Mapping the Distribution of Litter in the Lake Tahoe Basin

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Acknowledgments

Having grown up on Lake Tahoe's north shore, I spent time hiking its surrounding mountains and playing at the local beaches. I always made sure to leave these places better than I found them-- which wasn't hard considering the seemingly endless bits of trash littering the ground wherever I went. Back in the summer of 2020, I began formally planning to map the distribution of litter around Lake Tahoe as I was hiking Tunnel Creek and picking up trash. I reached out to Heather Segale, the Education and Outreach Director at the Tahoe Environmental Research Center to ask if anyone was similarly thinking about litter distribution trends around the Basin. She informed me of the League to Save Lake Tahoe's ongoing volunteer litter clean ups, which were doing the exact thing that I was interested in -- picking up litter around the lake and collecting related data. My thesis leans heavily on the data collected by the League, and would not have been possible without that organization. Special thanks are due to Marilee Movius, Community Engagement Manager with the League, and Kat Walton, formerly the Outreach Associate at the League. Additionally, I would like to extend thanks to my thesis readers, Mary Ann Cunningham and Kirsten Menking, and my major advisor Pinar Batur, all of whom are wonderful professors at Vassar College. I would like to thank the Environmental Studies program and the Earth Science and Geography programs at Vassar College as well, for guiding me through my academic journey and exposing me to my passions. Finally, I would like to acknowledge the inspiration for this project, beautiful Lake Tahoe. I am incredibly lucky to call it my home, and I will never stop trying to protect and improve this special place and revel in its splendor. Lake Tahoe is a place that I hope everyone has an opportunity to visit. This thesis seeks to educate and inform regarding the impacts of litter on Tahoe's environment in order to ensure responsible visitation and enjoyment in the future.

In exploring environmental stewardship in Lake Tahoe, it is paramount to acknowledge its original stewards, the Washoe (Wa She Shu) Indians. The Washoe lived at Lake Tahoe far before any European descended colonizers. The discovery of Lake Tahoe is often attributed to the individuals who happened upon the Lake amid the westward gold- and silver- mining driven expansion. However, for many generations prior to European colonization, the Lake provided refuge and sustenance for generations of indigenous peoples. In fact, European settlers have a legacy of environmental degradation in Tahoe beginning with the logging campaign in the 1860's to supply timber for growing mining operations and western settlements (Makley, 2014). Due to this deforestation, most of the trees in Tahoe are new growth. The Washoe people lived at the shore of Lake Tahoe during the warmer part of the year and migrated to the Carson Valley for the colder part. Their habitation of Lake Tahoe was far more symbiotic than that of the European descended settlers. It is important to center the knowledge of Washoe peoples when working to preserve and protect Lake Tahoe's environment. However, this is a continual struggle, due to the unfortunate erasure of the Washoe people culture from the area. Today, very few landmarks or establishments honor Washoe history, let alone acknowledge their presence at all. Increased visitation and use of the Lake Tahoe area, paired with the effects of climate change, requires a return to the native customs and knowledge of sustainable living by all who visit and live in the Basin.

Pre script

It should be noted that the number one environmental concern of environmentalists, and humans at large, should be decreasing global carbon emissions to the point of zero. Greenhouse gas emissions are the number one driver of climate change and rising global temperatures. This thesis is presented in a time when the "revolution" to adopt zero emission fuel sources and technologies is just beginning. That being said, the topic of litter, or rather the campaign to decrease litter, while not equal in footing as the movement to eliminate carbon emissions, is a topic that deserves serious thought. The presence of litter in spaces that we use and care about, such as schools, parks, neighborhoods, and universities, is a visual representation of our perception of the natural world and our blatant misuse of its resources. Although the fight against climate change is one that, for the time being, will be dominated by those who create our infrastructure and produce our energy supply, litter is an issue that each one of us can control on a daily basis. If you are someone who feels powerless or overwhelmed by the scale of climate change, you have the ability to do something positive for your local environment, by picking up litter, hosting a litter clean up with friends and family, or simply reading this thesis and sharing the concepts with others. Now is a critical time for human adaptation. We must change the way we think about and use all of our natural resources. Although trash on the street is not the biggest problem we face, the way that our environment looks and feels reflects our collective values and the way we think about and treat our planet.

Introduction

Lake Tahoe is a breathtakingly beautiful place due to its location and unique environment. The 22 mile by 12 mile cobalt-blue lake is nestled in a bowl of granite peaks in the Sierra Nevada Mountain Range and is fed by a watershed that is 501 square miles in area. Due to its awe-inspiring vistas and natural attractions, this alpine lake draws visitors all year round. According to the EPA, the Basin is home to only 50,000 permanent residents, but draws around 15 million tourists per year (US EPA, 2016). Because Lake Tahoe hosts so many visitors, a continual struggle in the Basin (which includes all of the towns and developments located within the watershed) is promoting sound environmental practices to tourists and locals alike. In this regard, one of the most unsightly and frustrating problems in the Basin is litter. In Tahoe, litter deposition is a problem for neighborhoods, trails, and beaches. Since 2014, the League, which is the oldest and largest non-profit in the Basin dedicated to environmental advocacy (League to Save Lake Tahoe, n.d), has collected and disposed of 41,733 lbs. of litter (LTSLT 2021, unpub. data).

This project studies Lake Tahoe's litter problem through scientific, political, and social lenses. I rely on this model in order to approach the issue of litter in Lake Tahoe from a multidisciplinary standpoint. A proper exploration of the environmental effects of litter pollution in forested ecosystems and freshwater systems is grounded in a scientific understanding of litter as an environmental threat to ecosystems. A political lens helps in understanding the different entities that own and manage the land around Lake Tahoe and how these entities regulate and address litter deposition. Because litter is intimately affected by the actions of the public, a social lens is employed to investigate the concept of an environmental ethic, including social campaigns geared toward environmental stewardship and litter mitigation measures that have been impactful in the Basin. This literature review provides a contextual deep dive to better understand the litter data collected by the League.

The League was founded in 1957, and since then it has focused on monitoring development in the Basin while working with policy makers to protect the Lake. The League utilizes and supports science to inform decisions while promoting local grassroots efforts to protect Tahoe's clarity (League to Save Lake Tahoe, n.d). Since 2014, the organization has been hosting a series of litter clean ups. This program began with 'League clean ups,' or annual litter clean ups at repeated sites timed to coincide with peak tourism and important dates such as July 4th and Earth Day. These clean up events attract an average of about 694 volunteers per year (LTSLT 2021, unpub. data). In 2019, the League launched an additional volunteer clean-up program called the 'Tahoe Blue Crew. 'This program allows volunteers to identify a "litter hotspot" of their own choosing and to organize less formal clean ups. These clean ups occur as frequently as the site adopter sees fit. In 2021, I began volunteering with the League by adopting my own litter hotspot, and so far, I have led three litter clean ups.



Fig. 1: Two of the three litter clean ups that I led in 2021 with my family. The picture to the left was taken on January 7, 2021, at the Mt. Rose sled hill (Mt. Rose Meadows). Pictured left to right is me (Madio Wallner), Sophia Reed, and Margret Eadington. At this site we collected and removed around 8lbs of litter. The picture to the right was taken on August 1,2021, at the Crystal Bay Fire Lookout. Pictured left to right is

me, Diana Eadington, and Roxanne Reed. At this site we collected and removed .5lbs of litter from 1.7mi of trail.

Both litter clean-up programs involve citizen science where volunteers are given a data sheet to catalog the types of litter they are collecting. The dataset generated from the programs reveals important trends about the types of litter deposited and areas of high impact and use. This thesis utilizes such data to inform an exploration of Tahoe's litter problem in ArcGIS, and features original maps using that software. In addition to a literature review, this thesis includes a project component whereby the League data are presented in a web dashboard that displays litter distribution in a way that will hopefully serve as a valuable tool to educate those who enjoy and appreciate Lake Tahoe.

Related Scholarship

Although Lake Tahoe is a spectacularly unique place, this project draws on literature from other natural sites of interest that have experienced similar challenges or represent similar ecosystems. I use this approach, in part, because research specific to Lake Tahoe is sorely lacking, but also because using case studies of related places provides meaningful insights. It is my hope that framing Lake Tahoe and its challenges within a larger framework of natural site management in the U.S will provide additional context with which to understand and implement solutions to littering.

Chapter 1: Environmental Lens

In order to explore the effects of litter on Lake Tahoe's environment, I have consulted studies that deal with some of the top five waste products identified from the League's litter dataset, including data from both clean-up programs. The most pervasive litter items picked up in the Basin, by item counts, are **cigarette butts**, **plastic pieces**, **paper pieces**, **food wrappers**, **and glass pieces** (**Table 1**). Centering these top five litter items was done to ensure that the sources reviewed are relevant to waste deposition that occurs in the Basin. In this exploration, I am focused on ways that litter impacts terrestrial and aquatic ecosystems, specifically alpine forest environments as well as freshwater ecosystems.

Table 1: Cumulative counts of the five most common litter types collected since 2014 by the League via the League and Blue Crew clean-up programs. (LTSLT, 2021 unpub. data)

Cigarette butts	Plastic pieces	Paper pieces	Food wrappers	glass pieces
164,394	103,324	70,208	44,043	23,744

CIGARETTE BUTTS

Cigarette butts are the top litter item collected by the League in terms of item counts, a finding that mirrors global trends. Since 2014, volunteers with the League have collected 164,394 cigarette butts (LTSLT, 2021 unpub. data). The majority of these butts have been collected from the Stateline/Heavenly Village area in South Lake Tahoe (fig. 2). This area is a commercial zone at the base of Heavenly Mountain Ski Resort as well as the site of South Tahoe's major hotels and casinos. During an Earth Day community clean up in 2019 at Stateline/Heavenly Village, a whopping 3,247 cigarette butts were collected by a total of 60 volunteers. Regionally, other cigarette butt hotspots around the Lake are: Tahoe City on the west shore, Kings Beach and Incline Village on the north

shore, and Stateline/ Heavenly Village, Regan Beach and the Upper Truckee River Bike path on the south shore (Fig. 1).



Cigarette Butts Collected around the Lake Tahoe Basin

Esri, NASA, NGA, USGS, Douglas County, NV - GIS Dept, California State Parks, Esri, HERE, Garmin, SafeGraph, METI/

Fig. 2: Distribution of cigarette butts around the Basin. The parameter is normalized by hours worked to avoid skewing of data and to allow comparison across figures 2, 3, 4, 5, and 6. The largest concentration of cigarette butts collected occurs in South Tahoe, specifically the Stateline/Heavenly Village area. Other sites that have

experienced high numbers of butt collection in South Tahoe are Regan Beach and the Upper Truckee River Bike Path. Other hotspots around the Basin are Tahoe City, Kings Beach and Incline Village.

According to a study done by Kungskulniti et al. (2018), tobacco waste products are the most common item of plastic pollution found in beach clean-ups, worldwide . This trend is significant to Lake Tahoe, which has many beaches. Cigarette butts are made of non-biodegradable cellulose acetate, which is a type of plastic (5Gyres.org, n.d).

In addition to being aesthetically unpleasant, cigarette butts are very harmful to ecosystems, in large part due to the effects of toxic chemicals leaching into aquatic environments. Some of these chemicals include, but are not limited to, acetic acid, hexamine, arsenic, and chromium (5Gyres.org, n.a). Additionally, of the 4000 identified chemical compounds that result from the production and burning of cigarettes, 69 have been found to be carcinogenic (Kurmus et al., 2020). A research paper by Slaughter et al. (2011) explores the ways these chemicals affect different freshwater fish species. Most notable were the effects on the species *Pimephales promelas*, commonly referred to as the freshwater fathead minnow, which demonstrated an LC50 (lethal concentration 50, i.e., the concentration at which 50% of individuals in a group of animals tested were killed) of 1 cigarette butt per liter of water. This study is relevant to Tahoe because the Lake is home to several fish species, including three native fish from the minnow family: Lahontan Speckled Dace, Lahontan Redside, and Lahontan Lake Tui Chub (NDOW, n.d.). What makes the Slaughter et al. (2011) findings regarding freshwater minnows especially concerning for Lake Tahoe is the fact that Tahoe is nearly a closed watershed, with 63 input streams and only one outlet (US EPA, 2016). This means that pollutants that find their way into the Lake sit in the body of water for a long time before leaving via the Truckee River. In fact, according to the EPA, water entering the Lake today has a residence time of about 650 years. Unfortunately, cigarette butts that are improperly disposed of also become a source of microplastics in the environment. These particles result from the breakdown of larger plastic items, including cigarette filters, which undergo a reduction in size because of photodegradation and other chemical breakdown processes (Kungskulniti et al., 2018). Cigarette butts as litter are harmful in their own regard, however, the fact that they are plastic-based materially adds to the problem of plastic pollution in Lake Tahoe.

PLASTIC PIECES

Another one of the top five litter items identified by the League is plastic pieces. This category includes pieces of plastic that are variable in size but large enough that the litter gathering volunteer was able to locate and collect them. Based on the League's litter data, there are several hotspots where plastic pieces have been collected in the highest numbers. Regionally these locations are: Tahoe City and Lake Forest Beach on the west shore, Kings Beach on the north shore, Zephyr Shoals, Nevada Beach and Sand Harbor on the east shore, and Stateline/Heavenly Village, Regan Beach, and the Upper Truckee River Bike Path on the south shore (Fig. 2). The most plastic pieces collected from one site was at Regan beach in 2018, where 121 volunteers collected a total of 1,211 pieces.



Plastic Pieces Collected around the Lake Tahoe Basin

Esri, NASA, NGA, USGS, Douglas County, NV - GIS Dept, California State Parks, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

Fig. 3: Distribution of plastic pieces collected around the Basin. The most plastic pieces were collected at Regan Beach, as well as Stateline/Heavenly Village, UTR Bike Path, Nevada Beach, Zephyr Shoals, Sand Harbor, Kings Beach, Tahoe City and Lake Forest Beach.

The issue of plastic pollution in the Basin recently came to the attention of the media and locals when researchers from the Desert Research Institute (DRI) discovered microplastics in the lake in 2019. According to DRI, microplastics (particles smaller than 5 mm) are a harmful contaminant in marine and freshwater environments due to their ubiquity in such systems. The DRI also cites larger secondary plastic as the main contributor to microplastic pollution. The source of microplastics in Lake Tahoe is uncertain. Considering that larger plastic pieces were among the top five collected litter items from the League's litter data, however, it is likely that this litter is a significant source of the microplastics found in Lake Tahoe. In fact, according to a recent article published by the EPA, improperly disposed litter found on Lake Tahoe's beaches is believed to be the Lake's primary source of plastic pollution (Gill, August 25 2020). This type of microplastic is referred to as secondary microplastic, which is derived from larger plastic debris due to the processes of photo-degradation, physical, chemical, and biological interactions (Li et al., 2018).

Microplastics are detrimental to the environment for many reasons, including harm to animals that consume the debris, and many studies have found freshwater systems to be polluted with microplastics. Notable examples are the Great Lakes region (Eriksen et al., 2013), Lake Garda in Italy (Imhof et al., 2013), and the remote Lake Hovsgol in Mongolia (Free et al., 2014). In fact, the Graham Sustainability Institute at the University of Michigan has reported that plastics have been discovered in the Great Lakes at the highest concentration seen anywhere on the planet. A study by Eriksen et al. (2013) on the Great Lakes, found microplastics at an average abundance of 43,000 particles/km², with the highest sample showing 466,000 particles/ km². Microplastic pollution in freshwater systems is an undeniable issue. However, few studies have been conducted to assess microplastic ingestion by freshwater fish and other biota. One of these few studies, conducted by Sanchez et al. (2014), assessed wild gudgeons in French rivers. This study confirmed that 12% of the collected fish had ingested microplastics and speculated that an additional 28% had consumed what researchers suspected were microplastics. (Sanchez et al., 2014). Ingestion of microplastics by fish and other biota has been linked to starvation and false satiation in animals (Li et al., 2018). In other words, animals consume plastic, thinking it is food, and as a result, feel full, but have not taken in sufficient nutrients. In addition, plastic debris consumed by biota clogs their internal systems, leading to various negative health effects and death.

Along with the threat of starvation, microplastics consumed by biota have been found to be toxic. According to a 2018 study by Li et al., polymeric compounds and the additives used to create them, such as copper, are toxic to living organisms. Other additives to plastic, like colorants, stabilizers, and plasticizers, have been found to contain heavy metals such as chromium, cadmium, and lead, which are known carcinogens (Li et al., 2018). Aside from the harmful additives and chemicals used to create plastics, microplastics in freshwater systems are also dangerous due to their potential to absorb toxins from the environment. When ingested, these toxins desorb, which can be harmful to biota (Li et al., 2018). All of the toxic threats presented by microplastics in freshwater systems become more dangerous through the possibility of bioaccumulation, a process where harmful chemicals are stored in the fatty tissues of organisms rather than expelled as waste products. This storage becomes an issue when predators consume prey containing toxins. The predation leads to a buildup of toxic chemicals in larger and larger taxa and potentially poses a threat to humans who consume fish. In fact, fish are bio accumulators with the highest potential to transfer residues from water to humans (Dorea, 2008). Bioaccumulation of toxic materials typically occurs in marine systems because global industrial activities have released chemicals referred to as organohalogenated pollutants that have entered the world's oceans. While this issue is well documented in marine systems, there is less scholarship on bioaccumulation of toxic materials in fish from freshwater systems and potential human health threats. Despite this, we know that microplastic pollution is an issue in Lake Tahoe and that the lake is a destination for fishing. Anglers who fish in Lake Tahoe mainly catch lake trout, rainbow trout, brown trout, and mountain whitefish (Cordone and Frantz, n.d). The presence of microplastics in the Lake, paired with the fact that anglers fish the Lake, only adds to the threat microplastic pollution poses for freshwater biota and ultimately, human health.

PAPER PIECES

Paper pieces represent the third largest litter category in the League's dataset. These pieces have been found in the highest number regionally in Tahoe City (west shore), Kings Beach and Incline Village (north shore), Sand Harbor, Zephyr Shoals and Nevada Beach (east shore) and Stateline/Heavenly Village, the base of Heavenly Mountain Ski Resort, and Regan Beach (south shore) (Fig. 3). The most paper pieces collected in a single clean up event were collected from Regan Beach in 2018 where 121 volunteers collected a total of 1,859 pieces.



Paper Pieces Collected around the Lake Tahoe Basin

Esri, NASA, NGA, USGS, Douglas County, NV - GIS Dept, California State Parks, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

Fig. 4: Distribution of paper pieces collected around the Basin. Paper pieces have been found in high numbers In Tahoe City, Kings Beach, Sand Harbor, Zephyr Shoals, Nevada Beach and South Tahoe. In South Tahoe, the notable hotspots are Stateline/Heavenly Village, the base of Heavenly Mountain Ski Resort, and Regan Beach. Scholarship related to the environmental impacts of paper litter is limited. Paper is biodegradable as it is made from plant material. Biodegradability means that a substance can break down/degrade with the presence of oxygen and sunlight, which allows nutrients to return to the soil. Despite this fact, paper litter is still an unwanted and unsightly issue in the Basin.

Though biodegradable, paper requires the input of many harsh chemicals during its production and thus poses a potential source of chemicals entering the environment when paper is littered. The process of converting wood into paper, or pulping, involves several steps including chipping, cooking (chemical processing), washing, and bleaching. Some of these steps, namely cooking and bleaching, involve the introduction of chemicals to break down lignin and to manipulate the color (Rullifank et al., 2020) and thus make paper a source of potential chemical pollution when littered. There are three methods of chemical pulping: soda, sulfate, and kraft pulp making. The soda and sulfate processes utilize alkali chemicals in their cooking liquids, which are referred to as white liquor, black liquor, and white chemicals. White liquor typically consists of caustic (NaOH), sodium sulphite (Na₂S), and sodium carbonate (Na₂CO₃) and is the main chemical mix used in this process. The wood material is then treated with black liquor, which is a washing liquid that contains lignin and dissolved chemicals. Finally, the pulp is treated with white chemicals, which contain chlorine dioxide (ClO₂) to bleach for color. These steps together make up the chemical cooking process which occurs at high temperatures in a digester. Bleaching is the process of adding chlorine dioxide to bleach the pulp into a lighter color in order to create the bright white office paper that has become standard in our society. Once this paper product reaches its end state, it is sold to be used in a multitude of purposes such as in offices or schools or used for packaging purposes. It is common for the highly refined paper to then be printed with ink. Ink is typically made from a soybean oil or linseed oil base and then combined with resins, solvents, pigments and other additives such as lubricants and alkali materials (YoYoInk, n.d). Ink is also very toxic to the environment. Thus, at the end of the paper's lifecycle, if it becomes litter, there are many associated chemicals that have the ability to percolate into and harm the environment.

In addition to the threat of chemical inputs into the environment, paper litter is an issue because the production of paper converts carbon capturing trees and forests into a material that, if misused, becomes litter. In effect, paper litter is a tragic irony because the once natural plant mechanism for carbon storage has been converted into an unsightly and unnatural stain in the ecosystem. On average, plants absorb 3.7 units of CO₂ during photosynthesis to create one unit of plant tissue (Shea et al., 2022). Trees and other leafy plants sequester CO₂ by taking it in from the atmosphere and using it to build the plant structure. When plants die, they return the carbon to the ground during the process of decomposition. When trees are harvested and used as paper, humans effectively render those trees incapable of sequestering carbon. We have reached a time when reducing greenhouse gasses to the point of zero is critical in order to avoid the worst effects of climate change. Because of this, we cannot afford to limit systems that naturally sequester carbon, especially if the material product that results from this resource destruction is littered rather than recycled.

FOOD WRAPPERS

Food wrapper litter is a broad category that includes mostly the bright colored plastic and aluminized mylar packaging that on-the-go snacks are wrapped in. More specifically, this category includes things like discarded chip bags and candy wrappers as well as items that have visible food brands or nutrition facts. This category excludes food wrappers that don't contain obvious writing or bright packaging colors, such as paper wrappers that burgers or sandwiches come in. In the League's litter data, the food wrapper category also excludes styrofoam, plastic, and paper take-out containers, which have their own respective categories. Regionally, food wrappers were collected in the highest numbers in Tahoe City (west shore), Kings Beach (north shore), Sand Harbor and Nevada Beach (east shore), and Stateline/Heavenly Village, the base of Heavenly Mountain Ski Resort, the Upper Truckee River Bike Path, Regan Beach, Lakeview Secret Beach, and Camp Richardson/Fallen Leaf Corrals (south shore) (Fig. 4). The most food wrappers collected in a single clean up event occurred at Zephyr Shoals, a beach on the southern end of the Lake's east shore, where 15 volunteers collected 1,058 food wrappers in 2016.



Food Wrappers Collected around the Lake Tahoe Basin

Douglas County, NV - GIS Dept, California State Parks, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, Esri, CGIAR, USGS

Fig 5: Distribution of food wrappers around the Basin. Food wrappers have been found in the highest numbers proportional to hours worked at Tahoe City, Kings Beach, Sand Harbor, Zephyr Shoals, Nevada Beach,

Stateline/Heavenly Village, Heavenly Mountain Ski Resort, UTR Bike Path, Regan Beach, Lakeview Secret Beach, and Camp Richardson/Fallen Leaf Corrals.

Food wrappers are typically made out of a type of plastic called oriented polypropylene (Leeke, 2019). However, this plastic base is often laminated with an aluminum layer, giving it a distinguishing shiny side. A 2007 research paper by Sheavly and Register attributes much of the litter around the world to what humans consume, namely the packaging that accompanies such products. In the Basin, food wrappers are one of the most unsightly litter objects found. The bright colors and metallic sheets juxtapose with the tranquil mountain beauty of the area. Not only are food wrappers unsightly, they have the ability to catalyze negative litter trends. A 2017 study titled "Beacons of litter: A social experiment to understand how the presence of certain littered items influences rates of littering", examines how the presence of existing litter in a place leads to additional deposition. In that study, certain litter types were categorized as "beacons," or litter that attracts additional litter. That study identifies food wrappers, including "brightly coloured and larger items of rubbish, such as drinks containers, crisp packets, chicken boxes and sandwich packs" as beacons of litter (Tehan et al., 2017). In the Basin, packaged, on-the-go snacks are commonly consumed while hiking, recreating at the beach, but are also consumed in neighborhoods, parks, and basically everywhere people venture.

GLASS PIECES

Glass pieces are the final of the top five litter items found around the Basin (Fig. 5). Glass pieces are mostly residual from bottles that have been broken. However, some glass pieces found in neighborhoods or commercial areas are attributed to construction sources. According to the League's litter data, glass pieces are found in the highest numbers in Tahoe City (west shore), Kings Beach (north shore), Sand Harbor (east shore), and Stateline/Heavenly Village, Trout Creek Bike Path, the Upper Truckee River Bike Path, the Tahoe Keys Community, and Kiva Beach (south shore). The most glass pieces collected at a single clean up event occurred at the Meyers Bike Path, south of South Tahoe, in 2017, where 25 volunteers collected a total of 981 pieces.



Glass Pieces Collected around the Lake Tahoe Basin

Fig 6: Distribution of glass pieces collected around the Basin. Glass pieces were collected at the highest number, proportional to hours worked at Tahoe City, Kings Beach, Sand Harbor, Stateline/Heavenly Village, Trout Creek Bike Path, UTR Bike Path, Tahoe Keys and Kiva Beach.

Packaging glass is glass produced to store and transport products and is made from three major components: Silicon (quartz sand), soda, and lime (Wakefield Equipment, 2021). According to the data collected in a global 2007 Ocean Conservancy Coastal Cleanup, glass beverage bottles made up 5% of collected items from the total 6 million pounds of waste collected across 76 countries (Ocean Conservancy, 2007). Glass as litter is harmful due to its potential to injure humans and animals. In a beach context, broken glass poses a threat to recreators who traverse an area barefoot and risk stepping on it. Glass litter may also be harmful for wildlife who might accidentally consume or interact with it.

Similar to the discussion of paper litter, glass that is littered rather than recycled also poses an indirect environmental threat. The process of creating glass on an industrial scale requires resources and energy. It has been debated whether recycling of glass is beneficial environmentally compared to making more glass from raw materials. A 2021 study conducted by Zegardlo and Druzba weighed the environmental costs of transporting glass to recycling facilities and the use of water to wash the used bottles against the costs of producing new glass and found that recycling reduces parameters such as human toxicity, air pollution and depletion of natural resources even given the energy/pollutant input from transport and washing of the materials.

Chapter 2: Political Lens:

What are governing entities doing about litter?

Not only is litter unsightly and irresponsible, it is also illegal in both Nevada and California. In the state of Nevada, littering is punishable with fines and potential jail time. The punishment depends on the type of litter deposited. For example, per Nevada Revised Statute chapter 475 (*NRS 475.030*), throwing a burning cigarette out of a moving vehicle is a misdemeanor, carrying penalties of up to six months in jail and/or fines of up to \$1,000 (NRS, n.d). Littering is also illegal in California under Penal Code (PC) 374, however, instead of the possibility of jail time, littering offenses in California are merely charged as an infraction and call for a fine and community service time (CA Penal Code § 374.4, 2017).

Land Designations Around Lake Tahoe

Although littering is illegal in the states of Nevada and California, there are additional litter policies specific to different land designations common around the Basin. Today, the land around Lake Tahoe is divided up between privately owned land, state parks, national forests, and wilderness areas. There are three major U.S. National Forest protected areas around Lake Tahoe: The Tahoe National Forest (CA) to the northwest, the Toiyabe National Forest (NV) to the east, and the El Dorado National Forest (CA) to the west and south (Fig. 7)

These protected areas are under the supervision of the U.S. Forest Service (USFS), which falls under the U.S. Department of Agriculture. A national forest designation means that the land is owned collectively by the American people but is protected and managed by the USFS. In these areas, management has widely diverse objectives, including conservation, timber harvesting, livestock grazing, watershed protection, wildlife, and recreation (US Forest Service, n.d). The National Forest system has regulations that are designed to protect forested areas from visitor misuse, including littering. For example, regulation 261.11 parts a-e, published under Title 36 of the Code of Federal Regulations, states that all forms of littering are prohibited, including, but not limited to, "failing to properly dispose of garbage" and polluting waterways (US Forest Service, n.d).



Land Designations in the Tahoe Basin

Fig. 7: Boundaries of the National Forests as well as the Wilderness Areas around the Basin.

In Lake Tahoe, the three National Forests adjoining the Lake were consolidated to form the Lake Tahoe Basin Management Unit (LTBMU) in April of 1973 (US Forest Service, n.d). The

LTBMU has several distinct focus areas, including erosion control management, watershed restoration, fire and fuels management, forest management, and recreation management. Under the umbrella of recreation management, the LTBMU addresses visitor use issues, including littering, in national forests. In March of 2020, the LTBMU and the Tahoe Regional Planning agency (TRPA), partnered to co-lead a third entity known as the Land and Recreation Managers and Public Information Officers Coordinating Committee. These groups meet bi-weekly to discuss ways to respond to increased visitation to the Tahoe Area, and a major focus of their work has been litter abatement strategies. Per the Sustainable Recreation & Tourism Workshop Summary & Outcomes Report, published in February of 2021, there are certain near-term goals that directly influence litter and littering behavior in the Basin. One example is a desire to expand the League's Keep Tahoe Blue, Tahoe Blue Crews, and the Clean Tahoe program. Expansion of these programs is beneficial in terms of removing litter from trails, neighborhoods, and beaches. However, in order to address littering behavior, the committees have begun to strategize on how to create and disperse a'' Tahoe ethos'' – a behavioral code of conduct that is understood and ideally agreed to by both locals and visitors to the area.

Aside from National Forest lands, the Basin has many state parks. On the Nevada side, the Lake Tahoe Nevada State Park is composed of four sites: Sand Harbor, Spooner Lake and Backcountry, Cave Rock, and Van Sickle. On the California side, there are four state parks: Emerald Bay State Park, DL Bliss State Park, Burton Creek State Park, and Ed Zeberg Sugar Pine Point State Park.

Although the regulations in state parks differ depending on the state, both Nevada and California state parks include information about littering on their websites and on educational placards at the parks. For example, on Sand Harbor's website, under a link called Field Notes, there are a list of guidelines pertaining to litter, including 'practice Leave No Trace', 'litter must be properly disposed of', and 'do your part, Keep Tahoe bears wild'. It is the hope that patrons to the state parks abide by these rules. However, litter data collected by the League indicates otherwise. Another land designation around Lake Tahoe is wilderness area. The Wilderness Act of 1964 is a designation that aims to protect natural areas in an undisturbed state by barring the presence of permanent human-made structures, such as roads and buildings, and by prohibiting the use of motorized machinery (US Department of Justice, n.d). Wilderness areas are maintained by the National Parks Service. In the Basin, there are two wilderness areas: Desolation Wilderness and Mount Rose Wilderness (see Fig. 7). Just outside of the Basin are two other wilderness areas: Granite Chief Wilderness and Mokelumne Wilderness.

Although these areas are off limits to housing and commercial development, they are open to public recreation, often after obtaining a wilderness permit. In fact, Desolation Wilderness is the most heavily used wilderness area per acre in the United States. This is likely attributable to the fact that portions of both the Pacific Crest Trail and the Tahoe Rim Trail pass through it. Littering in Wilderness areas is not permitted. However, as in most places where there is high visitor use, litter is deposited. One of the major issues with addressing litter deposition in Wilderness areas is the fact that these areas are often remote and therefore difficult to service with waste receptacles or litter clean ups, either volunteer led or organized by the National Park Service. According to a 1978 USDA Forest Service General Technical Report, objections to litter in wilderness areas are heightened because litter in these more natural spaces seems more salient despite the fact that, in general, litter deposition is lighter in road-free environments than in developed areas.

Despite the fact that littering is illegal under the jurisdiction of both the states of Nevada and California, and prohibited in National Forests, National Parks, and Wilderness areas, littering continues to occur in the Basin, to the extent that it remains a central concern of land managers. This poses the question of why, then, are people still littering, and what is being done to address this behavior in Tahoe?

Chapter 3: Social Lens

When studying litter, it is important to consider the question: why do people improperly dispose of garbage in the first place? Through extensive review of the literature, it is clear that there are two main routes to litter deposition, intentional and unintentional. According to the 2009 National Visible Litter Survey and Litter Cost Study, conducted by the non-profit environmental agency Keep America Beautiful, most littering behavior stems from a lack of personal ownership. In other words, litterbugs believe that there is someone else who will pick up their litter. In the case of accidental litter deposition, such as a hiker dropping a food wrapper or a plastic bottle bouncing out of the bed of a truck, more litter accumulates.

In this section, I further review studies that attempt to explain why people intentionally litter. A 2017 study titled "Beacons of litter: A social experiment to understand how the presence of certain littered items influences rates of littering" examined whether the presence of litter in an area results in higher rates of additional litter deposition, a phenomenon the authors termed "beacons of litter". Ultimately, the study found that people are more likely to litter where litter is already present. Additionally, the authors found that litter can act as a social cue, implying a level of social acceptability towards littering at a site (Tehan et al., 2017). In Tahoe, litter is present on beaches, trails, and neighborhoods as indicated by The League's data. This existent litter is likely acting as a beacon for more litter by promoting the message that it is acceptable to litter in Tahoe. The 2017 Tehan et al. study also found that males were more likely to litter than females, and that the most litter was deposited by individuals in the under 16 age demographic. Additionally, the study found that individuals who were alone were found to litter more than those in groups. The study acquired these findings by identifying areas of differing visitor use and passively observing littering behavior for two hours at a time. In general, studies that report on litter demographics broadly find that males, younger adults, and those living in rural areas are more likely to litter. However, in many cases, studies that examine litter demographics are not totally representative because it is difficult, if not impossible, to examine sites that are inclusive of all of the different environments across America.

Many such studies are limited by site types, such as rural vs. urban or commercial vs. noncommercial. A different study by Schultz et al. (2013) similarly examined littering trends on a wider scale. This study was conducted at 130 outdoor public sites across 10 different states, including rural, suburban, and urban areas in all states. At each site, random individuals were unobtrusively monitored, and their littering behavior was documented. The study found that of all of the individuals demonstrating disposal behavior, 17% littered. Additionally, the study found that individuals within the 18–29-year-old age group littered more, and that the presence of existing litter encouraged littering, while the presence of more receptacles in a study site reduced littering rates (Schultz et al., 2013).

The findings of these litter studies are relevant to Tahoe, because in order to tackle the issue it is important to understand who is littering. In the Basin, there is a pervasive "us vs. them" mentality whereby locals believe that tourists are responsible for degrading Tahoe's environment. The relationship between tourism and full-time residence in Tahoe is complicated as locals understand that tourism to the area, albeit annoying due to crowded roads, beaches, and trails, is a main driver of the area's economy. In a 2021 article published in Sierra Nevada Ally, Hauserman writes that "for several decades there was an undercurrent of resentment towards those who came to visit, but there was also an understanding of the economic importance of visitors". It is difficult to determine who exactly is littering in Tahoe. However, the data collected by the League provide some insight to the times of the year when more litter is collected. Figure 8 displays the total pounds of litter collected by the League's litter programs since 2014, by month. July represents the month with the most litter collected (14,539 lbs.) followed by April (5,878 lbs.). This distribution is likely due to the fact that the Keep Tahoe Red White and Blue (KTRWB) clean ups occur at Tahoe's most popular beaches just after the 4th of July. These clean ups bring in the highest amount of litter and since they began in 2015, have collected around 8,417 lbs. total of trash (Griffo, 2020). Additionally, the League runs annual Earth Day cleanups that occur every April, and which contribute to the higher amounts of litter collected in that month. These trends, however, represent clean up rates rather than

the actual littering rates, making it difficult to infer whether increased visitation is actually leading to more litter deposition. Additionally, the winter months experience high rates of visitation in the Basin due to the prolific ski industry, however, the data displayed in figure 8 show that winter months experience low rates of litter collection. This is likely due to the fact that fewer volunteers run litter clean ups in the winter weather compared to months where there is less snow and warmer weather.



Fig. 8: Total amounts of litter collected by the League (in lbs.) per month and numbers of volunteers active in litter removal. July shows the largest amount of litter collected, with 14,539 lbs., which is more than double the value for April, the month with the second largest amount of litter collected (5,878 lbs.).

Based on the League's data alone it is difficult to determine whether peak visitation times and thus tourists, are responsible for increased litter deposition. For the peak in litter collection in the month of July, it is reasonable to assume that increased visitation to Tahoe's beaches on the 4th of July is the reason that KTRWB clean ups are necessary. These specific clean up events are predicated on the fact that many people, including largely people from out of town, will be using the beaches and unfortunately leaving their trash. Although it is difficult to tell who is littering from the League's data set, it would be possible to figure out who is volunteering. I did not have access to the volunteer information. However, I know that one must fill out a waiver to participate in the League's clean-up programs. It would be beneficial for future studies to identify the percentage of volunteers that live locally versus those that live outside of the Basin. This would shed some light on a possible positive environmental impact that visitors may have on the area.

Environmental Messaging as a Social Response to Litter

There is a complex history of environmental messaging and campaigns that have sought to instill responsibility into wilderness explorers and outdoor recreationists. One of the earliest and most influential campaigns is Leave No Trace (LNT). LNT is the official education policy for managing outdoor recreation in the National Wilderness Preservation System as well as in many public lands. LNT is based on seven core principles that seek to minimize the effect that outdoor recreation has on natural spaces. These are: 1): travel and camp on durable surfaces, 2) plan ahead and prepare, 3) be considerate of other visitors, 4) respect wildlife, 5) minimize campfire impacts, 6) leave what you find, and 7) dispose of waste properly (BLM, 2007). Although LNT relates best to backcountry travelers- those who camp and hike without access to human built facilities -- the principles are still applicable to Tahoe. In the Basin, backcountry hiking is certainly a sought-after activity. However, the litter and data collected by the League to Save Lake Tahoe represents diverse sites around the Basin, including beaches, trails, and neighborhoods. LNT principles regarding disposal of waste are represented in the common phrase heard around the Basin: "pack it in, pack it out." This phrase originated from Leave No Trace and refers specifically to the idea that backpackers must bring out of wilderness areas all of the items that they carried in. According to a Bureau of Land Management environmental education site: "There is no reason why people cannot carry out of the backcountry the extra food and packing materials which they carried in with them in the first place" (BLM, 2007). Anywhere that people bring items, whether it be to the beach or on a day hike,

the expectation is that all potential litter items should be brought back and disposed of properly. This phrase is well circulated in the Basin and is applicable even to beachgoers, who must hike short trails to get to the beaches.

In 1972, an incentive program was implemented in the Glacier Peak Wilderness area at Mt. Baker National Forest to address the issue of backcountry wilderness area litter by soliciting recreationists to pick up litter that they came upon (Muth & Clark, 1978). Park rangers gave out litter bags to children and adults and offered them prizes, such as coupons to sporting goods stores or stickers and pins for picking up litter. In cases where litter was more dispersed and remote, park rangers would collect the litter and then ask hikers to carry out and dispose of the already full litter bag, using a prize as an incentive. In the first year of the program, 47 five-gallon bags of litter were carried out of the Glacier Peak Wilderness area. Despite this success, the study found that incentives for adults, such as sporting goods store coupons, were not very effective and often misinterpreted as a ploy for publicity on the part of the store. Recreationists who were interviewed agreed that incentives should not be necessary and that visitors should be stewards of a place because it is the moral thing to do. Although the incentive part of this study was deemed ineffectual, the program embodies LNT principles by encouraging recreationists to pack out their own litter as well as any additional litter they were able to collect.

Keep Tahoe Bears Wild

Another campaign concerned with litter in the Basin is Keep Tahoe Bears Wild, a partnership between the United States Forest Service, Lake Tahoe Basin Management Unit (LTBMU), California Department of Fish and Wildlife, California State Parks, Nevada Department of Wildlife, and the Tahoe Regional Planning Agency. These agencies come together to disseminate information about how to best live and recreate in bear country. Central to the campaign's messaging is responsible disposal of garbage. Not only is litter in the Basin unsightly, it is harmful because it attracts bears. Because bears are opportunistic omnivores with a sense of smell 10 times greater than that of a bloodhound, they eat any and all food that they can find, including discarded litter and improperly contained garbage (Keep Tahoe Bears Wild, n.d). Keep Tahoe Bears Wild suggests that residents use bear-proof garbage bins, and that recreationists keep a clean campsite, refrain from feeding wildlife, and appropriately dispose of garbage into bear-proof containers. Additionally, improperly disposing of garbage can lead to litter deposition when bears break into garbage cans and drag and deposit waste around the site.

Keep Tahoe Blue

The discussion of an environmental ethic and associated messaging in Tahoe is incomplete without mentioning the "Keep Tahoe Blue" campaign (Fig. 9). "Keep Tahoe Blue" is a phrase that appears on bumper stickers across the country, as well as a phrase that gets circulated around the Basin.



Fig. 9: Keep Tahoe Blue bumper stickers are commonplace around the Basin.

The phrase was coined by the League to promote Tahoe-specific environmental stewardship. This phrase is meaningful because it advances the idea that Lake Tahoe is a place that people care about and want to protect and sustain for the future. While the phrase alludes to practices that promote lake clarity, such as monitored development, erosion prevention, and limiting nutrient-rich pollutants from entering the Lake, it also implies a broader call for environmental stewardship in the Basin -- one that addresses litter. Keeping Tahoe Blue means also keeping the area around Lake Tahoe litter free.

Take Care Tahoe

The Take Care Tahoe campaign "Take Care" is another example of a social response to littering in the Basin. Take Care is a movement that is focused on promoting sustainable use and enjoyment of Tahoe. According to the Tahoe Fund, a non-profit dedicated to funding environmental projects in Tahoe, Take Care is "the unified messaging campaign for the entire region, composed of more than 60 partners that love Lake Tahoe and want to see more people connect with this beautiful natural environment" (Tahoe Fund, n.d). One major focus of Take Care is litter prevention. Take Care is known for its cute graphics that communicate how to protect Lake Tahoe (Fig. 10). These graphics, posted in the Basin, remind visitors and locals alike to take care of Tahoe by properly disposing of their waste, whether it be cigarette butts or broken plastic sleds.



Fig. 10: Litter specific posters generated by Take Care Tahoe.

SOCIAL RESPONSES TO LITTER

Volunteer clean ups

Aside from campaigns, another powerful social response to litter in the Basin is litter clean ups. In the Basin there are many entities that organize volunteer-led litter clean ups. The League is perhaps the most notable organization that offers volunteer clean up events. There are certain large clean up events that the League hosts every year. These include several Earth Day cleanups, most notably the South Tahoe Community clean up at Heavenly Village, as well as popular bike path clean ups. In addition to the League, Clean Tahoe is another organization that focuses on picking up litter in the Basin. Clean Tahoe has served the South Tahoe area since 1988, traveling set routes and picking up litter, contributing to an impressive 350 miles of thoroughfare cleaned (Clean Tahoe, n.d).

While many initiatives address litter in the Basin, most fail to consider the litter that enters the lake itself. An organization called Clean Up the Lake addresses this problem in Lake Tahoe by running scuba clean ups and removing litter from the lake bottom. Clean Up the Lake is working toward a goal of cleaning 72 miles of shoreline in Lake Tahoe. So far, they have cleaned 43 miles of shoreline beneath the lake's surface, and in doing so, have collected and removed 18,215 lbs. of litter. (Clean Up the Lake, n.d).

Infrastructure Implementation

The deposition of cigarette butts in Tahoe has caused social response from the communities around the Lake, since they are the most littered item from the League data. In fact, based on the League data, 250 cigarette specific canisters were placed around Tahoe in 2019 at litter hotspots (Mountain Democrat, 2019). Figure 11 shows the number of cigarette butts collected by both of the League's litter programs per year. It also shows the number of volunteers for each year.



Fig 11: Total counts of cigarette butts collected by the League by year. Number of volunteers per year is also included. 2020 saw the most cigarette butts collected despite the implementation of cigarette butt specific canisters.

Based on the figure, between 2019 and 2020, volunteers actually picked up more cigarette butts despite the addition of cigarette butt specific canisters. Although implementing more litter mitigation infrastructure, such as garbage and recycling bins, is an important social response to litter, this action alone has not had the intended positive effect. These data show that more must be done to holistically approach the issue of litter deposition in the Basin.

Conclusion

Preserving Lake Tahoe's natural beauty has been a continual struggle considering its status as a major tourist destination. Aside from visitation, the Basin has seen a steady increase in residences, and in light of the COVID-19 pandemic, even more people have purchased homes and moved to the area. According to the Tahoe Daily Tribune, "For years there has been an increased amount of people moving to the lake from the Bay Area and Silicon Valley areas to predominantly purchase a second home or for retirement, but COVID-19 created a sense of urgency for those on the fence about buying a second home away from the hustle and bustle of the big city."(Griffin, 2020). The pandemic has placed new emphasis on spending time outdoors and this, paired with the ability to work and attend school remotely, has inspired many who are financially able, to relocate to Lake Tahoe. This phenomenon has brought significant burdens to the area such as increasing rents and the difficulty for the workforce to support the influx of residents. This trend has also exacerbated Tahoe's litter problem. Laney Griffo, with the Tahoe Daily Tribune writes, "The pandemic has inspired people to get outdoors and visit Lake Tahoe. But with the surge of visitors comes an influx of trash and land managers are struggling to keep up with overflowing dumpsters." Historically, more visitation has led to more litter deposition as is seen in the trend for the month of July in figure 8. However, it is possible that with more people moving to the Basin, more people will volunteer with the League's litter programs helping to manage the issue. Over time, the League has seen an increase in the number of volunteers who participate in litter clean ups.



Volunteers with The League to Save Lake Tahoe

Fig. 12: Increasing rate of volunteerism with the League's litter programs. The data set includes incomplete data for 2022 so that column should be omitted when interpreting the overall trend. Fig. 12: Annual numbers of volunteers with the League's litter programs. The original League litter program began in 2014, and in 2019, an additional litter clean-up program called the 'Tahoe Blue Crew' was launched. These data show an increasing trend for volunteerism.

Not only is this trend hopeful, it is also promising because the more volunteers that pick up litter, the more visibility the litter problem garners. From my own personal experience running litter clean ups with the Tahoe Blue Crew, I can attest that picking up litter on the beach and on trails causes other patrons to stop, ask questions and engage with the process of litter collection.

However, simply enlisting more volunteers to run litter clean ups cannot entirely mitigate the issue of litter deposition in the Basin. Fig. 13 shows the total pounds of litter collected and removed



by the League's litter programs, a trend that has been increasing.

Pounds of Litter Collected by The League to Save Lake Tahoe

Fig. 13: Pounds of litter collected by the League's litter programs. The trend is increasing. 2022 data should be omitted as the data set did not contain up to date data for that year.

The relationship between pounds of litter collected and the number of volunteers with the League's litter programs is likely positively correlated. As more volunteers lead litter clean ups around Tahoe, more litter is collected. This idea represents the main limitation to the data collected by the League. While this thesis attempts to understand litter deposition trends around the Basin, it is somewhat limited by the design of the dataset. There is room for a future investigation of the trends represented by figures 12 and 13. If volunteerism continues to increase, perhaps there will be a decrease seen in the amount of litter collected in lbs. per year. This would mark a shift whereby there are more people collecting litter than there are litterbugs.

Suffice it to say, the issue of litter is not one that is unique to Lake Tahoe. Litter is found almost everywhere. At my own college campus, Vassar College in Poughkeepsie, NY, litter is an issue despite the fact that groundskeepers clean the campus "as often as time allows given the current staff" (D. Jaeger 2022, personal communication). In light of this, I helped organize a service day at Vassar College, and personally ran the litter pick up on campus. In this regard, on April 16, 2022, I ventured out with 7 student volunteers and over the course of two hours our team filled and disposed of two 55-gallon bags of litter.



Fig. 14: Pictures from the Vassar College Service Day taken on April 16, 2022. The image to the left shows some of the student volunteers from the litter pick up on campus: (left to right) Claire Karlin, Madio Wallner, Dimple Kangriwala, Anshuman Das and Lucy Brown. The picture to the right shows some of the largest and most unexpected litter items found including an office chair and a suitcase. This group collected two 55 gal bags worth of litter from Vassar's Campus.

The most commonly picked up litter items were: cigarette butts, plastic pieces, masks and food wrappers. The stand out items were an entire office chair, a suitcase and a metal container that once housed electrical equipment. This litter clean up on Vassar's campus was informative because it revealed that the buffer zones, or naturalized areas on campus were the most littered. While groundskeepers effectively keep the mowed lawns litter free, ironically the areas that seem more natural bear the brunt of hidden litter. This spatial trend would be interesting to apply to Tahoe in a future study where litter collection amounts are compared between trails and natural, non-trail settings.

Overall, the efforts of the League's litter programs as well as the clean-up at Vassar College evidence that human activity tends to leave a place littered, that littered areas become beacons of litter, and that the main litter markers tend to be common items such as cigarettes, food wrappers and plastic pieces. As discussed in this paper, there is absolutely no doubt that littering is highly toxic to our environment and that it is still prevalent in Lake Tahoe, and around the world. The good news is that the negative effects of litter to ecosystem health are becoming more widely understood, and more volunteers are gathering in larger numbers to act as stewards to places that they love. There is still, however, much work to do.

In order to help highlight and solve the litter problem in Lake Tahoe, the literature review component of this thesis delves into the issue of litter in Lake Tahoe from a three lens perspective, including reviewing environmental threats, relevant policies and social responses. The project component of this thesis provides a platform for people to explore the data for themselves. Towards that end, I have created a dashboard using ArcGIS online, wherein the League's litter data are visually displayed. This interface allows the user to interact with maps that are specific to the top five litter items found in the Basin, as well as an interactive map that displays all of the relevant data. These maps have pop-ups enabled, allowing users to click onto the map to see data such as counts of litter items as well as numbers of volunteers and distances cleaned. The dashboard can be accessed at this link: https://www.arcgis.com/apps/dashboards/75204fb68b3d455b92cc20973299b76. It is my hope that this platform will be utilized by the League and others that have an interest in preserving environmental harmony and the majestic beauty of Lake Tahoe.

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