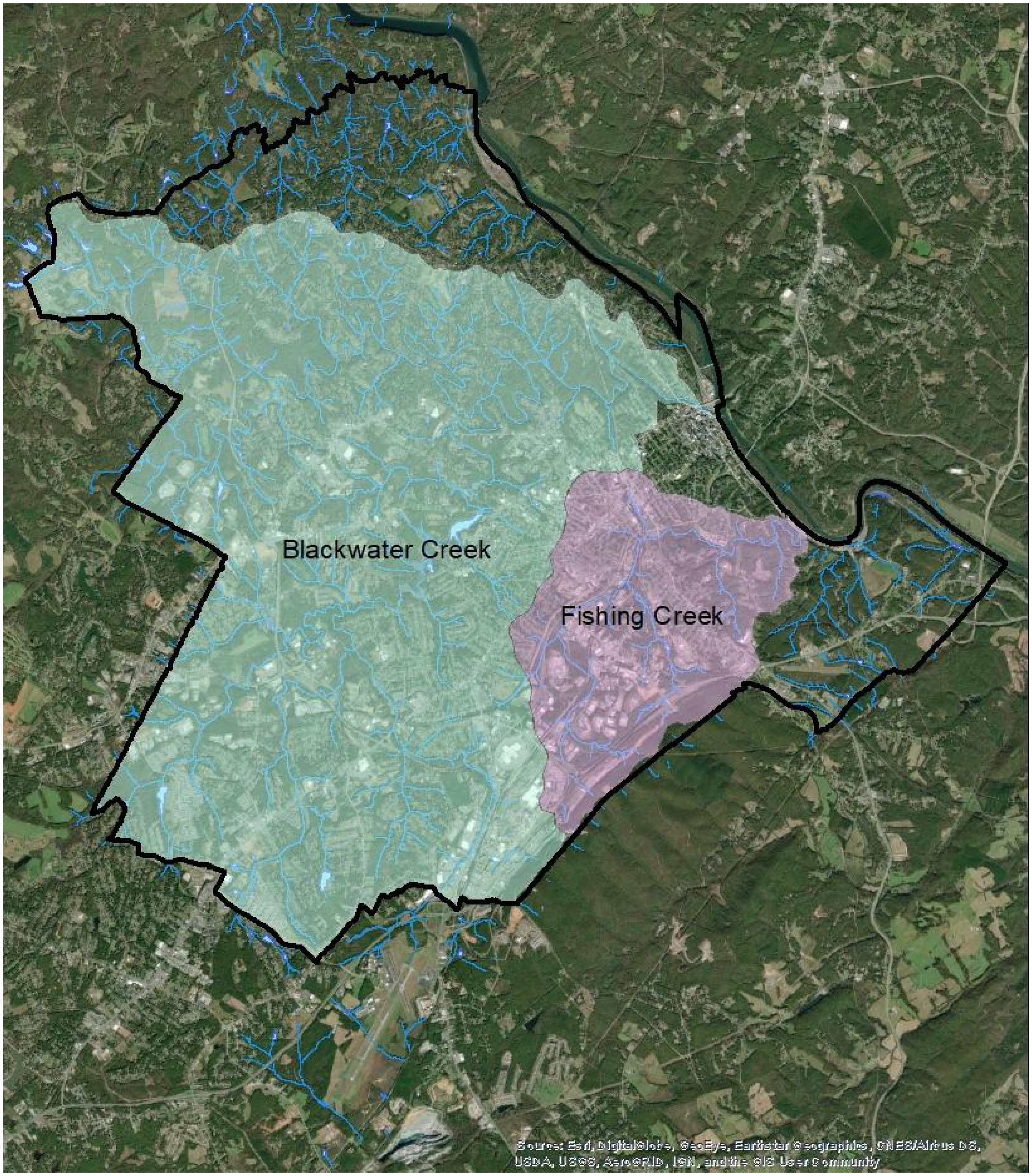

Figure 1. Map of Blackwater Creek (green) and Fishing Creek (pink) watersheds within the boundary of the City of Lynchburg (black line). The bright blue lines indicate streams in the entire city flowing throughout the two watershed drainages. Some of the streams reach outside of the City of Lynchburg boundary, but only those within the boundary were considered in this research. Created using ESRI's ArcGIS 10.1 and data collected from Virginia GIS Open Access Portal (2021).

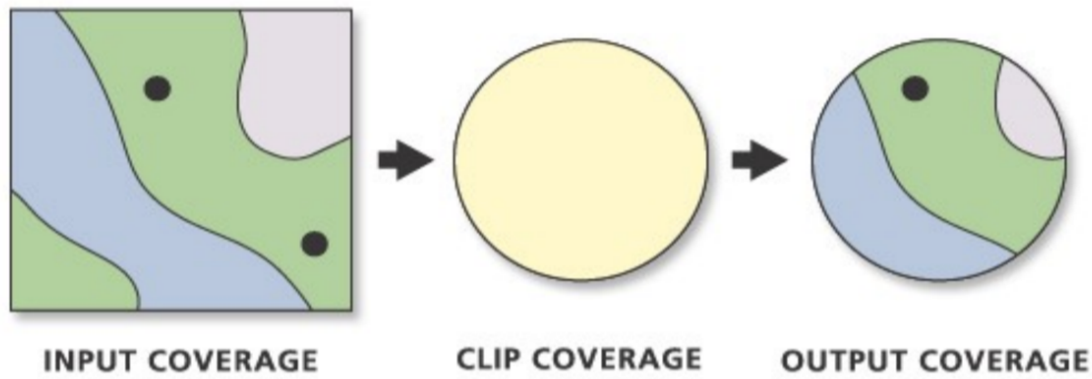

Figure 2. The Input Coverage displays the entire area being studied, in terms of this research, the City of Lynchburg. Using the Clip Coverage tool, we were able to minimize the study area and zone in on two specific locations, Blackwater Creek watershed and Fishing Creek watershed. These two watersheds are considered the Output Coverage. Once the two watersheds were specified, each could then be delineated based on the attribute calculations desired (ArcGIS 10.1).

GIS layers obtained from the open portal include zoning, parks, recreation access points, streams, contour lines and other features (Table 1). Each of these were useful to determine differences between the two watersheds. From the output coverage made for Blackwater Creek and Fishing Creek, we calculated the total area of each watershed, the percent area of Lynchburg City they take up, the mileage of streams, area of city parks, mileage and access points for trails, along with the area and its percent zoned resource conservation (RC). Resource Conservation refers to protecting natural resources (water, soil, timber, oil, etc) from over use by maintaining a fair amount of the resource to be available for future needs. Units for the studied areas were not specified by the Virginia GIS Open Access Portal (2021), requiring the use of ArcGIS's "measure tool" to determine them. The benefits of this feature include performing geodetic area measurements by drawing a polygon figure of the specified area to obtain the calculation of the unknown area of locations and features within each of the watersheds. The target audience of this research (i.e. general public and city officials) are most familiar with Square Mile (Sq. Mi.) measurements resulting in all calculations being converted to this.

2.3 | Site data collection

Criteria used to select sample sites within Blackwater Creek and Fishing Creek watersheds were determined primarily by the creek's proximity to a roadway and if the location could be easily accessed by foot. Access to the sample site was important to be able to collect data at each of the three locations (upper, middle, and lower) along the entirety of the two creeks. Due to weather, logistics, and the availability of helpers to conduct trash collection, each of the watersheds were visited at separate dates to accommodate those assisting with data collection. However, every attempt was made to replicate weather conditions leading up to each day of data retrieval, collecting effort was similar both days.

Depicted in Figure 3, the three locations for debris collection along Fishing Creek were at these coordinates: 37°23'52.6" N 79°09'10.2"W (upper collection point), 37° 23' 46.545" N, 79° 8' 18.1831" W (middle collection point), and 37° 23' 55.2106" N, 79° 7' 23.5016" W (lower collection point). Data collection was conducted on December 20th, 2022 on a high 30 to mid 40 degree day with clear blue skies, no cloud in sight, and sun shining. No large storms, which could influence trash travel, had occurred before the day of collection. The three locations for debris collection along Blackwater Creek were at these coordinates: 37°24'19.8"N 79°11'18.1"W (upper collection point), 37°25'25.9"N 79°09'33.8"W (middle collection point), 37°24'58.8"N 79°08'21.9"W (lower collection point) shown in Figure 3. Data collection was conducted on March 2nd, 2022 on a mid 60 to low 70 degree day with clear skies, sun shining bright. This data collection took place after some winter storms which could have influenced higher transport and accumulation of trash within an area.

Manual data collection was conducted along the sides of the creek, within the waterway, as well as on the road above the site if applicable. A total distance of 100 yards was walked upstream and downstream of the sample site to provide ample data collection. Six people per site assisted in debris retrieval. Each person was provided with gloves, a safety vest and a trash grabbing tool to ensure their safety during debris collection. Although some of the debris was too large to be placed into a trash bag, it was still collected and counted toward the grand total of trash obtained at the sites. In the case of debris being covered by heavy items or intertwined with greenery, it was left uncollected but recorded as part of visual data. Total time spent at each sample site was between 45-60 minutes. A general consensus of what types of debris collected from each location was written down to obtain results and understand differences of trash accumulation along the two creeks.

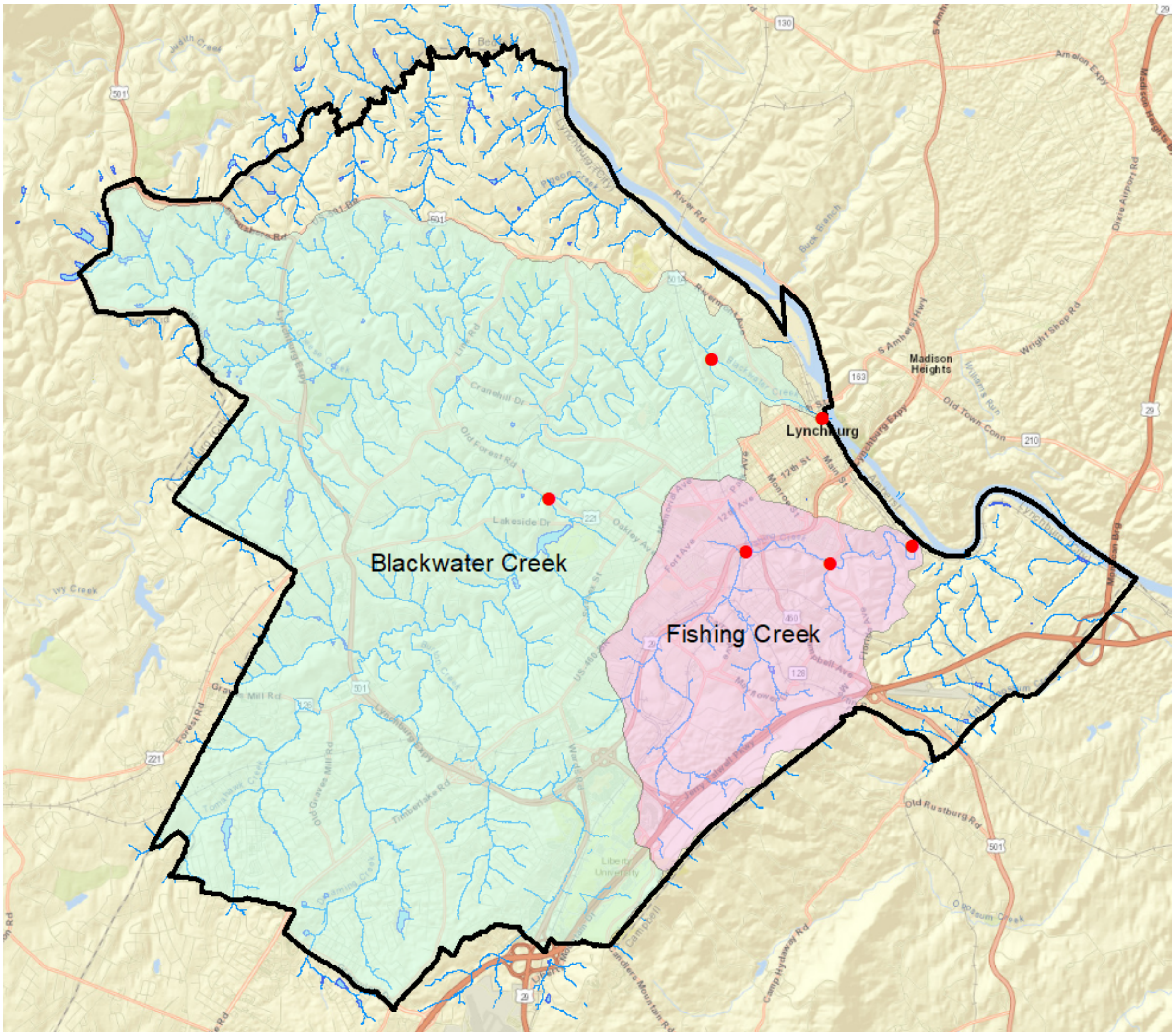

Figure 3. Red dots indicate three chosen locations for debris collection within both Blackwater Creek and Fishing Creek watersheds. This figure depicts the separation between each of the sites indicating the wide spread data collection that was conducted in this research.

3 | RESULTS

3.1 | GIS summaries

By means of the Virginia GIS Open Access Portal (2021), GIS data layers pertaining to the entire City of Lynchburg were acquired. For the purpose of comparisons between the two watersheds, data obtained (Table 1) was overlaid onto a map of the entire city which displayed the delineation outlines for Blackwater Creek and Fishing Creek watersheds (Figures 4&5).

Although each of the GIS descriptive summaries observed were important, this study particularly looked to understand the discrepancy between the number of park and trail access points for each watershed. These summaries can be used in support for more implementation of recreational activities within the Tyreanna and Pleasant Valley neighborhoods.

Table 1. Calculations of each data layer present in Figure 1. This data provides key aspects to the research by increasing the understanding of the size and recreation opportunities present in each of the two watersheds. The entire City of Lynchburg was taken into consideration and then broken up by each watershed to individually study each of the characteristics below. Since the entire city was observed, not all of the data for Blackwater Creek and Fishing Creek add up to the calculations of the Lynchburg City column.

Measure	Blackwater Creek	Fishing Creek	Lynchburg City
Area (Sq. Mi.)	31.80	6.83	49.47
Miles of Streams	128.15	20.01	236.71
Amount of City Park Access Points	19	9	38
Area of City Parks (Sq. Mi.)	1.31	0.64	1.55
Area Zoned Resource Conservation (Sq. Mi.)	1.89	0.31	3.03
Percent Zoned Resource Conservation	5.94	4.54	6.13
Trail Access Points	8	1	24
Trail Distances (Mi.)	36.29	1.48	41.18
ADA Trail Distances (Mi.)	12.39	1.48	15.41

Figures 4 and 5 highlight the number of trail and city park access points, denoted by purple and green dots respectively, found throughout both watersheds. In total, Blackwater Creek has 19 city park access points and 8 trail access points compared to Fishing Creek which only has 9 city park access points and 1 trail access point (Table 1). Almost all of the access points for both trails and parks are located near or within neighborhood residences, allowing easy access for visitors, with very few being found close to businesses. From the information obtained, we concluded that Fishing Creek watershed is significantly lacking in outdoor activity sites compared to Blackwater Creek watershed, but the access that is present is within neighborhood communities, possibly increasing use.

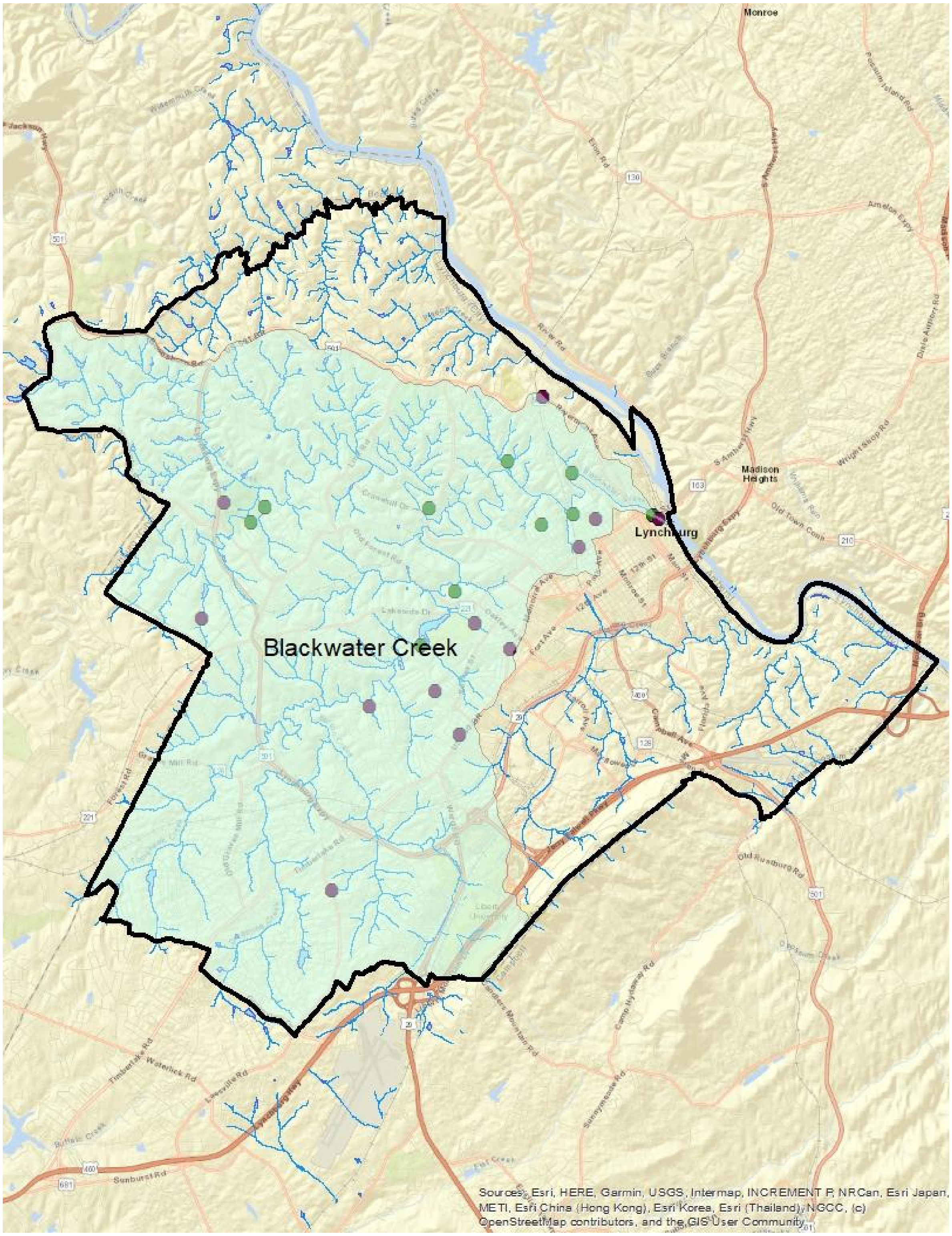

Figure 4. Map of recreational access within the Blackwater Creek watershed. Created using Esri's ArcGIS 10.1 and data collected from Virginia GIS Open Access Portal (2021). Green points symbolize official trail access areas and purple points depict park access points. There is a fairly even amount of green and purple points offered and they are spread out across the entire watershed providing access for a variety of residents.

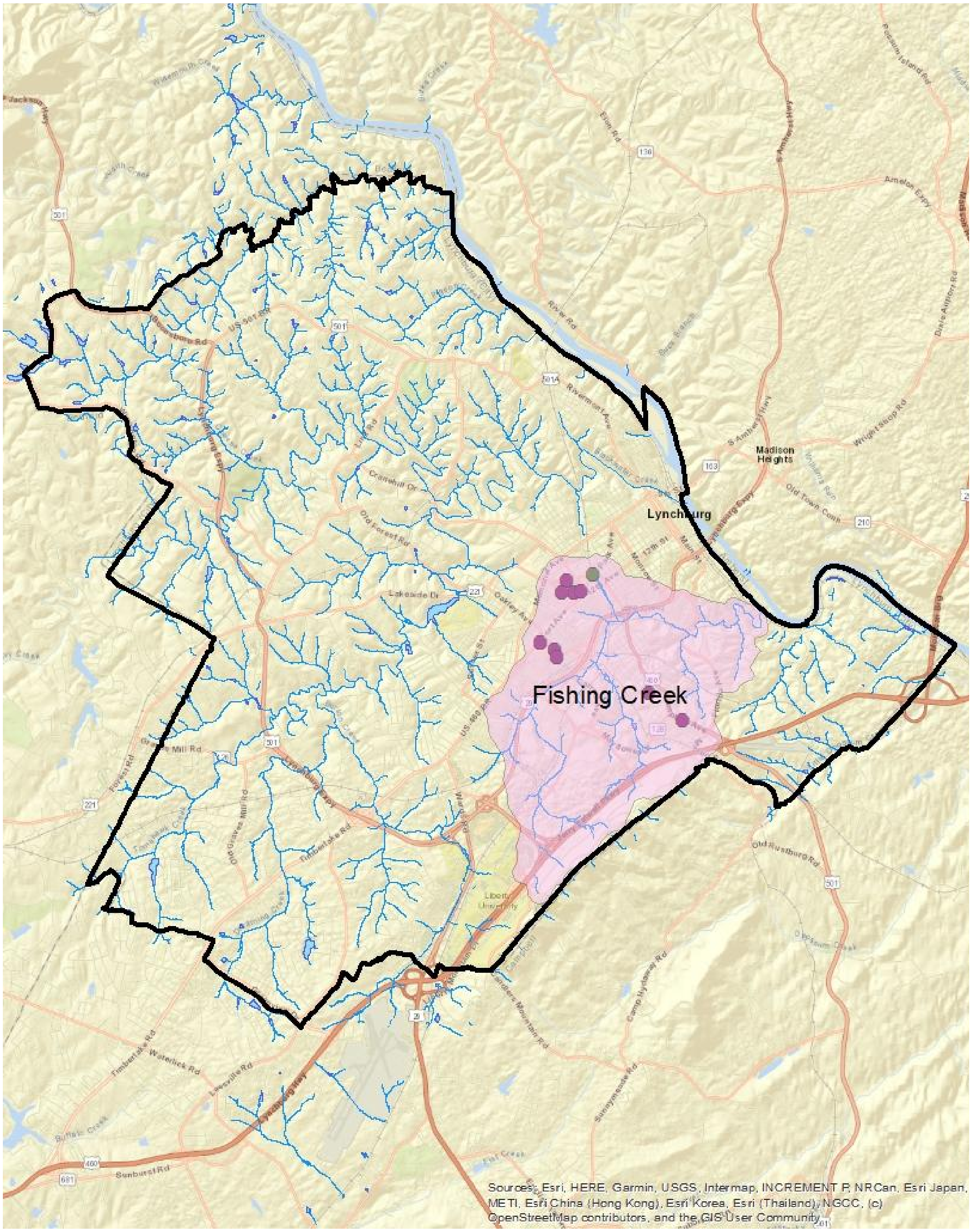

Figure 5. Map of recreational access within the Fishing Creek watershed. Created using Esri's ArcGIS 10.1 and data collected from Virginia GIS Open Access Portal (2021). Green points symbolize official trail access areas and purple points depict park access points. All but one of the points are purple signifying a dominance of park access points but only the one trail access. It is important to note that the said trail access point is labeled "Blackwater Creek Natural Area" even though it is within the Fishing Creek watershed.

3.2 | Site data collection

This pilot study sought to establish methods to determine whether the implementation of an established trail system along a creek results in a decrease of anthropogenic waste accumulation within a watershed. Two watersheds were used as study locations (Figure 1), one with an established trail system and another without (Blackwater Creek watershed and Fishing Creek watershed respectively), along with trash cleanup being conducted at three sample sites for this research (Figure 3). At each of the three study sites, descriptive data was recorded in reference to the debris found and key features that may have contributed to or limited trash accumulation within the area. Table 2 summarizes the amount of trash bags full of debris collected for each site and lists other large items that were too heavy or bigger than able to fit within a trash bag.

Table 2. Summary indicating the amount of trash bags and large debris that were collected at each of the sites. Large items include anything too heavy or bigger than able to fit within a trash bag. Due to some debris being tangled in vegetation or too heavy to carry, these items were visually accounted for and were included in the total count of trash collected.

Blackwater Creek Debris Count		
	Trash Bag Count	Large Items
Hill Street	8	>10
Hollins Mill Park	2	0
Depot Grill	4	>10
Total	14	>20
Fishing Creek Debris Count		
	Trash Bag Count	Large Items
Campbell Ave & Holiday Street	8	>10
Florida Avenue	11	>10
Winston Ridge St & Concord Tpke	5	5
Total	24	>25

Blackwater Creek Data Collection

The first study site visited within the Blackwater Creek watershed was Hill Street. Layout of the area includes a convenience store named Kwik Stop, located downstream, and the road which crosses above the creek. Walking distance between the road and the edge of the creek is around ten yards. Debris collected was mostly beer cans and snack wrappers along with large items such as a pile of dumped car parts stashed in the parking area above the creek, a traffic cone, tires, 5-Gallon buckets and an old igloo ice box top (Table 2). Distribution of the debris varied with the left bank of the creek consisting of common, everyday use items (paper, styrofoam, wrappers) while the right bank contained larger items (cone, tires). Little to none of the debris collected was found in the creek as most of it got stuck in the runoff rock drainage, located along the slope leading to the creek. Further upstream and downstream of the creek we ground truthed whether debris accumulation was occurring outside of our designated 100 yard collection area and found that there was minimal excess upstream, but more trash was present downstream. A significant amount of the additional debris was accumulated below the Kwik Stop. Although debris outside of the sample site boundary was present, it was not collected as it would have skewed the findings of the study.

Hollins Mill Park was the second site at which an estimate of two trash bags were collected. No businesses, stores, or homes are within 100 yards of the sample site, but the road runs parallel to the park and perpendicularly crosses above the creek. Walking distance between the road and the edge of the creek, right under the waterfall, is around thirteen yards. We were granted limited access to the sample site due to construction occurring during the day of data collection. As a result of this, the entire left bank of the creek was untouched causing an exact total of trash bag collection to be unknown, but an estimation was made (Figure 6). As seen in Figure 6, a visual inspection of the left bank revealed a limited amount of debris on the shore. Most debris was located along the trail after the waterfall with some also in the water. Trash data consisted primarily of plastic bottles, snack wrappers, and paper products (Table 2). Signs reminding visitors not to litter and six trash receptacles were present in multiple areas of the park. Overall, very minimal pieces of trash were gathered at this location within the 100 yard collection and ground truthing found little evidence of additional pieces further upstream or downstream of the sample site.

Figure 6. Hollins Mill Park location. Pictured is the left bank of the creek that was inaccessible for data collection as a result of construction. From a distance there are no visible large pieces of trash, but there could have been small items present.

Downtown, in front of the restaurant Depot Grill, was the final study site along Blackwater Creek at which a total of four bags of trash were collected (Figure 7). Businesses, a skate park and road access are all key features surrounding the sample site. Walking distance between the road and the edge of the creek is around twelve yards. Unlike the other two locations within Blackwater Creek, this site does not have a road crossing above the creek, but rather the road runs beside roughly thirteen yards away. Additionally, this sample site is where all of the water from the creek feeds into the James River. Observations of surrounding vegetation, which was mangled and flattened, indicates that the creek water rises a couple of feet higher than its standard depth which can result in an increase of debris transportation. In terms of debris collected, there was an entire trash bag found dumped from a household. Aside from the dumped trash, other debris included a large humidifier, broken glass shards, fabric items (blankets and clothing), and a variety of bottles (glass, plastic, aluminum) (Table 2). Beyond the 100 yard sample parameter of this location, there was a significant amount of debris downstream with some present upstream. Further upstream and downstream of the creek we ground truthed whether debris accumulation was occurring outside of our designated 100 yard collection area and found that there was minimal excess upstream in the creek, but there was a decent amount present on the ground above which could blow down into the creek. As well, trash was still present downstream along the banks of the river.

Figure 7. Trash bags full of debris collected at the mouth of Blackwater Creek leading into the James River. One entire trash bag from someone's home was dumped at this location.

Fishing Creek Data Collection

Starting at the corner of Campbell Avenue and Holiday Street located in the upper section of Fishing Creek watershed, a total of eight bags of debris were collected. Key features surrounding the creek include Seven Hills Food Co which is roughly 200 yards away from the creek edge, along with train tracks and the main road that both run above the creek. Furthermore, the entrance to Kemper Station trail, a connector trailway to the main Blackwater Creek trail, is located about 1400 yards away from this sample location. At the point we sampled, walking distance from the road to the creek is around twenty yards. Most of the small debris items consisted of red solo cups, snack wrappers, and aluminum cans (Table 2). Larger debris items such as a sofa cushion, an old laptop computer, miscellaneous metal pieces, tires, and varieties of cloth items were also found (Figures 8&9). A majority of the debris was located on the hill or banks of the creek, but there were additional items floating in the water and trapped in vegetation. During examination as to whether debris accumulation occurred outside of the sample site area, we found that it did not tend to occur further outside of the sampling zone.

Figure 8. Examples of the larger items such as some sort of soft cushioning, a tire and a sofa pillow collected along Fishing Creek at the first location.

Figure 9. Other miscellaneous items include a piece of unknown cloth and some metal in the bottom left corner. The cloth is extremely dirty indicating that it has most likely been there for a significant amount of time along with the metal which is rusted and stuck in the ground.

Located on Florida Avenue, the second study site saw a total of eleven trash bags of debris collected. The KDC - Tri Tech VA business is right beside the creek along with neighborhood homes within 130 to 200 yards of the sample site. Other features include train tracks and the main road both crossing above the creek. Pertaining to data collection, roughly a quarter of the trash collected came from the road while the rest was found along the slope leading up to the creek or on the banks of the creek. Typical trash gathered included a tremendous amount of fast food waste (cups, wrappers, straws), glass alcohol bottles and soda cans (Table 2). Some larger items such as train track debris were found underneath the railway and occasionally in the creek (Figure 10). Similar to site one of Fishing Creek, we found that debris did not tend to accumulate outside of the 100 yard sampling zone.

Figure 10. Examples of debris assumed to have come from the railroad above. The items were extremely heavy and showed signs of rust.

At the intersection of Winston Ridge Street and Concord Turnpike was where the third study site along Fishing Creek took place. This section of Fishing Creek is where its water feeds into the James River through underground pipe transportation. Layout of the land is characterized by the export business WestRock along, train tracks running parallel to the business, roughly 200 yards from the entrance to the sample site, and some households that line Winston Ridge Street. In total, five trash bags of debris were collected (Table 2). Typical items gathered included beer and soda cans, plastic grocery bags, a tire, and chip bag wrappers. During initial observation there was minimal debris present around or within the creek. Most of the trash pieces were found at the top of the road, close to the factory. Concerning the lack of debris in the area downstream and upstream, ground truth observations upstream of the 100 yard collection research parameter were conducted and found that this section has very limited litter. Further observations downstream were not possible as the drainage system goes underground.

4 | DISCUSSION

This research contributed to urban greenway literature by exploring two freshwater systems, their recreational access, and the influence these land-based human activity areas have on debris spread throughout the waterway. Although the EPA's Trash Free Waters program brings to light the goals of prevention, removal and research of aquatic debris, field-data collections for freshwater systems continue to be scarce resulting in the need to conduct more studies such as this one (Blettler et al. 2018). An understanding of debris estimates and how to mitigate its spread in freshwater systems is unclear, but this study established methods to do so. Through GIS mapping, determining the impact of recreational activities on debris spread, and proposing strategies, these methods assisted in understanding how to limit litter accumulation within a watershed. Results from this study revealed that the presence of signage distinguishing a waterway as ‘protected' and the addition of trash receptacles, all assisted in the reduction of trash accumulation at our research study sites. Additionally, implementation of incentives for businesses is another suggestion to assist in eliminating litter spread. Despite these findings, we can not indefinitely conclude that the implementation of a trail system alone aids in limiting debris within a watershed.

A city owned park, Hollins Mill has signage indicating that the Blackwater Creek waterway is protected by the Adopt A Stream initiative (Figure 11). These initiatives are implemented by the Department of Conservation and Recreation in conjunction with the VA Department of Environmental Quality and partially funded by The Litter Control and Recycling Fund (Figure 11). Consistently managed by these organizations, we can conclude that they have a significant influence on limiting the debris accumulation at Hollins Mill Park ultimately assisting the health of the entire watershed. From this research we found that the least amount of debris was collected at this sample site between both Blackwater Creek and Fishing Creek (Table 2) signifying that the signage is a contributing factor to decreasing debris. Furthermore, six trash receptacles were present at this location. The readily available trash cans currently offer somewhere for visitors to dispose of trash and could have an influence on people’s propensity to dispose of their own or others trash properly if implemented at recreational areas such as ones developed in Fishing Creek. To maintain a healthy watershed in terms of trash accumulation, signage and trash receptacles must be applied to establish a low impact trail way development in Fishing Creek. These developments will limit any further littering and could decrease debris that is already present within the watershed.

Figure 11. Signage located at Hollins Mill Park indicating the protection of Blackwater Creek's stream. Organizations in charge include the Department of Conservation and Recreation, the Va Department of Environmental Quality and The Litter Control and Recycling Fund.

Another recommendation to assist in eliminating litter spread is to establish incentives for businesses. At Hill Street, the Kwik Stop convenience store seemed to be an influencer in debris accumulation at the sample site. Convenience stores are known to sell goods that are foodservice packaged. These types of packaged items have been determined by Keep America Beautiful (2009) to account for 47% of the debris said to be found in local waterways. Analysis whether the debris collected in this study is originating directly from Kwik Stop was not conducted but the business and its patrons can be assumed to be contributing factors. Instituting incentives for businesses, such as the Kwik Stop, who implement secure trash containment receptacles and planned cleanups would help in reducing trash aggregation. As a result of these findings, I would suggest that business incentives for decreasing litter be implemented prior to development of a trail system along Fishing Creek.

5 | FUTURE STUDIES

Due to time constraints, fewer sample sites than initially planned were implemented, the length of time between debris collection events was significant, and quantitative categorization of trash collected was not conducted. To improve this research, data collection at more study sites along with categorization of debris and conducting data sampling within the same month should occur at both of the creeks. Methods conducted in the Tasseron et al. study (2020) where collected data was separated into piles based on composition, would be helpful in determining the most common type of trash found within the creeks. Using these methods in conjunction with the GIS mapping of businesses present along each of the creeks may assist in establishing a concrete understanding as to locations influencing debris feeding into the creeks. GIS mapping can also be used to map future areas for recreation establishment.

During data collection, we came across a fair number of train track lines that looked abandoned and could be repurposed as trailways. Primary goals of the *Tyreanna & Pleasant Valley Neighborhood Plan* are to increase recreation activities and overall connectivity between Fishing Creek watershed, Blackwater Creek watershed, and other sections in the City of Lynchburg (Lynchburg Planning Commission 2022). Greenways are just one suggestion to assist in this connectivity which can be further implemented in Fishing Creek by providing location suggestions for future greenway trail development such as these train track lines. Beginning GIS mapping of abandoned railroad lines close to residents and in an area where visitors would like to go is necessary to establish where greenway establishments could occur in Fishing Creek. As well, observing whether the abandoned railroads and existing paved trails present in the Blackwater Creek trailway could connect is another avenue to increase connectivity. Discovering ways to use Blackwater Creek and Fishing Creek as connections between neighboring communities throughout the city rather than splitting them is the step in the direction of creating a better living space for the citizens of Lynchburg. This research is one step towards advocating for these new developments, but a body of people who can advocate to policy makers and raise public consciousness of the establishment is necessary as well (Hayes and MacLeod 2008).

Coincidentally, advocacy began when the City of Lynchburg published the "Lynchburg Parks, Recreation and Open Space Master Plan project map", also referred to as the Social Pinpoint map (2021). This project requested responses from city residents as to what type of recreational developments they desire and where they should be implemented (Figure 12). All posts were anonymous, including these statements for recreation development in the Tyreanna and Pleasant Valley neighborhoods:

"Kemper Street trail extension utilizes existing dirt road and out of service train right of ways to continue Kemper street trail across the 29 bypass".

"Fishing Creek greenway. Could connect to a possible Kemper Street trail extension and/or from the end of Garfield Ave….would add easy access to Genworth building as well as other businesses in the area".

"Connect greenway to liberty greenway on Odd Fellows Rd which would provide greenway access to LU Mtn trails and facilities".

Numerous other anonymous statements were made in favor for more recreation developments and connectivity to occur on the side of town where Fishing Creek watershed resides. First hand interest in recreation activities by city dwellers within the Fishing Creek watershed is just the first step of many which will influence the City of Lynchburg's official development ideas for the area.

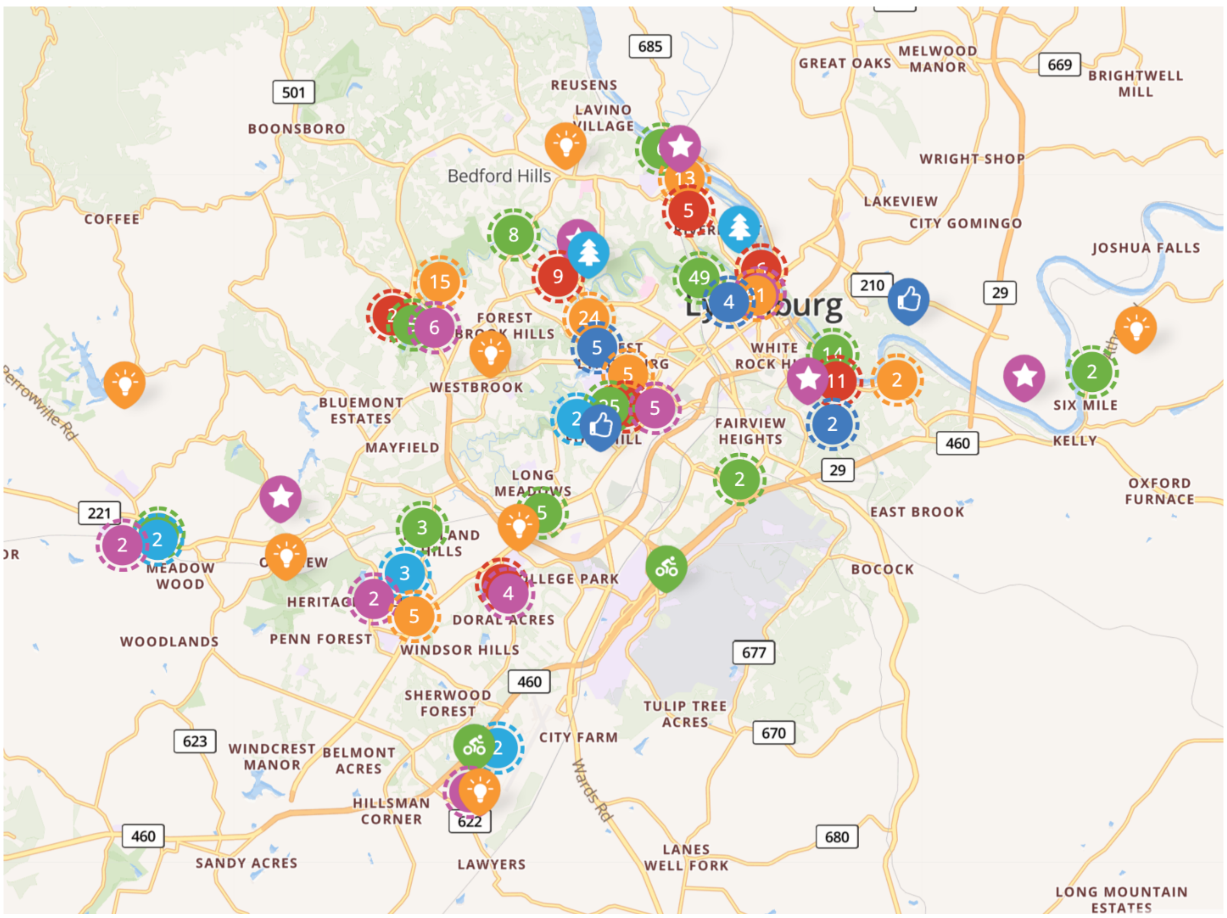

Figure 12. Lynchburg Parks, Recreation and Open Space Master Plan project map. The city asked that residents share their ideas on what recreation facilities and programs are needed and where they should be located. Dots that have numbers higher than one indicate that there are multiple suggestions within a close proximity of one another.

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