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Accessibility or Environmental Conservation? Evaluating the relationship between Environmental Protection and Hiking Trails Accessibility via LiDAR & Remote Sensing

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BINGHAMTON UNIVERSITY
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Introduction

- Binghamton University Nature Preserve spans 190 acres of land, with a notable 20-acre wetland, serving a multifaceted purpose. It is dedicated to preserving the ecological integrity of this landscape, fostering biodiversity, and facilitating research and environmental education.
- The current lands that comprise the Nature Preserve used to be a dairy farm. In 1970, the University officially decided to establish the nature preserve and the boundary of it.

Accessibility

- The **Americans with Disabilities Act (ADA)** has specific guidelines and standards for designing hiking trails to make them accessible to individuals with disabilities.
- **Information accessibility**: The hikers should have adequate information before entering the nature preserve, including the trail conditions (length, slope, difficulty level, etc.), navigation, emergency contact, potential hazards, and trailhead information.

Study Area

Environmental protection

Positive:

- **Conservation awareness**: Hiking fosters a deeper connection with nature, promoting support for conservation efforts through environmental awareness and appreciation.
- **Stewardship**: Hikers may become advocates for natural area preservation, actively participating in volunteer stewardship initiatives to protect the ecosystems.

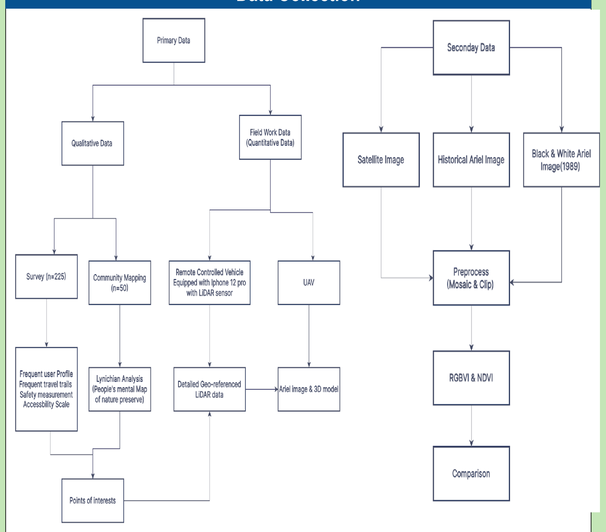
Negative:

- **Soil Erosion**: With the increasing number of visitors, especially on steep or fragile terrain, the constant foot traffic can wear down the topsoil and vegetation, leading to bare patches and gullies.
- **Invasive species**: Hiking and outdoor activities can unintentionally spread the invasive species, disrupting native ecosystems and altering their natural balance.
- **Habitat disruption** and **wildlife disturbance:** Frequent foot traffic in nature preserves can disrupt fragile ecosystems and damage plant and animal habitats.
- **Litter (trash) pollution and noise pollution:** Noise pollution from large groups of hikers can disrupt the peace and tranquility of the environment, affecting both wildlife and other visitors. Hikers can inadvertently leave litter or pollutants behind, such as trash.

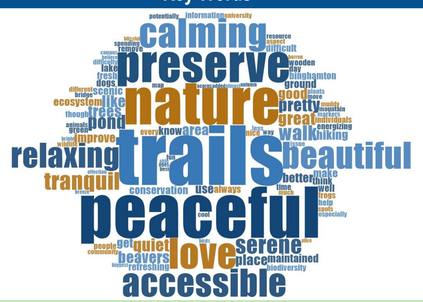
Study objectives

This research focuses on Binghamton University nature preserve as a case study to explore the intricate balance between two vital objectives: ensuring equal access for all user demographics, while safeguarding the ecosystem services it provides.

Data Collection

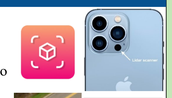


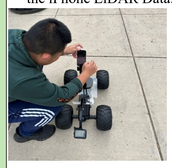
Key Words



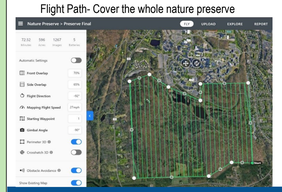
Methodology

- Flew UAV (drone) through the study areas.
- Used Drone2Map to make a 3D model of flight area and ortho-mosaics
- Rover (Remote-controlled Vehicle) equipped with an iPhone 12 Pro LiDAR Sensor was used to surveillance the trails at ground level.
- DJI Osmo 6 Stabilizer was used as a backup method for ground surveillance when encountering the Marsh or bump areas.
- LiDAR data were collected through PIX4D Catch and processed in PIX4D Matic and PIX4D Cloud.
- Ground Control Points were captured using RS-2 to geo-referenced the iPhone LiDAR Data.





Flight Path- Cover the whole nature preserve



Flight Path-Corridor Flight Path through Most Frequent Used Trail

Survey & Community Mapping Results

Undergraduate Student Mental Map

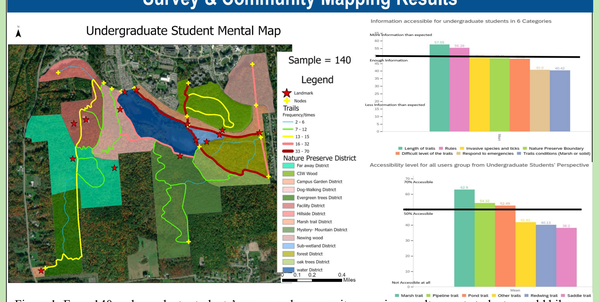


Figure 1: From 140 undergraduate students' survey and community mapping results, most students would hike around Harpur ponds and wetlands. They divided the nature preserve into different districts based on their function and usage. Students need more information to guide them to hike in the nature preserve.

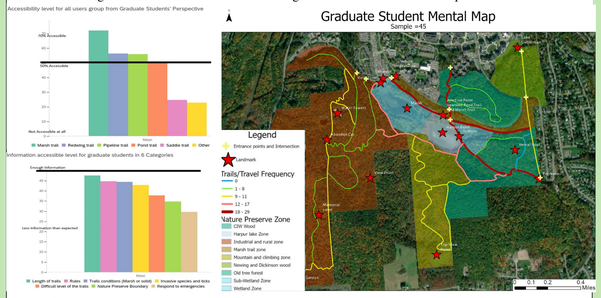


Figure 2: From 45 graduate students' survey and community mapping results, most students would rather hike in areas close to academic areas (Pond trails and Marsh trails). They lack enough information to guide them to hike in the nature preserve.

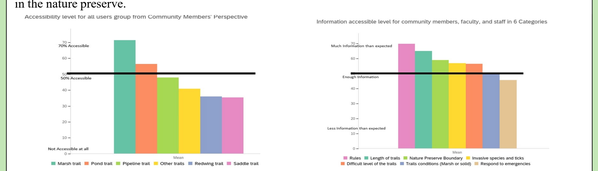


Figure 3: From a total of 45 community members, faculty, and staff survey results, most of the community members thought that most of the trails were not accessible for people with disabilities or seniors, and information was available for them to have pleasure hiking experience in the nature preserve.

In summary, based on the overall 230 users' experience, frequent hiking trails are more than **50% accessible** for all user demographics. Information or guidance is **not enough** for students, especially first-time visitors, to acknowledge the condition of the trails in the nature preserve. Points of interest have been extracted through the survey, which is the frequent hiking districts around Harpur ponds and wetlands.

Historical Data Analysis

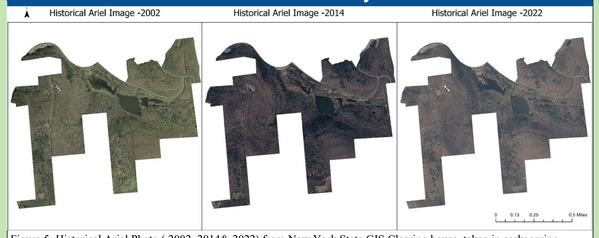


Figure 5: Historical Ariel Photo (2002, 2014& 2022) from New York State GIS Clearing house, taken in early spring.

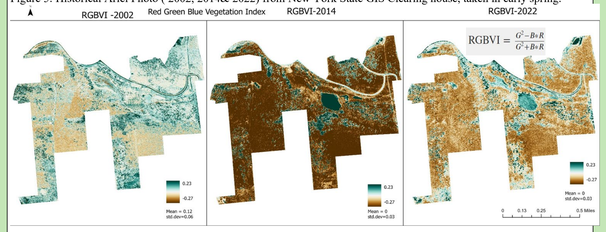
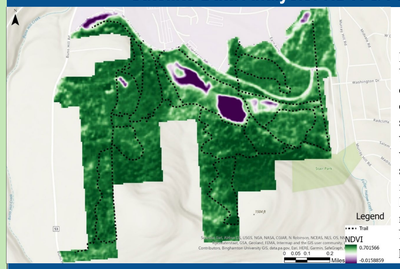


Figure 6: Red Green Blue Vegetation Index(RGBVI) has greater accuracy in classifying and measuring the vegetation density in 3 bands (without NIR) Ariel images. RGBVI defines values from -1.0 to 1.0, where negative values are mainly formed from functions corresponding to empty areas of rocks and sand. Values close to zero are primarily formed from water bodies and building construction. Positive Values correspond to vegetation.

Satellite Data Analysis: NDVI & Prediction



$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Figure 9: Normalize Difference Vegetation Index (NDVI) was computed using ArcGIS raster calculator based on Sentinel-2 satellite imagery (9/28/2023), which provided 4-band images with a 10-meter resolution. Deeper shades of green on the map indicate higher vegetation density. Interestingly, there appears to be a negative correlation between NDVI values and the travel patterns of individuals.

Drone Data Analysis

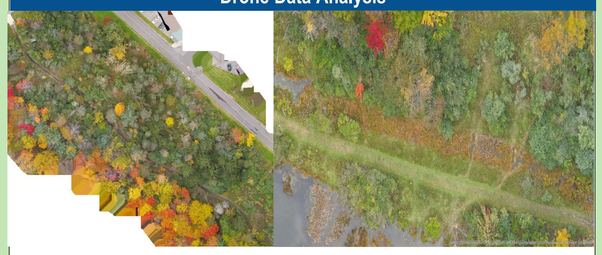
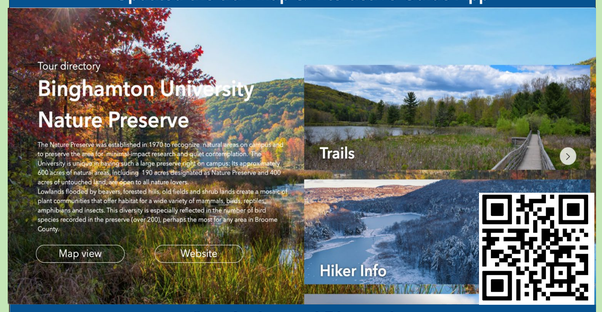


Figure 10: Utilizing corridor flight modes, researchers gain a thorough overview of the condition of Marsh trails. Most hikers enter the preserve through the Marsh trail and depart at the intersection to view the bridge. The two images demonstrate that trails experiencing higher foot traffic tend to exhibit more pronounced barrenness and erosion compared to less frequented areas.

LiDAR Analysis

Figure 11: LiDAR gives researcher a detailed texture of each trail. Although the wood board made the trails partially inaccessible for wheelchairs, etc., it minimized the trail's impact on the environment and protected the underneath vegetation.

Updated the trail Map & Interactive Guide App



Conclusion and Discussion

Figure 12: Original development model for nature preserve development in 1968, from University Archives.

- Prior to its acquisition by Binghamton University, the entire area was owned by Harry Lewis Dairy Farm, making the land highly vulnerable to disruptions.
- In 1969, with students and faculty protests, the University officially altered the official playground plan and designated it as a nature preserve instead. Without students and environmental enthusiasts' efforts, this area would not be a nature preserve.
- From the historical environmental survey report, most of the soil were classified as silt loam, 20% sand, 60% silt, and 20% clay. All the soil are acid. These oil characteristics increase the susceptibility to erosion and the potential for compaction.
- Most of the soil has poor drainage and low fertility. The native species adapted to these conditions well but still depended on maintaining and improving the soil's conditions.
- These conditions collectively result in a slower recovery of the nature preserve from land disturbances, rendering it more susceptible to extreme weather events and natural hazards.
- In recent years, the rising number of visitors has led to a heightened risk of land disturbances, soil erosion, and compaction within the nature preserve. Unethical behaviors further exacerbate these issues, as straying from designated trails, the proliferation of invasive species, and litter pollution diminish its resilience and increase its vulnerability to extreme weather conditions.
- In the future, as a result of climate change, the ecosystem of the nature preserve may face potential destruction and could require an extended period for recovery.
- Accessibility, especially information accessibility, needs to improve to maximize the benefits of the nature preserve and achieve the goals of the nature preserve, including promoting environmental education, environmental awareness, and appreciation of the ecological function of the land.
- Making the nature preserve 100% accessible (ADA or ABA compliance) would damage the ecosystem service and make the ecosystem more fragile, but trails may be classified as all accessible, partially accessible trails for people with disabilities.

Policy Implication

- One possible solution would involve partially closing the nature preserve. According to the survey results, some parts of the nature preserve were seldom used, and some parts of it were frequently used. Temporally closing frequent disturbances using areas and giving it some time to recover the ecological services would be one feasible option. It also encourages visitors to explore other non-frequent areas.
- Installing professional red-light detectors on frequent-use trails to track the number of visitors per week.
- Engaging public participation (PPGIS) - Survey 123 has been designed for hikers to report land disturbances or other relevant problems and establish a dashboard for managers to solve the problems or continue monitoring the progress.
- A mobile/ web App will be designed and replace the current paper version brochure to guide the visitors to improve information accessibility.
- Continue using UAVs to monitor nature preserve the latest situation.

Limitation and Future Work

- Survey responses were mainly from frequent hikers and distributed through main advertising sources within local and campus communities. Some underrepresented groups of people may haven't answered the survey.
- Technology limitation: without accurate equipment to count the total number of hikers per week, GPS accuracy of iPhone LiDAR sensor, three bands of data (RGB) captured through historical images and UAV
- Future work: Monitor the land change in the future. Design an Interactive mobile phone App and collaborate with other campus to reflect the regional pattern.

Reference

Xu, X., Liu, L., Han, P., Gong, X., & Zhang, Q. (2022, December 14). *Accuracy of vegetation indices in assessing different grades of grassland desertification from UAV*. International journal of environmental research and public health. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9779174

Zaitunah, A., Samsuri, & Sahara, F. (2021). *Vegetation Cover Change and Its Diversity in Urban Areas of Medan*. https://doi.org/10.21203/rs.3.rs-510164/v1

Environmental Survey of SUNY Binghamton [typescript]. Richard Jarvis (Nature Preserve special collection, 1970). Archives and Special Collections, Binghamton University, Vestal, NY.

Nature preserve Binghamton University. Nature Preserve - Binghamton University. (n.d.). https://www.binghamton.edu/nature-preserve/index.html

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