5. Climate Change and the Westhampton Lake: Review and Recommendations

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Abstract

The Westhampton Lake is a campus icon and one of the University of Richmond's most prominent features. The significant attachment that members of the University community hold toward the lake imbues great value on the lake as a key geographic element of campus (Devine-Wright, 2013). However, the lake's status as a campus monument does not absolve it from the greater effects of climate change, a phenomenon which will continue to transform the geography and ecology of the lake. Without a concrete understanding of the implications of current and future climate change on campus, the community may leave the Westhampton Lake susceptible to environmentally unsustainable practices which threaten the lake and, thereby, the face of campus. Over the course of the semester, student researchers collected and analyzed existing information about Westhampton Lake so as to educate the greater community on the lake's health. This research team also offers recommendations so as to sustain the lake in the face of climate change on a local scale.

Introduction

This research recognizes the significance of Westhampton Lake not only as an ecological area existing in connectivity with the James River and the Chesapeake Bay Watersheds, but also as a distinct and central geographical feature of the University of Richmond campus. If the University is committed to sustainability and to cultivating the campus's natural beauty, then it is

in the University's best interest to preserve the health of Westhampton Lake in environmentally sustainable ways. The spatiality of the University places the lake at the center of all campus processes and features it as a natural place of beauty inherently connected to the University. The significance campus community members thereby place on the lake, a sentiment geographers call "place attachment", is critical to communicating the realities of climate change to the campus community (Devine-Wright, 2013). Through reaching out to the Westhampton Lake as a "place" on campus (linked to space, history, and ecology), addressing the effects of climate change on the lake will likely have a more resonant impact on the campus community than addressing climate change in a more remote place (Devine-Wright, 2013). The lake must also be linked to larger watersheds like the James River, the Chesapeake Bay, and other places affected by global climate change, as well as to its history, in order to effectively move community members to action.

Little has been documented on the origins and early uses of the Westhampton Lake. The University came to purchase the lake in its original bid for what is known as campus today, as part of 290 acres of land. The lake, previously known as Ben Green's Old Mill Pond, stretched 1326 feet in length, spanned over 14 acres, and split the property into two distinct parts. The lake's location between the two halves of the property served as a natural buffer between the men's college and the women's college, intrinsically linking it to the coordinate colleges' origins at the University (UR 2014).

Since the founding of the University, the Westhampton Lake has always been a significant aspect of campus grounds. In May of every year in the 1920s until the 1950s, a "Water Carnival" was held on the lake where students would compete in activities like distance swimming, skiing, and boating. The lake used to freeze over in winter and reports from as early

as 1926 note that students took quickly to skating in droves across the surface in January and early February (Collegian, 1926). There was also a diving pier and boat house on both the Westhampton and Richmond sides of the lake, housed with lifeguards from both colleges (Collegian, 1926; Collegian, 1927).

In 1976, University authorities banned swimming in the Westhampton Lake, yet the lake continued to be a hub for light-hearted student revelry. Fraternity brothers reported being thrown into the lake by fellow brothers as a chapter tradition in the 1980s (Kozuchowski, 2011). Jumping into the lake was an informal tradition for first-year students who had underwent Richmond College Investiture night, but was deserted after a student drowned during the festivities in September 1999 (Kozuchowski, 2011). Three other incidents of deaths in the lake have been reported in 1922, 1939, and 1969 (Kozuchowski, 2011). Since the most recent incident in 1999, students have largely stayed out of the water (Kozuchowski, 2011), although the lake continues to be the signature scenic feature of the University and thus enjoyed by students and the surrounding community (Figure 1). Therefore, the researchers of this study have compiled information and recommendations to create a healthier and more sustainable lake, in anticipation of future impacts of climate change on the Westhampton Lake.

Figure 1: The Westhampton Lake.

Methodology

The research team utilized a mixed methodology to best understand the past and promise of the lake. Researchers carried out archival research in the Collegian's digital archives, analyzing articles from as early as 1922 to the present day, to better comprehend the lake's social and geographic history in relationship to campus.

Researchers conducted five structured interviews with staff and faculty on campus in order to pool local knowledge and resources of the lake. The researchers recruited staff and faculty referred to them by Dr. David Salisbury and Dr. Peter Smallwood, or by the researchers' interviewees. The structure of these interviews and the nature of the questions depended on the specialty of each expert. Interviews took place in each interviewee's office and typically lasted around thirty minutes. The researchers compiled much of their primary data about the Westhampton Lake from these interviews.

Because the researchers found little recent data on the lake and none focused on climate change, the team also aggregated literature and data on lakes of similar size, climate, and ecology to the Westhampton Lake to assess the potential impacts of climate change. Researchers focused on issues and research pertaining to mid-Atlantic lakes in urban areas, university campuses, or areas with a great deal of impervious surfaces. Sources of literature and data include academic texts on geography and ecology, previous scientific studies on lakes and similar bodies of water, and reputable news articles on climate change. Researchers then applied the knowledge obtained from these studies to the context of Westhampton Lake's unique spatial and environmental circumstances. The researchers also pinpointed adaptive and mitigation solutions for the effects of climate change on similar bodies of water, which seem feasible within the University's context and capacity.

The research team also used spatial analysis in order to assess the spatiality of campus and the possible effects of climate change on the geography of campus. Maps were developed using spatial data from the University's Geographic Information System as well as data from the U.S. Geological Survey (Multi-Resolution Land Characteristics Consortium, 2011). They have been included in this chapter as figures.

Climate Change: Putting the Westhampton Lake in Context

The earth's climate has been fluctuating throughout its entire history. There have been extended periods of both warmer and cooler global climates, which have shifted at both a slow and rapid pace. However, the more recent warming trend over the past 1,300 years has been a hot topic for scientists, politicians and economists around the world as it is very likely the result of anthropogenic activities, in particular the emission of carbon dioxide and other greenhouse gases (Global Climate Change). The large amounts of gases emitted at a consistent rate create a 'heat blanket' around the earth, by trapping energy in the atmosphere and causing it to warm, which is known as the greenhouse effect. While this effect is necessary for life on earth, too much buildup of energy in the atmosphere can have powerful and negative effects for the climate, ecosystems and humans. Some of the future impacts of global warming have already begun, including sea level rise, global temperature rise, warming of the oceans, decline of arctic sea ice, glacial retreat and acidification of the oceans. The effects of global warming are often examined on a worldwide scale, which, while important, also makes it difficult for people to understand how they can be personally affected on a smaller and more local scale. Evaluating the effects of climate change on a local scale is important not only because of the value of understanding climate change, but also to reinforce the idea that everyone can be making lifestyle choices about adaptations and mitigations to counteract future impacts.

The climate of Virginia is generally wet and warm with mild winters, and is not excluded from the impacts of global warming. Over the past century, temperatures have increased, particularly in the winter months, where average temperatures have risen 1°C (Repetto 2012). Precipitation patterns have also changed, with a decrease of summer rainfall by 0.50mm/day and an increase of fall precipitation by 0.50mm/day. In addition, there have been more periods of, and more unpredictability in intense precipitation, and more frequent wet and dry periods (Repetto 2012). If greenhouse gases continue to be emitted at the same, if not higher, levels as they are today, the average temperatures and amount of precipitation in Virginia are predicted to continue to rise. The severity of storms and hurricanes are also predicted to increase due to Virginia's proximity to the coast, which provides warm, moist air over warm ocean waters, and studies predict that by the year 2080, Category 4 and 5 hurricanes will be 80% more likely than today (Repetto 2012). The changes in long-term climate patterns and climatic variability will likely have significant effects on agriculture, human life, and natural ecosystems, but more importantly, will have greater impacts on the already stressed ecosystems and areas of development in Virginia.

Climate Change and the Chesapeake Bay Watershed

The Chesapeake Bay Watershed is currently experiencing climate change related problems that parallel the issues affecting the Westhampton Lake. The largest problem the Chesapeake Bay Watershed is currently facing is the loss in riparian buffer zones[1]. Loss of this biome has been detrimental to the landscape and the health of the James River Watershed, and,

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A riparian buffer zone is the area between the land and a river or stream that contains a niche habitat and serves as a biofilter for non-point source pollution.

therefore, the larger Chesapeake Bay Watershed. Riparian buffer zones act as a filter for fertilizers and pesticides, and prevent harmful contamination of the river systems (State of the James). On campus, natural riparian buffer zones have been replaced with parking lots. These impervious surfaces are aiding harmful runoff and contributing to the high levels of nitrogen and phosphorus (Figure 2).

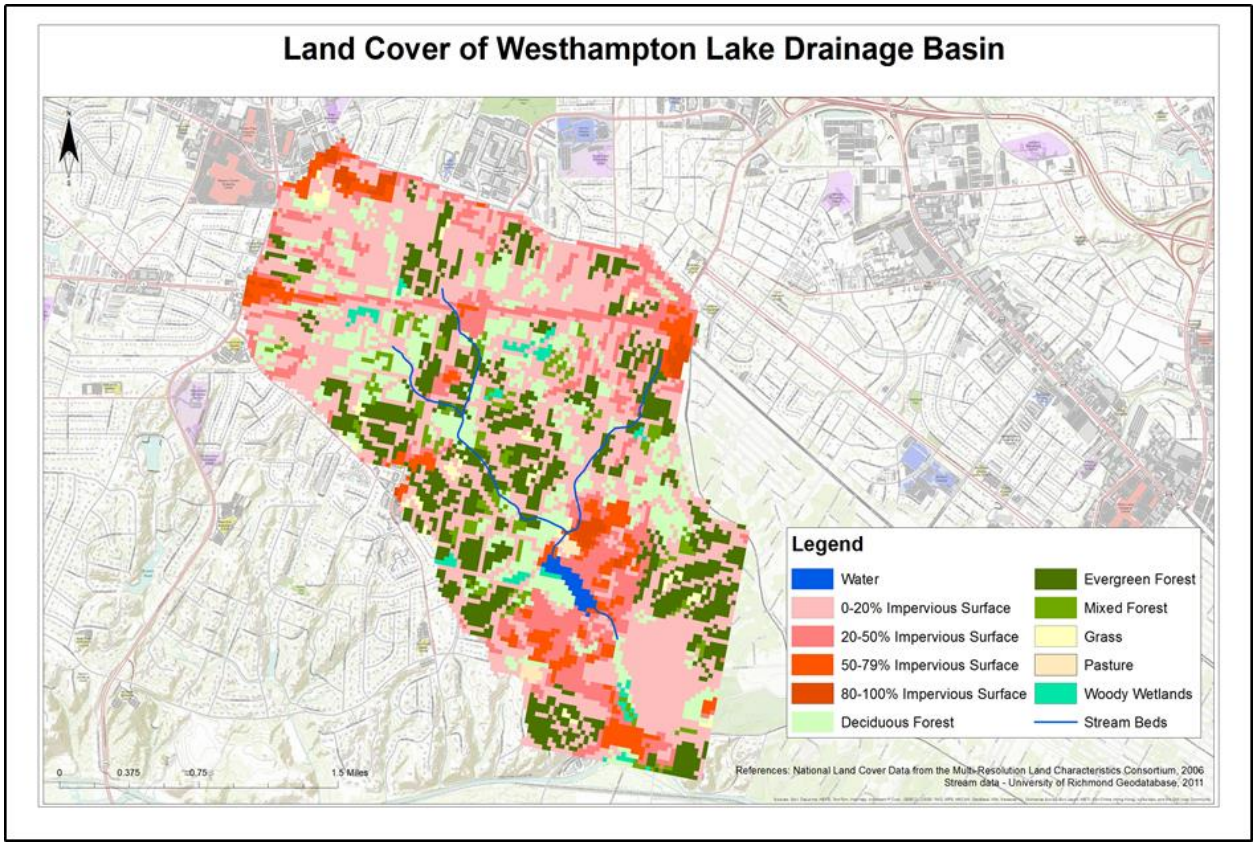

Figure 2: Westhampton Lake sits within a drainage basin hosting a mosaic of land cover and land uses.

Impacts of Climate Change on Westhampton Lake

The University's campus environment is very susceptible to the effects of global warming facing the rest of Virginia and the Chesapeake Bay, and one of the most vulnerable areas of campus is Westhampton Lake. Home to a variety of flora and fauna, the lake is a valuable ecosystem in the James River Watershed and a campus icon. The lake is approximately

14 acres in size, but its drainage basin spans over 1632 acres of land including roads, residential areas, a golf course, and forested land. Considered an urban lake, Westhampton Lake is at higher risk to environmental degradation as the urban development in its drainage basin diminishes the resilience of the ecosystem to climate variability. Paved areas such as roads increase peak stream flows during storms (Rogers and McCarty, 2000).

Lake Dredging

Westhampton Lake is drained approximately three quarters each summer to allow for maintenance. The lake is dredged to remove excess sediment and materials from the lake bottom and maintain the holding capacity. The University of Richmond uses a long-reach dredger. The long-reach dredger digs into the lake bed and pulls out light colored, sandy sediment. Approximately fifty truckloads of this sediment are removed and transported off-site (Glass, 2014). If the sediment were not removed, the bottom of the lake would rise and the shallow water would create a swampy area. Lake dredging largely impacts the aquatic ecosystems. When the lake sediments are disrupted an increase of turbidity occurs, which can negatively affect aquatic species such as fish and turtles (von Mayer date). Westhampton Lake can take anywhere between seven hours to seven weeks to refill, depending on the watershed and amount of rain during that timeframe (Glass, 2014).

Literature review

In order to determine how climate change will affect Westhampton Lake in the coming decades, the researchers examined several previous studies on lake dynamics in the US and Canada. In a study done in 1999, limnologists simulated the effects of a doubling of CO2 levels in the atmosphere in order to determine the effects on small lakes in the United States. The

results of the study indicated that an increase in CO2 emissions caused lake minimum and maximum temperatures to increase by up to 5.2 degrees Celsius, and an increase of seasonal summer stratification[2] by up to 66 days more (Fang and Stefan, 1999). The authors believe that the result of these changes would include shifts in species distributions, and a change in fish habitat (Fang and Stefan, 1999).

In another study on four lakes in Wisconsin, simulations of a doubling of CO2 levels in the atmosphere were also used to determine the effects of climate change on lake health. The authors found similar results, including an increase and intensity of stratification and an increase of maximum surface temperatures (DeStasio, *et al.* 1996). In addition, the authors found that surface temperatures at times exceeded upper lethal levels of warm and cool water fish, and also caused a change in the migration of planktivores.

Research done on data collected from long-term ecosystem monitoring and stations across America indicated that changes in climate – precipitation and temperature in particular – would have a significant effect on the quality of surface waters (Murdoch *et al.* 2007). The authors of this study found that changes in water quality during storms, snowmelt, periods of elevated air temperature and/or drought could cause conditions that exceed thresholds of ecosystem tolerance and lead to water-quality degradation. In effect, the degradation of the water quality would create a habitat unfit for most of the species of the lakes. Furthermore, as stated previously, the annual fall precipitation has increased in Virginia, thereby increasing the risk of flooding for all parts of the James River watershed, including Westhampton Lake.

Summer stratification is the separation of lake waters into three layers due to and winds, and is an important process for fisheries management, phytoplankton populations and water supply quality.

A more extreme result of climate change and Westhampton Lake includes an amoeba called *Naegleria fowleri,* which are found in warm, fresh bodies of water such as lakes and rivers. When inhaled through the nose, these amoebas consume cerebral fluid and gray matter, causing death in 99% of cases (Drummond, 2013). While cases of *N. fowleri* are very rare, scientists believe summer heat waves and rising water temperatures are causing the recent occurrences in unexpected locations in the US. While students are currently banned from swimming in Westhampton Lake, some still do so and the increasing water temperatures of the Lake could threaten not just students' college career, but also their lives because of *N. folweri*.

Identified problems in the lake

In 1998, the University convened a study group in response to perceived degradation of Westhampton Lake. This group outlined the conditions and causes of degradation of the lake and gave recommendations for maintaining the health of the lake in the future. According to the report, accumulation of silt, excessive fertilizers, algae blooms, bacterial contamination and overfishing of bass populations were the biggest threats to Westhampton Lake in 1998 (Bishop, et al. 1998). The report attributes the accumulation of silt, leaves and fertilizers in the lake to storms washing debris down Little Westham Creek and into the lake. As the area of the lake is small relative to its drainage basin (approximately less than 1%), it is very susceptible to land use. Therefore, an increase in precipitation in the Richmond area, caused by climate change, will have profoundly negative impacts on the Westhampton Lake. More rainwater draining into the lake will carry fertilizers and debris from the surrounding neighborhoods and wooded areas and dump them into the Lake. Allowed to accumulate, the fertilizers and debris will cause phosphorus build-up and result in algae blooms, which will decrease water quality. In a recent

interview with Steve Glass, Horticulturist and Landscape Manager, Glass indicated that debris cleanup in the two creeks feeding into Westhampton Lake remains today the biggest concern for water quality in the lake (Glass, 2014). Mr. Glass and other University employees physically walk the creeks almost every day to clean up wayside debris as a form of lake maintenance (Glass, 2014).

Another major issue regarding the lake is the high levels of bacteria in the water, most likely caused by droppings from waterfowl and dogs from the surrounding residential areas. In 1994, coliform bacteria sampling in the lake was performed at four different locations on the lake: the gazebo, the Richmond side of the lake, the Westhampton side of the lake, and by the Commons. Monthly concentration averages were taken for each site, and the monthly average for the entire lake was compiled from this data. In 1994, the monthly average concentration of coliforms in Westhampton Lake was about 500 coliforms per 100 ml of water, while the US EPA recommends a standard for contact recreation of less than 200 coliforms per 100 ml of water (Bishop, et al. 1998). Westhampton Lake was deemed unfit to swim in because of these high coliform bacteria concentrations.

Over the past six years, Maren Reiner, director of the University's biology laboratories, has conducted regular water quality tests of Westhampton Lake with biology classes. To evaluate the quality of the lake, students from the courses performed three sampling techniques over the course of two weeks, including bacterial plate counts, water quality parameters, and species diversity counts. In the fall of 2010, the average coliform count per 100 ml sample was 5061.6 coliforms, a dramatic increase from the 1994 data (Bishop J.W. et al., 1998). The increase in coliforms can be attributed both to an increase in waterfowl in the lake, as well as a rise in average water temperatures which encourages E. Coli growth. However, the data collected over

the past six years has not been consistently taken, and has been performed for instructional purposes for biology students, decreasing the reliability of the data. Despite this, the use of Westhampton Lake for educational purposes should not only continue, but should be encouraged to expand.

Recommendations

Community outreach

With the help of the campus and the community, Westhampton Lake can overcome climate change issues and therefore, our first recommendation is a strong community outreach. The drainage basin of the Lake extends to several surrounding communities, and in order to address the future issues of the lake, an informed public is necessary. An informational website displaying the status and role of Westhampton Lake in the James River watershed should be available for students faculty and staff at the University, as well as neighborhood residents.

In addition, Westhampton Lake is the perfect educational tool for not only classes on campus, but for the surrounding neighborhoods as well. Students at the University of Richmond will benefit from learning about the lake and climate change issues in relation to the James River Watershed and Chesapeake Bay Watershed. Also, elementary, middle, and high school students would greatly benefit from this learning opportunity. The residents in the neighborhoods surrounding campus will benefit from learning about the drainage basin they are living in and how the fertilizers, pesticides, and lawn debris from their yards will affect their environment.

One step that has already been taken to educate the public is the implementation of informational signs around Westhampton Lake which were researched and designed by students in the Earth Lodge program. There are a total of five signs around the Lake, including, “Common Tree Species on Campus”, “Fauna around Westhampton Lake,” “History of

Westhampton Lake," "Our Place in the Watershed," and "Carbon Sequestration and Storage." While these signs are informative, they are only the start to what the University should be doing to engage the public with the Westhampton Lake ecosystem.

On campus, implementing a dog waste system with plastic bag dispensers for dog walkers would not only help the health of the lake, but would also educate community members on why dog waste systems are important. Signs around the lake explaining why the geese should not be fed and what how phosphorus is added to the water from their waste would educate community members and members of campus alike.

Shoreline Stabilization and Geese Removal

The removal of geese from Westhampton Lake would benefit the health of the lake and the greater watershed as well; because of the amount of phosphorus their waste produces (Manny *et al.*, 1994). In order to remove the geese from the Westhampton Lake ecosystem and also prevent erosion of the Lake edges, we suggest the University should fund and enact a shoreline restoration project. Thicker geese deterring vegetation, such as pachysandra and periwinkle, planted on the Lakeshore would prevent geese from being able to reach the water, and eventually cause their migration away from campus (NH Lakes, 2010). Furthermore, increased vegetation would create natural stabilization for the lake's edges, which would eradicate the need for lake dredging each summer, and also prevent erosion caused by increased flooding due to climate change.

Installation of a Floating Wetland Island

We recommend a floating wetland island for the Westhampton Lake. A floating wetland island is both aesthetically pleasing and functional. This man-made ecosystem mimics natural wetland

habitats and effectively removes excess nutrients from the water, sequesters carbon, increases dissolved oxygen levels, helps to buffer pH, provides aquatic and avian habitat, and will offer public education opportunities (Stewart *et al*., 2008). Native plants are grown on the wetland island and their roots reach through the island to the water column below. As water passes through the underwater roots, they work to pull problematic nutrients out of the water. The Biohaven Wetland Islands have been proven to pull 0.55 grams per square foot of dissolved phosphate from the water per year and 10.48 grams per square foot of total nitrogen from the water per year (figure 3) (http://www.bluewing-env.com).

Pollutant	Daily Rates $mg/ft^2/day$	Annual Rates $g/ft^2/year$
Nitrate ($NO_3^?$)	21	7.67
Total Nitrogen (TN)	28.7	10.48
Ammonia (NH_3)	25.8	9.42
Total Phosphorus (TP)	1.9	0.69
Dissolved Phosphate ($PO_4^?$)	1.5	0.55
Copper (Cu)	0.35	0.13
Zinc (Zn)	2.3	0.84
Fine Particulates (FP)	3.1	1.13

Figure 3: Floating island pollutant removal rates for eight pollutants. Information provided by Bluewing environmental solutions and technologies.

The company, Bluewing Environmental Solutions and Technology advertises standard pricing for Biohaven islands to be $32 per square foot, which does not include the price of shipping, plant mix, installation plants, anchoring and design consulting (http://www.bluewing-env.com). In addition, according Floating Islands West LLC, it is important to consider the size of the waterway when purchasing and installing a floating wetland. The company recommends

750 sq. ft. of Biohaven wetland for every surface acre of water (http://www.floatingislandswest.com). We recommend for the Westhampton Lake, the University should purchase and install a 160 sq ft floating island, which is similar in size to the one recently installed at the Lewis Winter Botanical Gardens Lake, located in Richmond. The floating wetland should be installed on the north side of the gazebo on the Westhampton Lake. If the floating wetland proves successful in Westhampton Lake, we recommend that the University should then purchase two additional floating wetlands and install them on the south side of the gazebo as the system would be extremely beneficial for the health and sustainability of Westhampton Lake.

Conclusion

The University of Richmond Board of Trustees approved the 2011 Campus Master Plan to match the university's campus to the reputation staff and faculties alike have worked to achieve. Throughout the development and expansion, the University has vowed to work in ways consistent with its commitment to sustainability and promised to preserve the green space that is so iconic on this campus. Along with making campus more navigable for pedestrians and bikers, creating additional areas for social and intellectual spaces, and developing the southern portion of campus, the University of Richmond has committed to making improvements to the Westhampton Lake and Little Westham Creek valley by creating a continuous path around the lake and along the creek. A path will increase connectivity to campus and the community and serve as an educational, research, and recreational amenities (Campus Master Plan 2011). Implementing the recommendations outlined in this report will not only aide in helping the Westhampton Lake reach a sustainably healthy state, but it will also preserve the lake as a natural icon on campus for generations to come.

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