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WORCESTER POLYTECHNIC INSTITUTE

# **BACKCOUNTRY EDUCATION**

## **Developing Lessons For Responsible Recreation**

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THIS PROJECT IS AN INTERACTIVE QUALIFYING PROJECT (IQP) SUBMITTED TO THE FACULTY OF WORCESTER POLYTECHNIC INSTITUTE  
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# Abstract

## **Project Sponsor:**

- Michael Benson, *Backcountry Wilderness Manager for the United States Forest Service*

## **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*

*Approximately 7 million people visit the White Mountain National Forest annually. Many of these hikers are unprepared for the terrain and weather and call 911. Visitors also impact the forest by increasing erosion and trampling off-trail flora. We conducted 11 interviews with search and rescue responders and Wilderness educators to identify both issues within the forest and effective teaching methods. Then we created lesson plans about the 10 Essentials and Leave No Trace principles that the United States Forest Service can use in the classroom or on a trail. The lesson plans include 14 interactive activities, adaptable for different ages, to help reduce hikers' impacts on the environment and improve hiker preparedness and safety.*



# WPI



# Acknowledgements

*Our group would like to thank everyone involved in our project, from sponsors, to interviewees, to strangers we conversed with on trails. We appreciate all your input and guidance.*

*Specifically, we would like to thank our advisors, Corey Dehner and Seth Tuler for their guidance and assistance. We would also like to thank you our project sponsor Michael Benson, Backcountry Wilderness Manager of the Pemigewasset district, for allowing us to work with him and sharing his insight on the White Mountain National Forest, safety, and environmental stewardship.*

*Additionally, we would like to thank Justin Lagassey, Outdoor Education teacher for Pemibaker high school, for guiding us while teaching and allowing us to teach his students.*

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# Background

Hiking can be a fun and relaxing way to connect with nature, and to get exercise. Whether you are hiking on a beginner trail in the forest or a highly technical trail climbing a mountain, it's important to be prepared. Even though search and rescue (SAR) teams can help with emergencies, it can endanger their lives if a hiker is not educated and prepared for basic situations (Shimanski, 2008). The goal of our project was to, in collaboration with the United States Forest Service (USFS), develop materials for USFS employees to use to teach middle schoolers and up through experiential, nature-based lessons about the environment, and how to safely navigate the White Mountain National Forest (WMNF) backcountry.

## INTRODUCTION

There are many cautionary tales about hiking accidents and dangers, which can help illustrate why it is important to be educated before becoming a statistic. In 2022, a 19-year-old woman, named Emily Sotelo, was on the precipice of her 20th birthday and of completing all forty-eight, 4000 ft tall mountains in New Hampshire. She had climbed forty peaks in the White Mountains already and was a trained Emergency Medical Technician. On November 20th, wind started to blow at nearly 60 mph and heavy snow began to fall on Mount Lafayette. Despite all her experience, Sotelo didn't bring winter clothes, such as a hat or warm boots. In that weather, on a mountain summit with very little shelter to be found and wind speeds so strong that one almost can't walk, even someone who was prepared might have had trouble (Mountain Safety, n.d.). Despite trying to escape by running down the mountain, to seek shelter or to find help, the 19-year-old died of hypothermia (Koczwara, 2023). Michael Benson, the Backcountry Wilderness Manager of the Pemigewasset district in the White Mountains National Forest, believes it is crucial to talk about hiker fatalities and what leads up to them to reduce SAR numbers and decrease environmental impacts from hikers. In Sotelo's case, she neglected to pack the appropriate gear for the weather at the summit (M. Benson, personal communication, April 4, 2023). This lack of preparedness can endanger oneself and the SAR volunteers. While volunteers are looking for a hiker, they often have to go off trail and may even trample rare plants, which can severely damage the environment. It is a lesson that experience doesn't outweigh preparedness, when one small decision can destroy so much. Decisions made in the backcountry affect both hiker safety and environmental stewardship. In order to educate people on these topics, we researched national forests, hiking challenges, wilderness safety, and how to effectively teach.

## NATIONAL FORESTS

### *National Forest History*

National forests have existed for over a century and serve an important purpose in resource conservation and outdoor recreation. National forests evolved from the forest reserves established under the Organic Act of 1897. This law created forest reserves as a way to regulate timber production, keeping a balance between prospering forest and timber output (Chronology of National Forest Management Laws and Regulations, 2016). In 1976, the National Forest Management Act (NFMA) was passed, creating national forests as we know them today. NFMA created the standard that is used by the USFS when it comes to land and resource management in national forests. Under NFMA, the USFS is responsible for protecting the land and properly managing its resources to ensure that the forests and their resources will last for as many years as possible (Chronology of National Forest Management Laws and Regulations, 2016; This Is Who We Are, 2019).



*Figure 1: View of the White Mountains from the top of Mount Willard.*

# Background

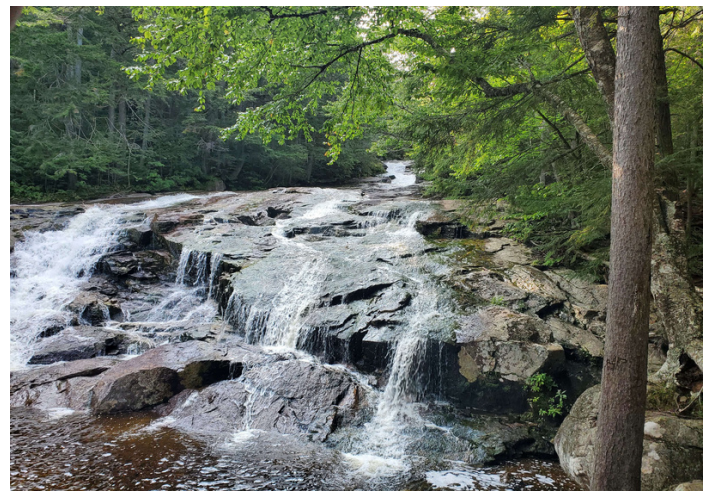
As of 2013, the USFS manages 154 national forests across the country, and approximately 193 million acres (By the Numbers, 2016). Across the land managed by the USFS, approximately 44 million of those acres constitute wilderness areas (Parks with Wilderness, n.d.). Wilderness areas were created under the Wilderness Act of 1964 and are meant to be spaces untrampled by humans. They exist as a way to preserve and protect natural ecosystems and wild areas, while also serving as quiet sanctuaries for solitude or introspection and reflection. It is common to have species in the Wilderness areas that are endangered, and may only exist in one location (The Wilderness Story, 2017). There also exists areas called alpine zones which are areas within national forests that are above the treeline but typically below the snow line (Allaby, 2010). Much like Wilderness areas, in alpine zones there is a wide variety of plant life, and most times some plants that grow within alpine zones are incredibly fragile and only grow in one alpine zone in the country (M. Benson, personal communication, April 4, 2023).

## **The Importance of National Forests**

National forests help preserve biodiversity, provide natural resources, and can be an asset to public mental and physical health. These forests serve an important role in the preservation of genetic diversity within and across a species. These genetic variations can allow a species to survive in a wide variety of circumstances (Biodiversity, 1999). With an increase in biodiversity comes an increase in genetic diversity, which can lead to plants of the same species being different in their inherited traits. This can give way to new strains of species that have different characteristics which allow them to survive in different environments (Gaston & Spicer, 2013). Increased biodiversity also provides food security, since having multiple strains can make a species more resistant to extinction, having multiple strains of food crops ensures that one bacterium cannot wipe out a staple crop (Rathore & Jasrai, 2013).

National forests are also a source of natural resources for the United States of America. As of 2013, 20% of America's clean water supply is provided by national forests and grasslands (By the Numbers, 2016). Additionally, national forests protect watersheds, which minimize flood damage and help clean water supplies by promoting a healthy ecosystem of microorganisms to filter out pollutants (Leshy 2022; Rathore & Jasrai, 2013).

Another example of these resources are medicinal plants, some of which only grow in forests in the eastern region of the United States. There are approximately 500 plants native to North America that have been identified as having medicinal properties. National forests provide a place for these plants to grow and be harvested for their medicinal use (Chamberlain et al., 2000). The USFS is also one of the leading providers of timber, selling 3.3 billion board feet of timber in 2019 (USDA Forest Service Surpasses Goals and Breaks Records in 2019, 2019). The USFS reliably and renewably provides timber since they are committed to preserving the forests as well as providing resources. This commitment to forest conservation means that the USFS is one of the leaders in developing new advancements and techniques for reforestation, ecological restoration, and seedling production (Dumroese et al., 2005).



*Figure 2: A rushing waterfall along the Basin-Cascade trail in the White Mountains.*

National forests can be an asset to the public's health, both mental and physical. Since national forests are open to the public, they can provide people with a nature experience, and a chance to improve their health. There are three areas in which nature can benefit human health: improved air quality, opportunity for physical activity, and reduced stress (Bratman et al., 2019; Hartig et al., 2014). Trees and plants absorb carbon dioxide and other pollutants out of the air resulting in areas with more vegetation having better air quality (Hartig et al., 2014). Nature environments also contain a microorganism called mycobacterium vaccae, which has been linked to boosted immune function and a decrease in major depressive disorder (Kuo, 2015; Lowry et al., 2007).

# Background

Being in nature has also been linked to stress reduction. Researchers looked at the heart rates of college students after doing stress-inducing tasks. Students who spent time in nature recovered from stress faster, meaning that their heart rates slowed faster and their blood pressure decreased faster (Hartig et al., 2003). However, before enjoying these benefits, it's important to think about the challenges that come with hiking.

## Hiking Challenges

There are numerous challenges that come with hiking in the backcountry, which consists of areas beyond the trailhead; these challenges are listed in Table 1 (M. Benson, personal communication, April 12, 2023).

Challenges of Hiking in the Backcountry			
	Risks	Challenges	Solutions
Weather and Seasons	<ul style="list-style-type: none"> <li>- Sudden temperature change</li> <li>- Heat stroke, dehydration, hypothermia</li> <li>- Pop-up storms with wind</li> </ul>	<ul style="list-style-type: none"> <li>- Lack of appropriate clothing</li> <li>- Limited knowledge on risks and danger</li> <li>- Unwillingness to back down from challenges</li> </ul>	<ul style="list-style-type: none"> <li>- Educate about 10 Essential Items, 12 Safety steps</li> <li>- Check the weather forecast in forest and summit</li> <li>- Have a plan for dangerous weather</li> </ul>
Terrain	<ul style="list-style-type: none"> <li>- Steep hikes increase risk of fatigue</li> <li>- Hikers can fall off cliffs</li> <li>- Rocky terrain can lead to injury</li> </ul>	<ul style="list-style-type: none"> <li>- Fatigue</li> <li>- Difficult terrain catches people off guard</li> <li>- Not everyone listens to recommendations</li> </ul>	<ul style="list-style-type: none"> <li>- Pay attention to surroundings</li> <li>- Bring appropriate footwear</li> </ul>

Table 1: Risks of hiking, issues that arise, and possible solutions (Procter et al., 2018).

An important consideration for hikers prior to leaving is the weather. First, weather can vary suddenly along a hike and depend on the elevation. Areas above the treeline can have drastically different weather and less shelter from the elements than areas below. These weather differences require hikers to be prepared for issues like hypothermia, which is one of the primary reasons people require emergency services and rescues (Procter et al., 2018; Serreze, 2020).

Second, good preparation means paying attention to seasonal differences. Hiking in the winter is more dangerous than hiking in the summer, as it requires more supplies to avoid hypothermia, especially when going above treeline on a mountain ("Safe Hiking in New Hampshire", n.d.). Hiking in the spring or summer at high altitude can be dangerous because of changing temperature and wind speeds. For example, the top of Mount Washington has experienced wind speeds of up to 231 mph! The environmental challenges hikers face means that adequate preparation is essential to safely enjoy a hike ("Normals, Means, and Extremes", n.d.).



Figure 3: All of the 10 essentials laid out, emergency shelter, insulation, tools, navigation, first aid, fire, illumination, sun protection, food, and water.

## WILDERNESS SAFETY AND ETIQUETTE

A lack of preparedness is one of the main causes of search and rescue, noted from a survey of overnight hikers in Australia (Nemeth et al., 2021). By properly preparing for the terrain, seasons, and wildlife, hikers reduce the risk of hurting themselves, other hikers, SAR teams, and nature. Hikers can't predict what will happen, but they can do their best to know the area and bring what they should to stay safe, especially when experiencing unexpected conditions. Safely hiking in the backcountry involves being prepared by bringing appropriate items, clothing, maps, and a plan ("Safe Hiking in New Hampshire", n.d.). A good start is bringing the Ten Essentials, which are items that hikers need to have with them on a hike (The Mountaineers, 2020). A survey of 199 New Hampshire hikers found that 78% of them didn't carry all of the Ten Essentials (Mason, et al., 2011).

# Background

While hiking can be dangerous at any time, packing appropriately, checking the weather, knowing physical limits, and telling people one’s plan can reduce the likelihood of accidents (Wagner, 2020). Going on difficult hikes and pushing oneself can give valuable experience for knowing when to stop, however many young people overestimate their level of fitness and assume they can accomplish anything. If you go too far it quickly becomes dangerous (M. Benson, personal communication, April 4, 2023).

## Search and Rescue—An Increase in Calls

There are many challenges to existing SAR resources, which are exacerbated by the recent increase in SAR requests. New Hampshire’s Department of Fish and Game (NHDFG) receives an average of 180 calls for help per year. In order to successfully find, rescue, and give medical help to those in need, the NHDFG team spent \$545,000 on SAR in 2022 alone (Gokee, 2022). These calls stretch the resources for rescues and each call can take several hours to complete, leaving less time and money for trail work. Another contributing factor to these strained resources is the 20% increase in outdoor recreation resulting from the Covid-19 pandemic (Ferguson et al., 2023; Wagner, 2022). A greater number of inexperienced hikers contributes to difficulties for Forest Service employees because it can lead to dangerous situations, such as going off trail and getting lost (M. Benson, personal communication, April 4, 2023). With more people going out and hiking, it’s important to address the lack of education in safety and etiquette.

## Environmental Stewardship

Environmental Stewardship Issues, Challenges, and Guidelines			
	Trampling	Littering	Awareness
Issues	- Harms rare alpine plants - Hurts the ecosystem	- Pollutes water ecosystem - Harms ecosystem	- Disregard for other hikers - Entering restricted areas
Challenges	- People still want to explore - Lack of awareness of the effect on the environment	- Disregarding existing policy and laws - Comprehension of teaching by children	- Some people are unwilling to learn and change, even if they are aware of the rules
Guidelines	- The Forest Service advises to stay on trail - Leave No Trace principles	- It’s illegal to litter - Dispose of waste responsibly	- Have respect for other hikers - Be aware of surroundings

Table 2: Issues from hiker environment interaction, guidelines from experts, and challenges with guidelines (U.S. National Park Service, n.d.).

Environmental stewardship is the protection of the natural environment through conservation and sustainability and is essential for preserving national forests (see table 2; Stewardship Definitions, n.d.). Stewardship helps address trampling, littering, lack of awareness and unnecessary contact with plants, all of which could damage the forest’s ecology (Marion, 2014). It is also illegal to knowingly remove or damage an endangered plant in a National Forest (Endangered Species Act of 1973).



Figure 4: A picture taken on a trail in the day, in the night with no light, and in the night with a headlamp.



# Background

A lesser known, but highly damaging impact, is when hikers unknowingly bring seeds along on their clothes into a trail introducing invasive species. These species drive out the native species, effectively changing the ecosystem (Dolman & Marion, 2022).

To avoid these ecosystem damages, the Center for Outdoor Ethics created seven principles to guide people when recreating in the outdoors. This set of principles is called Leave No Trace (LNT) and includes guidelines like planning ahead, proper waste disposal, leaving what you find, and respecting wildlife (U.S. National Park Service, n.d.). This is especially important for the WMNF because it gets around 6 to 7 million visitors a year, and if visitors don't practice LNT, they can damage the surrounding environment (M. Benson, personal communication, April 4, 2023).

Not everyone is aware of environmental stewardship and LNT principles or why it is important to follow them. This can be partially attributed to people becoming more disconnected from nature as the years pass (Miller et al., 2014). Respect for the ecosystems and wildlife is the basis of good environmental stewardship and is essential for exploring the backcountry (Marion, 2014). However, to establish that respect, more needs to be done to educate hikers, especially in the WMNF.



*Figure 5: Katelyn Beirne following Leave No Trace principles by picking up leftover trash,*

## EDUCATION TO IMPROVE SAFETY AND ENVIRONMENTAL STEWARDSHIP

One of the leading contributors to the high number of SAR operations is a lack of hiker preparedness due to errors in judgment, fatigue, physical conditioning, falls, and weather (VonHofe, 2022). These numerous emergency service responders and volunteers that travel through the backcountry can also damage the environment by searching off trail in fragile terrain or when two people carrying a litter walk on the edge of a narrow trail (C. Blair-Smith, personal communication, September 7, 2023). The dangers of hiking in the WMNF backcountry and the consequences that occur from hiking need to be well communicated with visitors. In response, the USFS sponsored the development of interactive programs to educate visitors about safety and stewardship in the WMNF. Backcountry Wilderness Manager, Michael Benson, wanted lessons on trail preparedness, trail etiquette, and survival techniques to keep hikers safe and protect the local ecology (M. Benson, personal communication, April 4, 2023). Environmental education offers a good foundation for developing these lessons about the outdoors.

### *Environmental Education Approaches*

Environmental education aims to teach students about environmental issues and problem solving related to safety and stewardship (US EPA, 2012). For environmental education to be effective, it needs to incorporate an active learning approach, which involves students participating in interactive activities with the instructors through project-based learning, while using critical skills to devise creative solutions to problems (Derevenskaia, 2014). Students gain knowledge through project-based active learning because the process of participating increases engagement and retention (Arik & Yilmaz, 2020; Fang et al., 2023).

Another advantage of active learning is that it incorporates a constructivist learning approach, where new knowledge is built upon previous knowledge. This structure makes the teacher a guide in activities while the students become their own teachers. This method has proven to be effective by constructivist learning programs that found significant improvement in student academic achievement (Arik & Yilmaz, 2020).

# Background

The active learning approach leads students to take an active role in recognizing environmental problems and offering solutions (Arik & Yilmaz, 2020). Experiential learning uses core principles of “do, observe, think, and plan” which builds on the foundations of active learning. The structure outlined by experiential learning allows participants to take control of their education by reflecting on their experience, which increases their retention and confidence. The benefit of having participants guide their own learning is that they take responsibility for their environmental behavior and build their knowledge on their own experience rather than building on an established experience level (Corscadden & Kevany, 2017).

## **Environmental Education Programs**

Environmental education programs provide insight on effective educational methods. The Promoting Environmental Awareness in Kids (PEAK) program, originally created in 2001, aims to increase awareness of LNT, promote stewardship of public lands, meet the demands of diverse youth populations, and have fun through experiential learning (Miller et al., 2014).

The PEAK program revealed that while it may effectively teach the principles of LNT, much of the knowledge is lost after a few months. Even worse, is that individuals may have known the principles of LNT, but they didn't necessarily follow them (Schwartz et al., 2018). In order for an environmental stewardship program to be successful, it needs to be either taught before an outing or practiced frequently over a longer period of time.

To combat WMNF visitor unpreparedness, the NHDFG and WMNF established the hikeSafe program. The program has a code that details appropriate gear and other planning procedures that help recreationists hike safely in the environment (Safe Hiking in New Hampshire, 2023). In addition, visitors can purchase hikeSafe cards, the profits of which go towards funding search and rescues. However, the funds generated from the program don't cover the cost of all of the SAR missions that occur in the White Mountains (Buy Your Voluntary hikeSafe Card, n.d.). This program is one of the most proactive ways the White Mountains and NHDFG tries to educate visitors and keep them safe. Even with environmental education programs such as hikeSafe, the roughly 185 annual SARs underscore the need for more education for WMNF visitors.

The high number of SAR missions and the environmental impacts hikers have on the backcountry suggests that there needs to be more programs to reduce these impacts. By identifying knowledge gaps for backcountry hikers, and the best ways to address them, we can reduce the environmental impacts from hikers and increase their safety.



*Figure 6: Students from Worcester Polytechnic Institute learning about the Leave No Trace Principles with Erik Samia.*

# Methodology

## INTRODUCTION

As a result of the jump in outdoor recreators since the 2020 COVID-19 pandemic, there has been an increase in emergency calls for search and rescue (SAR) and a decrease in environmental stewardship in the White Mountain National Forest (WMNF). In collaboration with the United States Forest Service (USFS), and more specifically, Michael Benson, the Backcountry Wilderness Manager of the Pemigewasset District, we developed a series of adaptable, interactive lessons that the WMNF can use to educate visitors on trail preparedness and environmental stewardship. We created two lesson plans that include interactive education and hands-on activities that can be adapted to a variety of environments and group sizes. These lessons incorporate topics from preparedness and Leave No Trace (LNT). To accomplish this goal, we completed the following four objectives shown in Figure 7.

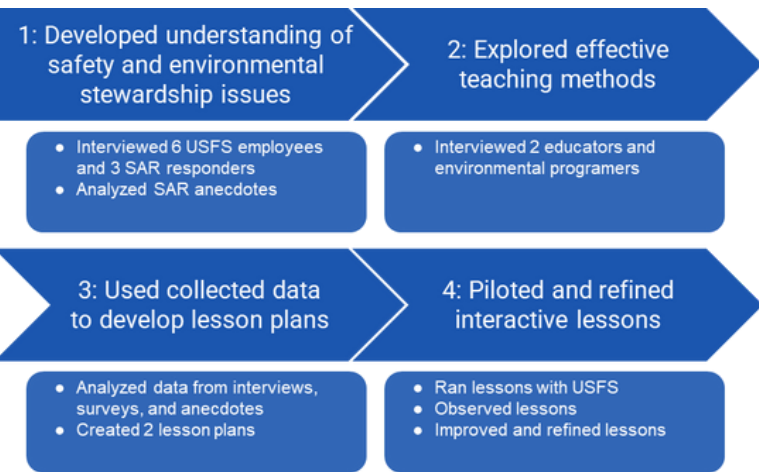


Figure 7: A flow chart of project objectives and tasks.

## OBJECTIVE ONE: DEVELOPED UNDERSTANDING OF SAFETY AND ENVIRONMENTAL STEWARDSHIP ISSUES

To develop our understanding of safety and environmental stewardship in the WMNF, we researched issues hikers face. Next, we analyzed what had been done to improve these issues in the WMNF. We conducted content analysis and semi-structured interviews with 6 USFS employees (for interviewee informed consent, see appendix B1).

For more information on interviewees, see figure 2 below. They provided us with information to create an educational program that utilized the best knowledge and resources that exist.

Interviewee's Expertise	
Interview Topics:	Who We Interviewed:
Preparedness & SAR Experience	Michael Benson (USFS), Lt. James Kneeland (Fish and Game), Stan Carte (USFS), & Justin Preisendorfer (Conway Mountain Rescue Service)
Environmental Stewardship	Michael Benson (USFS), Nancy Ritger (Appalachian Mountain Club), Caroline Blair-Smith (Outward Bound), Stan Carte (USFS), Brooke Brown (USFS), & Erik Samia (Appalachian Mountain Club)
Teaching Experience	Nancy Ritger (Appalachian Mountain Club), Caroline Blair-Smith (Outward Bound), Nikki Keown (USFS), Christian Bisson (Plymouth University), & Renee Plourde (USFS)

Tabel 3: A table of purposes for interviewing people and listed interviewees.

We conducted further research about national forest wildlife, climate, and the backcountry through peer-reviewed journals, a tour of Mt. Washington observatory, and personal experience hiking mountains such Mt. Pemigewasset. This was the best way to contextualize issues that hikers deal with in the White Mountains. Then we learned what constitutes the backcountry and effective communication of preparedness practices by conducting semi-structured interviews with Michael Benson, and used snowball sampling to identify additional interviewees (see appendix A1). We examined common causes of search and rescue missions through interviews with SAR volunteers, such as Lieutenant James Kneeland and Caroline Blair-Smith. We then performed content analysis of search and rescue data, including data on injuries and deaths in the WMNF, provided by Lt. Kneeland of New Hampshire Fish and Game. We used the knowledge we acquired from these interviews to understand the issues hikers face.

# Methodology

Next, we investigated what has been done to improve environmental stewardship for WMNF hikers by conducting 2 semi-structured interviews. We interviewed Nicolette Keown, the USFS conservation education coordinator, about methods to educate people on environmental stewardship and safety (see appendix A7). We then interviewed Erik Samia, Appalachian Mountain Club Trails Projects Coordinator, on how the Leave No Trace principles help inform hikers about environmental stewardship. These interviews are essential because they “capture and communicate someone else’s experience of the world in his or her own words” and that is important for understanding efforts to make hiking safer (Maxwell, 2013). This background information and analysis formed the foundation for development of the interactive lessons.

## OBJECTIVE TWO: EXPLORED EFFECTIVE TEACHING METHODS

To evaluate effective teaching methods and applications of environmental education, we conducted a semi-structured interview with Professor of Adventure Education, Christian Bisson of Plymouth University, Nicolette Keown of the USFS, and Renee Plourde of the USFS (see appendix A9, A7, and A10). A similar approach was done in China where environmental education teachers were interviewed about their experiences and strategies used in teaching environmental education (Cheng & So, 2015). In addition to teachers we also interviewed 2 WMNF Visitor Center employees on how they educate unprepared visitors before they reach the trail. The Visitor Center employees talk to many visitors, some of which are unprepared and want to gain more knowledge about their hike. Many unprepared hikers, however, go straight into the woods without checking into the Visitor Center (N. Keown, personal communication, September 13, 2023).



Figure 8: An example of a fake pathway in a classroom used in our lesson plans.

## OBJECTIVE THREE: DEVELOPED LESSON PLANS

After analyzing all of the data collected in objectives 1-2, we developed a list of challenges on hiker preparedness and environmental stewardship. We worked with Mr. Benson to identify which topics to prioritize in the lessons. To do this we conducted a content analysis on the information obtained through interviews. Using our background knowledge and drafted activities, we created a set of lessons that incorporate effective teaching methods. We created a basic structure that each lesson would follow, which included engaging with students on what they know, a brief introduction lecture, involved activities for students, and a wrap up session. This format was then adapted to each topic as a template for conveying different learning outcomes for adaptable time frames.

We conferred with Michael Benson to make sure our teaching methods fit within project parameters of being adaptable and incorporating active learning to teach safety and environmental stewardship in the White Mountains. From there we replicated teaching methods distinguished from our research to structure lessons.

# Methodology

## OBJECTIVE FOUR: PILOTED AND REFINED INTERACTIVE LESSONS

To assess the effectiveness of our lessons in educating participants, we first piloted our lessons with other Worcester Polytechnic students. We then reached out to high school teacher Justin Lagassey who teaches an outdoor recreation leadership course at Plymouth Regional High School in order to pilot our lessons with his students. All participants gave their informed consent to partake in our research. While we provided the lesson to participants, two team members acted as direct observers. There have been numerous studies on environmental education and the active learning methods used, including the 57 studies referenced by Arik & Yilmaz, which we will reference when implementing our lessons (Arik & Yilmaz, 2020). The direct observer noted the trends that occurred with the participants and analyzed how they reacted to their environment (see appendix H). Our observations helped us gauge the participant's level of engagement, excitement, and content retention.

We handed out a post-lesson survey which provided additional insight as to what the participants thought worked well and what areas could be improved. Then we refined our lessons based on feedback from post-lesson surveys and qualitative observations from student performance. This helped us evaluate what worked well to make sure what topics or teaching practices needed to be emphasized. The qualitative and quantitative data provided us comprehensive insight for improving our lessons.



*Figure 9: Katelyn Beirne demonstrating an activity piloted with Worcester Polytechnic Institute students.*

# Findings

## HIKING IN THE WHITE MOUNTAIN NATIONAL FOREST

The White Mountain National Forest (WMNF) sees roughly 7 million visitors a year and has some of the oldest trails in the nation (S. Carte, personal communication, September 8, 2023). Spanning almost 800,000 acres and 1,200 miles of hiking trails, the WMNF has a guaranteed spot on almost every hikers to-do list. However, most hikers aren't aware that the WMNF is special. Due to its age, the WMNF trails were built before trail science was widely utilized. This means that most trails in the WMNF go straight up the mountain, as opposed to other national forests and parks where the trails have switchbacks—sharp cuts from one direction to another that make hiking a steep trail a bit easier.



Figure 10: A comparison of two trails, a trail from a mountain in North Carolina, built with switchbacks (top). On the right is the Franconia Ridge loop trail in the WMNF which goes straight up steep rocks.

The White Mountains are also home to some of the most extreme weather in North America. The highest peak in the northeast, Mount Washington, has seen wind speeds of over 200 miles per hour and temperatures as low as negative 50 degrees Fahrenheit. While the wind speeds on Mount Washington is an extreme case, all of the White Mountains experience extreme weather differences between the base of a mountain and the peak of a mountain. Hikers need to be knowledgeable of, and prepared for, the wide variety of trail and weather conditions present within the WMNF.

### UNPREPARED VISITORS

Due to the variety of weather and trail conditions in the White Mountains, it's important to be prepared for a wide variety of scenarios. If you don't do proper research and proper packing beforehand, it's all too easy to get into dangerous situations on these trails.

#### *Planning Ahead is Important and Underemphasized*

One of the most important, but underemphasized, Leave No Trace (LNT) principles is "Plan Ahead and Prepare." **It is common for visitors to hike a trail and not fully consider the weather, terrain, or difficulty.** Hikers often rely on their phones for information about the mountain and under utilize pre-research. Nicolette Keown, conservative education coordinator for the United States Forest Service (USFS), shared that many hikers believe their phones will maintain enough charge and service throughout a hike for them to rely on (personal communication, N. Keown, September 14, 2023). This false sense of security can cause visitors to be overconfident and get into situations that they cannot get themselves out of, prompting them to call search and rescue (SAR). Planning ahead includes hikers having all Ten Essentials and other valuable resources for unique circumstances such as sudden changes in climate (personal communication, J. Preisendorfer, September 15, 2023).

# Findings

## Environmental Concerns

The backcountry in the WMNF is damaged by routine usage, and hikers' lack of knowledge of LNT principles. Many people don't realize that items such as orange peels or apple cores cannot be left on the ground; they think that since it is organic it will decompose (Esplin and Collier, 2018). Moreover, this kind of litter can cause problems for wildlife that may eat the peels and get sick. People also operate under the assumption that one person won't make that much of an impact. For example they will walk off trail in order to get a better view. However, if all 7 million visitors did that then it could cause serious damage to the surrounding environment (Esplin & Collier, 2018).

**Even visitors who follow LNT, may still cause an impact.** Any time someone hikes on a trail, it has an impact, contributing to erosion and disrupting wildlife. The sheer number of people that visit the WMNF puts pressure on trails, especially the popular ones such as Mount Willard and Franconia Ridge (personal communication, N. Ritger, September 5, 2023). We learned that the Falling Waters trail, that leads to the Franconia Ridge, has seen 1,492 hikers in one day alone, and an average of 763 hikers over the weekends in 2023 (see appendix G). Figure 11 shows the number of hikers who hiked the Falling Waters trail every day from June 1st to July 31st in 2023, the large spikes in the graph are on weekends, either a Saturday or a Sunday. As more people use a trail, the more it will be worn down, speeding up existing erosion. Trail erosion includes things such as trail widening, as people step off to the side to get around mud or let other hikers pass. This widening translates to less space for the natural vegetation to flourish.

People hiking Falling Waters trail in 2022

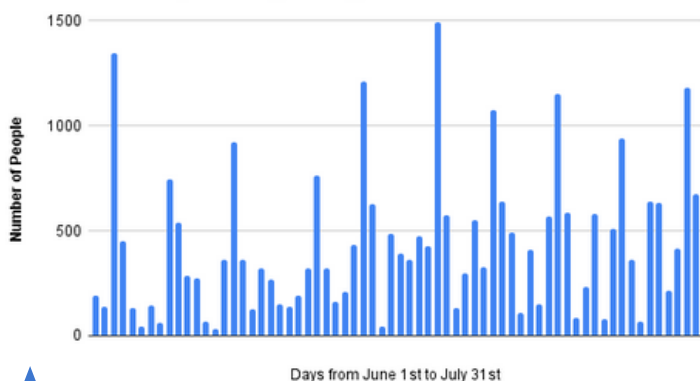


Figure 11: Number of hikers on Falling Waters trail from June 1-July 31, 2022 (trail counter data, provided by M. Benson, USFS, 2022).

While the LNT principles help protect the environment, they also help protect hikers, which is why it's so important to follow them. The first principle of being prepared involves conducting research for trail maps and information like weather.

## Safety Concerns

Weather and the changing seasons is a big reason that people can get into trouble in the WMNF. The most dangerous seasons, especially for unprepared hikers, are Spring and Fall. According to Brooke Brown, USFS Pemigewasset District Ranger, the difference in temperature can be intense from day-to-day, and there are large variations in weather between elevations (personal communication, B. Brown, September 13, 2023). Changing weather and varying weather by elevation can be dangerous, and requires preparedness to handle.

All of the three Search and Rescue responders we interviewed explained that **carrying the Ten Essentials would either reduce the severity of injury or remove the need for a rescue.** In an effort to address the situation, in 2014, the WMNF set up a trailhead steward program that uses volunteers to stand at the head of popular trails. These volunteers stand at the head of popular trails and talk to as many people as possible to make sure they are prepared for the hike. However, most trails don't have trailhead stewards and many visitors go straight to the trails without going to a visitor center or talking to USFS employees. Unfortunately, the number of SAR missions went from 171 missions in 2014 to 225 missions in 2015, so while there are testimonials from professionals who state that trailhead stewards have helped, unknown circumstances have caused SAR numbers to increase over the last ten years (see appendix F). In May of 2003, New Hampshire Department of Fish and Game (NHFG) paired with the USFS to create the hikeSafe program. This program was created to educate people on how to be safe and prepared when hiking, to help reduce SAR calls and injuries (*hikeSafe*, 2023). Trail stewards and the hikeSafe program help educate hikers, but struggle to reach all 7 million people that visit the WMNF trails. With the sheer amount of inexperienced hikers visiting the WMNF, there are unfortunately a large number of calls to SAR.

# Findings

## SEARCH AND RESCUE

SAR operations, both volunteer and professional, are used to rescue people in the backcountry who are in imminent danger because they can't rescue themselves. These operations are intensive and can last from several hours to several days. Volunteer SAR responders are on call 24-7, which means that when a call comes in they are often at work or doing other personal errands (personal communication, J. Preisendorfer, September 15, 2023). There are many issues that come with SAR, the best way to deal with them is to prevent the need for SAR.

### *What SAR Looks Like in WMNF*

The SAR teams that operate in the WMNF are made up of both volunteers and professionals. This means that there are some SAR teams run by NHFG who are paid to be available and participate in search and rescues, but there are also SAR teams made up of volunteers, such as Conway Mountain Rescue Service and Upper Valley Wilderness Response Team for Pemigewasset. **Many people don't realize that when they call SAR for a rescue, that it isn't going to be an immediate response.** For volunteer teams, it can take several hours before they are able to get to the caller. Team members have to be notified of the call, they need to often leave work and gather their gear, and then be debriefed before going to the trailhead. All of this can take several hours to do, which is much different from a 911 call where emergency responders are often able to respond in under an hour (personal communication, J. Preisendorfer, September 15, 2023).

### *SAR Poses Significant Risk to Responders*

When SAR operations happen, SAR responders are placing their own lives at risk. SAR operations can involve multiple responders traversing through harsh weather conditions and terrain. This is why people should self-rescue whenever they are able (personal communication, J. Preisendorfer, September 15, 2023).

Many times when SAR is called in, local emergency services such as Emergency Medical Technicians (EMT) and police are called as well. EMTs are obligated to try to get to an injured party, even if that person is hiking in the backcountry, provided it won't put the rescuer's life in danger.

According to Caroline Blair-Smith, National Safety Director for Outward Bound and SAR volunteer, many EMTs don't have training or knowledge pertaining to prolonged exposure in the backcountry, especially carrying the weight of their medical equipment, which can lead to injuries such as sprained ankles (September 7, 2023). SAR responders try to refrain from calling in emergency services, but sometimes emergency services are necessary.

SAR teams have to think about their own safety, meaning they will not go into hazards such as storms, avalanches, or during the night to save people unless absolutely necessary. In most cases responders will tell a caller to make shelter as best they can and then a SAR team will head out as soon as conditions allow it. The exception to this, is if there is a storm or another hazard coming in the next morning that would put the SAR team members in more danger (personal communication, J. Preisendorfer, September 15, 2023). Further exacerbating these problems is the increase of hikers due to the Covid-19 pandemic.



*Figure 12: A cloudy, rainy day on Lonesome Lake.*



# Findings

## Covid's Effect on SAR

When the 2020 COVID-19 pandemic hit the United States, it caused many more people to spend time outdoors and take up hiking as a hobby (M. Benson, personal communication, April 4, 2023). National parks and national forests felt this effect, and it's reflected in SAR numbers. Non-response calls are 911 calls where SAR dispatchers decide that the call doesn't warrant a team of rescuers. These non-response calls include things like people not having a headlamp or flashlight and finding themselves on a trail after dark. In this case the dispatcher would tell the caller to make camp for the night and keep going down the trail when the sun rises. As illustrated in Figure 12, below, in 2020, during the height of the pandemic the non-response calls that NHFG received increased by almost 65% (see appendix F).



Figure 13: Number of response calls over 7 years, the highest number of calls at the beginning of the COVID-19 pandemic, in 2020 (Search and Rescue data, provided by J. Kneeland, NHFG, 2016 - 2022).

While non-response calls don't require a huge amount of money or volunteer hours, they take up a lot of time, and when there's so many calls, that time adds up.

## SAR Operations Cost NHFG ~\$250k/year and NHFG is Only Reimbursed ~10% of the Time

SAR operations cost a substantial amount of money. Rescue operations have to fly and fuel helicopters, have emergency responders at the trail heads, and coordinate with different groups to safely rescue people. SAR operations don't have many avenues of getting back the money spent on rescuing people. The NHFG has the ability to bill people for SAR, but generally only recoups costs from around 10% of missions when the person needs rescuing because of their own negligence (personal communication, Lt. J. Kneeland, September 9, 2023). Volunteer SAR groups can't recover their costs because they have no ability to bill for missions. As a result, volunteer SAR groups are completely funded from donations or federal subsidies (personal communication, J. Preisendorfer, September 15, 2023).

For the past 11 years, the average annual cost of SAR missions was \$247,992 for NHFG alone, but the average number of SAR missions billed was only 11.94%. The number of SAR operations has stayed roughly the same over the past few years, between 148 and 195 missions annually. In 2022, SAR volunteers spent 5172.1 hours conducting over 185 rescue missions (see appendix F). As illustrated by Figure 13, below, most SAR calls come from hiking in the backcountry as opposed to any other backcountry activity. This frequency of SAR missions also has an adverse effect on the environment.



Figure 14: Number of SAR missions across different recreational activities in the outdoors (Search and Rescue data, provided by J. Kneeland, NHFG, 2012 - 2022).

# Findings

## Environmental Concerns

Many SAR missions involve people wandering off trail and getting lost. This can cause a lot of environmental damage to the woods, particularly because SAR team's goal is to get to the injured party as fast as possible. Responders may follow LNT practices, but the sheer number of responders who may have to spread out and cut paths through the woods means they inevitably damage the environment and trail. Even if a mission does not involve going off trail, responders may need to carry a stretcher, which means two people typically walk on the edge of the trail, widening the trail and trampling plants (personal communication, J. Preisendorfer, September 15, 2023). This adds to trail impact on top of normal visitor use, and these environmental and SAR concerns make it important to reach people before they hit the trail.

## INCREASING SAFETY AND STEWARDSHIP THROUGH EDUCATION

The best way to make sure people are prepared, is to reduce SAR numbers and to protect the WMNF is through preventative measures. If you don't reach people by the time they step past the trailhead, then it's already too late (M. Benson, personal communication, April 4, 2023). While there are many resources online for people to look at, many people won't.

Forest Service employees are often asked to give conservation education presentations and struggle to find time to develop these programs given multiple priorities (personal communication, B. Brown, September 13, 2023). Not everyone in the Forest Service is an expert hiker, and being asked to teach when you have next to no experience is a daunting task. We developed two lesson plans with a total of 14 activities. Our research shows that in order to do this effectively, each lesson plan needed to have many details about additional resources, discussion questions, required materials, a good age range and number of participants so that anyone could pick it up and teach it. Specifically, we created two lesson plans for use by the USFS. One is on the Ten Essentials, along with hiking preparedness, while the other is on LNT and its principles (see appendix C).

Both lesson plans have between six and eight activities that relate to the topics. These activities can be taught by trailhead stewards who have 3 minutes and no resources, at a campground with a larger group who have over an hour, or lessons for teachers or Forest Service staff to deliver in a classroom or during an interactive trail walk. This way, the lessons are adaptable; based on how much time the teacher has, the location of the lesson, the group size, and the materials they have access to. Adaptability is essential to the USFS since they aren't always going to know when, where, and to whom they are giving lessons. Therefore, having activities that can be adapted to multiple situations and accessible to many different audiences and abilities quickly is key.

## Lesson Plan Layouts

The lesson plans are divided into three parts: an introduction, a list of activities, and a conclusion. Each plan has both a short and a long introduction and conclusion, a short one for shorter interactions like the ones that trailhead stewards have, and a long one for classroom or campground settings. Each lesson plan has between six to eight activities, which are individually broken down into four parts: the context of the lesson, required materials, step-by-step instructions, and post-activity discussion questions.

- Time:** 10-20 minutes
- Audience:** 12+ years old
- Number of Participants:** 5+
- Location:** indoors or outdoors
- Learning Outcomes:**
  - Ability to identify the 10 essentials, understand their importance on hikes
  - Develop skills for successful collaboration in groups
- Background:**
  - [10 Essentials List](#)
- Materials:**
  - Items from the 10 essentials
  - Items not from the 10 essentials
  - Small bag (hiking bag, plastic bag, etc.) where every item is stored
- Preparation:**
  1. Lay out all the items on a flat surface such as a table.
  2. List each item so participants are aware of the options before listing the 10 essentials.
- Activity:**
  1. Lay the 10 essentials, non essentials and a backpack on the table. Let participants figure out how to pack all the items into a backpack. Let participants figure out how to pack all the items into a backpack. Let participants figure out how to pack all the items into a backpack.

Figure 15: An example of our lesson plan layout.

# Findings

The lessons start off with a basic intro format that people can follow to kickstart the lesson. These intros are just guidelines, and serve more as a tool for those who haven't taught this material and don't know where to start. They detail how to grab people's attention and give them the basic rundown of what the lesson is about, either the Ten Essentials or the LNT principles. There is then a list of activities for the instructor to choose from. Each activity details how long it will take, whether it's for inside or outside, the best group size for the activity, and the best age range for the activity. This allows the instructor to tailor the lesson to their specific situation. Activities also include specific directions on how to give each activity to the group, so that way people can simply pick up the lesson plan and go, they don't need to have a background in teaching. Each lesson plan ends with a conclusion, as a way to wrap up the lesson and keep people thinking about what they've learned after they leave.

**The best way to engage people and have them remember the lesson and what they were taught is to use hands-on activities and demonstrations.** This is especially useful when teaching multi-aged audiences such as a group of people ranging from small kids to adults. Children tend to have shorter attention spans so having them participate on an interactive topic will help keep their mind on the subject and not have it wander (personal communication, R. Plourde, September 21, 2023).

When engaging in an experiential learning lesson, it is essential to include demonstrations of why a topic is important. Demonstrations can capture people's attention and can make them more willing to participate in the activity that follows. For example, Stan Carte, Recreation and Wilderness Program Manager for the USFS, mentions a demonstration where a wool and cotton sock are soaked in water and, after shaking them around, compare how cold they are to each other (September 8, 2023).

Demonstrations such as this allow people to see the direct effects of conditions such as the weather and how it can affect them (personal communication, N. Ritger, September 5, 2023).



*Figure 16: Peter Poulos shows a hands on demonstration from the Ten Essentials lesson that helps grab people's attention and gets them engaged.*

## **Ten Essentials Lesson Plan and Activities**

The Ten Essentials lesson plan covers the items included with a handout detailing the Ten Essentials for people to reference during the lesson or activities (see appendix C). There are eight activities that teach about the Ten Essentials and detail why it is important to have each essential (see list of activities, appendix C). For example, the Navigating in the Dark activity teaches you the importance of carrying a headlamp in your backpack (see appendix C). Several of the activities also get participants thinking about what is and isn't included in the Ten Essentials, as well as other important things that they might want to take with them on a hike.

**When grouping participants for an activity, giving people certain roles within the group helps ensure that everyone is given equal chance to participate in the activity.** After piloting the Compact Packing activity with six Worcester Polytechnic Institute students, we learned that when participants are broken up into groups, one or two people can become leaders and start making all of the decisions for the group. Therefore, we structured the activities so that within group settings, people are given roles so that a few people aren't making all of the decisions. **Including detailed, step-by-step instructions make it so lessons can be taught by staff even with different levels of experience and knowledge.**

# Findings

After walking our project sponsor, Mike Benson, and our WPI faculty advisors, Corey Dehner and Seth Tuler through the 14 activities, they explained that the more detailed the descriptions, the easier someone who has never seen the activity before, would be able to deliver the lesson. Therefore, we added more details to the activity instructions and broke it down into specific steps so that anyone would be able to recreate the activity as we did.

## *Leave No Trace Lesson Plan and Activities*

The LNT lesson plan details the LNT principles and why they are important to remember and follow. This lesson includes both a handout with all of the LNT principles, as well as a short presentation to give during the introduction that encourages participant discussion (see appendix C). There are six activities in the lesson plan that talk about the different principles, why they are important and how to follow them correctly. Some activities also include thinking critically about each principle, and deciding whether or not a certain behavior follows LNT. For example, the 'Is It Leaving no Trace?' activity lists a number of different behaviors, and people have to think about and decide if that behavior follows LNT or not (see appendix C).

**Offering a reward of external incentive for participants can help keep them engaged with an activity.** After piloting the 'Is It Leaving No Trace?' activity with six Worcester Polytechnic Institute students, we learned that they lost interest in activities if they didn't think there was a goal. Therefore, we structured the activities to include some form of reward or turn it into a competition to keep participants engaged. **Longer activities are hard to keep engaging the whole time.** When piloting the 'Picking Up and Packing Out Trash' activity with students from Plymouth Regional High School's Outdoor Recreation Leadership program, we learned that the longer an activity goes on the less likely it is that participants will be engaged the whole time. Therefore, we structured it so that during longer activities, there are sub-activities or competitions for participants to do so that they stay engaged with the instructor and the activity topic.



*Figure 17: A sunset overlooking the WMNF taken from Bald Mt.*

# Recommendations & Conclusion

## RECOMMENDATIONS

### *Plan Ahead and Prepare is Under Taught*

Plan ahead and prepare is an overlooked and under taught principle of LNT, which causes people to be unprepared when hiking (personal communication, R. Plourde, September 21, 2023). We recommend that the USFS or future WPI projects involve making lessons specifically teaching people how to plan ahead and what they should consider before going on a hike can help reduce the number of injuries in the backcountry.

### *Accessibility*

Since lesson plans need to be adaptable, it is important to consider disabilities. We recommend that the USFS creates sections for lessons that address how people may have difficulties learning the lessons without accommodations.

### *Organizing SAR Data by Season and Severity Could Help Understand Treads Better*

Currently, though NHFG logs every call and rescue, they don't analyze these calls by season or by severity as shown in figure 9. Our research illustrates that, though the number of calls has remained consistent in the past five years, the severity of calls may have changed. We also believe that the season may influence both the number of calls and their severity. If NHFG could organize their data based on both severity of injury and time of year, perhaps it would be easier to increase staff during periods when more injuries occur and more could be done to target visitors with data in shoulder seasons.

A	B	C	D	E	F
	Total Missions	Cost of Missions	Total CO Hours	#of Missions w/Volunteers	Total # of Volunteers
2022	184	\$320,474.01	5159.5	108	1312
2021	183	\$235,226.53	3814.75	93	1272
2020	173	\$200,517.54	3388.25	80	1004
2019	169	\$261,741.38	4663.75	84	926
2018	148	\$194,001.00	3349.25	81	908

Figure 18: Search and Rescue data, organized by categories like total missions, cost of missions, and the number of volunteers. (Search and Rescue data, provided by J. Kneeland, NHFG, 2018 - 2022).

## CONCLUSION

We believe that the lesson plans we developed in collaboration with the USFS will help reduce the SAR mission numbers, reduce the damage on the environment, and bring more awareness to being prepared. These lesson plans can help USFS employees reach more people and help protect the forest they love.



Figure 19: Darkness falls over the WMNF and a single tree.

# LIST OF REFERENCES

Allaby, M. (Ed.). (2010). *A dictionary of ecology* (4th ed). Oxford University Press.

Arik, S., & Yilmaz, M. (2020). The Effect of Constructivist Learning Approach and Active Learning on Environmental Education: A Meta-Analysis Study. *International Electronic Journal of Environmental Education*, 10(2), 44–84. <https://eric.ed.gov/?id=EJ1239355>

Benson, Michael. (2023). *Franconia Ridge Hiker Counter, 2019-2023* [Data set], 2019-2023. United States Forest Service.

Biodiversity, N. R. C. (US) C. on N. and E. V. of. (1999). *What is Biodiversity?* National Academies Press (US). <https://www.ncbi.nlm.nih.gov/books/NBK224405/>

Brassil, G. R. (2020, November 29). As hiking surges during the coronavirus pandemic, so does the risk of injury. *The New York Times*. <https://www.nytimes.com/2020/11/29/us/as-hiking-surges-during-the-coronavirus-pandemic-so-does-the-risk-of-injury.html>

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., De Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J. J., Hartig, T., Kahn, P. H., Kuo, M., Lawler, J. J., Levin, P. S., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R., Ouyang, Z., Roe, J., ... Daily, G. C. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances*, 5(7), eaax0903. <https://doi.org/10.1126/sciadv.aax0903>

By the Numbers. (2016, February 1). US Forest Service. <https://www.fs.usda.gov/about-agency/newsroom/by-the-numbers>

Chamberlain, J., Bush, R., Hammett, A. L., & Araman, P. (2000). Managing national forests of the eastern United States for non-timber forest products. XXI IUFRO. World Congress 2000, *Forests and Society: The Role of Research*.

[https://www.srs.fs.usda.gov/pubs/VT\\_Publications/00t13.pdf](https://www.srs.fs.usda.gov/pubs/VT_Publications/00t13.pdf)

Cheng, I. N. Y., & So, W. W. M. (2015). Teachers' environmental literacy and teaching – stories of three Hong Kong primary school teachers. *International Research in Geographical and Environmental Education*, 24(1), 58–79. <https://doi.org/10.1080/10382046.2014.967111>

Chronology of National Forest Management Laws and Regulations. (2016). United States Department of Agriculture.

Corscadden, K. W., & Kevany, K. (2017). The TREEhouse: A hybrid model for experiential learning in environmental education. *Applied Environmental Education & Communication*, 16(1), 56–67. <https://doi.org/10.1080/1533015X.2017.1282334>

Department of NH Fish and Game. (n.d.-a). Buy Your Voluntary Hike Safe Card | New Hampshire Fish and Game Department. Retrieved April 14, 2023, from <https://wildlife.state.nh.us/safe/index.html>

Department of NH Fish and Game. (n.d.-b). Hiking Safety | New Hampshire Fish and Game Department. Retrieved April 25, 2023, from <https://www.wildlife.state.nh.us/outdoor-recreation/hiking-safety.html>

Derevenskaia, O. (2014). Active Learning Methods in Environmental Education of Students. *Procedia - Social and Behavioral Sciences*, 131, 101–104. <https://doi.org/10.1016/j.sbspro.2014.04.086>

Dolman, M. R., & Marion, J. L. (2022). Invasive plant hitchhikers: Appalachian Trail thru-hiker knowledge and attitudes of invasive plants and Leave No Trace practices. *Journal of Outdoor Recreation and Tourism*, 40. <https://doi.org/10.1016/j.jort.2022.100581>

Dumroese, K., Landis, T., Barnett, J., & Burch, F. (2005). Forest Service Nurseries: 100 Years of Ecosystem Restoration. *Journal of Forestry*, 103(5), 241–247. <https://doi.org/10.1093/jof/103.5.241>

Endangered Species Act (1973), (1973).

# LIST OF REFERENCES

- Esplin, B., & Collier, E. (2018, July 13). Our 5 Most Common Litter Sightings. *Leave No Trace*. <https://lnt.org/our-5-most-common-litter-sightings/>
- Fang, W.-T., Hassan, A., & LePage, B. A. (2023). Outdoor Education. In W.-T. Fang, A. Hassan, & B. A. LePage (Eds.), *The Living Environmental Education: Sound Science Toward a Cleaner, Safer, and Healthier Future* (pp. 229–260). Springer Nature. [https://doi.org/10.1007/978-981-19-4234-1\\_8](https://doi.org/10.1007/978-981-19-4234-1_8)
- Ferguson, M. D., Lynch, M. L., Evensen, D., Ferguson, L. A., Barcelona, R., Giles, G., & Leberman, M. (2023). The nature of the pandemic: Exploring the negative impacts of the COVID-19 pandemic upon recreation visitor behaviors and experiences in parks and protected areas. *Journal of Outdoor Recreation and Tourism*, 41. <https://doi.org/10.1016/j.jort.2022.100498>
- Gaston, K. J., & Spicer, J. I. (2013). *Biodiversity: an Introduction* (2nd ed). Wiley.
- Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, 23(2), 109–123. [https://doi.org/10.1016/S0272-4944\(02\)00109-3](https://doi.org/10.1016/S0272-4944(02)00109-3)
- Hartig, T., Mitchell, R., De Vries, S., & Frumkin, H. (2014). Nature and Health. *Annual Review of Public Health*, 35(1), 207–228. <https://doi.org/10.1146/annurev-publhealth-032013-182443>
- Hike Safe*. (2023). Hike Safe. <https://hikesafe.com/>
- Kneeland, James. (2023). *Search & Rescue Mission Data, 2012-2022* [Data set]. New Hampshire Fish and Game Department.
- Koczwara, K. (2023). Why do hikers keep dying in the White Mountains of New Hampshire? - The Boston Globe. BostonGlobe.Com. <https://www.bostonglobe.com/2023/01/24/magazine/why-do-hikers-keep-dying-white-mountains-new-hampshire/>
- Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology*, 6. <https://www.frontiersin.org/articles/10.3389/fpsyg.2015.01093>
- Leave No Trace Seven Principles (U.S. National Park Service). (n.d.). Retrieved April 14, 2023, from <https://www.nps.gov/articles/leave-no-trace-seven-principles.htm>
- Leshy, J. D. (2022). *Our Common Ground: A History of America's Public Lands*. Yale University Press. <https://doi.org/10.2307/j.ctv240df66>
- Lowry, C. A., Hollis, J. H., de Vries, A., Pan, B., Brunet, L. R., Hunt, J. R. F., Paton, J. F. R., van Kampen, E., Knight, D. M., Evans, A. K., Rook, G. A. W., & Lightman, S. L. (2007). Identification of an immune-responsive mesolimbocortical serotonergic system: Potential role in regulation of emotional behavior. *Neuroscience*, 146(2), 756–772. <https://doi.org/10.1016/j.neuroscience.2007.01.067>
- Marion, J. L. (2014). *Leave no trace in the outdoors*. Stackpole Books.
- Mason, R. C., Suner, S., & Williams, K. A. (2013). An Analysis of Hiker Preparedness: A Survey of Hiker Habits in New Hampshire. *Wilderness & Environmental Medicine*, 24(3), 221–227. <https://doi.org/10.1016/j.wem.2013.02.002>
- Maxwell, J. A. (2013). *Qualitative research design: an interactive approach* (3rd ed). SAGE Publications.
- Miller, J., Hill, E., Shellman, A., Ramsing, R., & Lawhon, B. (2014). Measuring the Effectiveness of the Leave No Trace PEAK Program. *Journal of Youth Development*, 9(2). <https://doi.org/10.5195/jyd.2014.59>

# LIST OF REFERENCES

Mount Washington Observatory | Normals, Means, and Extremes. (n.d.). Retrieved March 22, 2023, from <http://www.mountwashington.org/experience-the-weather/mount-washington-weather-archives/normals-means-and-extremes.aspx>

Nemeth, N., Adams, V. M., & Byrne, J. A. (2021). Factors affecting the preparedness of overnight hikers in national parks: Insights from Tasmania, Australia. *Journal of Outdoor Recreation and Tourism*, 35, 100388. <https://doi.org/10.1016/j.jort.2021.100388>

Parks with Wilderness - Wilderness (U.S. National Park Service). (n.d.). Retrieved April 4, 2023, from <https://www.nps.gov/subjects/wilderness/wilderness-parks.htm>

Peters, A., Ruess, R., & Heurich, M. (2022). What are the Effects of Recreational Activities on Wildlife Behavior, Physiology, and Demographics? *Naturschutz Und Landschaftsplanung (NuL)*, 55(1), 24–35. <https://doi.org/10.1399/NuL.2023.01.02>

Procter, E., Brugger, H., & Burtscher, M. (2018). Accidental hypothermia in recreational activities in the mountains: A narrative review. *Scandinavian Journal of Medicine & Science in Sports*, 28(12), 2464–2472. <https://doi.org/10.1111/sms.13294>

Rathore, A., & Jasrai. (2013). Biodiversity: Importance and Climate Change Impacts. *International Journal of Scientific and Research Publications*, 3(3), 536–540. <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=0c1d9d3279cf15dde398c77a371f2684055f35d2#page=537>

Rock steps and Switchback on the Lower Piney Trail. (2017, November 27). WNCOutdoors.info. <https://www.wncoutdoors.info/photo-gallery/montreat/rock-steps-and-switchback-on-the-lower-piney-trail/> under <https://creativecommons.org/licenses/by-sa/3.0/us/>, no changes were made.

Schwartz, F., Taff, B. D., Lawhon, B., Hodge, C., Newman, P., & Will, E. (2018). Will they leave what they find? The efficacy of a Leave No Trace education program for youth. *Applied Environmental Education & Communication*, 17(4), 299–309. <https://doi.org/10.1080/1533015X.2017.1411217>

Serreze, M. C. (2020). Climates of Tundra and Alpine Biomes. In *Encyclopedia of the World's Biomes* (pp. 286–294). Elsevier. <https://doi.org/10.1016/B978-0-12-409548-9.12022-6>

Shimanski, C. (2008). Risks in Mountain Rescue. Mountain Rescue Association. <https://mra.org/wp-content/uploads/2016/05/risksinrescue.pdf>

Stewardship definitions. (n.d.). Retrieved April 26, 2023, from <https://www.noaa.gov/office-education/noaa-education-council/monitoring-resources/common-measure-definitions/stewardship-definitions>

The Wilderness Story. (2017, August 23). US Forest Service. <https://www.fs.usda.gov/managing-land/wilderness/wilderness-stories>

This Is Who We Are. (2019, July 8). US Forest Service. <https://www.fs.usda.gov/about-agency/this-is-who-we-are>

US EPA, O. (2012, December 13). What is Environmental Education? [Overviews and Factsheets]. <https://www.epa.gov/education/what-environmental-education>

USDA Forest Service surpasses goals and breaks records in 2019. (2019, December 19). US Forest Service. <https://www.fs.usda.gov/news/releases/usda-forest-service-surpasses-goals-and-breaks-records-2019>



# LIST OF REFERENCES

VonHofe, J. (2022). A PRICE TAG ON ADVENTURE: DISORDERLY CONDUCT LIABILITY FOR SEARCH AND RESCUE IN AMERICA'S NATIONAL PARKS. Wyoming Law Review, 22(539). <https://advance.lexis.com/document?crd=00b13066-a1d8-4195-987f-8617c2f308a6&pddocfullpath=%2Fshared%2Fdocument%2Fanalytical-materials%2Furn%3AcontentItem%3A6696-R001-FCK4-G2J5-00000-00&pdsourcingtype=&pdcontentcomponentid=243491&pdmfid=1516831&pdisurlapi=true>

Wagner, A. (2022). How has the COVID-19 pandemic affected outdoor recreation in America? Pennsylvania State. <https://www.psu.edu/news/health-and-human-development/story/how-has-covid-19-pandemic-affected-outdoor-recreation-america/>

Wagner, P. (2020, August 5). Recreate Responsibly to Help Prevent Search and Rescue - Olympic National Park (U.S. National Park Service). <https://www.nps.gov/olym/learn/news/recreate-responsibly-to-help-prevent-search-and-rescue.htm>