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Merrill W. Linn Conservancy - Dale's Ridge

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May 10th, 2023



In collaboration with:

Chad North - Operations Manager, Merrill W. Linn Conservancy

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Origins

The Dale's Ridge property itself comprises approximately 140 acres of land which is owned by the Union County Historical Society, an organization that focuses on promoting the history of Union County through educational programs, displays, publications, and events (Merrill Linn Conservancy).

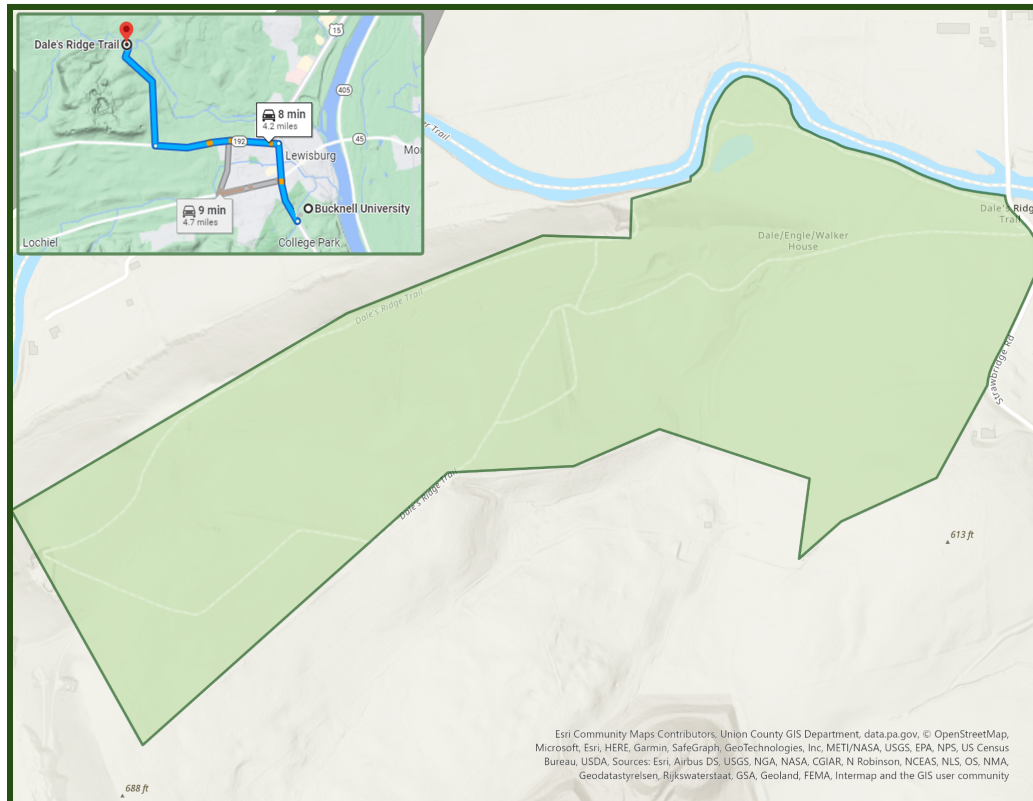


Figure 1: Map of the Dale's Ridge Trail property showing distance relative to Bucknell and the boundary of the land easement.

There are a variety of organizations that work directly with the property including the Merrill Linn Conservancy (MLC), the Union County Historical Society, The Audubon Society, and the Buffalo Creek Watershed Alliance (BCWA), a subdivision of the MLC. The historical society handles the historical homes on the property. The Audubon Society is responsible for maintaining bird and pollinator-friendly landscaping surrounding the homestead section of the property; they have placed a variety of birdhouses and bat boxes adjacent to the trail. The

property has been a working farm in operation since the early 1700s with portions of the farm routinely rented out for active agricultural use by the Union County Historical Society (Hosterman Creative, n.d.). BCWA has carried out routine testing of Buffalo Creek, the main water feature on the property, since 2002 and advocated for stream protection as well as restoration projects within the watershed. Various course-related labs from Bucknell University's Biology and Geology and Environmental Geosciences departments also regularly interact with the property. BCWA has completed small bank restoration and riparian buffer enhancement projects for the portions of Buffalo Creek within the property.

Since the beginning of the COVID-19 pandemic, Dale's Ridge has seen a significant increase in daily usage; this combined with the long-term erosion problem at the site has led to significant trail degradation, which was seen through our trips to the trail. Buffalo Creek located at the northern border of the trail is beginning to erode to the very edge of the trail, overuse has caused significant soil compaction and exposure of roots, and the switchback portion of the trail is becoming less stable due to mud. At the beginning of the pandemic, this site also experienced a forest fire, damaging a significant portion of the once-thriving ash forest surrounding the trail.

The Merrill W. Linn Conservancy has begun to address these issues at the site in hopes of continually increasing usage and restoring the once-thriving ecosystems. The Merrill Linn Land and Waterways Conservancy was founded in 1988, and their main goal is to protect woodlands, agricultural lands, streams, and wetlands. The conservancy sponsors many family-oriented events that bring people to these areas (Merrill Linn Conservancy). This is where we were introduced to our community partner, Chad North, he is the Operations manager for Merrill Linn Conservancy. This project began, due to the impact of COVID-19 on these protected areas, and the overuse they saw during the pandemic. This is the beginning of a project that will continue

with future 411 courses to maintain the area while adding more outreach opportunities.

Significant conservation efforts have made little progress due primarily to changes in staff and membership/donations within the conservancy; as these efforts begin to pick up, Chad North also hopes that the conservancy will increase in total membership and donations. The Conservancy is dedicated to the restoration of Dale's Ridge Trail but these efforts are not possible without the funds that membership and donations provide the organization.

Goals

The goals for this project are centered around improving the quality and quantity of community engagement and public education on conservation and sustainable practices while gaining financial support for the conservancy. The other primary goal for this project is to develop a comprehensive management plan that addresses ecosystem health for forested areas and Buffalo Creek's floodplain, sustainable trail practices to reduce erosion and benefit fringe biota, and expand our understanding of the Dale's Ridge ecosystem.

I. Community Engagement and Participation

Trail Brochure and Signage

Chad, the property's operations manager, has asked us to figure out the best way to update the brochure to increase its educational value for the property. This process includes four main attributes. There have been a few trails reroutes not officially accounted for in the map, so one of our goals would be to remap the trail system in an easy-to-follow format for trail users. Another aspect of the brochure includes its corresponding trail signs and descriptions. There are several posts labeled on the brochure that currently connect to signs that are missing from the trail or descriptions that account for aspects of the trail that have changed or are no longer

present. Our goal here would be to redesign signs on the trail to connect to the most educationally beneficial aspects of the trail and provide comprehensive information on property history, the importance of conservancies, and the ecological makeup of the property. This would also include updating photographs in the trail brochure to better visually connect users to the information being provided. We were able to accomplish this goal and remap the trail for the updated brochure, as well as reduce the number of panels on the brochure.

Conservancy Membership & Financial Support

As Chad stated that the conservancy is only capable of working through the financial support of donations and memberships, we hope to facilitate an uptick in membership rosters for the conservancy. This will help us improve community engagement and awareness while also supporting the conservancy financially as a means to accomplish its mission statement to protect land and waterways in the PA region. This will consist of promoting donations to the conservancy as well as improving the interface to join the conservancy both through information provided on-site and online. Although we do not know whether or not there has been an increase in donations and membership, our survey did help us gauge how many people were interested in donating in the future.

II. Dale's Ridge Ecological Management Plan

Ash and Cedar Health

Chad identified two arboreal species of major concern on the property including the Ash and Cedar trees. The ash-borer beetle swept through the property, virtually wiping out the Ash population, and we hope to propose the best practices for reintroducing the species to its native habitat and facilitating education on the phenomena's connection to sustainable practices and modern environmental issues. Cedar trees once serve an important role as windbreakers

separating parcels of farmed land on the Dale's Ridge property. However, they are facing health concerns and showing signs of decline, so the second part of this goal would include understanding why the Cedar trees are facing decline as well as proposing best practices for supporting the remaining population into the future.

Secondary Forest Management

The final aspect of ecosystem health that our community partner and our group identified on the easement was the status of the forested areas and their connection to overall ecosystem health. Since forest management is directly connected to arboreal health, our goal would be to create a detailed account of the current status of this environment, propose best practices for improving its diversity and capacity to rehabilitate the Cedar populations and promote sustainable trail use. We hope to suggest a variety of methods that could promote further arboreal regeneration and sustainable futures for forested areas.

III. Trail Maintenance and Sustainable Longevity

Trail Compaction and Erosion

Identified by Chad North, there are a number of sites on the trail that have experienced soil compaction and degradation. This has exposed tree roots on the trail that were previously not visible. This soil compaction has led to both increased erosion and muddy portions of the trail that prompt users to walk around, effectively widening the trail in undesired sections and degrading the surrounding vegetation. One of our goals for this project is to propose best practices that will help address soil compaction and erosion on the ridge trail and switchbacks in our comprehensive management plan. The portions of the trail that run along buffalo creek also are at risk of eventual degradation due to erosion on the banks of the creek. In tandem with

addressing trail erosion, we hope to propose methods or possibly selective plantings that could assist in stabilizing the Buffalo Creek channel.

Switchback Trail Stabilization

One of the driest portions of the trail in need of assistance identified by Chad North is the switchbacks between the North side of the ridge and Buffalo Creek. The switchbacks were originally constructed using logs and rebarbs as supports to hold them in place. However, from the increased usage of the trail as well as erosion of the slope, there are a number of sections on the switchbacks where logs and supports have been replaced. These replacements are denoted as temporary solutions by Chad and the conservancy plans to eventually consult an engineering firm to reconstruct the switchbacks for long-term use. However, our goal for them is to find best practices that could help address the erosion and degradation concerns in the meantime as well as review a Bucknell Civil Engineering project that provides a detailed account of the integrity and best practices for maintaining the switchbacks.

Needs

One of the main needs of the property is sustainability practices and community engagement. Looking at the needs of this project, it's all about restoration and maintenance. Chad North has certain needs to be met that are appropriate to the needs of the community. Chad North is the voice of the community to ensure that people have outdoor spaces that are safe, and accessible. The community of East Buffalo Township has a lot of economic disparity, looking at the region that has a relatively high income compared to the areas around it. Their annual income is exceptionally high at over \$96,000 a year compared to Lewisburg which is significantly lower

(East Buffalo Township). Geographically there is a lot of land and open space, which is typical for a rural Pennsylvania area.

Within the area, there is the Lewisburg Area School District along with Bucknell University. The Township has the Lewisburg Armory which is a national historic place. They also have their local Municipal building, along with trails such as Dales Ridge and the Rail Trail for outdoor recreation. Their police department and other facilities are a part of the greater Buffalo Valley Regional Department which is located within Lewisburg. The community seems to be quite active on social media through two main Facebook groups, one titled, Friends of Buffalo Township PA and the other titled, Lewisburg PA uncensored with thousands of members on each. Although only parts of Lewisburg are included there is a significant difference between the two areas. Lewisburg contains city-like experiences through shops, movie theaters, museums, and local restaurants, the East Buffalo Township is very rural with a lack of closeness due to the large amounts of space and land. Knowing all of this helps us to better understand how important outdoor spaces and recreation is to the area. Not only is it a space for people to be outside but it is a very educationally based place. With community-funded activities such as the Children's Museum which brings children and families to Dales Ridge, there are a lot of aspects of the trail that need to be met, preserved, and upkeep. The Conservancy also needs to update its trail brochure and signage in order to convey the desired sustainable and ecological information that the property wants to represent and advocate for. Some of the things the conservancy will need are mapping equipment, which can be provided through Bucknell Resources, and updating their networking skills through interactions with other local conservancies.

Assets

Chad North is a great asset for us and our project. One major asset is his understanding of the area, the trail, and what needs to be done. During our meetings, he has efficiently outlined what he expects from us, our project, and the areas we must focus on. He grew up here, went to Bucknell, and currently lives and works in the area, all while being an avid hiker. His hiking and trail knowledge is an incredible asset, as he knows what trail maintenance needs to be done. Additionally, his relationship with the Lewisburg community will be beneficial for our outreach goals, as he knows who to reach out to and potentially their interest level. The community has a deep and meaningful relationship with land and agriculture. The community seems to be very invested in these projects, however, not much has been done. There is a large group of people who actively use this site which leads us to conclude that they would be willing to put an effort or donate money to see changes be made. There are a lot of other organizations that will also be very impactful to us such as the Historical Society and the Autobahn Society, which are local groups that also have a lot of information for us. Bucknell also has a lot of resources for us such as professors and student-run and let groups that would be able to provide a lot of insight to us along with a lot of help.

East Buffalo Township is quite big, roughly 15.273 square miles and Bucknell only makes up 4.23% of that, so the majority of the township is residential or preserved agricultural land (“About”), with a population size of roughly 7,500 (“U.S. Census Bureau Quickfacts”). This is quite apparent during our drive to Dale’s Ridge, as a lot of the land is either uninhabited, protected, or farmed on. This is an asset because the community is reliant on protecting and interacting with nature, especially since this is a huge source of income for some. Additionally, the median household that has been reported by the U.S. The Census Bureau between 2017-2021

is roughly \$100,000, while 6% of people live in poverty (“U.S. Census Bureau Quickfacts”). This is a community asset because those with a higher income can afford to donate or the Conservancy membership fees more than lower-income households. Furthermore, more money means that the Conservancy may be able to afford trail restoration and maintenance, which can be experienced by everyone in the community.

Our community partner also made us aware that they have been awarded COVID-19 relief grants which would be a great asset if we do need money for some reason throughout this project. Besides our community partner, Bucknell University also has a lot of assets through ArcGIS and other resources through the geology and environmental science department that will be great tools for mapping the trail. Another thing that Bucknell has to offer us is professors who are skilled in identifying wildlife and species that are along the trail just because at the moment we are not experts in this so having professors such as Professor Trop and McTammany that could aid us through this would be very helpful.

Literature Review

Throughout this journey, we have realized that there is a lot of information that needs to come from scholarly readings. In order to create best practices for Chad and the conservancy, we needed to understand the way in which proper trails are operating, and what can be done to manage it most efficiently. Almost if not all of the information that is provided in the literature review is also included within the management plan that was sent to Chad. The information provided below was some of the most important information that was included in our tiered management plan, which includes, Trail Erosion and Compaction, Understory and Arboreal Management, and Community Engagement.

I. Trail Erosion and Compaction

Impacts of Trail Use on Soil Properties

The primary concern for managers of trail systems is to prevent post-construction degradation due to recreational use on a variety of trail types as well as under natural processes such as rainfall and water runoff (Marion & Olive, 2006). It has also been identified that trail design and the guidelines under which they have been constructed have proved critical for methods of analysis in understanding how they influence our trail-use behaviors (Stevenson et al., 2022). Within the context of these findings, common impacts on the trails and surrounding ecology include vegetative density and composition diversity loss, soil compaction, erosion, the prevalence of muddy portions on the trails, exposed rock and tree roots, and trail widening (Stevenson et al., 2022; Marian & Olive, 2006).

Looking at Dale's Ridge, all of these issues have been identified by Chad North on different portions of the property's trail, influenced by the nature of their use. There are three main types of trail formats to be considered: Foot/ vehicle trails located adjacent to Buffalo Creek, switchback trails located on the North side of the ridge's slope that connects the top of the ridge to Buffalo Creek, and regular pedestrian trails that make up a majority of the 2-mile long trail system. The Buffalo Creek portion of the trail is the only surface-covered trail with < 5" gravel. The trail is used for property access by vehicles and shows evidence of off-road vehicle use such as ATVs. Marion and Olive additionally identify that soil erosion leads to soil and nutrient loss, increased sediment load in downslope waterways, and alteration to overland water flow, a major concern for maintaining the Switchbacks located downslope from areas of the ridge trail showing evidence of erosion (Marion & Olive, 2006). They suggest that any significant reduction in use, and even possibly closure of the system for periods, "must occur" on

heavily used trails to achieve any significant reduction in impact. Soil compaction, soil erosion, and subsequent changes to the trail morphology also present a social significance when considering the user's experience at Dale's Ridge (Jewell & Hammit, 2000). As seen on the trails, some portions contain many exposed roots and rocks. These present both visual adverse impacts on a visitor's experience and safety concerns (Jewell & Hammit, 2000). Maintaining some form of erosional assessment on the trails could prove pivotal for creating long-term reductions in sediment load downslope for Dale's Ridge.

Methods for Erosional Assessment

As soil erosion impacts ecological, social, and managerial effectiveness and circumstances for trail systems, it is important to develop methods for assessing soil erosion for managerial use and implementation of mitigation strategies (Jewell & Hammit, 2000). Jewell and Hammit review several methods for assessing trail erosion ranging from qualitative assessments to long-term quantitative analysis. One of these methods is the 'Condition Class Method' (Jewell & Hammit, 2000). This method involves specifically defining the class ratings of erosional states to provide qualitative accounts for managerial roles on trail conditions (Jewell & Hammit, 2000). This method requires the least amount of technical training to be used and is the most efficient method for time use reviewed by Jewell & Hamitt. This method could be particularly applicable to the Dale's Ridge property as trail maintenance is primarily carried out through on-professional volunteers. This would assist the conservancy pinpoint locations on the trail that require the most immediate attention for mitigating soil erosion and improving the ecological and social quality of the trail given increased use. Such a method may face issues when being implemented at Dale's

Ridge given the limited number of regular volunteers and the ability to facilitate training on assessment methods.

Best Practices for Mitigating Trail Erosion: Surface Water Control

The USDA's United States Forest Service (USFS) provides an extensive list of methods for dealing with surface water control that can erode trail treads as well as their support structures, leading to trail degradation and non-functional trail systems (USFS, 2023).

New Hampshire's Bureau of Trails additionally proposes several best management practices that deal with the “risk of sediment and other pollutants getting into waterbodies, maintain the natural flow of water in streams and wetlands, protect shoreland vegetation, and provide a safe stable trail system” (NH Bureau of Trails, Page 3, 2016). These are all ecological and practical concerns identified at Dale's Ridge. Similar to New Hampshire's environment, Dale's Ridge is within the temperate-mixed-deciduous forests found throughout the Northeastern US and receives a similar annual rainfall. As leaf litter, understory vegetation, and rainfall impact the dynamics of surface water flow, it is important to share these characteristics when attempting to implement best management practices for soil erosion (Akbarimehr & Naghdi, 2012).

USFS proposes a number of methods that work to divert surface water off of trails and remediate muddy sections that can result in trail widening from modifications to user behavior (USFS, 2023). Constructing trails to follow the natural contour lines of a hillslope allows surface water flow to be more evenly distributed across the trail length instead of concentrating in low points off a non-contour-based trail (USFS, 2023). Concentrated or channelized flow down the trail would result in high rates of trail erosion additionally increasing the sediment load

down-slope. Many of the Dale's Ridge trail follows this pattern except for the section of the trail located at the very top of the ridge, running immediately adjacent to the steep face of the North slope.

Another Method for remediating this erosion that would be applicable on this portion of the ridgetop trail includes grad reversals. Grade reversals utilize natural dips in the landscape and angle positive and negative grades to direct surface water flow across the trail as opposed to down it (USFS, 2023). One drawback to this approach is that it is implemented in new trail system designs, typically not existing trail systems. A major concern of Dale's Ridge is the area of a muddy trail inundated by pooling water. The USFS proposes adding 'knicks', 'rolling grade dips', and 'water bars' (USFS, 2023). Knicks involve creating an out-sloped drain by carving out a sloped semicircle about 3 meters long down the length of the trail section in question (USFS, 2023). Rolling grad dips are similar to knicks, but are typically used on steeper gradient trails and include a 3 to 6-meter ramp on the downslope side of the knick, directing surface water flow off of steeper sections of an existing trail (USFS, 2023). Waterbars are a common surface water flow control on trail systems, using a log or series of boulders that direct water flow downslope off of the lower endpoint of a trail (USFS, 2023). All three of these methods would be applicable to Dale's Ridge given the similar environments. One remaining question is how these systems would hold up after increased trail use, leading to concerns over the required regular maintenance.

The NH Bureau of Trails proposes a number of methods for dealing with switchback stabilization and erosion concerns on trails that deal with surface water flow (NH Bureau of Trails, 2016). When considering switchbacks, gabion baskets, and crib walls are identified as effective methods for stabilization (NH Bureau of Trails, 2016). Gabion baskets involve large

cobbles being placed in metal wire baskets, creating a firm base for the switchback sediment to rest on top off, often being reinforced through the introduction of root systems filling the basket's pore space (NH Bureau of Trails, 2016). Crib walls are retaining walls defined by bark-stripped logs (rot-resistant) being interlocked at 90-degree angles (NH Bureau of Trails, 2016). The sharp corners of Dale's Ridge's switchbacks are particular areas of erosional evidence and these crib walls would better stabilize the turns while redirecting water flow from eroding these punched areas of foot traffic that could render the trail unusable. The NH Bureau of Trails, 2016 also suggests water bars.

Another method for dealing with switchback erosion involves creating armored trails and supporting trail hardening (NH Bureau of Trails, 2016) These systems allow users to interact with the trail without contributing to soil loss, erosion, and compaction. Armored trails involve using materials such as tri-loc blocks, on-site blocks, turf pavers, and half-high blocks are all possible materials that can be added to switchbacks that exceed 20% gradients (NH Bureau of Trails, 2016). One possible concern that may arise for the conservancy when implementing such techniques could be the desire to retain a trail system that does not compromise the *natural* perspective described by typical users. A remaining question with these methods would ask how armoring could be added to the switchbacks for reduced erosion and durability while supporting the continued growth of fringe vegetation and design that compensates for the artificial addition.

National Park Service and Recreational Law

The National Park Service's article "Trail Management & Maintenance" discusses the history and importance of national parks and trails in the United States. The laws that are included in this article, such as the National Historic Preservation Act, National Trail System

Act, the Wilderness Act of 1964, as well as National Environmental Policy Act, and the Clean Water Act of 1977 could provide us insight into how natural areas are protected, as well as explain how laws have shaped Americans' attitude and understanding of nature and green spaces. Additionally, we found this helpful because it discusses what the NPS did to combat erosion from overuse. Essentially, they turned to local communities and groups like the Youth Conservation Corps to maintain the trail and practice "Leave No Trace principles" (NPS).

II. Understory and Arboreal Management

As of 2021, it is estimated that more than half of the global forest cover consists of secondary-growth forests, typically following the presence of intensive logging practices or prolonged agricultural use (César et al., 2021). Dale's Ridge falls within this category of arboreal ecosystems. The property started as a working farm in the 1700s and a significant proportion is still under an active commercial agriculture regime, growing crops such as corn, wheat, alfalfa, and soybeans. The section of the property that the conservancy manages is made up of almost 100% secondary-growth forest with some pockets of old-growth trees that remain from windbreaks in the original farmed land. A common issue in these secondary forests is that invasive species, human disturbances, and insufficient native species recolonization can inhibit the natural processes of successional forest development (César et al., 2021). In secondary forests succession gradients are dependent on soil structure, and human disturbances such as fire logging, habitat fragmentation, seed banks, and dispersal (César et al., 2021). The Dale's Ridge property is a post-agriculture secondary forest that regularly deals with human disturbances from trail use and even experienced a fire in recent years that burned through much of the understory and possibly the seed bank. Taking into account observations of limited species diversity for

Dale's Ridge understory and overstory species, one possible concern they are facing is the reduced effectiveness of the property's natural seed bank and diversity expansion.

Seed Banks & Understory Diversity

In temperate forests, above-ground biomass, an indicator of developed forest communities, is driven by the functional richness and variation in the tree and canopy size of overstory fauna, suggesting that increased phylogenetic diversity promoted a healthier ecosystem (Chun et al., 2020). In the understory of temperate forests, understory above-ground biomass is driven by high levels of diversity in height and species composition, again suggesting that increased diversity promoted a healthy and properly successional forested environment (Chun et al., 2020). High seed bank diversity is vital for promoting a diverse forest ecosystem but can be inhibited by homogeneous forest ecosystems and the presence of human disturbances or agriculture, all of which are present on the Dale's Ridge property (Plue et al., 2010). Several practices within the general body of literature could work towards increasing this diversity and overall ecosystem health on Dale's Ridge.

Understory Responses to Thinning

Maintaining and promoting biodiversity has become a staple aspect of modern forest management across many different forest types as ecosystems have faced threats of species loss and ecosystem simplification (Odion and Saww, 2007). This oversimplification is a major area of concern for much of the eastern United States as large predators have been removed and allowed species such as the white-tailed deer to rapidly expand in population, leading to large shifts in forest ecosystem composition (Knight et al., 2009). One possible method for increasing diversity could involve thinning both the overstory and understory vegetation in the area of Dale's Ridge. Thinning is the silvicultural intervention practice where trees, typically a mix of old and young,

are removed from a forest ecosystem to reduce the density of the stand and decrease competition so larger growth is possible on faster timescales (del Campo et al., 2022). Thinning has been found to contribute to the diverse development of forest understories when considering overall species, growth form, structure, and successional status diversity (Area et al., 2010). One of the benefits of this practice is that it does not result in a decrease in tree regeneration rates or create space for invasive or aggressive species to take over, a common issue at Dale's Ridge and the Great North East.

Invasive Species Management: Deer & Understory Vegetation

A critical component for maintaining a healthy ecosystem is properly addressing concerns of invasive species, as they have a number of adverse effects on species composition and ecosystem health (Knight et al., 2009; Goetsch et al., 2011). White-tailed deer no longer face natural predators in Pennsylvania's ecosystem and their *limited* population control is attributed to hunting capacity and accidental deaths associated with human infrastructure (Knight et al., 2009). Deer have also been connected as driving distributors of invasive species through seed dispersal, but more importantly, their overgrazing of native species has facilitated the overgrowth of invasive species (Knight et al., 2009). In our case, honeysuckle and Japanese knotweed are some of the invasive species negatively impacting or inhibiting the growth of native species identified by Chad North and BCWA. Invasive species' success has been directly linked to the preferential foraging of deer populations and the creation of open-patch environments as herds travel through areas (Knight et al., 2009). These open-patch environments are subject to successional patterns dominated by prolific invasive species with higher germination and growth rates.

A 60-year-long study published in 2011 monitored deer exclusion plots and their impact on species diversity and ecosystem health in temperate deciduous forests of Pennsylvania (Goetsch et al., 2011). Their results “strongly suggested that over-browsing by deer has converted what was once a species-rich and lush understory of forbs and shrubs into a departure understory dominated by a few ferns, grasses, and browse-resistant trees” (Goetsch et al., 2011). The plot where deer were excluded represented an artificial environment without the presence of its main grazers but supports the idea that lower levels of deer populations can facilitate the growth of diversity in such environments (Goetsch et al., 2011; Royo et al., 2010). One possible method for dealing with this issue could be the introduction of deer exclusion fences rotating over different portions of the trail property with a combination of invasive species management. These two methods in tandem could help facilitate the regeneration of a diverse and natural forest understory that could carry its positive impacts throughout the rest of the ecosystem, facilitating overstory health and diversity, contributing to improvements in soil quality, and even also help contribute to erosion reduction and less abrasive surface water flow for Dale’s ridge.

Honeysuckle is also a significant threat across Dale’s Ridge. The spread of this species directly impacts the ability of native species to thrive. The presence of honeysuckle has been directly linked to a decreased forest and understory density due to its tendency to outcompete native species; specifically, the presence of honeysuckle in riparian buffer zones is directly linked to a decreased plant density (McNeish and McEwan, 2016). This plant also poses a threat to the animals at Dale’s Ridge; having “substantial effects on food resources for fauna, resulting in alterations in food-web dynamics and disease-vector population dynamics” (McNeish and McEwan, 2016). While not the most sustainable, one of the most effective methods in honeysuckle management is yearly stem cutting followed by the application of 18% glyphosate,

an industrial herbicide (McNeish and McEwan, 2016). Despite the potential usage of pesticides as removal, across multiple studies assessing the long-term impacts of honeysuckle removal, it has been “found that 7–8 yr after *L. Maackii* removal, plant cover, tree seedling density, and species richness increased—suggesting removal of *L. Maackii* can enhance plant ground cover and affect ecosystem productivity and function” (McNeish and McEwan, 2016).

Invasive Species Management: Ash Borer Beetle

Adult Emerald Ash Borers (EABs) begin to emerge in late May, with their peak season for activity between June to mid-July. Beetles eat ash leaves for 5-7 days before mating begins, females then continue to feed for 5-7 more days before eggs mature. Female beetles place eggs into bark cracks or beneath bark flakes. Eggs hatch within 7-10 days of being laid; newly hatched beetles immediately chew through the outer bark of the ash tree (McCullough, 2019).

Since its introduction to the United States in 2010, Emamectin Benzoate has proven to be one of the most effective pesticides in controlling the EAB. Multiple studies have also shown that treating trees that have succumbed to EAB with this method is substantially less expensive than removing and replacing those trees (McCullough, 2019).

Sustainable management techniques are commonly used to manage and encourage recovery of a forest affected by the Emerald Ash Borer. This process involves the usage of a parasitoid as a method of “biocontrol”; over an approximately five-year period, the introduction of this parasitoid caused an ~76% reduction in the density of Emerald Ash Borer Larvae in forests across the Northeastern United States (that it was introduced to). This significant reduction in larvae has been shown to encourage recovery rates in surviving trees (Duan et al., 2021). The four species mentioned by the USDA (2020) are *Spathius Galinae*, *Oobius Agrili*, *Tetrastichus Planipennisi*, and *Spathius Agrili*. These are four species of stingerless wasps that

control EAB infestations by laying their eggs in the EAB eggs. *Spathius Galinae* is particularly well adapted for colder climates, making it ideal for usage in Northern states (USDA, 2020). These wasps are not attracted to humans or pets and are unable to sting. These wasps will only target EAB eggs; however, they have been found to attack any similar beetle species present in the forests they are introduced (USDA, 2020). Even though these wasps are being introduced, research in the United States has shown they will target the EAB over all other insect species present.

The U.S. Department of Agriculture’s Animal and Plant Health Inspection Service (APHIS) determines the number of sites it can support on a yearly basis depending on the total production of wasps. Once the release areas have been identified, APHIS ships the wasps to the sites, where they are released in accordance with the Biological Control Release and Recovery Guidelines. Usage of these tiny, stingerless wasps has led to 20 - 85% reductions in EAB sites across entire properties they have been released in (Popkin, 2021).

III. Community Engagement

Effective Trail Signage

Currently, Dales Ridge does not have effective trail signage. Having an accurate map of the trail is crucial to a trail. Dales Ridge has a lot of wrong information in terms of their maps, with missing signage, and lack of detail on the maps it is very difficult for a user to understand the current map. Samantha Senda-Cook writes in her journal, *Materializing Tensions: How Maps and Trails Mediate Nature.* *Environmental Communication* 7, no. 3, which highlights how an accurate map and detailed map is crucial to a hiking experience. The lack of that is something that will deter people from using the trail. She argues in her journal that, “ maps and trails

materialize tensions of access–preservation, and safety–risk, functioning as mediators between recreators and nature” (Senda-Cook 2012).

Trail Brochures

In order to make an effective trail brochure, there are elements of Trail Design and Layout that allow for the most effective way to share information. Through research, there are many techniques to make a strong trail brochure, graphics and services websites state, *Keep it Simple*, “Keeping the design fairly simple and easy to understand will allow them to understand what you do” (Service Graphics, n.d.). Another article from M.L. Hugo, which highlights the way in which the tourism industry has failed sustainability, and thus effective planning of trails and information is crucial. The information should be presented in the most clear and straightforward method as possible (Hugo 2010).

Increasing Conservancy Participation

Understanding how community outreach leads to more donations, and more memberships allow more conservation efforts to take place. Looking at the Susquehanna Greenway partnership, the website provides an online outlet to learn more about the trail, which if advertised the correct way could provide community members insight into the trails which is enticing. If this information was publicized it would provide community members with a reason to go see the trail for themselves. (Susquehanna Greenway Partnership). Comparative to other conservancies, there is a lack of transparency about joining or donating which prevents people from doing so. In order to get the most community engagement people need to be aware of the impact donations have on the conservancy. Community outreach is a vital part of conservation

efforts, and providing details about a trail and all it has to offer is a great way to get people to see it.

IV. Impacts of COVID-19 on Hiking Trails

Sites like Dale's Ridge play a critical role in providing affordable and accessible physical activity. Approximately 43.3% of the total US population's lifestyles are qualified as sedentary; for adults, this is defined as less than 150-minutes of walking or moderate physical activity per week, and for children, it is defined as less than 60-minutes per week (Mitten et al., 2016). The United States is one of the most sedentary countries in the world; long-term risks of sedentary lifestyles can include obesity, cardiovascular problems, hypertension, and type II diabetes, and contribute to significant mental health problems such as depression and anxiety (Mitten et al., 2016). Hiking has been cited as a low-cost, effective way to reduce the number of sedentary lifestyles across America. Regularly going on a moderately paced walk or hike can lead to long-term health benefits, noticeable improvements in mood and mental health, and weight loss (Mitten et al., 2016). Studies have specifically shown that hiking people tended to enjoy it significantly more than other forms of exercise; this is attributed to the enjoyment of nature that comes with hiking, compared to runners, hikers frequently spend more time outdoors exercising (Mitten et al., 2016).

With hiking being cited as such a prominent form of low-cost outdoor activity, the US-wide significant increase in trail usage since the beginning of the COVID-19 pandemic comes as no surprise (Brown et al., 2021). As restrictions worsened and the country as a whole grew more aware of their health, hiking trails in certain rural areas saw consistent, year-round increases in usage by up to 200% (Brown et al., 2021). Specifically, trails in rural areas are identified as the only group to show a constant, year-round increase in usage; trails in suburban

and urban areas still saw certain months of decrease (Brown et al., 2021). Dale's Ridge specifically has seen a significant increase in usage since the beginning of COVID-19, not just from seasoned hikers and runners, but particularly from younger families and children. A study out of Germany found that since the beginning of the COVID-19 pandemic, three of the most significant groups using outdoor spaces are now "young people, families with children, and non-locals" (Derks et al., 2020). This trend is specifically true at Dale's Ridge and a similar trend is true across the United States: "We suspect, however, that "new" users are comprising a larger proportion of all trail users during the pandemic, and existing users are participating in trail use more frequently overall" (Brown et al., 2021). The net increase in visitors to Dale's Ridge is an incredibly beneficial trend for the conservancy; however, increased trail usage also contributed greatly to a long-term, increased rate of trail degradation (Brown et al., 2021).

Literature Review Applications

The *trail erosion and compaction* and *understory and arboreal management* components of our literature review were used along with their corresponding techniques and references within our methodology for developing a comprehensive management plan utilizing them on the Dale's Ridge property. They are listed within organized sections in the literature review, but these techniques were cross-referenced within the management plan document. Many of the techniques have to be used in tandem with others in order to provide the maximum positive impact on the trail and forest habitat. Some of the scholarly articles referenced in these sections are location specific and highly dependent on the climatic and environmental conditions of where the studies and reviews took place. In designing our methods, we took those factors into

consideration and curated more sources that are applicable in the climate and environmental conditions of Central Pennsylvania.

Our literature review about the *Impacts of COVID-19 on Hiking Trails* informed how we went about our methods because we knew there were specific problems, like erosion and overuse, that Dale's Ridge is currently experiencing. Many scholars recognize the detrimental effects of overuse on trails, especially post- COVID-19. We chose surveying because we wanted to hear from trail users about what they feel needs the greatest improvement. Based on our results, many mentioned that the switchbacks, trail signage, and water access needed to be improved. Additionally, we wanted to look into ways to get the community more involved and increase the Conservancy's engagement with younger families. After discussing this with Chad and our own research, we noticed that within the coming months, there will be a number of events that cater to families and young people in the area.

Methods

Based on our established goals of brochure redesign, community engagement, and trail maintenance we employed three different methods: in-person and online surveying, compilation and review of literature, and remapping and redesigning the Dale's Ridge Brochure.

Surveying

Surveying was done to increase community awareness of the Merrill Linn Conservancy and gain community feedback on the Dale's Ridge property. Development of this survey was a collaborative process with Chad, and our main goal was to make sure the questions he wanted us

to ask were included. We sent him several drafts of the survey and received feedback from him and Professor Stuhl before settling on our final survey (Appendix 1).

In-person tabling at Dale's Ridge was done on the weekends of April 1st and April 8th, from late mornings through the early afternoon. These times and dates were largely based on recommendations from Chad along with what we assumed would be peak times for hikers to use the trail. As a hiker approached we would say something to the extent of: "Hello, we're environmental students working with the Merrill Linn Conservancy to improve Dale's Ridge, would you have 3 minutes to give us any feedback/information/take our survey?" While being out on the trail was very important for engaging with the community, the major concern was the amount of people we were able to talk to. During our three tabling sessions, we were averaging about 10 hikers for every two hours. While these conversations were very meaningful and provided us with lots of information, it was not going to provide our community partner with high response rates that we had hoped to gain. The idea of an in person survey was largely based on recommendations by Chad North, he stressed the importance of us getting onto the property and talking to people about conservation face to face. Smartt Gullion and Tilton (2020) stress the importance of collecting results at important sites throughout the community and note that it is one of the most effective methods of community-based research. We set a table up in the parking lot of Dale's Ridge on days we thought would have high traffic. We offered granola bars as an incentive to take the survey or take a QR code for the survey.

Creating a Google Form allowed us to both streamline results from in person surveying as well as share our survey with numerous different Facebook groups and other message boards in local communities. Once the Google Form was created and finalized by Chad, it was sent to a Lewisburg Community Facebook page (~4300 members), Nextdoor App for Linntown (East

Buffalo Township), Buffalo Valley Bulletin Facebook page (~950 members), multiple clubs and organizations around the Bucknell campus, and the Message Center.

While the creation of an online survey helped with the lack of sampling size from in-person surveying, we ran into numerous design constraints during its creation. Firstly, in order to hand the survey out in person we had to make sure it would take under 5 minutes from start to finish so we were not interrupting hikers. Secondly, it proved to be difficult to match conversational, in-person answers to the limited options in the survey. This led to us adding an open response/feedback question to the survey, but due to this question being optional only ~33% of respondents used it. This limited the amount of in depth responses we could get, but allowed us to gain the necessary amount of responses.

In total these methods of surveying yielded 279 responses over a ~3 week distribution period and successfully led to a wide variety of responses and the collection of valuable information for the conservancy despite design or response constraints.

Literature Review - Management Plan

To address the ecological issues facing the Dale's Ridge Property we developed a long-term maintenance plan. This plan prioritizes sustainability, and is applicable to the diverse ecosystems present around the property, and includes trail and forest management methods. We created a "best-methods" report that we gave to Chad based on an extensive literature review (Link in Appendix 1). In total, there are around 20-30 different suggestions for management techniques, many of which work together to repair different aspects of the trail ranging from compaction to erosion and different aspects of the forest from invasives to wildfire recovery. In

order to best inform Chad, we include a decision matrix outlining the pros and cons of specific methods based on categories such as cost, accessibility, and time.

In order to create this plan, we also reviewed a Civil Engineering report about the switchbacks and parking lot of Dale's Ridge. This project provided a lot of important background and information regarding erosion occurring on the property, which is a critical aspect of our management plan and one of Chad's concerns about the property.

We found that this method produced a very in-depth and customizable approach to forest management, in the sense that we were able to tailor our methods to the exact ecologies and general climate of Dale's Ridge. There was a significant body of published literature regarding the key issues identified in collaboration with Chad that we were able to draw from for the creation of this plan. While not necessarily a con to this method, the amount of information was almost overwhelming. We had to make sure all recommendations and methods in the plan were directly applicable to the property. Directly suggesting a specific method also required an individual understanding of the method: we had to be able to describe the process and implementation of each suggestion in detail for the conservancy to consider its viability.

Brochure Redesign

In order to gain Chad's input on this part of the project, we showed him multiple, different examples of brochures for other trails and nature conservancies (local and non-local). We asked him to give feedback on aspects of each design and tell us what should and shouldn't be included in the redesign. Chad gave us a lot of freedom on the redesign and told us to include what we think is valuable in the brochure instead of rewording what is already there. Formatting of this new brochure was done in collaboration with the Bucknell Publications, Print, and Mail

department. We met with a woman from the office on 3/23 who set us up with a template outlining the location of each brochure panel.

The three design aspects Chad stressed from the beginning of this process were cutting the design down from 12-panels to 6 or 8, a larger, more detailed and precise map of the property, and color photography of the Dale's Ridge Property. In order to cut down the size of the brochure, we rewrote descriptions of posts located around the property. We were only able to accomplish one round of post revisions due to multiple levels of approval needed by the conservancy that we were not initially expecting. We were successfully able to include a larger, more detailed map of the property in this initial new brochure draft. While we were unable to take or source color photography for our brochure draft, space has been included with descriptions of what photos will be included: Chad highlighted the views from the ridge top as important imagery to include. In order to stress the importance of donations to the conservancy work, a new QR code was created and included in the brochure that leads to the donation website. As of the conclusion of this project, a skeleton of the brochure redesign has been passed on to the conservancy for further revisions and formatting.

This method of redesign allowed us to receive the most possible community feedback, and work in very close collaboration with our community partner, both of which are critical aspects of community based research (Smartt Gullion and Tilton, 2020). Despite this, we did not anticipate the timeline of feedback for this aspect of the project. While we had a solid plan and method developed, the time between rounds of feedback pushed around our timeline for working on this aspect of the project a lot.

Remapping

Initially, we went to Professor Rob Jacob and Ellen Chamberlin in the Geology department to help with mapping. We learned how to use the Trimble surveying station as a method of remapping the trail, but ultimately decided, with the help of Rob Jacob, that it was way too in-depth for the scope of the brochure redesign and would take several days of work to complete instead of the few hours we allotted.

Remapping of Dale's Ridge was done using the app Strava. This app allows you to create walking paths with the precision that seemed to beat the handheld GPS devices we also tried to use. We walked the trail with our phones in our pockets, each running Strava. Using the current trail map as a reference, we made sure to get all reroutes and alternative paths that run through the property. Posts that are currently identified on the trail map of the current brochure were individually marked using the ArcGIS Collector phone app during this walk and added to the new, finalized map. Once the walk was completed, the path was exported from Strava as a .GPX file to ArcGIS. There it was put over a 1-meter Digital Elevation Model (DEM) provided by the Union County GIS office, and included in the brochure redesign (Appendix 1).

Strava has really similar accuracy to handheld GPS devices and the ArcGIS phone app (~20 to 30 ft of the exact location) but marks the path as one continuous line instead of individual points like other mapping methods. Exporting data from Strava to ArcGIS and working in ArcGIS with the data was incredibly easy and allowed remapping to be a very smooth process. The major con we found was this method was the premium features/paywall. The app comes with a one-month free trial, but if the conservancy wanted to continue with this method in the future, they would have to subscribe.

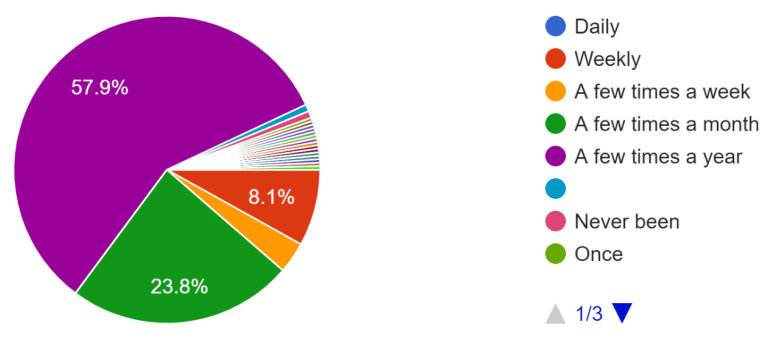
Results

Brochure

The most effective and important source to use while discussing community engagement and participation is the “Dale’s Ridge Trail Brochure”. This can be found on the Merrill Linn Conservancy website, as well as at the trail itself. Although the brochure is a critical source and starting point for our project, Chad has made it clear that there are many aspects of the brochure that must be changed. His first change was the remapping of the trail, due to the current one not reflecting the trail accurately anymore, in regards to signs and posts. We used this source as a template for the new brochure, especially since the descriptions under each post have critical information for hikers. Altering the language slightly and making it more modern will increase participation from younger generations and overall the level of education regarding nature and the species’ that can be observed on the trail. Additionally, the mission statement on the back and objectives like striving “to ensure that our natural resources of scenic, environmental ecological importance are preserved, managed, and monitored for the enjoyment of present and future generations” (13). As we discussed with Chad and among ourselves, it is important that we mention the importance of donation and conservancy membership somewhere on the brochure. We could include a QR code that brings users to the Merrill Linn Conservancy website, which will make the processes earlier for potential donors and those interested in activities sponsored by various groups.

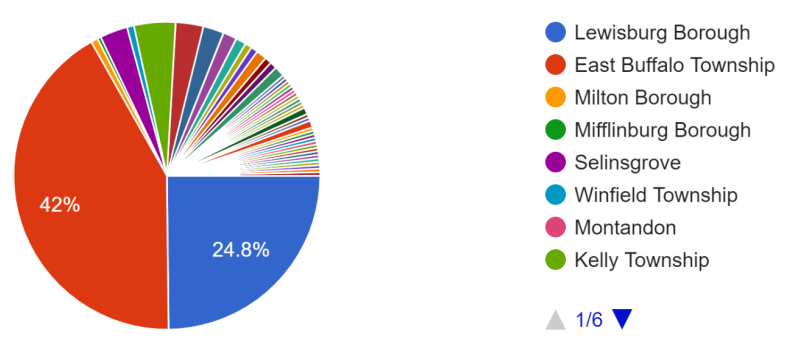
Survey Results

How often do you come to Dale's Ridge
273 responses



Pictured Above: First Question of Survey, this allowed for us to understand the amount of people on the trail, how frequently they attend, and allow us more data for later cross tabulation.

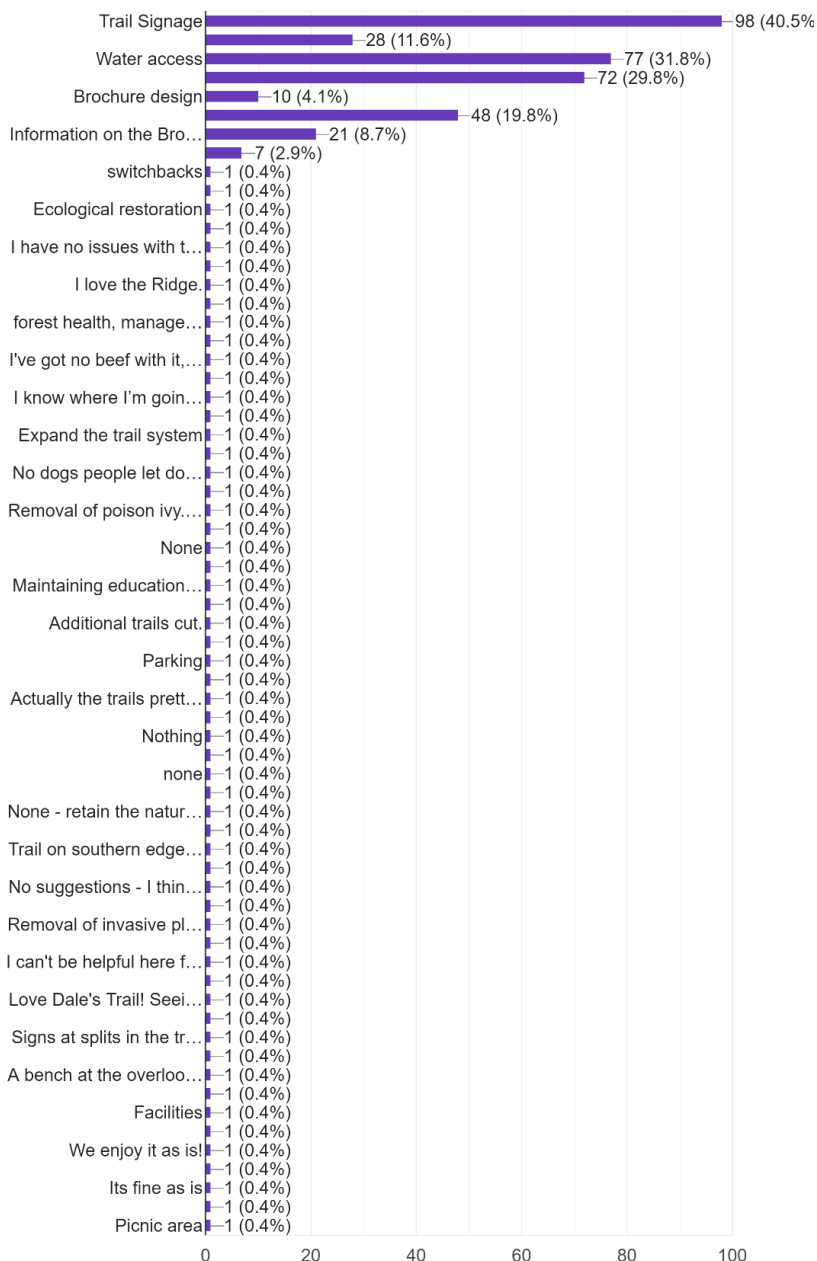
What is the township of your permanent residence?
274 responses



Pictured Above: Asking the Primary Residence of the trail users, this provides us insight into how far people are traveling to Dales Ridge.

Please indicate aspects of Dale's Ridge where you would like to see improvements made

242 responses



Pictured Above: What are the improvements needed to be made, some of the largest noticed improvements included, Trail Signage, Water Access, Trail Quality, Activities on the Property, Website, and Information on the Brochure. This provided us insight into the largest things being changed, along with allowing us insight into some of the appreciation users have for the trail.

Are you aware of the Merrill Linn Conservancy?

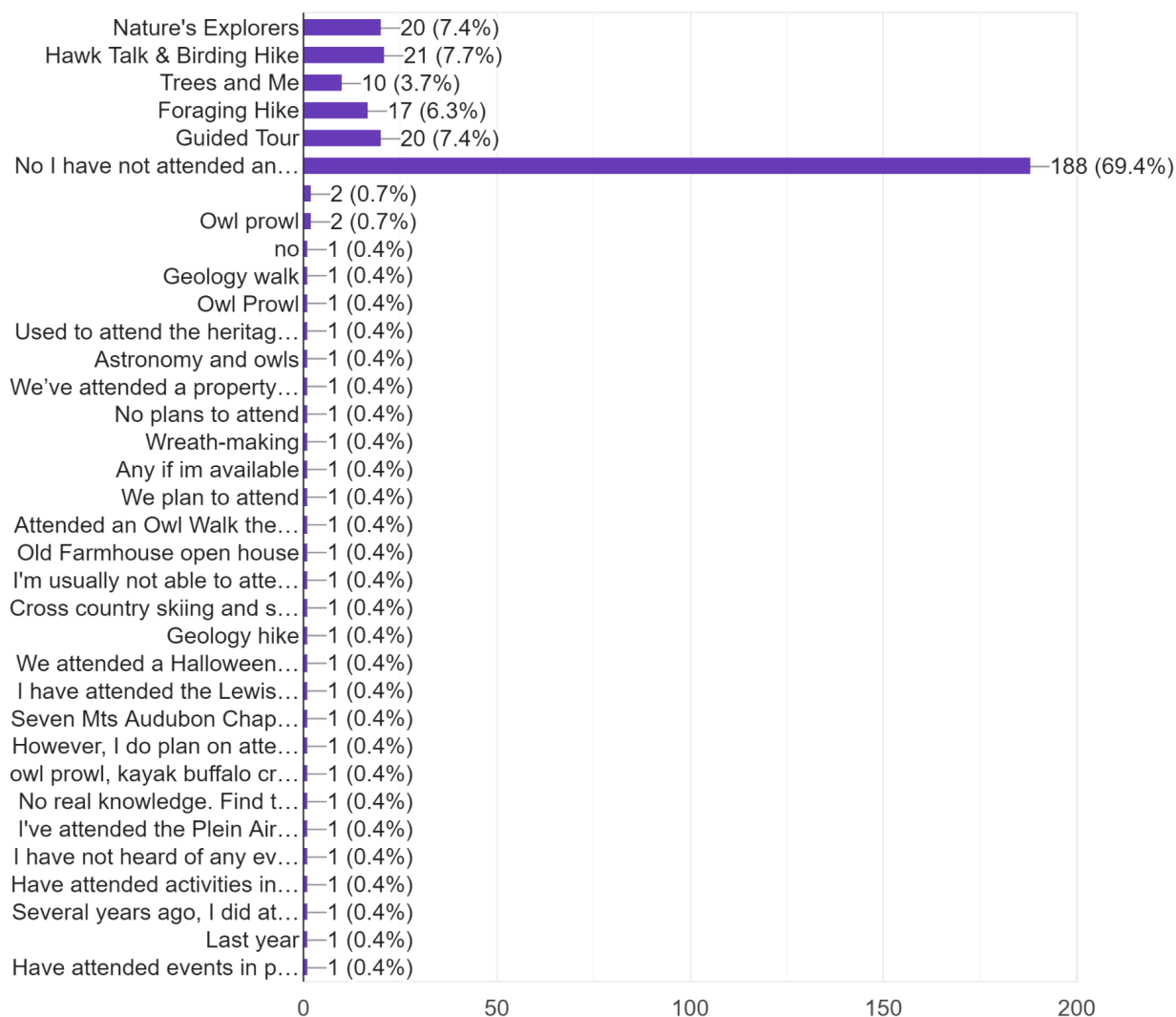
275 responses



Pictured Above: Understanding if people are aware of the conservancy, this question was asked with the hopes of understanding if the conservancy is doing enough to spread awareness.

Have you attended or plan to attend any of the events at Dale's Ridge indicated below?

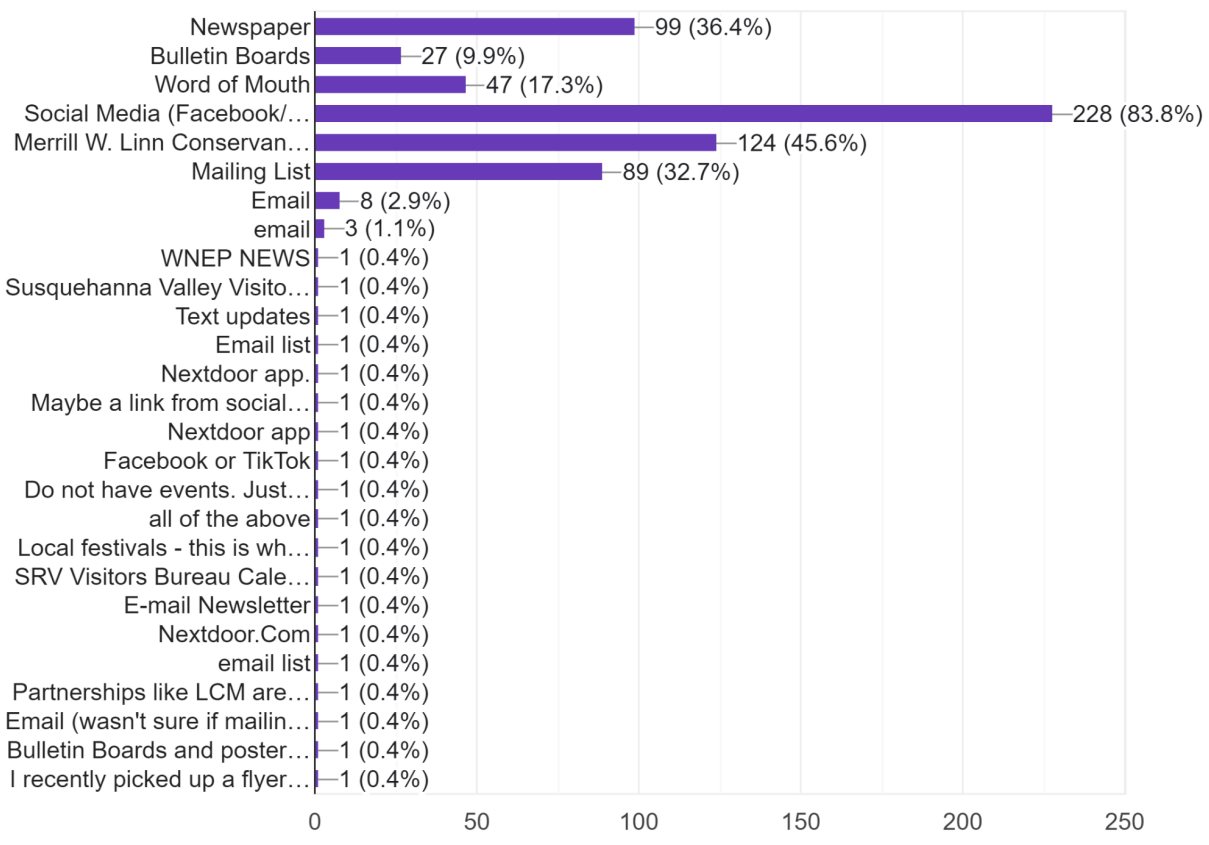
271 responses



Pictured Above: Asking about the frequency that people attend events, the conservancy just hired a new events coordinator, this provides them with insight into what events people want to see going forward.

What do you think is the best way to communicate with residents about upcoming events and news regarding Dale's Ridge or the Merrill W. Linn Conservancy? (Select all that Apply)

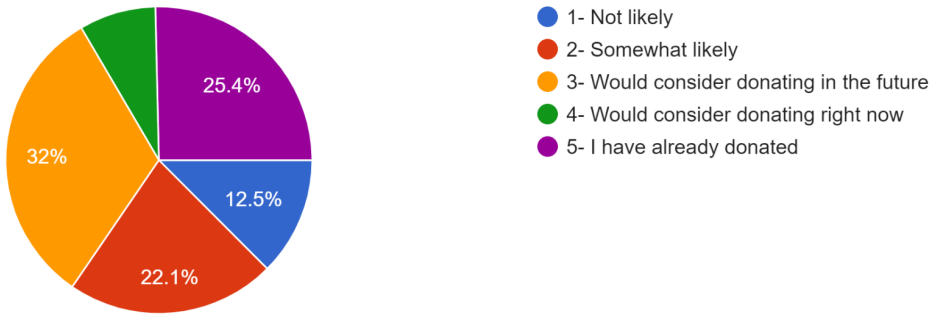
272 responses



Pictured Above: Asking the best way to communicate with residents about News regarding the trail and the conservancy. This allows for insight into being more transparent and clear with the users of the trail.

How likely are you to financially support the work of the Conservancy through donations for trail preservation?

272 responses



Pictured Above: Asking about the ability to financially support the conservancy, as stated earlier in the report, none of the work that was suggested can be completed without the support of donations or conservancy memberships.

Final Question Included: Do you have any other feedback about Dales Ridge and the Merrill Linn Conservancy, this included many positive comments about the love for the trail, and support for the work of the conservancy.

Management Plan Techniques

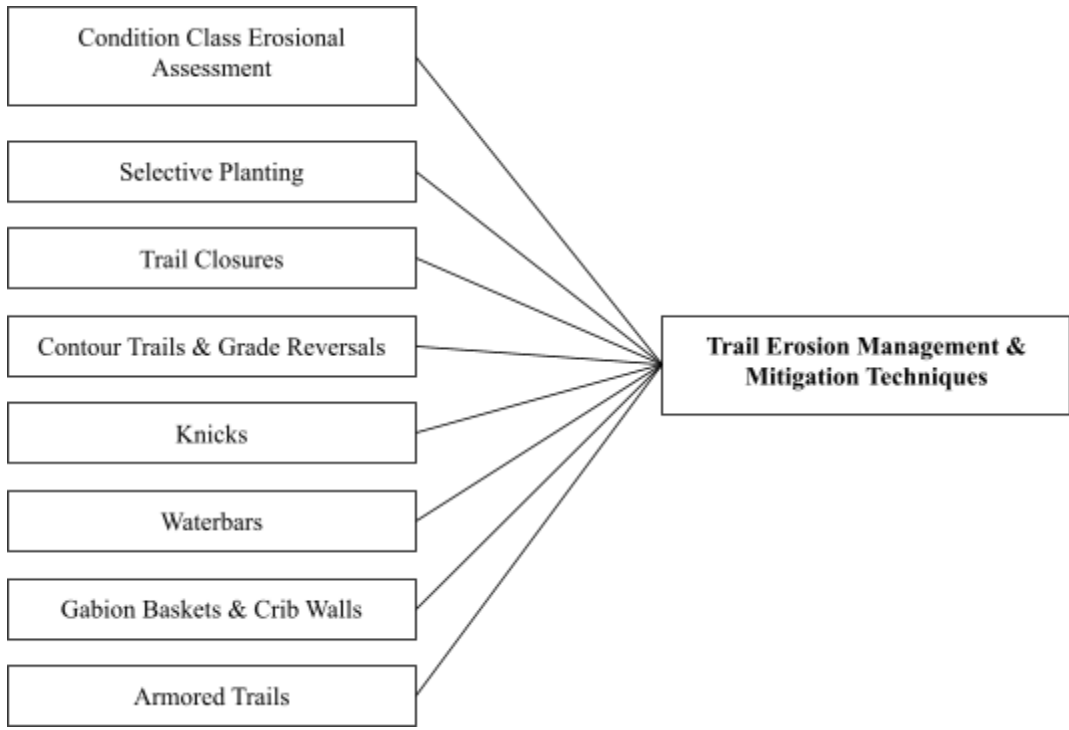


Figure 1. Outline of researched management techniques related to trail erosion

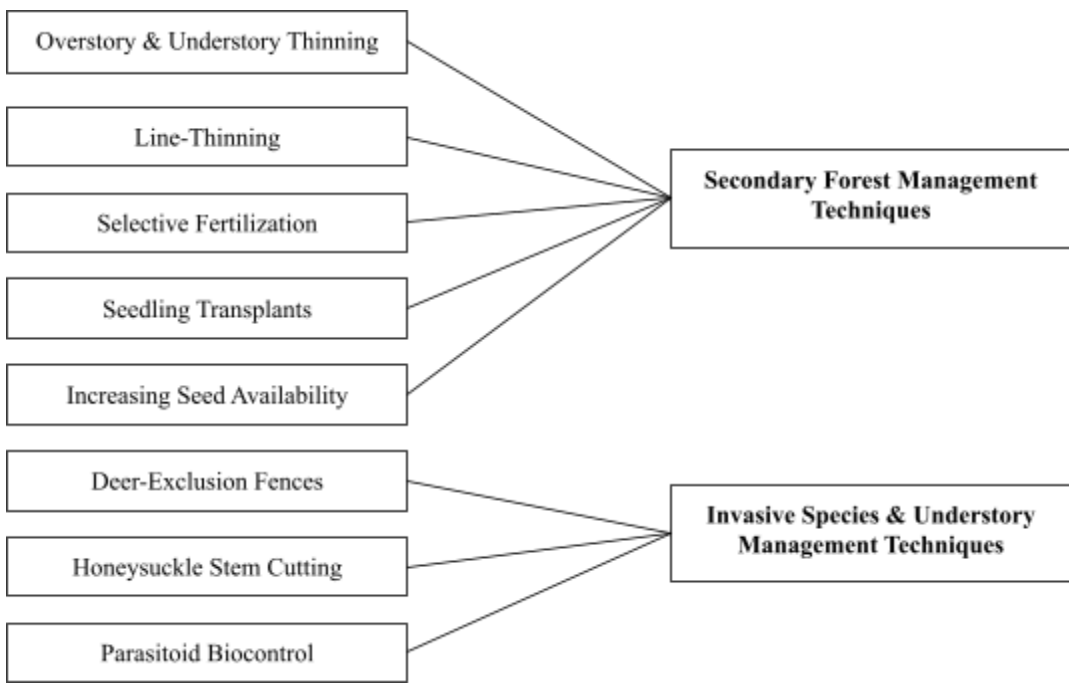


Figure 2. Outline of techniques related to secondary forests, understories, and invasive species management

Our management plan culminated in a comprehensive document that outlines the above management practices and techniques for secondary forest management, invasive species management, and understory management (Figure 1 & Figure 2). The management plan includes the outlined information of each technique included in the literature review in addition to an explanation of where it would be applicable and most useful on the property. For techniques that require purchasing or contracting of an external organization, additional information on local companies and governmental resources are also included. The full management plan is accessible via the “Forestry and Trail Management Plan” link located in the appendix.

Trail Remapping

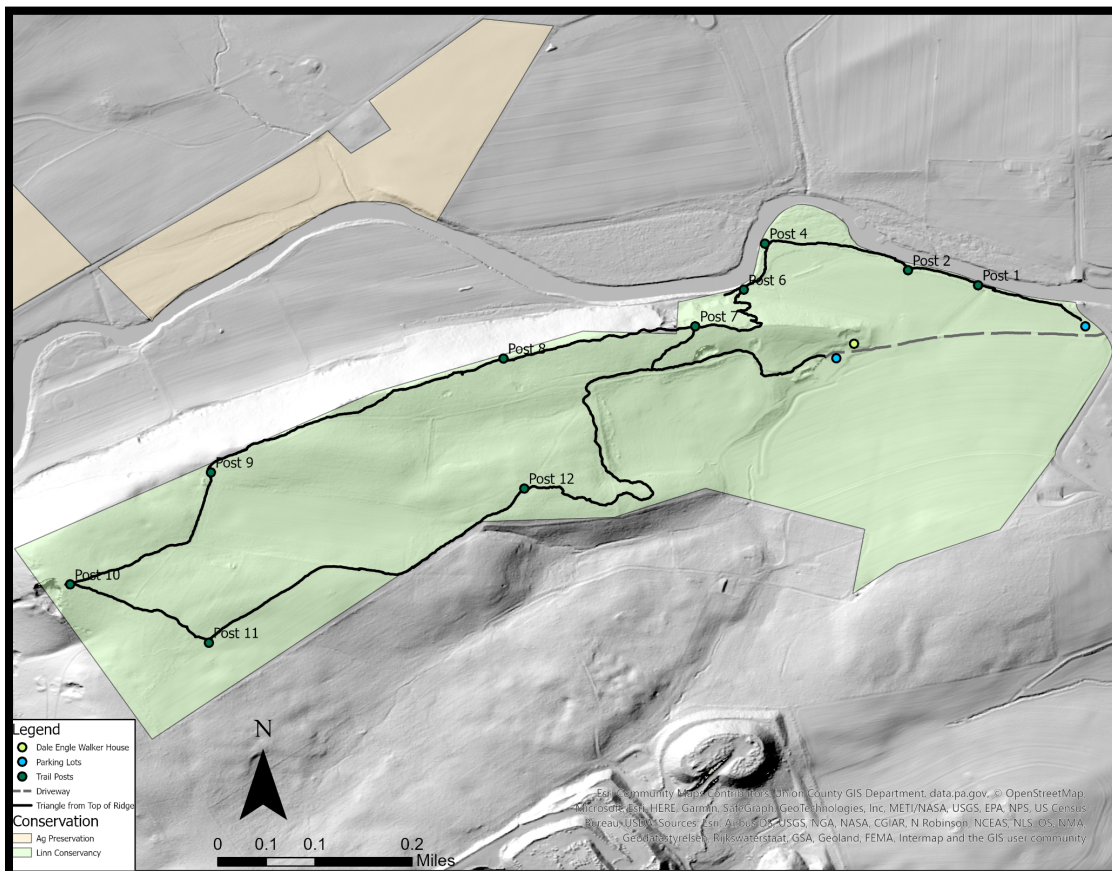


Figure 3: Updated map of the Dale's Ridge Trail using *Strava*. 1-meter DEM and conservation land borders provided by Union County GIS Office and PASDA (2023).

This final trail map contains key elements that the current map in the Dale's Ridge brochure is lacking. We have specifically marked the locations of parking lots around the property, the driveway, and the Dale Engle Walker House, updated the posts to match the current state of the trail, and marked reroutes that are not currently marked on the brochure map. One of the most significant changes made is immediately east of Post 12, the current brochure map shows a straight cut from the top of the ridge to the bottom that is not supposed to be included in the trail. Similarly, the route immediately south of Post 7 is a new addition to the trail map. Property boundaries were an essential design element, as Chad would like to be able to use this

map to argue for an expansion of the conservation easement land. The GIS file has been sent in its entirety to the conservancy for further checking of the accuracy before publication, they also intend to update this map in the future as infrastructure is improved around the trail.

Discussion and Analysis

Looking at the Data:

The way in which we collected the data was determined through our meetings with our community partner Chad North. He suggested we collect data to go to the trail during busy hours and collect data by engaging with users. Although we believe this is a great way to engage the trail users. We as a group feared this would not produce the results we hoped. We wanted to respect our community partners' suggestions, so we made an online survey as well that we could distribute if people on the trail did not want to talk to us. The way we did this is the survey we would ask in person would also be in an online format. We made small QR codes that we could hand out on the trail if people were interested in the survey just not at the moment.

When we got to the trail on the first day of surveying (4/1) we quickly noticed that many people did not want to engage with us before their hike. However, people were very susceptible to taking the QR code and completing the survey on their own time which they did. We had a table set up with water and granola bars which were very enticing to groups with families and children. Solo hikers were very focused on their hike and were much less interested in taking the survey.

After our first attempt at the trail, although productive and a great way to connect with the community we realized we needed more outreach in order to be successful. The way in which we sent out the survey was by the Bucknell Message Digest Center, with the hopes that

Bucknell Community would be able to help us give us insight into major changes or any changes. This provided insight from professors, faculty, staff, and students, which was a different perspective than everyday hikers. This was able to provide us with results however we wanted other ways to reach the community.

Analysis:

Based on the 279 responses we have received, as of May 1st , the majority of participants are using the trail a few times a year, followed by monthly and weekly users. We were somewhat surprised that the clear majority were users who only attend Dale's Ridge a few times a year. The second question will provide the Conservancy with a clear understanding of where most of its users are coming from. Nearly 42 percent of users' permanent residence is in East Buffalo Township, while the second largest group lives in the Lewisburg Borough.

It was unsurprising to us, especially after talking to Chad and trail users during our days surveying, that trail signage is a significant problem that must be improved in the near future. This was followed by trail quality, water access, activities on the property, and the Conservancy's website. To our surprise, the majority of users are aware of the Merrill Linn Conservancy and its mission, followed by somewhat aware and not aware at all. With that being said, four respondents are aware of the conservancy and are members. Additionally, we assumed there would be a clear majority of users who had not attended any events since this is the first year activities like Nature's Explorers, Hawk Talk & Birding Hike, etc are being put on for the community. Also through our discussions with Chad they have hired a new event coordinator, so with time we believe more people will attend the events. The best way to communicate with those who took our survey is through social media, specifically Facebook and Twitter, followed by the Conservancy's website and mailing list.

The final question provided us with a wide array of data based on people's willingness to financially support the Conservancy through donations. Although the data was very split between the five options, 32 percent of users said that they would consider donating in the future, are somewhat likely to donate, have already donated, etc. Which all indicate people's willingness to financially support the Conservancy. Looking at the survey, we also completed a cross-tabulation, this included seeking patterns and hoping to understand decisions selected by users.

The optional free response question yielded 94 responses out of 279 total responses (33.6% response rate). Reading through these responses both gave clarity to a lot of the areas improvement suggested by the community while also identifying other key themes related to the Dale's Ridge Property. One theme identified by this question was appreciation for Dale's Ridge, with multiple responses calling the property a local treasure and others saying how grateful they are for the conservancy for working on trail restoration. The responses to this question clearly paint Dale's Ridge as an important asset to the surrounding communities. One of the other themes identified is a need for transparency from the conservancy. Multiple individuals responded saying that they had contributed money to the conservancy but received little to no information about what projects the conservancy was using this money for. While the multiple choice questions identified the best ways to reach out to members, these responses highlight an overall need for more transparent and regular communication from the conservancy.

Through cross tabulation efforts there were some important takeaways that were analyzed. When looking at the frequency people go to the trail, with the likelihood to support the conservancy. In the survey, 22 respondents visit the trail weekly, out of all of these responses, every single one said they were on 2. (somewhat likely) to 5 (already donated) on our scale.

This means that no one who visits the trail weekly is a 1 (not likely to donate). Another cross tabulation we completed was awareness of conservancy and likelihood to donate, 14 of the 40 people who were not aware of the conservancy stated they were not likely to donate. Compared to 8 people who were not likely to donate of the 166 people who were aware of the conservancy and their mission.

Recommendations and Next Steps

Brochure

After discussing with Chad North, our community partner, on how to best update the Dale's Ridge brochure to reflect the current goals of the Merrill W. Linn Conservancy and to improve the trail user experiences, we agreed to move forward with restructuring the post associated content to fit an 8-panel brochure and better reflect current conservation and environmentalism on the property for the public. The 8-panel brochure was recommended to reduce printing costs as well as create a more concise and informative pamphlet for the trail. 16 respondents to our survey indicated that they would like to see improvements made to the website, so we added a QR code to the brochure that links to the conservancy donation website page.

The current drawings used in the brochure can be difficult to make out without color associations or larger sizes, so we agreed with Chad to include photographs of the relevant features and plants on the property. Another addition based on survey feedback will be an approximate time each distinct portion of the trail will take for the average trail user in order to better prepare people for the conditions they will encounter and the appropriate time needed to complete the ~2 miles of trail.

The next steps for the trail brochure will be for the conservancy to make an online version of it available on the conservancy's website similar to the current one, but make sure live links and QR codes are still accessible. We have discussed with Chad that the conservancy will have to handle the printing and distribution of the updated brochure, but we reached out to the printing services to get him price estimations and samples printed. We have created a first draft which needs to be approved by the conservancy, and any remaining work that is done, will need to be completed by the conservancy.

We acknowledge that given the approval and printing times needed for the Bucknell Printing office, we will be unable to complete a full-scale printing for the brochure. There are a number of local small businesses in the area that could possibly print the brochure including Green Ridge Graphics in Mifflinburg, PA, Klein Artworks Printing & Graphics in Danville, PA, Ink Spot Printing in Selinsgrove, PA, and Heritage Printers also in Mifflinburg, PA. The hope is that the conservancy works on the draft and uses it as the new brochure.

Surveying & Survey Results

Surveying for this project involved tabling for three days on the Dale's Ridge property, distributing QR codes for later access to the survey. Given the feedback of the survey relevant to identifying community concerns and desires for improvement on the property, we recommended to Chad that the survey is kept open and accessible via QR code and that the conservancy website is maintained in order to use responses to focus resources and labor on the property to greatest and most effective areas. This is something that Chad agreed on, and during our last meeting with him on April 26th, we gave him ownership of the survey, which he told us he plans to use for at least the next two years.

A number of recommendations arose from the 279 responses we have received thus far for the survey; 98 respondents indicated that they would like to see improvements made to the trail signage. After updating the brochure, we recommended to Chad to update the current posts to match the revised numbering scheme as well as replace posts that have begun to fall apart, specifically the current posts 6, 8, 9, 10, and 11. Trailheads and forks could additionally have trail signage added to clarify confusion as to the layout of the property or proper trail route as indicated by the feedback responses in our survey.

Another area of concern identified in the survey was information on trail closures. 228 of respondents indicated that social media (ex. The conservancy's Facebook page) and the conservancy website were the best ways to communicate updates or News regarding the Dale's Ridge property. We recommend to the conservancy that steps should be taken to regularly update both the website and Facebook page in order to appropriately notify the community on construction or trail issues that may inhibit trail accessibility or result in trail closures. The next steps for the Conservancy and Chad should include implementing these updates and continuing to observe survey responses to accurately gauge where the organization's and Chad's efforts should be focused in the future. One of the other strong responses that we got was the need for transparency. Many people who donated to the conservancy felt in the dark about where their money was going or what was happening with the conservancy. We suggested to Chad to make sure the conservancy is being transparent and providing information.

Trail Erosion Management

One of our main recommendations that we have discussed with Chad to address trail erosion involves developing a class identification method in order to identify and record where

erosional problems on the trail system are located and to what severity or condition the sites of concern are in. Regularly updating and recording this information will allow them to best utilize resources and labor from trail maintenance. We understand from speaking with Chad that trail closures are not a likely method for the conservancy to use in order to reduce trail user impact on soil compaction and subsequent erosion or mud puddling. However, given the body of literature, in some cases, we recommended closing portions of the trail for brief periods in order to allow the natural re-establishment of peripheral trail vegetation.

The main recommendations for dealing with erosional and pooling concerns on constructed trails include selective planting of native species, constructing knicks and water bars on the switchbacks and sloped trails to redirect water flow, and implementing armored trails via stone pavers or coarse gravel to strengthen soil cohesion and reduce compaction via foot traffic. While more expensive and likely more long-term solutions, gabion baskets, and crib walls could also be added to the switchbacks to improve slope stabilization, but an engineer with experience managing trail systems would be required for the design and construction of these methods. Chad has indicated that the conservancy still plans on hiring an engineering firm in the future to look at this issue. The next steps for the conservancy would be to implement a class condition method for recording trail erosion, implementing the methods listed above, and working to contact an engineering firm to work with the switchbacks.

Forestry Management

We agreed that the Dale's Ridge property needs to create and utilize a forestry and ecological management plan to improve the environmental conditions of the property's wooded areas on the Buffalo Creek floodplain, on the top of the ridge, and surrounding the actively

farmed portions of the trail. Chad has received a copy of our completed management plan where sources, descriptions, and best uses are outlined for Chad and the conservancy to use on the Dale's Ridge property. One of the largest concerns for the forest health and of the community as indicated in the feedback portion of our survey is the prevalence of invasive species.

One of the most prolific invasive species on the property is the bush honeysuckle, a species of honeysuckle originating in Asia. This plant has homogeneously taken over large portions of the floodplain and ridge understory, greatly reducing the plant diversity typically found in native PA forests. We recommended that the conservancy take a primarily invasive focused approach to improving the forest health via line thinning and removal of understory vegetation. In combination with transplanting native wood vegetation seedlings and selectively planting native species on successional peripheries, these methods will assist in establishing a more natural forest ecosystem on the property. Other techniques aimed at improving forest health and diversity we recommended to our community partner include selective fertilization, artificial seed bank contributions, deer-exclusion fencing, general overstory, and understory thinning.

Other associated recommendations for the forestry plan aim to improve interorganizational communication and information sharing between the property farm tenant, Buffalo Creek Watershed Alliance, the Linn Conservancy, and possibly the Powerline Company whose infrastructure cross-cuts the property and trail. Pertinent information would include water quality reports, infrastructure development, and various chemical use including pesticides, herbicides, insecticides, and other compounds used as the catchment zone for all of these organizations involving Buffalo Creek and the conservancy as land owners. This information would be useful in properly implementing these management techniques as well as identifying areas of pollution or contamination concern.

The next steps for the Conservancy would include implementing this management plan in locations indicated in the plan document, establishing communication with other organizations, companies, or individuals operating on the Dale's Ridge property, and reaching out to the Bucknell Biology Department to inquire about possible labs or projects where these techniques could be used and observed over time. On our last meeting, April 26th, we also met with the current trail manager who was made aware of the largest concerns and the trail management plan. He plans to use this trail management plan to look into the ideas that we suggested through the management plan.

Acknowledgments

We would like to sincerely thank everyone who has been involved with this project. Without their help and guidance, we would not have been nearly as successful with this project as we wanted to be.

- Our Community Partner, Chad North, has worked with us weekly and sometimes more to provide us with insight, data, guidance, and overall countless support for this entire project. He has been supportive of our goals, ideas, and timelines throughout the entire semester, his love for the town community, and Merrill Linn Conservancy shows and it is why we were able to get such productive work done.
- Professor Stuhl for being a helping hand in weekly meetings, keeping us organized and allowing us to step into new roles while providing support and guidance along the way. He prepared us for this project well along with skills that we can take into the real world.
- The greater community, we appreciate everyone who took time out of their busy days to fill out our survey. Without them, we would have lacked key information about how to

facilitate this project and its goals. Without these people being out on the trails, we would not have gotten such important information and feedback about what the community needs from the trail.

- The Biology Department, specifically Professor Rob Jacobs and Ellen Chamberlin, provided Chris and Shaun with detailed information on how to map the trail successfully which was a major part in our redesign of the brochure.
- The Merrill Linn Conservancy for providing us the flexibility to redesign the brochure.

Appendix

Forest and Trail Management Plan: [Link to Finalized Forestry and Trail Management Plan](#)

Survey: [Link to Survey](#)

Brochure Redesign: [Link to Brochure Redesign](#)

Site Photographs from First Walkthrough



Figure 4: Example of old signage on Dale's Ridge Trail (map taken from iPhone)

Figure 4 provides a direct example of the infrastructure along the trail Chad is looking to replace. Across the trail, a majority of the signage is made of wood that has been visibly worn down and weathered over time. These signs are in poor condition with some trail markers associated with the brochure even missing from their spots.



Figure 5: Example of bank erosion along the lower portion of Dale’s Ridge Trail that borders Buffalo Creek. Exposed roots are highlighted in the boxed area. (Map from iPhone)

Figure 5 shows the impact of Buffalo Creek, which borders the northernmost edge and lower portion of the property, causing significant bank erosion. This erosion has reached the very edge of the trail resulting in exposed roots and potential damage to the actual trail through this property.

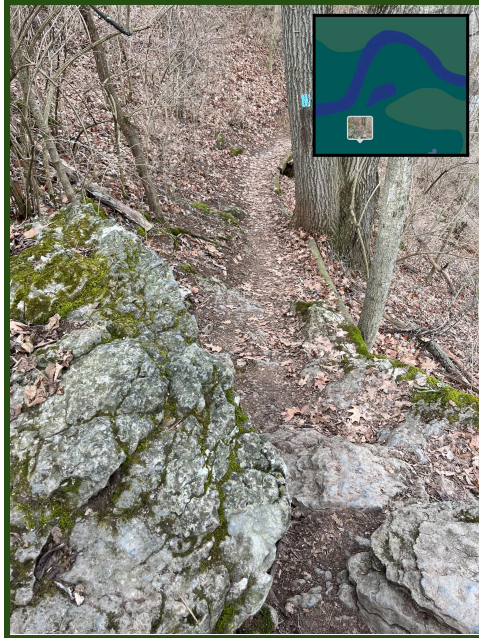


Figure 6: View from the top of Dale's Ridge looking down the switchback portion to show the slope of this section. The trail is compact with visible erosion down this section due to the steepness and usage (map taken from iPhone)

Figure 6 shows the slope of the switchback portion of the trail. This portion experiences significant erosion as precipitation hits the surface and flows downhill, the ground has experienced compaction due to constant use which also contributes to runoff and subsequent erosion.



Figure 7: Example of switchback infrastructure on Dale's Ridge Trail. Noticeable moss and movement of logs due to erosion are visible throughout the entire section (map taken from iPhone)

Figure 7 shows the current condition of the switchback infrastructure at Dale's Ridge. Much like the signage across this site, this wood is also visibly weathered and moved out of place. Erosion down the hill has led to the movement of these logs and the lack of replacement has allowed almost all of them to be covered in moss.

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