North Grounds Stream Restoration Design

The Role of Urban Greenways in Creating an Equitably Resilient City Through An Examination of the Rivanna Trail Network in Charlottesville, Virginia

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Civil Engineering

By
Shayla Utzinger

November 3, 2023

Nora Levasseur, Karin Brett, Lucas Bushey, Patrick Brown, Dorian Gaines

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-related Assignments.

ADVISORS

Prof. Pedro Augusto P. Francisco, Department of Engineering and Society

Prof. Jonathan L. Goodall, Department of Civil and Environmental Engineering

Introduction

Located behind the University of Virginia's (UVA) North Grounds, an unnamed tributary of the greater Meadow Creek and Rivanna River watersheds flows through Charlottesville's Rivanna Trail greenway. The small stream has experienced increased stressors due to new development and impervious surface construction in the areas directly adjacent to the stream, which is bordered on one side by UVA Grounds and facilities and on the other by the US 250/Route 29 bypass. Two reaches within the stream have been rated highest priority due to their extreme degradation and erosion, which threatens the health of the stream itself as well as that of the greater watersheds. The goal of this capstone project is to create a design to address the degradation in the stream and restore the health of the stream. Additionally, the design will be prepared to cope with increased runoff due to climate change events.

Running parallel to the the North Grounds tributary is a segment of the greater Rivanna Trail Network, an over 20 mile urban greenway that encircles the city of Charlottesville, connecting neighborhoods and residents with acres of "urban wilderness" (Rivanna Trails Foundation, n.d.). Through a network of both paved and more rugged paths, this system of trails provides users with access to many of Charlottesville's community assets such as 6 city parks, views of the Rivanna River and its tributaries, UVA Grounds, playgrounds, Charlottesville High school, and even a disc golf course. The Rivanna trail network is an example of an urban greenway, a term whose definition is very broad, however can be distilled to describe linear corridors of green space with a variety of functions (Hellmund & Smith, 2006). As urban populations grow and the effects of climate change become more apparent, the implementation of greenways has become widely used as a tactic to address urban climate resilience and adaptation (Kuiper & Infield, 2023). Greenways perform a variety of ecological, economic and social functions within the affected communities (Horte & Eisenman, 2020). Vulnerable populations, including minority and low income communities, will disproportionately bear the burden of climate change (Pachauri, Mayer, & Intergovernmental Panel on Climate Change [IPCC], 2014. This thesis will focus on

the equity of resilience functions of urban greenways primarily through the lens of climate justice. Through the examination of literature as well as a case study on the Rivanna Trail Network, this thesis seeks to further understand the role of urban greenways in the creation of a socially resilient urban landscape.

In combination, this socio-technical thesis and capstone design seek to examine different facets of the complex relationship between urban natural spaces and the communities and neighborhoods interacting with them. This Capstone design is a practice of creating resilient solutions to human impacts in the face of increased development, while the STS thesis examines the equity of the resilience functions provided by green spaces. In the face of a changing climate and growing urban population, these relationships become ever more important to understand. Once further understood, the benefits and detriments for both human society and the natural systems within urban space can be leveraged to weave landscapes that support equitable and resilient urban communities.

North Grounds Stream Restoration Design

Increased runoff due to human development and construction of impervious surfaces has had a serious effect on the health of a tributary of Meadow Creek in the University of Virginia's North grounds.With collaboration from the group's partners at Biohabitats, two sections (or reaches) within the greater tributary channel have been selected to be the focus of this Capstone design project. Characterized by steep banks and active erosion, the most degraded reaches of the stream hold the greatest potential for pollution reduction credits. The University of Virginia holds stake in this design project as it is particularly interested in these credits that they may achieve with this restoration.

In order to create a successful restoration design, the nature and extent of the degradation of the Meadow Creek Tributary must first be understood. Through the use of surveying, GIS, and lidar data the Capstone team will create a detailed model of the existing state of the stream. After collecting existing

conditions, hydrologic modeling will be done to evaluate the watershed extent as well as flow rates within the stream. The Hydrologic and Hydraulic (H&H) analysis will involve the hydraulic modeling softwares HEC-HMS and HEC-RAS to inform future design decisions. Additionally, total suspended solids (TSS), total phosphorus, and nitrate samples will be collected from the stream during both dry and wet weather events. This water quality data collection will be used to further assess the health of the stream, as well as to provide insight into the potential for nutrient credits and if the stream meets Total Maximum Daily loads (TMDL's) of the water bodies it feeds into. Water quality sampling will additionally provide a baseline that can be compared to in the future after the restoration project has been completed.

Using the results from the H&H analysis as well as water quality results, a design to address sediment loads, nutrient concentrations, salinity and bank erosion will be created. This design will be based on standards from the Virginia Stormwater Management Handbook and Virginia BMP Design Specifications, as well as professional advice from Biohabitats partners. The design will work to not only restore the stream to it's more natural state, but additionally prepare it to cope with increased influent runoff due to both climate change and further development in the adjacent areas. The stormwater conveyance design will likely include systems of step-pools, riffles, and bank stabilization to stabilize the channel, slow the flow of the stream and prevent further erosion. There is potential to reroute the connection of one of the reaches back to the main tributary stream, however further modeling must be completed to influence this decision. In addition to the engineering of the channel itself, a plan for managing the invasive plants on the site will be developed, along with a landscaping plan to introduce native species on sight to assist with erosion control. This tributary stream runs through the Rivanna trail network, a reroute of the trail will be required during the construction phase of this design. An additional challenge of this project will be to create a reroute plan that allows the continued use of the Rivanna trail recreation area.

The Role of Urban Greenways in Creating an Equitably Resilient City: An Examination of the Contributions of the Rivanna Trail Network in Charlottesville, Virginia

With 7 in 10 people projected to live in cities by 2050, the need to develop sustainable and resilient urban landscapes is more important than ever (World Bank, 2023). A changing climate adds additional challenges facing cities. In 2014, The Intergovernmental Panel on Climate Change reported with very high confidence that urban areas around the world will experience risks including heat stress, water scarcity, drought and inland and coastal flooding (Pachauri, Mayer, & IPCC, 2014) . The effects of climate change will not be felt evenly across populations. Those living in poverty, as well as other marginalized groups, will bear a disproportionate burden of and experience heightened vulnerability to the adverse effects of climate change (Pachauri, Mayer, & IPCC 2014; National Institute of Environmental Health Sciences [NIH], 2022). Strategies to adapt to and mitigate the risks of climate change are essential to integrate into urban spaces, and one of the strategies to do this is the implementation of green infrastructure.

Greenways are a form of linear urban green infrastructure and can be a powerful tool in creating a resilient urban landscape (Fink, 2016). The use of greenways to improve city resiliency has become prominent as they provide a number of social and ecological services, such as flood protection, biodiversity, recreation, and community connection (Martin, 2016). However, access to greenspaces in urban environments, as well as the environmental benefits that come with them, is often unevenly distributed across communities. Socioeconomic and ethnoracial disparities in both access to green spaces and also use persist in urban areas, and attempts to resolve these disparities can, in some cases, lead to "green gentrification." (Rigolon et al., 2020). Tactics for the planning and implementation of urban greenways that work toward equity as well as resiliency in urban spaces is essential as they become more commonly used.

In addition to an examination of existing literature on equitable green space, a case study of The Rivanna trail network in Charlottesville will be conducted. The Rivanna Trail greenway is a linear loop trail surrounding the City. It consists of over 20 miles of paved paths, more rugged trails, and spur connections shared by city residents and used to hike, run, bike, fish, and access many of Charlottesvilles community assets (Rivanna Trails Foundation, n.d.) . The network connects multiple neighborhoods within the city, as well as 6 city parks. The city of Charlottesville is racially and economically diverse, with an extensive history of inequality and displacement of minority communities (Cameron & Kahrl, 2021). Using references and examples from existing literature, spatial analysis utilizing GIS mapping and, if time permits, a regression analysis, this paper will seek to gain an understanding of the layout and access to the Rivanna Trail network, as well as provide recommendations for improvements and additions to the network to promote equity through the trail system.

Through the investigation into literature as well as a case study of the Rivanna Trail network in Charlottesville, this thesis seeks to understand the role of urban greenways in creating an equitably resilient urban landscape.

Conclusion

As urban populations continue to grow and the use of green urban infrastructure to reduce the impacts of climate change in cities are implemented, it is essential to understand the interactions between urban green spaces and the communities around them. Through the technical Capstone design project, the health of an urban stream will be assessed and modeled, and an engineering design created to restore the stream. Through STS research, the interactions between urban greenways and society will be examined through an environmental justice and equity lens. Together, an understanding of the engineering of green infrastructure and the equity of their implementation will come together to work towards the creation of resilient and equitable cities. Ideally the results of this thesis can be used to provide suggestions for

improvements and expansions to the Rivanna trail to provide more equitable access to urban greenways in the City of Charlottesville.

References

Cameron, Brian & Kahrl, Andrew. "UVA and the History of Race: Property and Power." (March 15, 2021). Accessed November 3, 2023. https://news.virginia.edu/content/uva-and-history-race-property-and-power.

Fink, Charles A. "Greenways As Resilient Global Landscape Solutions" 5 (2016).

Hellmund, Paul Cawood, and Daniel Smith. *Designing Greenways: Sustainable Landscapes for Nature and People, Second Edition*. Washington, D. C., UNITED STATES: Island Press, 2006. http://ebookcentral.proquest.com/lib/uva/detail.action?docID=3317417.

Horte, Olivia, and Theodore Eisenman. "Urban Greenways: A Systematic Review and Typology." *Land* 9, no. 2 (February 1, 2020): 40. https://doi.org/10.3390/land9020040.

Kuiper, Jacobien F., and Elisabeth Hamin Infield. "Greenways for Climate Adaptation: Avoiding the 'Green Paradox' While Improving Urban Resiliency." Accessed September 10, 2023. https://doi.org/10.7275/STRT-D854.

Martin, Tricia. "Greenways as Resilient Infrastructure: The Brooklyn Greenway Case Study" 5, no. 2 (2016).

Pachauri, R. K., Leo Mayer, and Intergovernmental Panel on Climate Change, eds. *Climate Change 2014: Synthesis Report*. Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2015.

"People Who Are Vulnerable to Climate Change - Climate Change and Human Health." National Institute of Environmental Health Sciences [NIH], 2022. Accessed November 3, 2023. https://www.niehs.nih.gov/research/programs/climatechange/health_impacts/vulnerable_people/index.cfm.

Rigolon, Alessandro, Samuel J. Keith, Brandon Harris, Lauren E. Mullenbach, Lincoln R. Larson, and Jaclyn Rushing. "More than 'Just Green Enough': Helping Park Professionals Achieve

Equitable Greening and Limit Environmental Gentrification." *Journal of Park & Recreation Administration* 38, no. 3 (June 2, 2020): 29–54.

"Rivanna Trails Foundation - Guide to the Trail." Accessed November 3, 2023. https://www.rivannatrails.org/Guide.

"Urban Development Overview." World Bank. April 03,2023. Accessed November 3, 2023. https://www.worldbank.org/en/topic/urbandevelopment/overview.