WORCESTER POLYTECHNIC INSTITUTE

DESIGN OF SIGNAGE AND INFORMATION SYSTEM

To Protect the Alpine Zone

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THIS PROJECT IS AN INTERACTIVE QUALIFYING PROJECT (IQP) SUBMITTED TO THE FACULTY OF WORCESTER POLYTECHNIC INSTITUTE LOCATED IN WORCESTER, MASSACHUSETTS, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE.

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Abstract

Project Sponsor:

- *Nathaniel Scrimshaw, World Trails Network-Hub for the Americas Chair*

WPI Faculty Advisors:

- *Corey Dehner, Director of White Mountains Project Center and Associate Teaching Professor*
- *Seth Tuler, Co-Director of Boston Project Center and Associate Professor*

We worked with the World Trails Network Hub for the Americas to develop a comprehensive backcountry signage and digital information system designed to inform hikers how to minimize their impact in the fragile alpine zone of the White Mountains. We gathered information through 8 interviews, 3 hiker observations (observing 100+ people), 5 resource observations, and 2 surveys and learned more about alpine zone flora and the best methods for protecting it. Using these data, we created a six-part-system including six physical signs and their associated informational content for placement along the Franconia Ridge Loop Trail. Each sign has a unique QR code that links hikers to a new digital repository with additional information about the alpine zone and how to protect it.

Acknowledgements

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Background

The White Mountain National Forest is an area brimming with life and awaiting adventure. This New Hampshire and western Maine forest is home to many popular hiking trails and allows visitors to unplug from society. The White Mountains are within a day's drive of all New England's metropolitan areas, parts of Canada, and New York, making this area a popular tourist destination that accommodates upwards of 6 million people annually (White Mountain National Forest - About the Forest, n.d.). Since the COVID-19 pandemic, areas like the White Mountains have experienced an uptick in visitors (McGinlay et al., 2020). During the summer of 2020, for example, National Forests in New England (White Mountain National Forest and Green Mountain National Forest) saw about a 61% increase in visitors (Ferguson et al., 2022). An increase in visitors has led to increased damage to the alpine zone as visitors hike off-trail for varying reasons and inadvertently trample sensitive species. To support visitors and the ecosystems within the forest, the signage and information systems in the areas require improvement.

Overview of the White Mountains

The White Mountain National Forest (WMNF) is managed by the United States Forest Service (USFS), a federal agency under the United States Department of Agriculture. The Forest Service's mission is to "sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations" (*White Mountain National Forest - About the Forest*, n.d.). The Forest Service in the White Mountains works to achieve its goals by working with the community to provide resources and experiences that allow people to connect to the land.

The White Mountains' landscape ranges from mountainous hardwood forests to magnificent alpine peaks. The forest spans nearly 150,000 acres and contains 12,000 miles of hiking trails (Figure 1). The forest also has a large cultural significance – containing 21 prehistoric Native American sites, dating back 10,000 years (*White Mountain National Forest - History & Culture*, n.d.).

Since the establishment of the White Mountain National Forest in 1918, the area has been enjoyed by many for recreation. The WMNF provides numerous opportunities for people to enjoy nature. According to McGinlay et al., nature plays a crucial role in improving the physical and mental health of visitors and assisting in the improvement of people's well-being (2020). The WMNF provides an area for people to exercise, rest, and relax.

Alpine Zones

The WMNF includes alpine zones which are particularly fragile ecosystems. An alpine zone is an area of growth above the limit of the tree line. Typically, this means that the temperatures during the growing season average between 40 and 50 degrees Fahrenheit (*Mount Washington Observatory | Normals, Means, and Extremes | Mount Washington Observatory*, n.d.). Found at the tops of mountains, alpine zones are filled with rocky landscapes, sprawling meadows of low-growing plants, barren tundras, and marshy fens. Life in this area must grow to be hardy in the grueling temperatures and high winds, usually adapting by growing slowly and horizontally rather than vertically, as seen in Figure 2 (Mooney & Zavaleta, 2016). The beautiful plant life in the area is also very delicate taking many years to grow

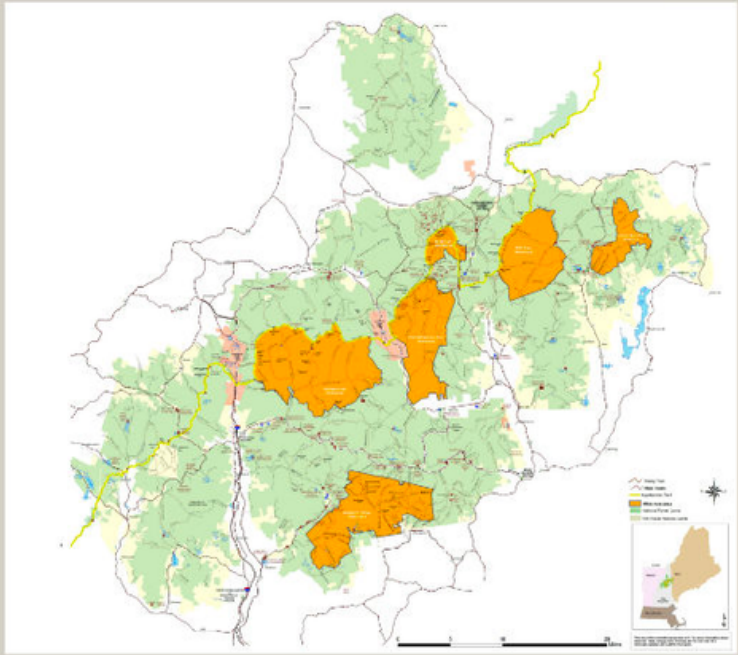

Figure 1: Map of the White Mountain National Forest (USFS, n.d.)

Background

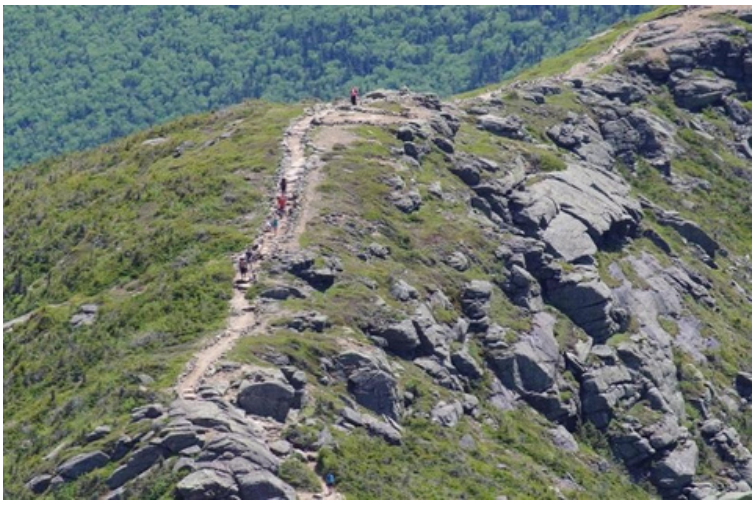

Figure 2: Horizontal Growth of Flora in the Alpine Zone in the WMNF (Scrimshaw, n.d.)

to full size and is vulnerable to damage. With the susceptibility of plant life, it is essential to protect this area. Doing so will allow the environment to exist and thrive for generations to come.

Why the Alpine Zone Matters

The alpine zone is home to many flora and fauna that rely on it to survive. If the alpine zone is not adequately protected, these organisms will slowly vanish. Many of the species that live in the alpine zone, such as the plant diapensia (*New Hampshire Division of Forests and Lands*, 2020), are listed as critical, endangered, or threatened. Fauna such as the takahē bird (O'Donnell et al., 2017) and flora such as mountain sandwort and diapensia, as seen in Figure 3, (*Maine Natural Areas Program, Natural Community Fact Sheet for Windswept Alpine Ridge*, n.d.) call the alpine zone their home, and require it for their survival. Some of the plants in the alpine zone have medicinal properties, such as Nardostachys jatamansi, which offer remedies for many unique conditions (Olsen & Larsen, 2003). With increases in global temperatures, the alpine zone becomes more vital to the inhabiting species. The unique, cold, wet climate of alpine fens is the last bastion for species that require these environmental conditions (Harbert & Cooper, 2017). The alpine zone allows for the species that depend on it to thrive, filling a crucial role in the food chain. Losing these species could cause a breakdown for many other species and ecosystems resulting in even greater loss.

Environmental Damage in the Alpine Zone

The uniqueness of the alpine zone environment and the species it supports warrant protection. Tragically, the increasing trend of global temperatures and the number of tourists visiting the alpine zone are detrimental to its health. Alpine ecosystems are threatened by climate change, shrubification (expansion of shrubs), and treeline migration due to warming temperatures and habitat loss. Climate change and an increase in hikers have led to invasive species, like dandelions and hawkweed, spreading across alpine zones. These invasive species are often directly spread by humans via their boots, cars, roads, and railways (Tirrell, 2022).

In addition to these threats, the behaviors of people visiting the alpine zones present a significant threat. Studies show that uneducated, less experienced, or incautious visitors are problematic for the environmental health of an area. Problematic behavior, including stepping off the trial, is harmful to the alpine vegetation, which is easily damaged by trampling (Martin & Butler, 2017). With an increase in visitors due to the COVID-19 pandemic, there has been a parallel increase in problematic behavior (McGinlay et al., 2020). Visitors are either unaware of the fragility of the plants, or negligent to the level of disturbance improper use causes to these sensitive areas (McGinlay et al., 2020).

Figure 3: Mountain Sandwort and Diapensia in Their Natural Habitat (Scrimshaw, n.d.)

Background

Damaging the alpine vegetation can reduce species diversity and reproduction ability, harming the alpine ecosystem (Martin & Butler, 2017).

Environmental attitude, behavioral control, and the subjective norm of one's behavior are factors that affect their intention to behave in an environmentally sustainable manner (Wang et al. 2019). Mind-wandering (MW) is the principle where one's attention drifts away from the current task or situation. When someone experiences MW they are habitual and absent-minded, unaware of their actions and current surroundings. A collection of studies evaluated by Kawashima et al. found that smartphone use significantly increased the rate of MW, with roughly 60% of overall smartphone use being habitual and absent-minded (2023). MW, with or without technology, leads to unintentional damages in nature.

Methods that Aim to Prevent Damage

Protecting alpine zones from environmental damage cannot solely rely on evaluating statistics and trends, but also on understanding the underlying causes of these damages. Contrary to MW, the environmental background and education provided by the site positively influence one's intention to be environmentally responsible (Wang et al. 2019). Expanding education systems enhances public awareness, thus increasing wilderness etiquette and usage, as well as public safety (Schneller, 2020). Some of these education systems include digital information systems, trail signage, and well-educated trail stewards. Additionally, trail science and design are more direct ways of encouraging hikers to stay on the trail. Various methods of education and trail science can heighten awareness and reduce hiker impacts.

Digital Information Systems

Information systems, in this context, refer to sources where visitors can gather information on a topic of interest. Examples include brochures, websites, or smartphone applications, developed with the intent of sharing knowledge.

Table 1: Benefits and Drawbacks of Using Different Methods to Change Hiker Behavior.

	Digital Information Systems	Signage Systems	Trail Stewards	Trail Design
Benefits	• Provide useful knowledge available in differing forms	• Vital information in useful places along trail • Can provide the *why* to staying on trail	• Provide useful information and have been found to be highly effective • Provides the *why* to staying on trail	• Directly guides hikers along the trail
Drawbacks	• Does not guarantee proper use of information • Relies on technology	• Limited amounts of information • May not be readby all hikers	• Not feasible for all hikers to be approached by	• Fails to educate hikers with why they should stay on trail
How they impact behavior	• Informs	• Informs	• Informs	• Guides behavior

Background

Digital technology enhanced with a geographic information system (GIS) provides readily accessible and quality information for hikers of various abilities (i.e., beginners, experts, etc.). GIS displays information, including maps, of a specific area. These maps may include official trail paths, trail signs and markers, and descriptors of unique plants native to the area. Information systems like these can be beneficial tools for informing and educating about a topic while enhancing decision-making skills (*What Is the Economic Impact of Geo Services?*, 2013).

Various organizations, like AllTrails, contain extensive data that provide visitors with the infrastructure to pursue recreational activities (Molnár, 2021). However, these data are typically user-developed and do not always encourage best practices among hikers. An organization specific to the White Mountain National Forest is the Appalachian Mountain Club, which through guidebooks provides useful information to visitors regarding best and safe practices and comprehensive maps with hiking directions. Organizations map out many popular hiking trails across the world and create the groundwork for a unique and standardized information system. These systems combine various disciplines to provide sustainable solutions to territorial management in agriculture, environmental organizations, and specialized tourism (Cuca, 2018). Implementation of an effective information system can reduce MW, while providing adequate information for users.

Trail Signage

Signage systems allow hikers to obtain information quickly in their environment. Signs are generally used to reduce confusion and danger for visitors and the environment (Molnár, 2021). The goal of signage systems is to present essential information in a clear, effective, and efficient manner. Park et al. explored the best ways to communicate through signs to reduce off-trail hiking in protected areas (2008). Their research revealed that more aggressive and educational signage systems were the most effective form of indirect management. The findings from Park et al. also support Bradford and McIntyre (2007) with the conclusion of attribution-based educational messages, such as "Your feet have trampled the vegetation on this island. Please stay on the main wood-chopped trail", are the most effective phrasing and tone. These messages educate hikers and help put the responsibility on them to protect the environment.

Trail Stewards

Trail stewards play an important role in environmental protection, through trail maintenance and in-person education. *Trailhead stewards* interact with hikers at busy trailheads to encourage safety and protection of public lands. *Backcountry stewards* hike trails conveying important information to hikers and performing trailside clean-up (*White Mountain National Forest - Volunteering*, n.d.). In the same ways that trail stewards can communicate the dangers of the White Mountains to visitors, they can express the vulnerability of the alpine zone to aid in its protection. Hockett et al. (2017) demonstrated in their study (located in Bear Island, Maryland) that personal communication was the most effective approach to reducing off-trail hiking.

Figure 4: Example of Existing Signage in the Alpine Zone

Background

Figure 5: Another Example of Existing Signage, Posted Before Entering the Alpine Zone

According to the study, personal communication between a trail steward and hikers about the importance of staying on the trail to protect vulnerable species reduced off-trail hiking from 70.3% to 43.0% (Hockett et al., 2017). This decrease in off-trail hikers shows the value of face-to-face communication when encouraging hikers to consider the vulnerability of the area and stay on the trail.

While it may be ideal for all hikers to speak with a steward before embarking on their hike, this is not realistic. Trail stewards strive to educate visitors on the vulnerability of the alpine zone, but are unable to be present along every trail 24 hours a day, 365 days a year.

Trail Design

Another method utilized to keep hikers on trails is how a trail is designed and constructed. Trail design includes using physical barriers, like rocks, logs, branches, or other organic materials to deter hikers from exiting the trail. This method has the potential to be effective when combined with other methods, however, visitors tend to remove physical barriers (Hockett el al., 2017). Park et al. explain that when blocking methods like this are utilized alone, hikers are often unaware of their purpose and are therefore not prone to stay on the trail (2008). Oftentimes, hikers leave the trail to follow an easier route or avoid an obstacle. These practices lead to both trail braiding and widening.

Additionally, trail design is used to minimize water-induced trail degradation (Burroughs et al., 2017). By using features such as water bars, reverse grades or designing side hill trails, erosion from the trails can be limited, maintaining the conditions of the trail and keeping people on it.

Combining Methods to Alter Hiker Behavior

The combination of the methods discussed above can decrease further damage to the alpine zone. On their own, information systems, signage systems, trail stewards, trail science, and education all help fix part of the problem (Table 1). Of course, these strategies should not be used in isolation. Research has shown that utilizing multiple methods is more effective than using a single method to keep people on the trails (Hockett et al., 2017). As such, combining information systems and signage systems can counteract their negatives (Table 1), with an information system allowing more compressed information to be put on a sign, and a signage system allowing hikers to know where and when to look for the information system. Trail stewards can fill in the gaps between signage, and the signs can fill in for when the trail steward cannot be present. Trail science and education can be worked in also to further increase the effectiveness by helping nudge hikers towards the signs, making the trail the utilized route, and having the signage and information system assist in educating the hikers for the future. The intention of using multiple methods is to decrease damage to the environment.

World Trails Network, the USFS, and Our Project

World Trails Network-International (WTN) is a non-profit organization based in Switzerland. The WTN works to connect diverse trails of the world to promote

Figure 6: Use of Scree Walls on Either Side to Keep Hikers on Trail (Scrimshaw, n.d.)

the protection, creation, and enhancement of trail experiences. They accomplish this by communicating with trail associations, trail advocates, walkers, hikers, and other people interested in the outdoors to develop global collaboration on improving the trails of the world (*About – World Trails Network*, n.d.).

The World Trails Network–Hub for the Americas (WTNHA) is a branch of the WTN based in Thornton, New Hampshire. The WTNHA collaborates with the USFS to protect the forest and improve WMNF trails (N. Scrimshaw, personal communication, April 7, 2023).

In collaboration with the World Trails Network–Hub for the Americas, we developed a replicable and modifiable information system for the WMNF aimed at protecting the alpine zone.

Figure 7: World Trails Network-Hub for the Americas Logo (WTN Americas, n.d.)

Methodology

The goal of our project was to develop a system containing physical interpretive signage and a digital repository to facilitate the protection of the flora in the alpine zone of the White Mountain National Forest. In fulfillment to this goal, we developed five objectives. We discuss these objectives in more detail below.

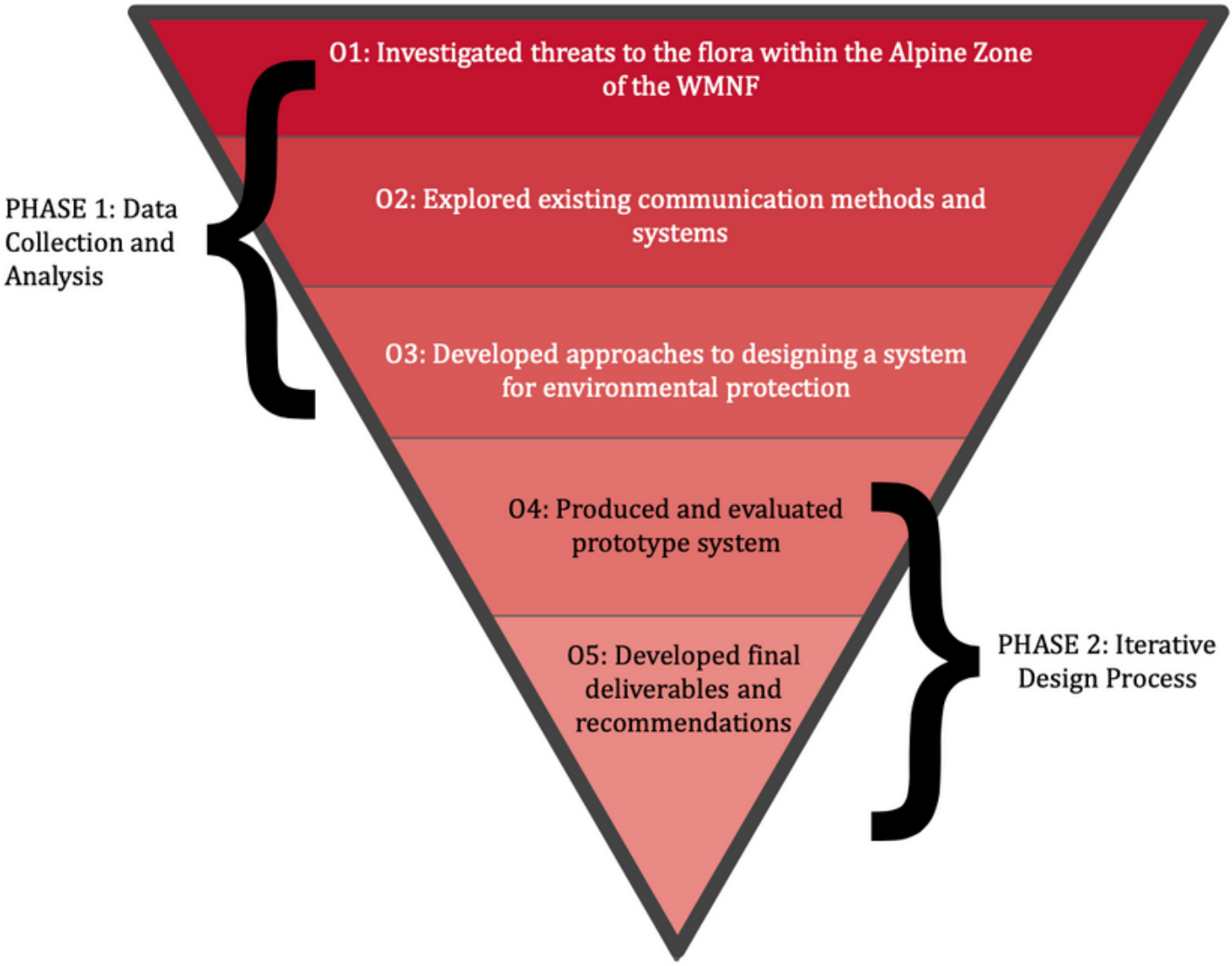

Figure 8: Diagram of Objectives

Methodology

Phase 1: Data Collection and Analysis

O1: Investigated Threats to the Flora Within the Alpine Zone of the WMNF

To effectively develop beneficial information systems, we explored threats to the ecosystem within the alpine zone of the White Mountain National Forest (WMNF) to understand the underlying need for these systems. Using mixed methods research allowed us to triangulate and understand the different aspects of the threats to the alpine zone (Maxwell, 2013).

The three primary methods we used to assess hiker-caused damage in the alpine zone of the WMNF included interviews with professionals, direct observation, and participant observation studies. Through interviews with professionals from varying organizations (see Appendix B and D), we established the collective perspective of those experienced in the WMNF. We also used snowball sampling to expand on the interviewee list and our knowledge base.

Congruent with the interviews, we began direct observation along trails within alpine and subalpine zones, namely in the following locations: Falling Waters Trail, Franconia Ridge Trail, Old Bridle Path, and the Welch-Dickey Loop Trail. In doing so, we assessed the damage and threats hikers directly placed on the flora of the alpine zone. Lastly, we used participant observation with other Worcester Polytechnic Institute (WPI) students on the Welch-Dickey Trail. We also conducted surveys with these students and gathered their opinions on the importance of following trail etiquette and staying on trail to avoid damaging the fragile ecosystem of the alpine zone.

O2: Explored Existing Communication Methods and Systems

In an effort to learn more about the existing USFS signage and information systems, we utilized a combination of methods, again allowing for triangulation of our results. These methods included interviews, direct observation, and participant observation, as mentioned in Objective 1, as well as archival research.

During the semi-structured interviews, we asked interviewees about their opinions of the systems currently in place. Additionally, we asked for their feedback on information they would like to see included in a future information system (See Appendix B for interviewees, Appendix D for questions).

To investigate the information systems used in the WMNF, we conducted direct and participant observation as mentioned in Objective 1. We hiked Welch-Dickey and Franconia Ridge loops and observed the ways in which people interact with the signage. We also hiked Welch-Dickey with the ten WPI students and watched how they interacted with the signage, and later gathered their opinions on the trail's design and signage, specifically what they noticed. From this observation and feedback, we were able to better understand a layperson's reaction to the trail design and information systems available to them. Through this method, we also were able to analyze the information available at trailheads and along the trails, giving us a better understanding of the systems that already exist.

To gain background on other current signage and information systems in place in the WMNF and their intended uses, we utilized the Appalachian Mountain Club (AMC) guidebook (Figure 9). The AMC is a not-for-profit organization that also works in the WMNF (and throughout the Northeast and Mid-Atlantic) to enhance protection, understanding, and enjoyment of the outdoors (*Home*, n.d.). We used the AMC guidebook throughout the participant observation hike to explore

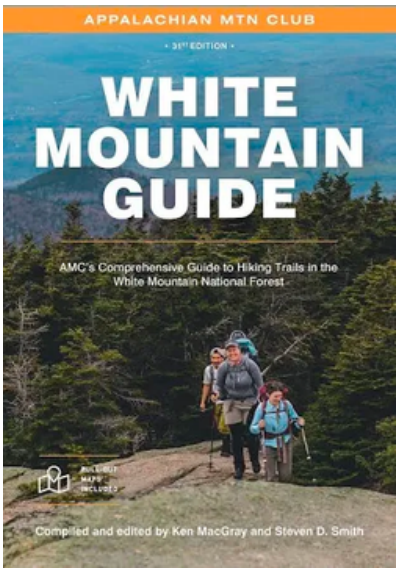

Figure 9: AMC Guidebook Cover

Methodology

their effectiveness and ease of use. Additionally, we analyzed a map of the Franconia Ridge Loop from the White Mountain Visitor Center to understand the information available through the maps and guidebook. Simultaneously, we identified information systems in places outside of the WMNF to explore additional approaches to communication systems. We investigated systems (signage and digital information) already in place in other locations, such as Yellowstone National Park and Underhill State Park (Mt. Mansfield). We used snowball sampling and archival research to expand our search for digital information systems. In one instance, we looked at mobile applications (apps) such as the Yellowstone National Park app for layout and planning of the mobile information system, and pamphlets such as the Green Mountain Club (GMC) Tundra Walk guide for ideas to include in the new alpine zone signage system.

O3: Developed Approaches to Designing a System for Environmental Protection

According to the third edition of the *Engineering Design Process*, after assessing the problem (in our case, the goals of Objectives 1 and 2), we identified the criteria that the design aimed to address (Haik, 2003). To identify these criteria, we compiled the findings from Objectives 1 and 2 into multiple tables to streamline analysis and analyze our data. These tables organized responses from interviews and data collected from the direct and participant observations. Through communication with Nathaniel Scrimshaw, we divided our deliverable system into two categories: the physical component and the digital component. The physical component included renderings and drawings in a 3-D Computer-Aided Design (CAD) program, materials list, and signage content. The digital component included the QR codes and digital information platform and content. We then created a list of design approaches (for the signage and digital content and the digital platform), considering criteria such as laws and regulations, effectiveness, and time constraints. We took this list of potential approaches to our sponsor, Nathaniel Scrimshaw (WTNHA chair), USFS employees, and trail stewards for their feedback on the most feasible solutions.

Phase 2: Iterative Design Process

O4: Produced and Evaluated Prototype System

After evaluating the list of potential approaches with our sponsor, we produced prototypes of the best design. Physical prototypes consisted of assembly drawings, containing physical parameters, tabulated bill of materials (BOM), and renderings in CAD. The program allowed for simple modifications, optimizations, and ease of delivery regarding the technical drawing package (TDP). After assessing the materials and hardware used by the WTN, we decided to use similar SPF, spruce-pine-fir, general lumber and torx-screw hardware. Following this, we included the respective material specifications to the elements within the CAD and BOM. Additionally, we used the data compiled in Objective 3 to develop suggested sign designs and a general template. The general template and the TDP were developed for ease of future use and reproducibility.

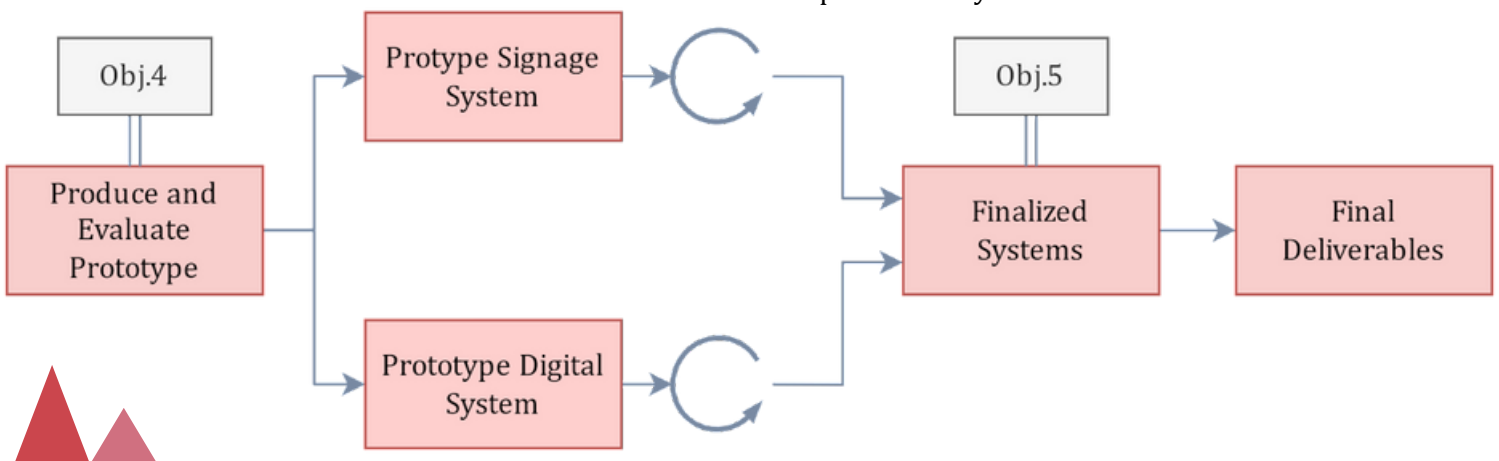

Figure 10: Diagram of Objectives 4 and 5

Methodology

Simultaneously, we utilized data and findings collected to develop a digital repository and templates for the content on the signs. The baseline contains important details about vegetation in the alpine zone. Within this system, there are documents for each planned QR code located along the trail. Additionally, we created templates for future expansion and reproducibility.

O5: Developed final deliverables and recommendations

We shared both parts of the final deliverable with our sponsor and gathered his feedback through discussion. With this feedback, we made changes and improved our designs. Using information gathered from both tested iterations and personnel feedback, we developed the final prototype system. Due to time constraints, we could only perform a brief test. Therefore, we left detailed instructions for future reproduction, expansion, and improvement.

Findings and Results

Alpine Zone Signage and Digital Repository System

The alpine zone is a delicate location with plants that grow on the scale of centuries. Many inexperienced hikers heading to the alpine zone are unaware of the dangers they pose to alpine vegetation. We explored methods to improve hiker responsibility with the goal of learning and understanding how to increase awareness and protection of the fragile alpine vegetation. We then addressed our findings by developing prototypes of interpretive signs and corresponding digital components that link via QR codes.

Addressing and Combating Alpine Damage

Hikers step off trail for a number of reasons, and alpine vegetation dies under their footsteps. ***Trail design, ease of passage, recklessness, and lack of awareness are the main reasons why people leave the trail.*** This was explained by six of six interviewees, who (when asked why hikers exit the trail) said that hikers leave the trail due to negligence, to rest, or to pass other hikers. Also, while observing the behavior of approximately twenty hikers on the Franconia Ridge Trail, we observed hikers step off-trail for a number of reasons including being unaware of being off-trail, taking an easier route, allowing others to pass, getting better views, resting, eating, and dogs being off-leash (observation, August 27, 2023). Additionally, McGinlay et al., found that disturbance to sensitive areas is caused by unaware or negligent visitors (2020), as mentioned in *Environmental Damage in the Alpine Zone.*

Effective trail design can address ease of passage and guide hikers along the trail. Poor trail design causes hikers to exit the trail to follow an easier or more convienient route. For example, in the Welch-Dickey subalpine zone, we observed five hikers step off trail. These hikers verbally expressed that they did not feel safe crossing the wet rock, and therefore walked off trail to dry rock (observation, September 22, 2023). Trail design plays a large role in keeping people on trail, especially in this instance, because people are walking off-trail for their perceived safety. If the trail was constructed to avoid wet and slippery areas of the rock, hikers would not need to step off the trail. Many hikers that walk off the trail are unconsciously doing so, to take a safer or easier route. Similarly, effective trail design includes a wide enough trail that allows hikers to pass each other without exiting the trial. Consequently, trail design is one method in preventing damage to the alpine zone and its vegetation.

While trail design is crucial, ***education, including trail and backcountry stewards, is the most effective method for keeping hikers on the trail.*** Five out of seven interviewees shared that communication and education through stewards was the most effective method for keeping hikers on trail and protecting the alpine vegetation. This was also supported by Hockett et al. (2017), who found that personal communication was the most effective approach to combat off-trail hiking, as mentioned in the section *Trail Stewards.* While hiking in the alpine zone of Franconia Ridge with Hailey Lynch, the World Trails Network-Hub for the America's (WTNHA) Franconia Ridge chief summit steward, we observed her interactions with around twenty hikers and found that every time she reminded a hiker to return to the trail to protect the plants, they complied immediately (observation, August 27, 2023). Stewards cannot always be available to inform hikers and protect the alpine zone. Lynch explained that the Franconia Ridge alpine zone only has one summit steward, whereas her previous position with the Green Mountain Club (GMC) had five stewards (personal communication, September 19, 2023). The lack of resources in the White Mountain National Forest (WMNF) further limits the contact stewards have with hikers, and forces the WTN and the USFS to incorporate other methods.

The Digital and Physical System

In collaboration with the WTNHA, we developed a system to supplement steward education by educating hikers about the alpine zone within the WMNF. The system includes both **interpretive signage** and a **digital repository**. This two-part system includes an introductory sign at the Shining Rock kiosk, and a total of six stops (shown on the map in Figure 11) along the Franconia Ridge. The first part is a physical sign and QR code. The QR code links users to the second part of the system, a unique digital page corresponding with the

Findings and Results

location of each sign (example of content at a sign in Figure 12).

Interpretive Signage Computer-Aided Design

The signage component on the system includes the specifications for three physical signs in one of three sizes (micro, mini, and midi) along the Franconia Ridge Loop Trail. We produced Computer-Aided Design (CAD) files and engineering drawings (see Appendix R, S, and T) to detail the specifications for each of the three sign sizes (micro, mini, and midi) for future use (see example sign in Figure 13). These were completed per request of our sponsor to allow for ease of reproduction and to budget for the cost of construction of these signs.

Interpretive Signage Components

To develop the content of the signage system, we considered placement, content, color, and imagery.

Signs should be placed in locations where people are likely to stop. Signs are only as useful as the number of people that read them. Therefore, when developing interpretive signs, we considered where the signs would be viewed most. Four out of five interviewees agreed that people were more likely to read signs in places where they were already stopping. We observed this

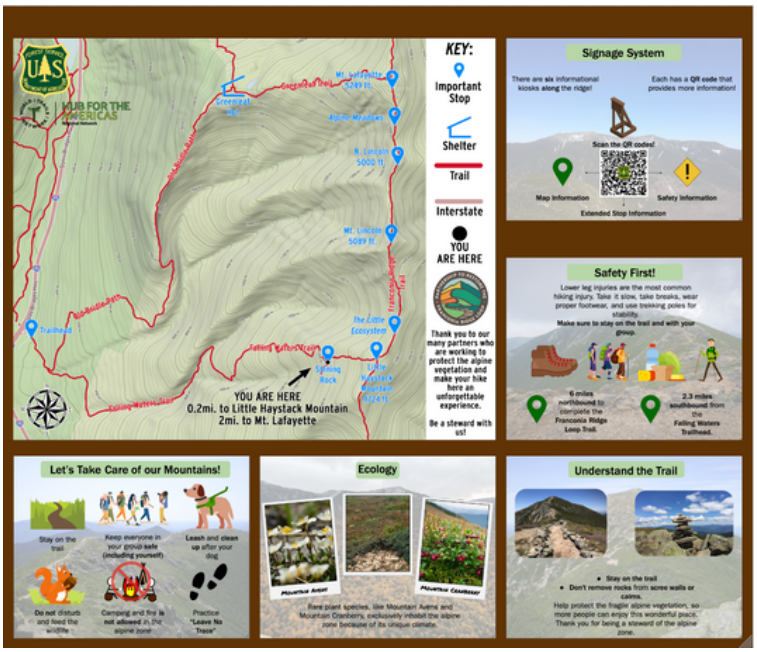

Figure 11: Updated Shining Rock Sign

Figure 12: Example of Content Signage Package From One of the Six Stops (The Little Ecosystem)

pattern while hiking Franconia Ridge, where some hikers who were eating lunch or taking a break used that opportunity to read the signage and observe the unique plants (observation, August 27, 2023). We discussed this finding with our sponsor, Nathaniel Scrimshaw, and with his expertise decided on six locations along the ridge, where people are likely to stop, as places for our interpretive signage spots.

Alpine zone signage is more likely to be read by visitors if it contains strong imagery, color, and limited text. Another method to encourage hikers to look at the signs is to make them visually appealing by using limited text and incorporating strong imagery and color. Four interviewees agreed that the signs in the alpine zone need fewer words, larger text, and more pictures. Araceli González, WTN World Trails Ambassador, noted specifically that younger generations are even less drawn to plain, colorless signs, suggesting that to grasp the attention of Millennial and Generation Z hikers, the signs need to appear more interesting (personal communication, September 18, 2023). This was also supported by the Cohort Hiking Survey, where 62.5% (5/8) of respondents agreed that color, images, and large/limited text would make the signs more noticeable while hiking.

When signage contains unique and memorable facts specific to the alpine zone, people are more likely to remember the message and stay on trail. According to our sponsor, Nathaniel Scrimshaw, people often talk about the information on the Little Ecosystem sign, a few miles from the sign's location (personal communication, August 27, 2023). This supports our

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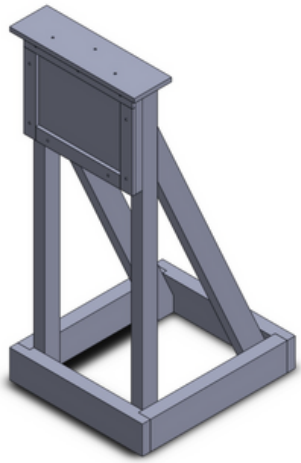

Figure 13: Example of a CAD Drawing of the Mini Kiosk

observations that the messaging on the sign is memorable and influences hiker behavior, even miles after the sign. Also, in an interview with Nicolette Keown, Lead Visitor Services Information Assistant Scientist with the USFS, she noted specifically that visitors have returned to the White Mountain Visitor Center after they visited Franconia Ridge, mentioning the signs and what they took from them (personal communication, September 5, 2023). This evidence supports that the messaging on the sign is memorable (see messaging in Figure 14). The message displayed on The Little Ecosystem Sign in Figure 13 has been proven to be impactful, so we mirrored our messaging to this for the other five signs (see Appendix P). From this, we added color to the text and made the images larger.

Digital Repository Component

The digital component is a way of providing more information to hikers, without overcrowding signage. Three out of five interviewees agree that some people want to learn more than the existing signs can provide (examples of current signs can be seen in Figures 14 and 15).

Additionally, our analysis of specific maps, apps, and guidebooks (listed in Appendix K) revealed more in-depth information than what could be included on any alpine zone sign. Reviewing these resources reiterated the need for QR code access to more comprehensive information included in the digital repository. We explored multiple different approaches to creating a digital repository, including WordPress, Google Drive, and building a website from scratch (see Table 2). ***A Google Drive folder is the optimal choice for this digital repository, because it is easy to transfer between hosts, easy to use and to navigate, easy to expand for future use, and both stable and secure.*** Using WordPress, or building a website from scratch, would be difficult to maintain and add documents without technological expertise. In addition, a website would need a database to host relevant documents, which a Google Drive folder is fit for. Therefore, setting up the database in a Google Drive folder with documents interlocking to each other was the easiest, most stable, and most secure way to achieve all of the requirements, and was chosen as a result, as seen in Table 2. Also, we streamlined the process for creating additional signs by making digital templates of the interpretive signage

CURRENT SIGNAGE **UPDATED SIGNAGE**

Figure 14: Current Sign in the Little Ecosystem that Includes a Shocking Fact and has been Proven to be Memorable.

CURRENT SIGNAGE **UPDATED SIGNAGE**

Figure 15: Example of Current Signage Content in the Alpine Zone Along Franconia Ridge.

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prototypes.

As mentioned above, content is important to get hikers to read signs. Signage that provides users with information that they want/need attracts them to the sign and people hiking in the backcountry are often looking for location, direction, and weather information. John Marunowski, Forest Partnership and Volunteer Coordinator for the USFS, discussed directing visitors to sources of information they are looking for (for example, weather, direction, location, maps) (personal communication, September 13, 2023). Four out of five interviewees explained that people frequently look for information regarding weather and travel, such as how long until the next peak. Consequently, we developed the digital component to include information that hikers are already looking for (weather and travel), as well as information about alpine zone vegetation (see Appendix M).

Signage and information in the alpine zone need to be accessible to people who speak multiple languages. People who visit Franconia Ridge speak many different languages. Franconia Ridge is a popular destination, and the WMNF's proximity to Canada and major metropolitan areas around New England brings many visitors whose primary language is something other than English. Nancy Ritger from the Appalachian Mountain Club (AMC) confirmed this and explained that the Greenleaf Hut, which is located along the Franconia Ridge Loop, sees many native Québécois speakers (personal communication, September 20, 2023). Lynch and Scrimshaw expressed a need for information to be available in additional languages, with French being the most important (personal communication, September 19, 2023). Therefore, we incorporated multiple languages, especially the dialect of French, Québécois, in the digital information system, as shown in Figure 16.

Another reason for developing the digital system is to provoke curiosity and encourage hikers to learn more. Keown and Scrimshaw suggested that the digital system can provide visitors a chance to take a deeper look at the location they are in. Keown shared that while most visitors are there for the views, exercise, and nature, some have a passion for the plants. She talked about a woman she knows who hiked specifically to see rare plants (N. Keown, personal communication, September 5, 2023). Through these conversations, we learned that ***it is important to draw the eye of the hikers to their immediate surroundings and appreciate the flora on the ground in addition to the breathtaking landscape.*** We incorporated this insight when we developed the digital repository. In our resource observations, we noticed that the GMC Tundra Walk guide encapsulated this goal well, by including different stops that noted attractions near hikers, like plants and animals, and identified distant mountains. Consequently, we developed each of the stops in the system to draw hikers to a specific aspect of their surroundings.

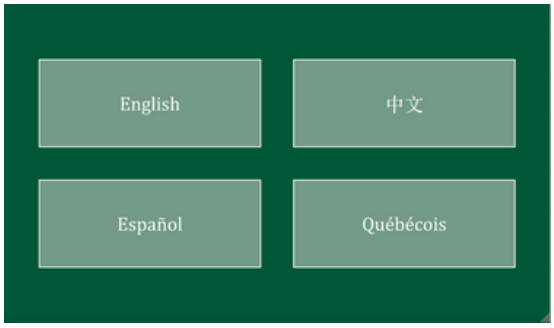

Figure 16: Landing Page for Choosing a Desired Language

Table 2: Comparison of Digital Repository Approaches

	Google Docs	Wordpress	New Website
Ease of Use	✓	✓	✓
Ease of Editing	✓	✗	✗
Transfer between hosts	✓	✗	✗
Expandable	✓	✓	✓
Stable and secure	✓	✓	✗

Recommendations and Final Thoughts

Throughout our research, we identified possible additions to the interpretive signage along the Franconia Ridge Trail and supplemented that information with a digital repository to increase hiker interaction with alpine zone signage. We propose the following four recommendations to further achieve education and therefore protection in the alpine zone of the WMNF.

We recommend incorporating an app, similar to PeakFinder (a smartphone app that allows users to identify the mountain peaks they are looking at using their geographical location and camera), into the digital resources, or providing a physical diagram, on-location, identifying nearby peaks. This addition may help to draw hikers' attention to the flora at their feet by redirecting their gaze. The design of the app should prioritize the peaks in the background, but then also give information about the alpine plants near the hikers, drawing their attention back to the foreground and giving the hikers an interest in investigating their immediate surroundings.

We recommend the installation of an interpretive sign, similar to the proposed Shining Rock kiosk, located at the Greenleaf Hut, shown in Figure 17. The Franconia Ridge Loop Trail, consisting of the Old Bridle Path, Falling Waters Trail, the trail along the ridge itself, and the Greenleaf Trail, can be hiked clockwise and counterclockwise. The piloted system is organized in the counterclockwise direction, as this is widely considered the safest and best route by our sponsor and USFS personnel. However, because some hikers travel in the clockwise direction, an introductory kiosk at the Greenleaf Hut would introduce the system along the ridge to more hikers, thus educating more people. We suggest that the WTNHA work alongside the AMC to provide the appropriate information needed for this kiosk.

Continued support for new languages is important for continued use of the digital repository. We recommend that the digital repository be expanded to include more languages. As detailed, we have begun the development in English, but also understand the need for the French dialect Québécois, Mandarin, Dutch, etc. Hikers from all over the world choose Franconia Ridge, and continuing to provide information in new languages, reinforces the work highlighted.

Additionally, we recommend that the system we developed be further investigated and studied. With limited time capacity, we were unable to implement our prototypes, collect hiker feedback, or make further improvements. Collecting data, such as hiker traffic on a trail, hiker comprehension of signs (through conversations with hikers), and alpine plant health, can provide useful metrics in evaluating the impact of the signage and information system.

We would also like to acknowledge the debate that comes with interpretive signs and technology in the WMNF. Over the course of this project, we have spent time contemplating the impacts of adding to the WMNF and in natural environments. We recognize that adding QR code technology is new and a potentially unnerving decision for some. However, by implementing this system, we are limiting the visual disturbances of signs, while still providing essential information for the protection of the alpine vegetation.

We developed this signage system and set of recommendations to educate hikers and aid in the protection of alpine zone vegetation. The Franconia Ridge Loop draws people in from all over the world, and we hope that this system will allow them to learn more about the area and protect it.

Figure 17: Proposed Greenleaf Hut Kiosk Location

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