# Broad Meadow Brook Trail Development

An Interactive Qualifying Project
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the degree of Bachelor of Science.


WPI | Worcester Community Project Center

Date:
December 16, 2015

Report Submitted to:

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# Acknowledgements

We would like to thank the employees from Mass Audubon's Broad Meadow Brook Wildlife Sanctuary for their accommodation throughout our project. We would also like to thank our advisors, Corey Dehner and Melissa Belz, our sponsors, Deb Cary and Martha Gach, and Devon Kurtz from the Blackstone Heritage Corridor for assisting us in our research. Lastly, we would like to thank all the individuals who helped in the proposal of this trail connecting Broad Meadow Brook to the site of the new Blackstone Heritage Corridor Visitor Center in Worcester, Massachusetts.

# Abstract

Mass Audubon is a non-profit Massachusetts-based environmental conservation organization that seeks to educate the public on statewide environmental issues. The goal of our project was to propose, Global Positioning System (GPS) map, and recommend educational approaches to a trail connecting the existing trail network at Mass Audubon's Broad Meadow Brook Wildlife Sanctuary to the site of the new Blackstone Visitor Center in Worcester, Massachusetts. Through interviews, comparative analysis of other trails, and research on the unique features along the interconnector trail, we proposed and blazed a trail route, developed educational components, and provided Mass Audubon with recommendations for further improvements along this trail.

# Executive Summary

## Background

From climate change to loss of habitat, there are a number of pressing 21st century environmental issues. The lack of human connection to nature could be to blame and according to a study done by the Kaiser Family Foundation and the Center for Disease Control (CDC), “A child is six times more likely to play a video game on a typical day than to ride a bike” (Chiu, 2005). This statistic represents a growing disconnect between humans and nature that many environmentalists hope to address.

Mass Audubon is a non-profit Massachusetts-based environmental conservation organization that seeks to educate the general public on statewide environmental issues. The new Blackstone Heritage Corridor Visitor Center will be established at the site of a former, historically significant, industrial mill, geographically near the existing trails of Mass Audubon’s Broad Meadow Brook Wildlife Sanctuary (BMB) in Worcester, Massachusetts. The new Blackstone Visitor Center is projected to be completed by 2017. By blazing and developing a walking trail connecting the existing BMB trails to the Blackstone Visitor Center, Mass Audubon hopes to provide the people of Worcester County with a more interactive experience with nature.

Sedentary lifestyles and lack of engagement with nature contributes to a number of health issues, including obesity, which can have a number of immediate and long-term health effects, increased risk for diabetes and cardiovascular issues, and psychological effects, such as depression and low self-esteem (CDC, 2015). By integrating nature into one’s routine, he or she can lead a healthier life. One way to increase a person’s experience with nature is through education and exposure.

Interpretive nature trails can be an effective way to teach about the environment and connect people with nature in an experiential way (Ostermann-Sussman, 1993). Nature trails present an opportunity for people to engage with nature in a more personal way. In this case, the trail not only serves as a way for people to get outside, but as a way to learn about the history of Worcester, Massachusetts as well. By using a trail to link the Broad Meadow Brook Wildlife Sanctuary (BMB) to the future Blackstone Heritage Corridor Visitor Center, residents and visitors, alike, will be able to experience the nature and history of Worcester in a unique way.

## Methodology

The primary goal of our project was to Global Positioning System (GPS) map and propose a trail connecting the existing trail network at BMB to the site of the new Blackstone Visitor Center. Secondarily, we also worked to identify key points along the trail where educational components interpret historical and environmental information for trail users. In order to accomplish this goal, we developed nine objectives broken down into three phases:

**Phase 1: Understanding Broad Meadow Brook Trail Users**

Objective 1: Identify our Target Demographic

Objective 2: Assess Current Trail User Perspectives

Objective 3: Connect with Surrounding Schools

**Phase 2: Trail Planning**

Objective 4: Determine the Most Feasible and Effective Trail-based Education Method to Implement at Broad Meadow Brook

Objective 5: Develop Educational Material to Use along the Trail

**Phase 3: Trail Creation**

Objective 6: GPS Map Ideal Trail Route

Objective 7: Identify Landowners Adjacent to Trail Path

Objective 8: Present Our Findings to Mass Audubon

Objective 9: Blaze the Trail

In phase 1, we sought to understand the trail's target audience and most likely trail users. We conducted interviews with Deb Cary and Martha Gach, Central Sanctuaries Director and Conservation Coordinator, respectively, from BMB. We also conducted interviews with Devon Kurtz, the Project Manager from the new Blackstone Visitor Center, administered a survey to current trail users at BMB, and interviewed school officials from Holy Name Junior/Senior High School and the Vernon Hill School to gauge their interest in using the trail for educational purposes. In phase 2, we determined the most effective educational approach for the interconnector trail and then developed interpretive material to be used along this trail. To do so, we conducted interviews with Ms. Cary and Ms. Gach from BMB, as well as Ms. Melinda Learning, an award-winning environmental educator. We also developed case studies of other nature trails concerning the effectiveness of interpretive, or educational, components along them. In phase 3, we GPS mapped various trail routes, identified and met with landowners along the trail, and proposed our findings and recommendations for the best trail route and complementing, interpretive materials to Mass Audubon.

## Findings and Recommendations

From the various research methods we completed, we identified numerous findings that allowed us to provide Mass Audubon with useful recommendations. In Table 1 we summarize our findings from the first two phases of objectives.

### Phase 1 Findings: Trail Users

We found that the most frequent users of the trail will be the current users of the BMB trails, visitors at the new Blackstone Visitor Center, and students from the surrounding schools (Cary and Gach Interview, 2015; Kurtz Interview, 2015). We also found that these trail users enjoy viewing interpretive material and agree that the trail should be marked clearly (Howie Fain Interview, 2015).

| | | | | |
|---|---|---|---|---|
| Phase 1: Understanding Broad Meadow Brook Trail Users | Objective 1 | Identify our Target Demographic | Finding 1 | • Current Broad Meadow Brook trail users,<br>• Visitors at the new Blackstone Visitor Center, and<br>• Holy Name Junior/Senior High School and Vernon Hill School students |
| | Objective 2 | Assess Current Trail User Perspectives | Finding 2 | • Enjoy viewing interpretive material on trail<br>• Want clear blazes |
| | Objective 3 | Connect with Surrounding Schools | Finding 3 | • Align educational material with area school curriculums. |
| Phase 2: Trail Planning | Objective 4 | Determine the Most Feasible and Impactful Trail-based Education Method | Finding 4 | • Non-physical structures work best for this trail: i.e. brochures, guided tour guides |
| | Objective 5 | Develop Educational Material to Use along the Trail | Finding 5 | • Connector trail with interpretive material that focuses on nature and history |

**Table 1: Findings from Phase 1 and Phase 2**

## Phase 2 Findings: Interpretive Materials

In phase 2, we found that interpretive signposts, self-guided brochures, and guided nature walks are all effective educational methods to use along a trail (Cary and Gach Interview, 2015; Fain Interview, 2015; Learning Interview, 2015; Osterman-Sussman, 1993). However, due to the decision by BMB to bypass investing in physical structures, such as interpretive signposts, along this trail because of the potential for vandalism, we recommend educational components that are less prone to vandalism. Since we were developing a connector trail, we wanted to capture the interests of the visitors from both centers. Consequently, we created interpretive, educational material for the trail that highlights each centers' focus: nature and history (Cary and Gach Interview, 2015; Kurtz Interview, 2015).

## Phase 3 Findings: The Ideal Trail

In phase 3, we found that no formula exists for an *ideal* trail, instead, a trail must be blazed taking into consideration unique features of the environment, and perspective of likely users. The existing trail network of BMB consists of trails of varying makeups and difficulties. The connector trail connecting the existing trail network to the Blackstone Visitor Center could take many different shapes. In order to identify the most feasible, implementable, and effective connector trail we separated it into four distinct sections as illustrated in Figure 1. Each section has unique characteristics that create the opportunity for different paths. Ultimately, because of existing land conditions, each section has potential for various options. Figure 1 also shows, in blue, the final trail route we recommended to Mass Audubon. We ultimately felt that the ideal trail for this area should include two unique views, the view of the Blackstone River Valley and the view of the Holy Name wind turbine, as well as three unique habitats, the Black Oak savanna, the low lying grasslands underneath the power lines, and the wetlands.

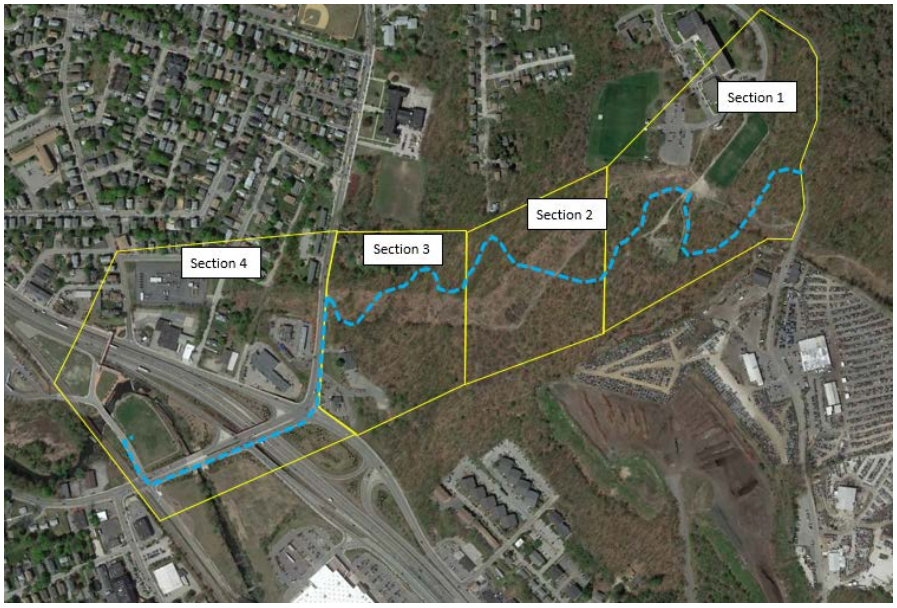


**Figure 1: Recommended Trail Route**

## Recommendations

At the conclusion of our research, we provided BMB with detailed recommendations for the best possible trail route, options for trail improvements, specific environmental and historical feature to highlight along the trail, and the methods by which to present these features to trail users. Figure 2 and Table 2 illustrate the points where we recommend the trail be improved.

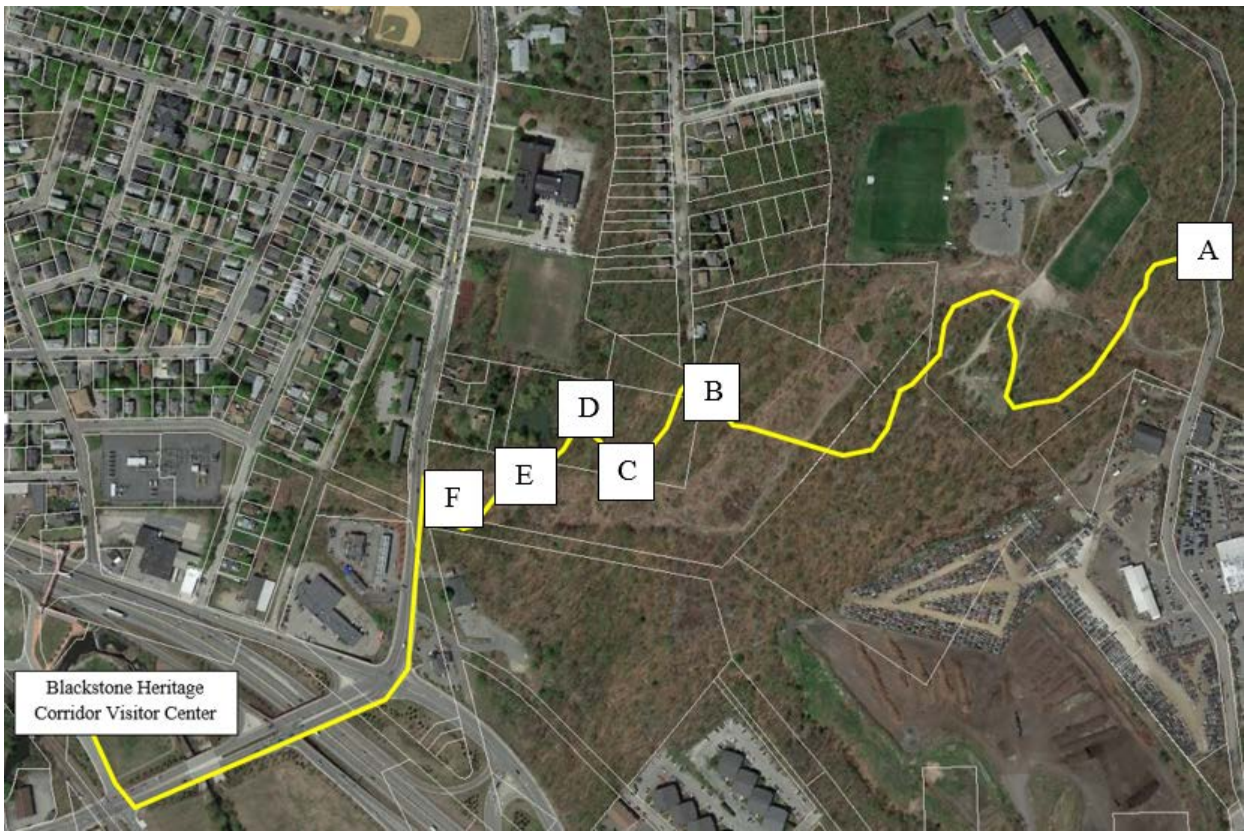


**Figure 2: Trail Route with Recommended Improvement Points**

The accompanying chart, Table 2, summarizes our recommendations for improvements at these six locations.

| Location | Recommended Improvement | Reasoning |
|---|---|---|
| A | Crosswalk | There currently exists no crosswalk to safely cross Granite St. |
| B | Rope Railing | This area consists of steep, rocky terrain and could benefit from a railing to make it safer. |
| C | Water Bars | This area has steep, worn terrain. Water Bars will make this section easier to navigate and maintain. |
| D | Viewing Platform | This section could benefit from a platform for trail users to view the pond. |
| E | Shallow Stream Ford | This section crosses over a small stream. A shallow stream ford will not disrupt the wetland and allow trail users to navigate across the stream while staying dry. |
| F | Accessible Trail | This section provides the opportunity to develop a small handicap-accessible trail from Providence St. to the viewing platform near the pond. |

**Table 2: Recommended Trail Improvements**

We also recommend a self-guided brochure to accompany the trail because we found that it is an effective and low cost educational method that does not have the potential to be vandalized. Figure 3 and Figure 4 show a draft brochure BMB might use.

As the visitor center opens and the trail becomes used more frequently, we recommend that BMB and/or the Blackstone Visitor Center offer guided tours along the trail. We found that guided nature walks, which allow people to explore and ask questions about what interests them, are most effective for learning (Fain Interview, 2015; Learning Interview, 2015; Osterman-Sussman, 1993). We also recommend other educational activities, such as scavenger hunts in the form of Geocaching, to increase trail use, because these types of activities can promote exploration and discovery.

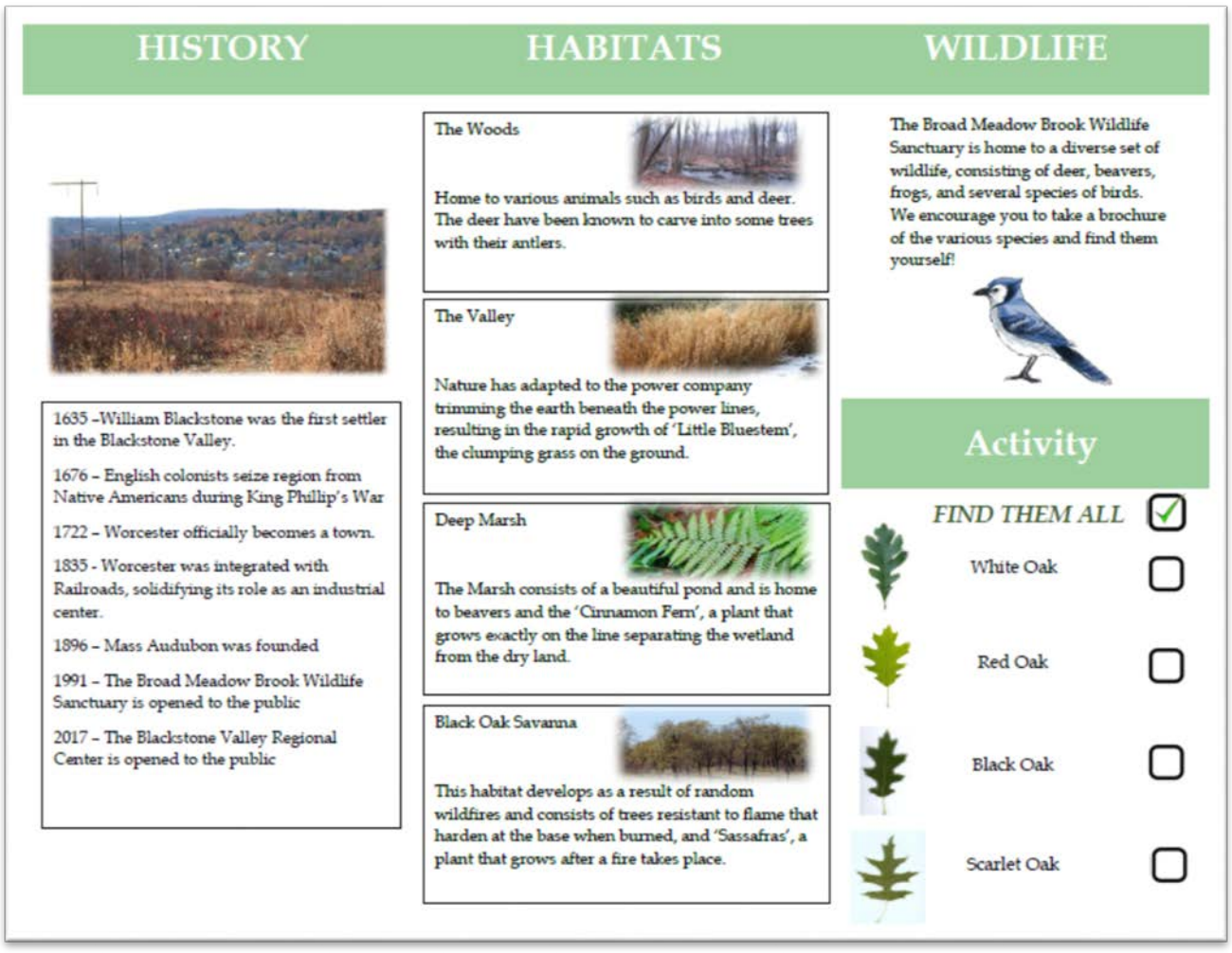


**Figure 3: Brochure Interpretive Material**

We recommend a kiosk at the trailhead where the street trail meets the natural surface trail on Providence St., as seen in Figure 4. This kiosk, which is less prone to vandalism because it is on a busy street, will inform people of the trailhead and where the natural trail begins. The kiosk will have a map identifying both visitor centers, and a description of the trail and some of its features.


**Figure 4: Brochure Trail Map**

We also recommend a viewing platform made of rock or cement where the trail crosses under the power lines. We recommend using a granite slab to tie in with the history of the granite quarries along the trail. This platform would most likely only be found by those looking for it while walking the trail and therefore, has little potential to be vandalized. The viewing platform would be flush to the ground and have arrows on it pointing up and down the power lines in the directions of the wind turbine at Holy Name and the view of the valley, respectively. This platform will be located at an area where there are multiple large rocks, providing people with the opportunity to take a break and children to play or climb on the large boulders.

## Conclusion

Mass Audubon tasked us with examining potential trail routes connecting the existing trail network of the Broad Meadow Brook Sanctuary to the future site of the Blackstone Heritage

Corridor in Worcester, Massachusetts. This trail would be used to educate residents and visitors, alike, of the nature and history of the region. We determined the area's landowners and the physical features to determine the best possible trail route and interpretive aspects.

As a result of research, we have determined that the ideal way to connect residents and visitors with the natural areas surrounding Worcester is through the trail outlined above. We recommend that this trail feature multiple scenic view points and an accompanying brochure to educate the trail's users of the ecosystem and history surrounding them. In addition, connections can be made to the surrounding schools as a way to build community partnerships through the trail.

# Table of Contents

# List of Tables

# List of Figures

# List of Acronyms

| | |
|---|---|
| ADA | Americans with Disabilities Act |
| AMC | Appalachian Mountain Club |
| ATV | All-terrain vehicle |
| BMB | Broad Meadow Brook Wildlife Sanctuary |
| CDC | Center for Disease Control |
| GPS | Global Positioning System |
| IQP | Interactive Qualifying Project |
| MIT | Massachusetts Institute of Technology |
| NPS | National Park Service |
| SCA | Student Conservation Association |
| UN | United Nations |
| UNESCO | United Nations Educational, Scientific, and Cultural Organization |
| USEPA | United States Environmental Protection Agency |
| WPI | Worcester Polytechnic Institute |

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|---|---|
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| Acknowledgments | Connor Kurtz |
| Abstract | Connor Kurtz |
| Executive Summary | Connor Kurtz & John Mulready |
| List of Tables | Connor Kurtz |
| List of Figures | Connor Kurtz |
| Chapter 1: Introduction | All |
| Chapter 2: Background | All |
| 2.0 Introduction | John Mulready |
| 2.1 Mass Audubon | Michael Harney |
| 2.2 Importance of Environmental Awareness | John Mulready |
| 2.2.1 An Indoor Lifestyle | John Mulready |
| 2.2.2 Health Benefits | John Mulready |
| 2.2.3 Importance of Education | Connor Kurtz |
| 2.3 Methods for Increasing Environmental Awareness | Connor Kurtz |
| 2.4 Case Studies | Connor Kurtz |
| 2.5 Trail Development | Connor Kurtz |
| 2.6 Connecting Broad Meadow Brook to New Blackstone Visitor Center | Michael Harney |
| Chapter 3: Methodology | All |
| 3.0 Introduction | John Mulready |
| Phase 1: Understanding Broad Meadow Brook Trail Users | Michael Harney |
| Phase 2: Trail Planning | Connor Kurtz |
| Phase 3: Trail Creation | John Mulready |
| 3.1 Conclusion | John Mulready |
| Chapter 4: Findings, Recommendations, and Conclusions | All |
| 4.0 Introduction | Connor Kurtz |
| 4.1 Demographic | Michael Harney |
| 4.2 Trail user Opinions | Michael Harney |
| 4.3 School Integration | Michael Harney |
| 4.4 Most Feasible and Impactful Education Method | Connor Kurtz |
| 4.5 Interpretive Material along a Connector Trail | Connor Kurtz |
| 4.6 The Ideal Trail | John Mulready |
| 4.7 Recommendations and Conclusions | All |
| Trail Route | John Mulready |
| Recommendations for Trail Improvement | John Mulready |
| Environmental and Historical Features | Michael Harney |
| Interactive Components | Connor Kurtz |
| Conclusion | John Mulready |

# Chapter 1: Introduction

Mass Audubon is a non-profit Massachusetts-based environmental conservation organization that seeks to educate the general public on statewide environmental issues. The new Blackstone Heritage Corridor Visitor Center will be established at the site of a former, historically significant, industrial mill, geographically near the existing trails of Mass Audubon's Broad Meadow Brook Wildlife Sanctuary (BMB) in Worcester, Massachusetts. The new Blackstone Visitor Center is projected to be completed by 2017. By blazing and developing a walking trail connecting the existing BMB trails to the Blackstone Visitor Center, Mass Audubon hopes to provide the people of Central Massachusetts with a more interactive experience with nature. They firmly believe that connecting people with nature is important for the continued growth of society.

Environmental awareness and education are important because they promote a sense of responsibility to create positive change in the natural world. A better understanding of the environment helps foster a sense of respect and a desire among people to preserve and protect the world around them. Children of the 21st century spend more time indoors than outdoors, and Americans, as a whole, lead fairly sedentary lifestyles (Chiu, 2005). According to Anne Bell, Ontario Nature's Director of Conservation and Education, children with a more diverse Environmental Education are more physically active, aware of good nutrition and behave in a more civil manner toward one another (Bell, 2007). A fundamental knowledge of the environment can provide for a future where citizens of the world respect and value nature.

Mass Audubon believes that many Massachusetts residents are overloaded with information, yet are increasingly disconnected from the world that sustains them (Mass Audubon, 2015). They envision a Commonwealth where people live with appreciation and

respect for the Earth and work together to ensure that it is protected. Creating an interpretive trail connecting the nature-filled BMB to the Blackstone Visitor Center is an effective way to spread environmental awareness (Ostermann-Sussman, 1993).

The Mass Audubon's Worcester, Massachusetts location, Broad Meadow Brook, has a passion for conservation and believes in the cultural, historic, and environmental education of visitors. Connecting the Broad Meadow Brook sanctuary and new Blackstone visitor center creates community connections between geographically close but culturally distant areas. By providing the people of Worcester with an interactive learning experience, Mass Audubon can promote change in individuals. The connection with nature will further environmental awareness.

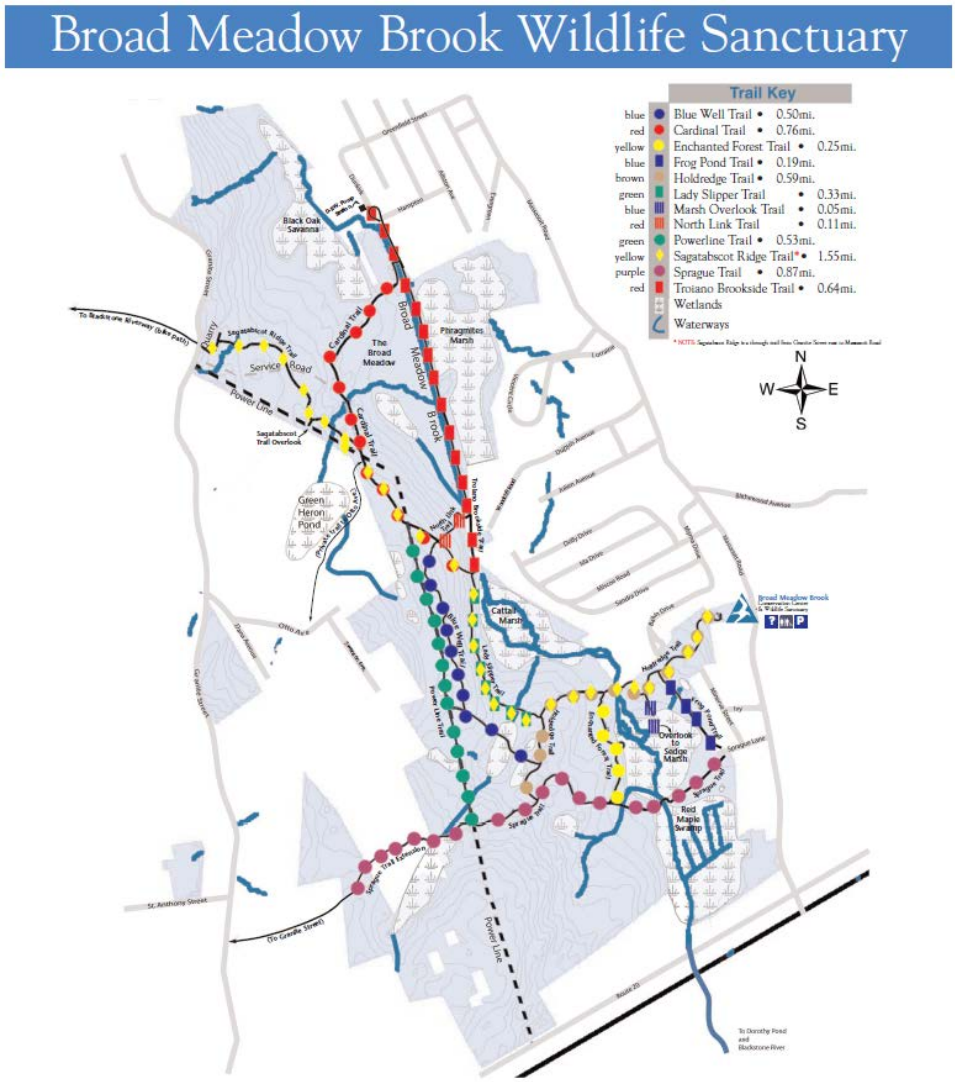



**Figure 5: Broad Meadow Brook Sanctuary Trails (Mass Audubon, 2015)**

Our project, in collaboration with Mass Audubon was to Global Positioning System (GPS) map and propose a trail from the existing BMB Sanctuary trails to the new Blackstone Visitor Center. Please see the existing trails at BMB Sanctuary in Figure 5. By creating a physical connection between these two locations, residents of the Worcester area can experience nature and history in a unique way.

To accomplish our goal, we developed nine objectives. These objectives include: identifying trail users, and the successes and failures of trails already in existence; learning how to blaze a trail; developing educational materials to complement the new trail; and finally GPS mapping the new trail. This information was crucial to identifying those whose land users pass over while using the trail. Ultimately, these objectives allowed us to create a trail capable of educating and connecting the people of Worcester, Massachusetts with nature.

In the following chapters, we discuss background information related to our topic as well as the methods we used to propose this trail. In Chapter 2, we discuss why human beings need to interact with nature. Also in Chapter 2, we introduce trail development, and we examine how trails have been used in other parts of the world. In Chapter 3, we re-introduce the goal of our project and provide an in-depth description of the objectives we completed in order to achieve our final project goal. In Chapter 3, we also detail the research tools we used to propose this walking trail. Finally, in Chapter 4, we display our findings and make recommendations for the future of the trail.

# Chapter 2: Background

## 2.0 Introduction

From climate change to loss of habitat, there are a number of pressing 21st century environmental issues. The lack of human connection to nature could be to blame and according to a study done by the Kaiser Family Foundation and the Center for Disease Control (CDC), **"A child is six times more likely to play a video game on a typical day than to ride a bike"** (Chiu, 2005). This statistic represents a growing disconnect between human and nature that many environmentalists hope to address.

In section 2.1, we discuss Mass Audubon and their mission. In section 2.2, we explore Environmental Awareness. In section 2.3, we examine potential ways to increase Environmental Awareness. Next, in section 2.4, we analyze the successes and failures of existing trails. Then, in section 2.5, we look at trail development methods. Lastly, in section 2.6, we illustrate how connecting the Broad Meadow Brook Sanctuary to the new Blackstone Visitor Center can better connect people with their environment.

## 2.1 Mass Audubon

Since its founding in 1896, Mass Audubon's mission has always been "to protect the nature of Massachusetts for people and for wildlife" (Mass Audubon, 2015). The Broad Meadow Brook Audubon Sanctuary is the largest urban wildlife sanctuary in New England comprised of over 400 acres. Broad Meadow Brook Sanctuary is a beautiful place where visitors have gotten to know nature on a profound level ever since the sanctuary's founding in 1991. The sanctuary offers several events such as 'Nature Adventures for 5-7 Year Olds" and "Friday Morning Birds" while hiking over the 400 acres (Mass Audubon, 2015). Broad Meadow Brook staff felt that they could connect more people with nature by creating a new trail. To do so, they reached out to Worcester Polytechnic Institute's Worcester Community Project Center seeking collaboration on

development of a new trail. Our project, in collaboration with Mass Audubon, was to propose a trail connecting the Broad Meadow Brook Wildlife Sanctuary and the future Blackstone Visitor Center, as a way to connect a larger audience with the environment. Enveloping visitors with nature's wonder is a cornerstone of Mass Audubon's mission, and they hope to stimulate as much community involvement as possible to foster a more environmentally conscious world.

## 2.2 Importance of Environmental Awareness

The United Nations (UN) Environment Programme, the UN agency responsible for establishing the global environmental agenda and promoting sustainability, defines environmental awareness as the ability to emotionally understand the surrounding world. This understanding includes the laws of the natural environment and sensitivity to the changes occurring in the environment (Osaka, 2000). Awareness is a relevant, although very broad, variable to consider when assessing knowledge of the environment, and one can interpret it to mean either awareness of issues or awareness of amenities (Fisman, 2005). In the following section, we discuss the impacts of a society lacking environmental awareness.

### 2.2.1 An Indoor Lifestyle

The environmental issues of the 21$^{st}$ century, including climate change, the lack of clean drinking water, and the decreasing amount of green space, can affect the everyday lifestyle of a person. Exposure to the natural settings, plants, and animals around people can affect their lives as well. These realities make it even more alarming that few children are now incorporating these places, plants, and animals into their everyday lives (Nabhan, 1995). Since the early 1990s, scientists have warned about the devastating consequences of environmental issues and the importance of acting quickly to mitigate potential threats. Unfortunately, there is a widespread lack of commitment to change the way people view nature, while the pace of environmental degradation is increasing (Saylan, Blumstein, 2011). In fact, "Carbon dioxide levels, at 395.5

parts per million, are at historic highs, while loss of biosphere integrity is resulting in species becoming extinct at a rate more than 100 times faster than the previous norm" (Milman, 2015).

Moreover, children are growing up with fewer natural experiences. Technology is becoming more prevalent, and as a result, children are spending less time outdoors. The lack of time spent on physical recreational activities has a detrimental effect on health, including obesity. Childhood obesity can have a number of immediate and long-term health effects, including increased risk for diabetes and cardiovascular issues, in addition to psychological effects, such as depression and low self-esteem (CDC, 2015). As illustrated by Figure 1, below, in 2013 the CDC found that 10% of Massachusetts' high school students were obese (CDC, 2015).

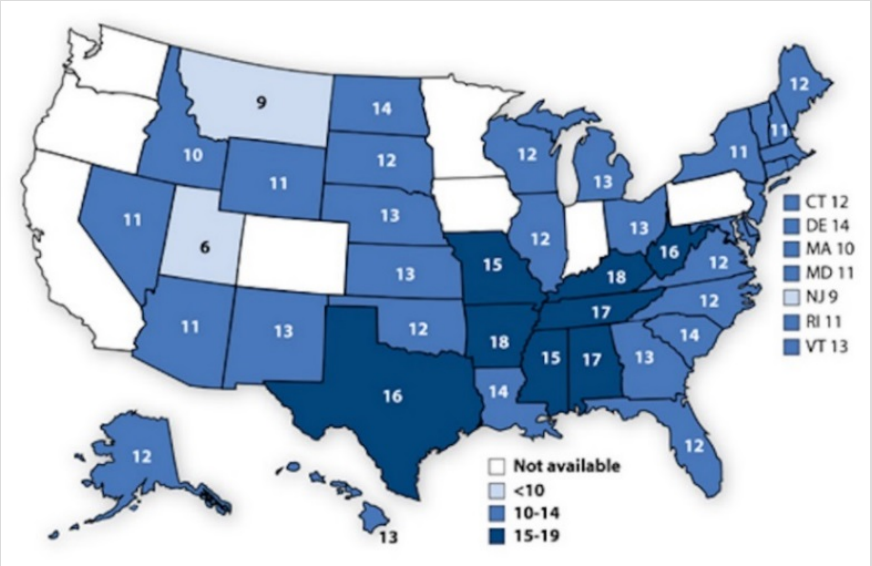



**Figure 6: Percentage of high school students who were obese — selected U.S. states, Youth Risk Behavior Survey, 2013 (CDC, 2015)**

In addition to physical health implications, withdrawal from nature is negatively impacting the cognitive abilities of children. According to Robin C. Moore, a Massachusetts Institute of Technology (MIT) graduate and professor of Landscape Architecture specializing in

the design of children's play and learning environments, daily, hands-on contact with nature is critical to children's health, citing this connection as a "prerequisite for sustainable development education" (Moore, 1997, pp. 217). According to Jolanda Maas, a VU University Medical Center researcher specializing in urban and rural sociology, an increased amount of green space and diverse natural surroundings has a positive effect on the health of the residents (Maas, 2006). A more environmentally aware lifestyle can have significant, positive effects on a person's well-being.

### 2.2.2 Health Benefits

A better understanding of the natural world would benefit people as well as the environment. Oxford defines a benefit as "an advantage that something gives you; a helpful and useful effect that something has" (Oxford Dictionaries, 2015). Louise Chawla, a professor of environmental design at the University of Colorado Boulder, conducted a study to examine how contact with nature affected the well-being of children around the world. Chawla concluded that Scottish families living less than twenty minutes from a green space described their families as healthier than those who lived further away. Chawla's report described Canadian teenagers who defined environments that support health as "being outside, in safe, clean, and green spaces where they could walk and participate in community activities" (Chawla, 2015, pp. 9).

Anne Bell, the director of Ontario's nature conservation and education programs, observed that elementary age children who experience school grounds or play areas with diverse natural settings are more physically active, more aware of good nutrition, more creative, and more civil to one another (Bell, 2007). Nancy Wells, a professor of design and environmental analysis at Cornell University, suggests that proximity and access to nature are crucial to a child's ability to focus and improve their cognitive abilities (Wells, 2000). Richard Louv, co-founder of the Children & Nature Network and a chair of Canada's Child in Nature Alliance,

claims that a ‘nature-deficit’ plays a part in some disturbing childhood trends, including obesity, depression and attention disorders, believing that spending less time outdoors diminishes the human experience (Louv, 2008).

There is an abundance of research showing that children who regularly connect with nature maintain a healthier lifestyle than those who do not. The United States Environmental Protection Agency (USEPA), a federal government agency charged with administering a number of federal environmental laws, defines “green space” as an open piece of land that is undeveloped and is open to the public, including parks and forests (USEPA, 2014). While much of America’s green space is found in rural areas, urban green space can play an important role in a resident’s life. Figure 3 shows a map of the amount of space dedicated to parks in Worcester, Massachusetts. While there is green space in addition to these parks, it is not maintained. The residents of Worcester could benefit greatly from additionally experiencing nature as it promotes a healthier community. According to Chawla:

> “A compelling body of evidence exists that trees and natural areas are essential elements of healthy communities for children. They need to be integrated at multiple scales, from landscaping around homes, schools, and childcare centers, to linked systems of urban trails, greenways, and parks for children’s creative play” (Chawla, 2015).

By integrating nature in a child’s life, they can lead a healthier lifestyle. One way to increase this nature-child connection is through education.

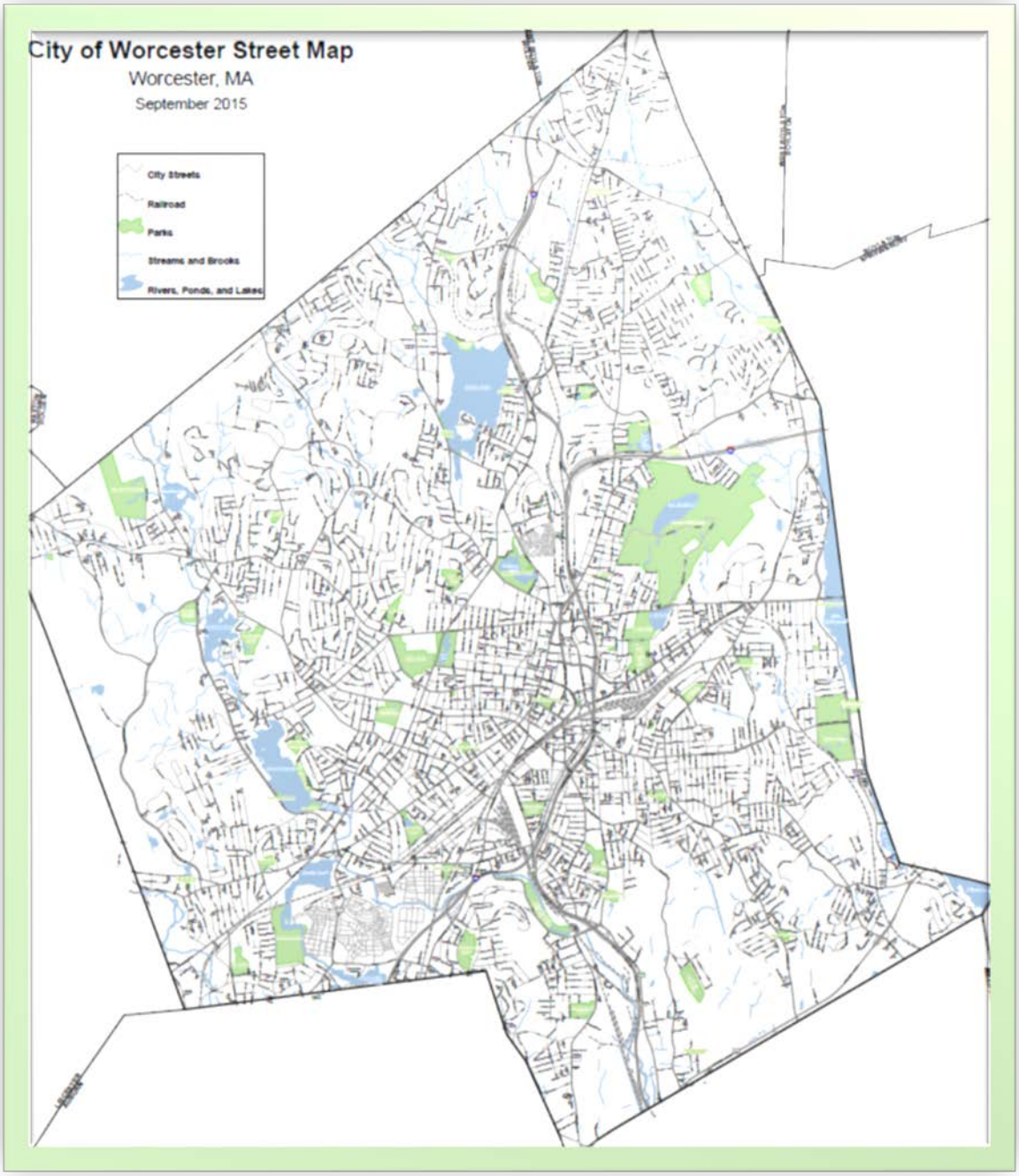



Figure 7: Green Space in Worcester, MA (City of Worcester, MA, 2015)

## 2.3 Environmental Education

The purpose of Environmental Education is to enable people to understand the environment around them and deliberately act in ways that are harmonious with the environment for the greater good of society and future generations (Sola, 2014). In order for people to change

their negative actions towards the environment, they must experience nature in a way that causes them to develop a personal connection with the environment (Wilson, 1994). To better understand the importance of Environmental Education, one must also clearly define the term and understand its goals.

### 2.3.1 Definitions and Goals

Before attempting to teach about the environment, in a classroom or along a trail, educators should understand the purpose and the desired goals of Environmental Education, as well as which methods historically have been most successful. According the USEPA, Environmental Education is:

> "A process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment. As a result, individuals develop a deeper understanding of environmental issues and have the skills to make informed and responsible decisions" (USEPA, 2015).

The Tbilisi Conference of 1977, the world's first intergovernmental conference on environmental education, laid out three main goals of Environmental Education, as shown in Table 3 (Palmer, 1998). These goals are useful because educators and advocates for environmental preservation, such as teachers, parents, environmentalists, naturalists, and wildlife experts, can apply them to many Environmental Education programs.

| | |
|---|---|
| **Goal 1** | To foster clear awareness of, and concern about, economic, social, political and ecological inter-dependence in urban and rural areas. |
| **Goal 2** | To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect the environment. |
| **Goal 3** | To create new patterns of behavior of individuals, groups, and society as a whole, towards the environment. |

**Table 3: Goals of Environmental Education (Tbilisi, 1978)**

### 2.3.2 Experiential Education

Once educators and advocates for environmental preservation recognize the goals of Environmental Education, they must understand which methods work best for accomplishing these goals, as well as the methods that traditionally have not worked as well. Education,

particularly formal, classroom education, does not currently do enough to teach students about nature (Saylan, Blumstein, 2011). Experiential education methods, such as interpretation or hands-on learning, are more effective for connecting people with nature (Wilson, 1994). Hands-on activities can enhance students' interest, motivation, and ability to think critically about environmental issues (Poudel et al, 2005).

Hands-on learning with nature enhances a child's learning because children more readily absorb information taught with a hands-on approach. Hands-on activities such as recycling, composting, encouraging green consumption, and planting trees and flowers help demonstrate nature's importance and a commitment to protect the environment (Cross, 2012). One example of an interactive, hands-on learning experience is *Nature's Classroom*, which is a leader in Environmental Education with sites in New York and New England. The National Science Teachers' Association, Commonwealth of Massachusetts, and State of Connecticut all have recognized *Nature's Classroom* for its excellence. Students typically go on 1-5 day trips to *Nature's Classroom* where they experience nature in a hands-on way, outside of the traditional classroom. Schools use *Nature's Classroom* as a way to complement school learning and to foster a sense of community and appreciation for nature in each student (Nature's Classroom, 2015). Programs such as *Nature's Classroom* are an alternative method to education, and more specifically to Environmental Education.

Environmental Education programs often rely on interpretation to help develop this personal connection with nature. Interpretation is a method of experiential learning that helps translate the meaning and significance of a place to the visitor (NPS, 2015). Interpretation can refer to guided tours by trained staff, but commonly includes information displayed through signs, frequently using visual aids and imagery, which help visitors relate to the story of a place.

“Interpretation helps build intellectual and emotional connections between visitors, and resources, encouraging them to care about and connect to a site” (Id.). Interpretation reaches people on a more personal and emotional level than traditional, classroom education because people develop a connection to the site and story (Id.). Environmental Education methods such as interpretation and hands-on learning help students develop an appreciation for nature.

Although interpretation typically does include some historical and environmental facts, Environmental Education should focus less on scientific facts and more on developing a caring and personal relationship towards the environment (Wilson, 1994). This is why formal classroom education fails to reach everyone and embark real change (Id.). Environmental Education is a process rather than a subject to master. Environmental educators should not teach, in the traditional sense, but rather attempt, by providing students with natural experiences, to inspire and convey a sense of awe and life-long interest in the exploration and potential stewardship of natural environments. Traditional, formal education in the classroom is not the most effective method to convey this sense of awe and inspiration (Id.). The process, opposed to the subject, of teaching about the environment is critical for students to develop an appreciation for nature.

## 2.4 Case Studies

Interpretive nature trails can be an effective way to teach about the environment and connect people with nature in an experiential way (Ostermann-Sussman, 1993). Case studies are the preferred strategy when trying to answer “how” or “why” questions in social science research (Yin, 2003). This section will provide examples, or case studies, of five interpretive nature trails, as well as the methods in which people developed these trails. The first example examines the first official educational, nature trail and its experiments with interpretive signposts, while the second example discusses the most effective ways to educate along a trail, and the third gives an example of a unique way to educate and increase participation on a trail. The final two case

studies give examples of the process in which people developed and mapped similar nature trails. Table 4 summarizes some of the notable features and components of each of the nature trails discussed in the case studies in the following sections.

| Features | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Trail** | Length | Width | Surface | Trail Description | Same Start/End Location | Wheelchair Accessible | Educational/ Interactive Components |
| *Palisades* | 0.5 miles | 3.0 feet | gravel | trail with pleasant curves; roughly a circle | yes | no | signposts ("friends") |
| *Estuary* | 1.0 miles | 5.0 feet | gravel/ paved | winding, hiking trail that is accessible all year round | yes | yes | signposts, brochures, guided tours |
| *Gruffalo** | | | | | | | activity trail; family events |
| *Santa Fe* | 10.0 miles | 10.0 feet | gravel/ paved | multi-use hiking/biking trail | no | no | interactive maps |
| *San Cristobal* | 1.0 miles | 8.0 feet | paved | winding, accessible trail through canyon | no | yes | interactive tree exhibit |

*The *Gruffalo Trails* case study was an event across England, which used many trails.

**Table 4: Summary of Case Study Trail Features**
**(Lutz, 1931; Ostermann-Sussman, 1993; Podlewska, Andres, 2014; De Anda et al, 2011; Cote et al, 2007)**

### *Palisades Interstate Park (New York)*

The Palisades Interstate Park in New York and New Jersey was established in 1925 and is considered the first official educational trail in the world (Lutz, 1931). In 1931, Frank Lutz, an expert on insects and wildlife, conducted an experiment that examined outdoor education

through nature trails. His team experimented with interpretive signposts, which he referred to as "friends", to help educate people about the wildlife along the trail (Id.). Lutz was the first person to use signposts as an interpretive component along a nature trail. Many trails still use interpretive signposts in the 21st century because they have proven to be an effective method of educating trail users about nature (Ostermann-Sussman, 1993).

### *Estuary Nature Trail (Oregon)*

During the early 1990s, Irene Osterman-Sussman, a graduate student from Oregon State University at the time**,** conducted a study on the effectiveness of Environmental Education along the Estuary Nature Trail in Oregon. She looked at the effectiveness of informal education programs such as interpretive signs, self-guided trail brochures, and guided naturalist walks. She concluded that all three methods were effective, but the guided naturalist walks were the most effective because they provided the most interactive experience (Ostermann-Sussman, 1993). Osterman-Sussman also collected data, through observation, and found that 54-77 % out of about 225 people actually stopped to read signs and that the average reading times for the people who did stop were 16-33 seconds (Id.). This second example complements the Palisades Interstate Park example because it not only uses signposts, but Osterman-Sussman also collected data showing that people do not always take the time to read every sign post and in turn, miss information.

To assess the effectiveness of the education, Osterman-Sussman administered a knowledge test of comprehension of the trail's educational points. The study purposely did not expose the control group to any interpretive signs, trail brochures, or guided naturalist walks. The results show that people exposed to the three educational programs scored significantly higher than the control group on a written exam about estuary wildlife (Id.). Osterman-Sussman also made sure the people in these groups, including the control group, were demographically

similar, in terms of age, gender, educational background, residence proximity, and number of repeat visitors. The study looked at about 900 participants, which evenly made up the four groups. The participants exposed to signage along the trail scored 11% higher than the control group (Id.). The participants provided with educational brochures scored 15% higher than the control group and the participants taken on a guided naturalist walk scored 22% higher than the control group (Id.). Ostermann-Sussman concluded that the educational programs at the Estuary Trail effectively educate visitors from all educational levels and backgrounds with guided naturalist walks being the most effective (Id.).

### *Gruffalo Trails (England)*

In 2014, The Forestry Commission of England used a well-known children's book to attract children and families to visit and explore 24 forests in England to celebrate Julia Donaldson's book, *The Gruffalo,* and its fifteenth anniversary. The connection with the book encouraged people to visit the trail, and being on the trail encouraged children to engage with nature (Podlewska, Andres, 2014). The Forestry Commission also gave out activity packs to families, which included a foraging bag for collecting woodland materials on an activity trail and encouraged children to learn more about the behavior of animals in autumn and winter (Id.). This illustrates how educators can utilize family focused events to increase trail participation.

### *Santa Fe (New Mexico)*

In 2011, students from Worcester Polytechnic Institute (WPI) completed a social science project in Santa Fe, New Mexico. The team used Smartphone applications and other technologies to collect Global Positioning System (GPS) coordinates and map certain segments of four multi-use trails for which the sponsor, Santa Fe Metropolitan Planning Organization, was trying to increase local usage. After collecting the data, the team designed interactive maps, which helped increase trail use and gave more people "a chance to connect with nature" (De

Anda, Chawla, Connor, Krebs, 2011, pp. 11). With the interactive maps, people have a better understanding of the area and where they are headed (De Anda, Chawla, Connor, Krebs, 2011). This illustrates how increasing interactivity and the ease with which visitors can access a trail map can increase trail participation.

### *San Cristobal Canyon (Puerto Rico)*

In 2007, on a project completed in Puerto Rico, students from WPI helped develop nature trails in the San Cristobal Canyon region. The students looked into how to design and develop nature trails and were able to design four trails, two of which would be completely handicap accessible (Cote, Cox, Rivera, 2007). They incorporated various trail standards in their design, such as trail grade and surface types, as well as features such as gentle curves and varying slopes to make the trail more aesthetically pleasing while still allowing for easy maintenance (Id.). The students also developed an interactive tree exhibit, which attempts to teach trail users about the different types of trees and plants in the San Cristobal Canyon area (Id.). The San Cristobal Canyon region trails show examples of what features make up a good trail in terms of it being aesthetically pleasing and requiring little maintenance.

## 2.5 Trail Development

Creating an interpretive nature trail requires knowledge about trail design and trail development. Experts have well documented the basic strategies for trail development (Long, Todd-Bockarie, 1994; Hultsman, 2001; National Park Service (NPS), 2006; Rathke, Baughman, 2007). Although these experts choose to present the general strategy in unique ways, the actual process remains similar (Cote, Cox, Rivera, 2007). David Rathke and Melvin Baughman, experts in trail design and professors at the University of Minnesota, College of Natural Resources, break down the trail development process in the following steps (Rathke, Baughman, 2007):

Step 1: Determine Trails' Purpose

Step 2: Inventory the Property

Step 3: Design the Trail

Step 4: Scout the Trail Corridor

Step 5: Clear the Trail

Step 6: Construct the Trail Tread

Step 7: Mark the Trail

*Determine the Trails' Purpose:* The first step is to determine the purpose of the trail in terms of whom the primary users are and whom the trail intends to educate. Determining the purpose of the trail is critical because it determines which type of trail to design and is therefore essential before moving forward in trail development. For example, accessible trails, intended to accommodate people with disabilities, must meet different standards in terms of surface, width, grade or slope, and trail edge width (Malibu Public Parks, 2006). Table 5 lists some of these features and their definitions.

*Inventory the Property: S*tep two typically includes locating key features on the property that may be educational or that visitors may enjoy, as well as areas to avoid that may lessen their overall experience (Long, Todd-Bockarie, 1994). For example, following along the path of power lines may make creating a trail route easier, but is less appealing to the visitors' eyes.

| Term | Definition | More Information |
|---|---|---|
| Grade | The slope, or the change in height over a certain distance. | For a description of different trail grades, see Appendix A, Table 9. |
| Clearing Height | The height above the ground which is absent of trees or branches. | For a figure explaining clearing height, see Figure 8. |
| Clearing Width | The dimension of the trail measured from one side to the other. | For a figure explaining clearing width, see Figure 8. |
| Trail Surface | The soil or material on the ground of the trail. | For soil texture descriptions, see Appendix B, Table 10. |
| Filter Strip | An area of vegetation between the trail and a small body of water. | For suggested filter strip widths, see Appendix C, Table 11. |
| Trail Tread Width | The width of the walking surface of the trail. | For suggested tread widths, see Appendix D and Appendix E, Table 12 and Table 13. |

Table 5: Trail Development Key Terms and Definitions (NPS, 1998)

*Design the Trail:* Step three includes the majority of the design process. Rathke and Baughman suggest a trail that is one-third level, one-third uphill, and one-third downhill. Rathke and Baughman also suggest that trails should have a clearing height of at least eight feet and a width of at least four to six feet (Rathke, Baughman, 2007). Figure 8 shows what clearing height, clearing width, and trail tread width refer to.

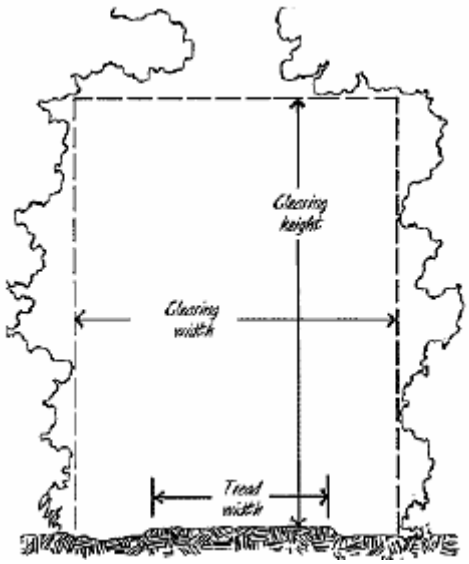



Figure 8: Clearing Height and Width (Rathke, Baughman, 2007)

Trails near water should be above the normal water line and have a filter strip between the trail and the water's edge. Trail developers should also avoid stream crossings to prevent any environmental damage to aquatic life (Long, Todd-Bockarie, 1994). The soil type also largely determines the water drainage along a trail, as well as the likelihood of erosion over time. Rathke and Baughman suggest avoiding clay for its poor drainage and sandy soils for the increased risk of erosion (Rathke, Baughman, 2007). One telling sign if the soil is suitable is its color. Soils that remain a continuous color have adequate drainage; however, soils that have spots of varying color do not drain well and are unsuitable for trail placement (Cote, Cox, Rivera, 2007). For more recommended trail and accessible trail standards, please see Appendix E.

*Scout the Trail Corridor:* Step four entails scouting out the proposed trail before beginning to clear the trail. Areas where the slope may be too steep or where there may be poor drainage could cause low spots of the trail to flood. Trail developers should also look for other potential obstacles, such as large trees or boulders that are too large to go around or over. The trail should be aesthetically pleasing, enjoyable for its users, and should disturb the environment as little as possible (Cote, Cox, Rivera, 2007). Simple curves and varying grades can help make the trail more interesting to users (Rathke, Baughman, 2007).

*Clear the Trail:* The fifth step requires clearing the actual trail. This includes removing and grading anything along the proposed trail. A variety of tools is available for clearing trails. For a list of common tools and their uses, please see Appendix F, Table 14. Use of the right tool helps to ensure safety because substitutes can be dangerous and ineffective (NPS, 1998). Clearing the path leaves the trail ready for construction and surfacing (Cote, Cox, Rivera, 2007).

*Construct the Trail Tread:* The sixth step is the actual construction of the trail tread. Choosing the trail surface also depends on what type of trail you choose. Some common types of

trail surfaces include compacted natural ground, gravel, picked gravel, asphalt, concrete, and wood (Cote, Cox, Rivera, 2007). For an accessible trail, compacted ground and gravel are not acceptable options due to the variability in the surface of the ground (National Center on Accessibility, 2001). Full access requires flatter, more permanent surfaces. Asphalt may seem out of place along a nature trail and therefore, trail developers should avoid using it wherever possible. Instead, compacted gravel fits in better with the natural environment and does not compromise accessibility. In low areas or in places where drainage is poor, using raised, wooden structures are one way to avoid the wet spots. The final choices for surfaces should be practical and meet all the requirements based on the type of trail (U.S. Department of Transportation - Federal Highway Administration, 2007; National Center on Accessibility, 2001).

*Mark the Trail:* The final step, step seven, is to mark, or blaze, the trail. This can be important to make sure that people using the trail know what path to follow to continue along the trail and eventually exit the trail safely without getting lost (Rathke, Baughman, 2007). Marking the trail can also mean creating a GPS map of the trail route.

As discussed in the paragraphs above, *step 1* is important for determining for whom you are designing the trail and how you precede with *steps 2-7.* Making a trail accessible requires additional considerations beyond *steps 1-7.*

### 2.5.1 Accessibility

People designing nature trails are often concerned with ensuring that everyone can enjoy the trails. Accessible trail development requires knowledge about and familiarity with the federal Americans with Disabilities Act (ADA). Accessible trail development methods try to ensure that persons with disabilities can gain the same environmental benefits as those without disabilities. The ADA typically regulates roads, sidewalks, buildings, and other highly controlled settings. Nature trails are not considered highly controlled man-made areas because they move with the

landscape and when creating one you want to change as little of the natural environment as possible (Cote, Cox, Rivera, 2007). Because of this, the United States Forest Service recognizes the difficulty of creating accessible trails. The Forest Service believes that full compliance with ADA rules would have a negative impact on the intent of nature trails and the environment (Forest Service, 2006). The Forest Service outlines four "Conditions for Departure" from the ADA rules to avoid any construction of trails that would disturb the natural environment, require construction materials or methods prohibited by governments, or be impractical due to terrain or prevailing construction practices. These four conditions can be found in more detail in Appendix G, Table 15.

Even with the 2014 updated ADA trail guidelines, the four "Conditions of Departure" remain valid reasons for non-accessible trail development (Macdonald, 2014). Numerous trails have succeeded in creating accessible trails while changing very little of the natural environment. The Minute Man National Historic Park in Massachusetts (NPS, 2002), Indiana Dunes National Lakeshore (NPS, 2000), and the Asan Bay Overlook at the War in the Pacific National Historical Park in Guam (NPS, 2001) are all award winning, highly accessible parks. By following the Forest Service Trail Accessibility Guidelines and keeping accessibility in mind during the initial design and development of a nature trail, developers can create a trail that lends itself to high accessibility and overall user enjoyment (Cote, Cox, Rivera, 2007).

In order to create an accessible trail, or any trail, developers must identify land ownership along the trail route. Negotiating property easements, especially in densely populated urban environments, may be necessary before development can begin.

### 2.5.2 Land Owner Liability

When developing a nature trail on areas of land partially owned by other people, developers must be sure to negotiate and get permission to use the land. A land easement is an

agreement that gives a person or persons the right to use another's real property for a specific purpose (NPS, 1998). The question of liability often arises when working with local landowners because they are usually concerned that if they allow an easement across their property for the trail and someone gets hurt on their property, that they will be liable. The property owners usually have a dual line of defense. The first is the liability insurance that they already have and the second is the Massachusetts Recreation Use Statute, which exempts landowners from liability when the recreationist has not paid a fee for the privilege of outdoor recreation (NPS, 1998; Brown, 2006). These defenses are important to explain to property owners when negotiating land easements.

## 2.6 Connecting Broad Meadow Brook to New Blackstone Visitor Center

Our project, in collaboration with Mass Audubon, was to propose a trail connecting the future Blackstone Visitor Center to the already existing Broad Meadow Brook trail system. By creating an interactive, natural experience for trail-users, we hoped to stimulate an appreciation and sense of respect for the environment. In doing so, we hoped to promote Mass Audubon's mission "to protect the nature of Massachusetts for people and for wildlife" (Mass Audubon, 2015). The trail, once formalized will be a lasting testament to the importance of nature in the lives of the community and will contribute to the wonder of the environment for many years to come. In our next chapter, Methodology, we describe the methodological approach we took to accomplish our goal.

# Chapter 3: Methodology

## 3.0 Introduction

The goal of our project was to Global Positioning System (GPS) map and propose a trail connecting the existing trail network at Broad Meadow Brook Wildlife Sanctuary to the future site of the Blackstone Visitor Center and identify key points along the trail where educational components interpret historical and environmental information for trail users. In order to accomplish this goal, we developed ten objectives broken down into three phases. In the next several sections, we discuss each phase along with its specific objectives, as well as the research methods used in order to achieve our project goal[1]. Our nine objectives are listed below.

**Phase 1: Understanding Broad Meadow Brook Trail Users**

Objective 1: Identify our Target Demographic

Objective 2: Assess Current Trail User Perspectives

Objective 3: Connect with Surrounding Schools

**Phase 2: Trail Planning**

Objective 4: Determine the Most Feasible and Effective Trail-based Education Method to Implement at Broad Meadow Brook

Objective 5: Develop Educational Material to Use along the Trail

**Phase 3: Trail Creation**

Objective 6: GPS Map Ideal Trail Route

Objective 7: Identify Landowners Adjacent to Trail Path

Objective 8: Present Our Findings to Mass Audubon

Objective 9: Blaze the Trail

[1] While this project held no risk for human research subjects, we submitted an application to WPI's Institutional Review Board for approval.

## Phase 1: Understanding Broad Meadow Brook Trail Users

Phase 1 consisted of identifying and understanding the wants and needs of the target audience. In phase 1, we learned everything we could about the target trail users to tailor the educational component of the trail's design to suit its needs. Ideally, we would have completed this phase first since the target trail user seemed likely to influence other aspects of the trail's design, such as how easy or difficult to make the trail and which landmarks we chose to emphasize. However, we chose to begin objectives 6 and 7 prior to starting phase 1 due to time and weather constraints.

### *Objective 1: Identify our Target Demographic*

Because we wanted to integrate a thorough and approachable educational experience, we identified the trail's target demographic and their interests. This meant learning everything we could about current and potential trail users to connect this trail to the Blackstone Visitor Center and the neighboring schools. Here, the term 'demographic' refers to not one trait, but several such as age, whether someone hikes alone, and impressionability. What we hoped to learn was also intentionally open-ended, because we hoped to notice trends between trail users and interests that we did not anticipate beforehand.

The 'demographic' of the trail user was important because it told us what type of trail we wanted to develop (which impacted the trail's design), and how we wanted to direct the 'educational aspect' of our project. To find our target demographic, we conducted a semi-structured interview with our sponsors at Mass Audubon, specifically Martha Gach (Conservation Coordinator) and Deb Cary (Director of Central Sanctuaries), to see if they had a specific demographic in mind for this trail and to assess who they perceived to be the main users of the existing sanctuary trail system. For interview questions with Ms. Gach and Ms. Cary, please see Appendix I. A semi-structured interview is a less rigid form of interviewing that has a

guideline, but is much more free-flowing in nature. The advantage of a semi-structured interview is that it plays to the knowledge of the interviewee. As cultural anthropologist, Dr. H. Russel Bernard, describes in *Research Methods in Anthropology*, a semi-structured interview shows we are fully in control of what we want from the interview, yet we are free to follow any new leads that are presented (Bernard, 2006). In more structured interviews, one inquires the depth of the interviewee's knowledge without its breadth. By allowing the interviewee to manage the questions in a give and take way, one achieves a greater breadth of information without compromising on depth. With a semi-structured interview, we found the answers to questions we would have not otherwise thought to ask. We also collected information on the demographic of the current sanctuary trail-users. To do so, we administered a survey to those entering and leaving various trails. From those, we learned the demographic and current viewpoints on types of trails and educational materials. The reason for a survey was to obtain a breadth of information from a variety of people that they might not think to mention conversationally in a quick straightforward manner.

### *Objective 2: Assess Current Trail User Perspectives*

An important part of our project was to identify the trail-goers and their collective views regarding other trails. Their opinions were likely the most important information we sought to obtain because of how they could influence the trail's design. To do this, we administered a survey and conducted semi-structured interviews.

To assess current trail users' viewpoints, we distributed a survey to trail users at the entrances and exits of various Broad Meadow Brook trails as described in Objective 1. First, we used our sponsor interviews and survey results to determine the most common audience demographics, and which educational techniques would be the most effective. We distributed our survey to anyone passing through the trail as we stood near the entrance. We stood there in shifts

from 10 am to 2 pm on Saturday, which is their busiest period, to ensure we reached the largest audience possible. By administering the survey, we hoped to achieve a general consensus as to what trail-goers were interested in as well as how they learn, and gather an informed opinion as how to best interpret trail features for them. To view the survey, please see Appendix J.

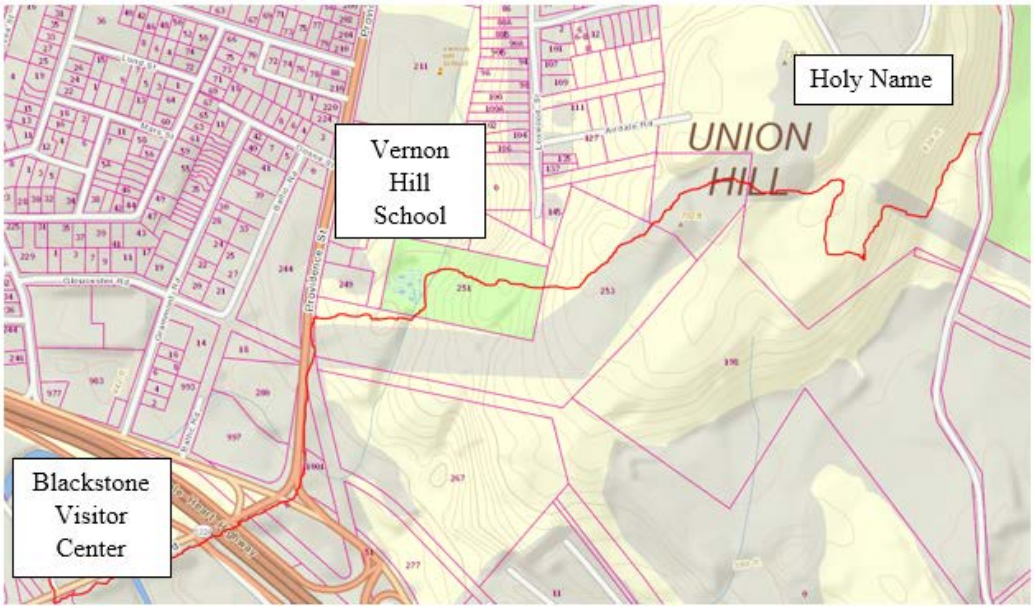
We also conducted a semi-structured interview with Howie Fain, a middle school teacher from Worcester East Middle School. In 2014, Mr. Fain took a group of 8$^{th}$ grade students on a walk through the trails in the area of the trail we proposed. We chose to conduct semi-structured interviews to hear about his overall experience with his students on the trails and gather information on what interested the students most. To view a list of interview questions with Howie Fain, please see Appendix L.

### *Objective 3: Connect with Surrounding Schools*

In objective 3, we connected with schools in the area surrounding the trail to gauge their interest in potentially using the trail for educational and recreational purposes. Holy Name Junior/Senior High School and the Vernon Hill School are two schools that were located in the general area of the proposed trail. We reached out to both schools and conducted semi-structured interviews with school officials to involve the schools and their students in the future trail.

We conducted a semi-structured interview with the Headmaster of Holy Name Junior/Senior High School, Edward Reynolds to inform him of Broad Meadow Brook's vision and our approach to designing the trail and get his students and teachers involved with the future, interpretive trail. We also conducted a semi-structured interview with the Athletic Director, Jim Manzello, to understand the school's property and the already existing trails at the school. This interview took place outside, walking the trails with Mr. Manzello, to find out which trails would be off limits due to potential interference with Holy Name's cross country course.

We also reached out to the Vernon Hill School Vice Principal, Patti Murphy-Brown, to involve her students and teachers. The Vernon Hill School is an elementary school near the potential trail route. However, unlike Holy Name, the potential trail routes we considered did not cross onto the Vernon Hill School's property. Therefore, when we met with the Vernon Hill School, we did not have to discuss the possibility of using their land for the trail. We simply discussed the school's interest in using the trail for educational and recreational purposes. The potential routes we considered came within 200 yards of the Vernon Hill School with a separate, shorter trail connecting to the school for easy access. Figure 9 shows a map of the area and a visual of the potential trails with respect to these two schools.




*Note: This map shows one potential route we considered and was not the final route we recommended. It should be used to view the proximity of the schools in relation to the general area of the trail.

**Figure 9: Map Showing Schools near Trail Route**

We conducted a semi-structured interview with Ms. Murphy-Brown to gauge her interest in supporting the trail and encouraging her teachers to use the trail to supplement their teaching. Establishing a connection with the schools was important because children need to experience nature at a young age. For a detailed discussion of why children need to experience nature, see

Chapter 2.3. Connecting the schools with the trail was also a way to fulfill Mass Audubon's mission of connecting people with nature. To view interview questions with surrounding schools, please see Appendix M. After we established whom the new trail would be for, understood the trail user's perspectives, and reached out to the surrounding schools, we were ready to move onto the trail planning phase.

## Phase 2: Trail Planning

Phase 2, Trail Planning, included objectives 4 and 5 and consisted of researching trail development methods, determining the most effective means to educate along the trail, and developing the educational material to include along the trail. We accomplished these objectives by conducting interviews, developing case studies, and conducting archival research and content analysis.

### *Objective 4: Determine the Most Feasible and Effective Trail-based Education Method to Implement at Broad Meadow Brook*

In objective 4, we determined the best education method to use along the trail at Broad Meadow Brook. Trail-based Education, or interpretation, is intended to help trail users understand and relate to a story about the land the trail travels along (NPS, 2015). Trail-based Education also helps build intellectual and emotional connections between trail users and resources, encouraging them to care about and connect to the land (Id.). We define a Trail-based Education method as educational components that help trail users interpret historical information or environmental features. We also researched which education methods, such as scavenger hunts, tend to attract visitors to the trail and increase trail usage. In order to achieve this objective we conducted interviews and content analysis through the development of case studies to determine the ideal Trail-based Education method to implement at Broad Meadow Brook Wildlife Sanctuary.

We conducted semi-structured interviews with Mass Audubon's Martha Gach, Conservation Coordinator, and Deb Cary, Central Sanctuaries Director, to understand what educational methods they have already implemented and which ones were less effective in the past at Broad Meadow Brook. We also conducted interviews with Ms. Gach and Ms. Cary to determine the best way to educate trail users along the trail that will connect Broad Meadow Brook to the new Blackstone Visitor Center. Please refer to Appendix N for a list of interview questions. Ms. Gach and Ms. Cary informed us that interactive signposts are not the best educational approach because they have historically been subject to damage or vandalism as the trail moves further away from Broad Meadow Brook Wildlife Sanctuary (Cary and Gach Interview, 2015). Consequently, we investigated other methods for educating and engaging trail visitors through interviews and case study research.

We conducted semi-structured interviews with Deb Cary and Martha Gach to understand what options BMB had for incorporating educational, or interpretive, material along this trail, and then conducted a semi-structured interview with an environmental education expert and looked at case studies to determine the most effective educational methods from the most feasible options for the Broad Meadow Brook trail.

We conducted a semi-structured interview with Melinda Learning from R. Stewart Esten Elementary School in Rockland, Massachusetts to understand how an experienced, environmental educator incorporated education along a nature trail. Ms. Learning is an elementary school teacher who, in 2014, received an Environmental Education award for her work with elementary school children from President Barack Obama. We interviewed Ms. Learning to get feedback on what methods she believes works best for educating along nature trails based on her past experiences. We used a semi-structured interview here because we

wanted to be able to respond with new questions based on Ms. Learning's responses. Please refer to Appendix O for a list interview questions for environmental educational expert, Melinda Learning.

We also examined case studies to determine the most effective educational methods along nature trails. As Robert Yin, notable American social scientist and expert on case study research, explains, case studies are the preferred strategy when trying to answer "how" or "why" questions (Yin, 2003). Researchers should conduct case study research in a professional manner and follow a systematic procedure because it is easy and common for the researcher to allow equivocal evidence or biased views to influence conclusions (Id.). We researched studies done on trails that look at how effective certain educational methods are, such as Irene Osterman-Sussman's study on the Estuary Nature Trail in Oregon (Ostermann-Sussman, 1993). For more information on the results and conclusions from her study, please refer to Chapter 2.4. We examined case studies where events such as scavenger hunts or even famous book anniversaries attracted visitors, students, and families (Podlewska, Andres, 2014). For more information regarding a similar event, refer to the Gruffalo Trails case study in Chapter 2.4. We conducted content analysis of these case studies to determine the most effective educational methods along trails.

### *Objective 5: Develop Educational Material to Use along the Trail*

Once we determined the most effective methods for interpreting features for visitors along the trail, we needed to decide what material to present. This objective also considered the results from objective 2, which assessed the perspectives of current Broad Meadow Brook trail users and established what people would like to learn about while using the trails. In order to achieve objective 5, we conducted archival analysis on the history of the land along and around the trail route by viewing maps provided by the Worcester Historical Museum (WHM),

interviewed Broad Meadow Brook staff to develop interpretive material to use along the trail, and interviewed the Devon Kurtz, the Project Manager of the Blackstone Visitor Center.

According to our sponsor, Deb Cary, "people love to know the history of the land" (Cary, Interview, 2015). In order to understand the historical significance of the land, we visited the WHM and conducted archival research on historic city maps and photographs of the area. Robyn Conroy, a librarian at the WHM, provided us with these maps and photographs.

We conducted semi-structured interviews with wildlife experts and staff at Broad Meadow Brook to understand the ecosystems, flora, and fauna of Worcester, Massachusetts. We conducted semi-structured interviews here because we wanted to gain additional information about topics based on the responses of the Broad Meadow Brook staff. Please see Appendix P for interview questions with Broad Meadow Brook staff.

We also conducted a semi-structured interview with Devon Kurtz, the Project Manager for the Blackstone Visitor Center. By interviewing Mr. Kurtz, we hoped to gain valuable information about what the plans were for the Visitor Center in terms of what would be inside and who their target audience would be. We also interviewed Mr. Kurtz to introduce the plans for the new Broad Meadow Brook trail connecting to his new Visitor Center and gauge his interest in working together to attract more visitors to both places. For a list of interview questions with Devon Kurtz, please see Appendix Q.

### Phase 3: Trail Creation

In the first two phases of this research, we identified the trail's intended users as well as the methods by which to educate users. The third phase involved the proposal of the trail using the findings from the first two phases.

### *Objective 6: GPS Map Ideal Trail Route*

To accomplish this objective, we learned how to use a GPS and how to convert GPS points into a map. The first method by which to learn this process was by interviewing the Broad Meadow Brook Staff. Please refer to Appendix R for interview questions. By interviewing the staff, we identified the systems they have used to map the existing trails and we identified any tools we needed to acquire. We conducted a semi-structured interview, because we did not know every question to ask about this topic, but began to understand more as the questions were asked, and it helped to make efficient use of time. However, this interview did not provide us with all of the information we needed.

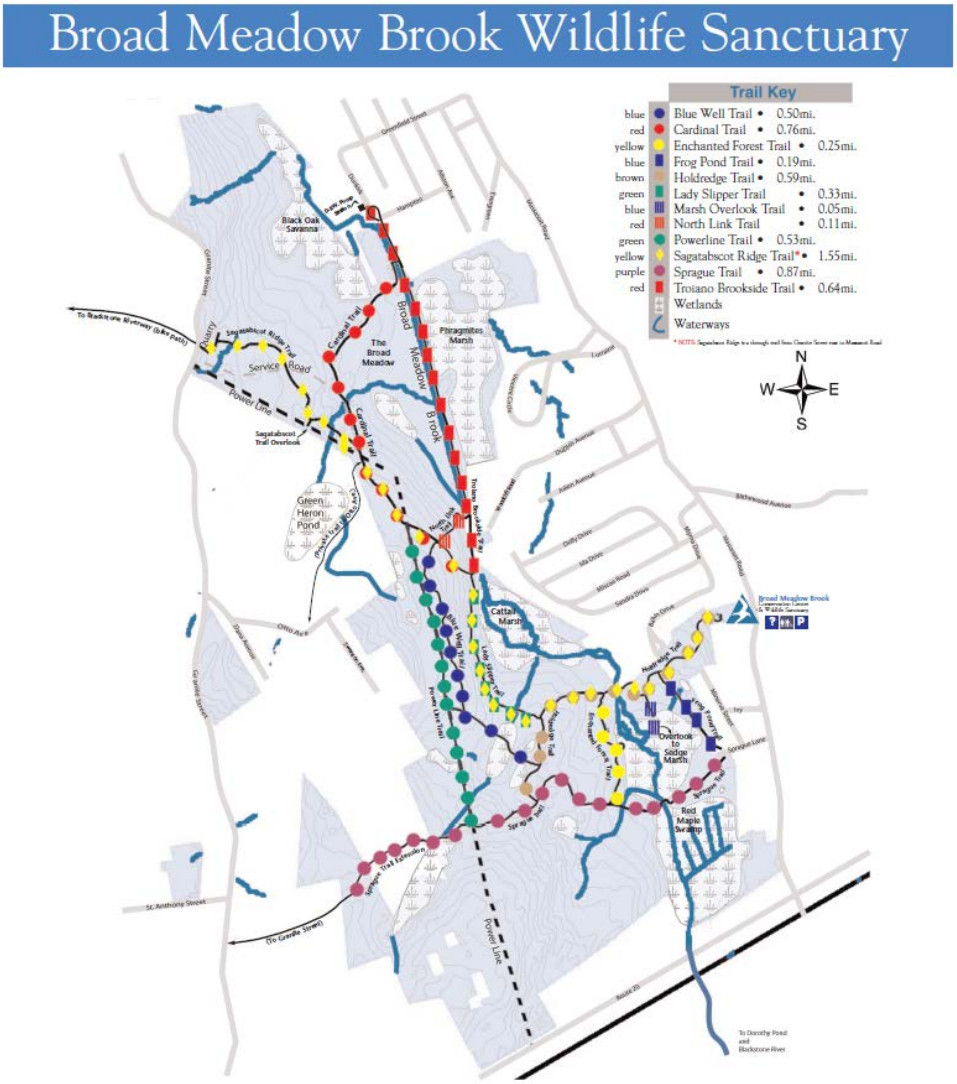



**Figure 10: Broad Meadow Brook Sanctuary Trails (Mass Audubon, 2015)**

To gather more information about creating a GPS map of the trail, we researched past methods that have proven effective. We conducted in-depth case study research on the

development of past trails, similar to the one we planned to develop connecting Broad Meadow Brook Wildlife Sanctuary to the future Blackstone Visitor Center. Figure 10 shows a map of the existing trail network at Broad Meadow Brook (as of October 2015). We developed case studies of trails created during similar projects, such as past Interactive Qualifying Projects at WPI or short-term trail development projects. For more information on the purpose of this trail and examples of relevant case studies, please refer to Chapter 2.1 and Chapter 2.4, respectively.

The chosen case studies also helped us understand additional trail features we needed to consider. Ideally, we would have used a similar matrix to that of Table 4, in Chapter 2.4, which summarizes the features of various trails, to develop this new trail and decide on the ideal trail route. However, due to property ownership and a subsequent lack of options in trail location, we were unable to have much say in which features, such as width, grade, surface, and wheelchair accessibility, to include in the proposed trail. If instead we were constructing this trail entirely on Broad Meadow Brook property and not following already existing trails, a matrix would be helpful for deciding which features to include in the construction of a new trail. The matrix lists trail features on the vertical axis and decision factors, such as feasibility, cost, and likelihood of increasing use, on the horizontal axis. To view an example of what the matrix might look like, please see Appendix H.

Additionally, we conducted a semi-structured interview with Joe Choiniere, Property Manager at Broad Meadow Brook, to understand his role and the work that goes into maintaining the trails. We conducted this interview to learn if there was anything we should consider, when choosing a trail route that would make the trail easier to manage and maintain over time, such as avoiding low spots where flooding may occur. We chose to conduct a semi-structured interview because we also wanted to walk part of the existing trails and the potential new trail with Mr.

Choiniere to hear his thoughts and recommendations. To view interview questions with Mr. Choiniere, please see Appendix S.

Before we hiked and physically mapped the trail, we researched the property boundaries by which we were constrained. Identifying these boundaries beforehand allowed us to walk the trail with more knowledge of the land we were on.

We then hiked the trail a number of times, using a GPS to capture the entire journey, in order to explore the vast possibilities of trail routes. By mapping the entirety of the hike, we could see each individual path we took in an effort to assess where the paths met. It was beneficial to explore a variety of options when GPS mapping the connector trail's route. The first option was to use free iPhone apps, including "MapMyHike" and "MapMyTracks," as a way to familiarize ourselves with GPS tracking. Ultimately we decided to use a Garmin eTrex HCX Vista to locate the connector trail because of its accuracy. When converting these GPS points into a usable track, we first used Google Earth Pro to lay the path onto an orthographic photo of the trail area. Google Earth Pro also allowed for the opportunity to see the paths in relation to property lines as a way to determine whose land the path was on. To verify the accuracy of Google Earth Pro, we used GIS software including ArcMap 10 and ArcGIS Online. When we completed the trail's GPS map, we identified the landowners along the trail route.

### *Objective 7: Identify Landowners Adjacent to Trail Path*

The trail's two endpoints are separated by a large section of land, and as such, there are a number of landowners involved. In order to formalize a trail, landowners and Mass Audubon would need to agree to an easement. Cornell University's School of Law defines an easement as "the grant of a non-possessory property interest that grants the easement holder permission to use another person's land." In particular, we are interested in an affirmative easement, which Cornell continues to describe as a type of easement that gives the easement holder "the right to do

something on the grantor of the easements' land" which in this case, is to build a trail (Cornell University Law School, 1992). This objective, along with previous objectives, contributed to defining the ideal trail route.

To accomplish this objective, we visited Worcester City Hall to obtain deeds identifying land ownership near the Broad Meadow Brook Wildlife Sanctuary. In speaking with Martha Gach and Deb Cary, we learned that there are stakes in the ground marking the corner points of the property in the area of the proposed trail (Gach and Cary Interview, 2015). However, without knowledge of the adjacent landowners, these stakes would be difficult to identify and make sense of. Once we identified area land ownership, we utilized the information from objectives 4-6 to propose an ideal trail route. To do this we used a Geographic Information System (GIS), ArcGIS, to overlay the GPS track of the trail and property ownership. To better understand GIS, we met with Juliet Swigor of the Massachusetts Department of Environmental Protection and she gave us basic training in using ArcGIS.

Once we had our proposed trail route, we worked alongside Mass Audubon to gain access to any private land we encountered. After determining property ownership, and identifying the cooperative surrounding landowners, we could progress to objective 8.

### *Objective 8: Present Our Findings to Mass Audubon*

In objective 8, we used the data acquired in objectives 1-7 to formulate and propose recommendations to Mass Audubon. Once we mapped the trail, we presented our findings and trail recommendations to our sponsors. We presented our recommended trail in a presentation, outlining the key features of the trail, and showing a map of the trail's route. This was effective in showing the trail in its entirety. Also, it allowed the viewers to see how the newly created trail would interact with the existing trails at the Broad Meadow Brook Wildlife Sanctuary.

We also took Broad Meadow Brook staff on a guided tour of the proposed new trail, identifying points along the trail we identified as environmental or historical teaching opportunities. This was most effective in demonstrating how future users would see the trail. The tour allowed us to present the new trail as the hands-on experience it is intended to be. Once the trail's path was agreed upon, we could move ahead in blazing the trail.

### *Objective 9: Blaze the Trail*

Once we agreed upon the trail's path, we could move ahead in marking the trail. A blaze is defined as a distinct marking used to designate the trail's direction, often placed on trees along the trail (Appalachian Trail Conservancy, 2015). To understand how blazes work, we first examined the various methods by which to blaze a trail. We did this by first hiking the existing trail network at Broad Meadow Brook to identify the current system used by Mass Audubon to mark their trail paths. As this trail is a continuation of Broad Meadow Brook's existing Sagatabscot Ridge trail, it would make sense to mark it as such.

However, because of easement negotiations, the trail could not be properly blazed at this time. Ultimately, in place of permanent blazes, we used a bright yellow duct tape to mark the trees. Duct tape would not fall off the trees during the winter and could be used by Broad Meadow Brook to identify the proposed trail until proper blazes could be used.

## 3.1 Conclusion

The Broad Meadow Brook chapter of Mass Audubon believes that connecting the new Blackstone Visitor Center to the existing trails at the Broad Meadow Brook Wildlife Sanctuary can help connect the people of Worcester, Massachusetts with nature and the area's history. We detail the findings and recommendations in the next chapter.

# Chapter 4: Findings, Recommendations, and Conclusion

## 4.0 Introduction

In this chapter, we first discuss our findings from each of the three phases of objectives outlined in the previous chapter. To understand which objectives correspond with which findings, please see Table 6. We then detail our recommendations for Broad Meadow Brook (BMB) and the development of the trail in terms of the trail route, the options for future improvements along the trail, and the interactive, educational components recommended to highlight the selected environmental and historical features.

## 4.1 Demographic

Finding 1: *We determined that the target demographic of the proposed trail included current Broad Meadow Brook trail users, future visitors to the Blackstone Valley Visitor Center, and the students of the Vernon Hill and Holy Name schools.* This information was obtained through our interviews with Martha Gach (Conservation Coordinator, Mass Audubon), Deb Cary (Central Sanctuaries Director, Mass Audubon) and Devon Kurtz (Project Manager, Blackstone Valley Visitor Center), as well as the interviews we conducted in an attempt to integrate the schools with the future trail (Section 4.3).

| | | | | |
|---|---|---|---|---|
| Phase 1: Understanding Broad Meadow Brook Trail Users | Objective 1 | Identify our Target Demographic | Finding 1 (4.1) | Current Broad Meadow Brook trail users, visitors at the future Blackstone Visitor Center, and students of Holy Name Junior/Senior High School and the Vernon Hill School will most frequently use the trail. |
| | Objective 2 | Assess Current Trail User Perspectives | Finding 2 (4.2) | Trail users, including those identified in Finding 1, enjoy viewing interpretive material while walking along trails and agree that clear blazes are important. |
| | Objective 3 | Connect with Surrounding Schools | Finding 3 (4.3) | Schools in close proximity will use the trail more frequently if they can easily connect and align nature with their curriculums. |
| Phase 2: Trail Planning | Objective 4 | Determine the Most Feasible and Impactful Trail-based Education Method | Finding 4 (4.4) | Although interpretive signs are effective, self-guided brochures and guided nature walks are better options for this trail. |
| | Objective 5 | Develop Educational Material to Use along the Trail | Finding 5 (4.5) | To capture the interests of potential users on a connector trail linking Broad Meadow Brook Wildlife Sanctuary with the new Blackstone Visitor Center, the interpretive material should highlight the focus of both endpoint destinations: nature and history. |
| Phase 3: Trail Creation* | Objective 6 | GPS Map Ideal Trail Route | Finding 6 (4.6) | A trail's best path is determined by pre-existing land features and intended use. |
| | Objective 7 | Identify Landowners Adjacent to Trail Path | Finding 6 (4.6) | A trail's best path is determined by pre-existing land features and intended use. |
| | Objective 8 | Present Our Findings to Mass Audubon | Finding 7 (4.7) | *See Chapter 4.7: Recommendations* |
| | Objective 9 | Blazing the Trail | Finding 8 (4.7) | *See Chapter 4.7: Recommendations* |

*Note: The findings from objectives 6 and 7 were grouped into one finding, *The Ideal Trail* (Finding 6), because of the nature of and the similarities between the two objectives.

**Table 6: Findings with Corresponding Objectives**

## Broad Meadow Brook Trail Users

Our conversations early on with Martha Gach and Deb Cary uncovered the primary demographic, the Broad Meadow Brook trail users. They referenced two distinct sets of trail users, experienced hikers who want a long hike extending from the Sagatabscot Ridge Trail to the Blackstone Visitor Center, and more casual trailer users who live close to the trail. They also expressed interest the possibility of involving schools in the region, namely Vernon Hill and Holy Name because of their proximity to the new trail, pictured in Figure 11, where the dotted lines represent existing trail paths. Once we identified the students as a probable demographic, we decided to add a third objective, (4.3 School Integration) to our first phase. 'School Integration' entailed finding ways for the Vernon Hill and Holy Name schools to work and educate along the trail as much as possible. For Vernon Hill, this entailed aligning field trips and curriculum with the trail's education. For Holy Name, this meant ensuring that both the school's cross country team and regular trail users had ample access to the trail.

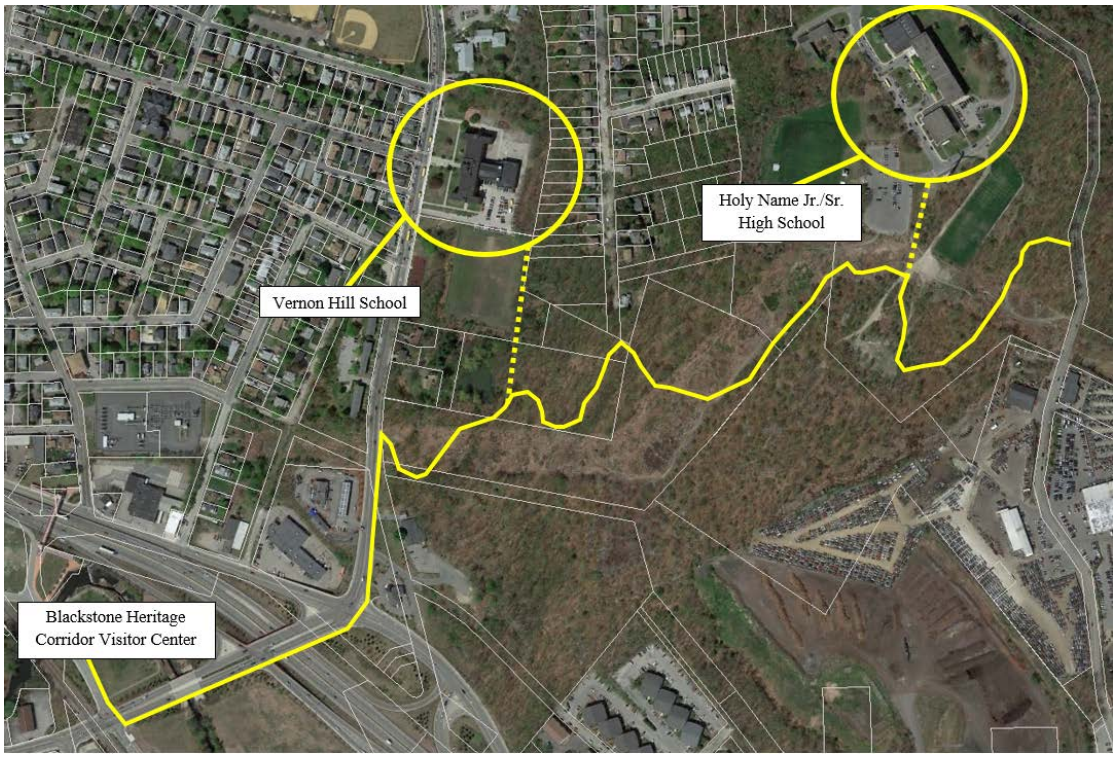



**Figure 11: School Proximity**

Martha Gach and Deb Cary also highlighted potential issues with the trail user demographic. Some current users have been known to ride dirt bikes and all-terrain vehicles (ATVs) along the unofficial trail paths. Such activities lead to liabilities for Broad Meadow Brook and the increased erosion of its land. As a result, Deb Cary and Martha Gach were eager to halt such activities if at all possible. However, both Ms. Cary and Ms. Gach were optimistic that when the trail became official "bad users should go someplace else over time" (Deb Cary Interview, 2015).

### Blackstone Valley Visitors

While Deb Cary and Martha Gach informed us about BMB trail users and encouraged us towards school integration, Devon Kurtz, Project Manager of the Blackstone Valley Visitor Center, described who he thought would be the typical visitors of the Visitor Center. Mr. Kurtz explained that the Blackstone Valley Visitor Center visitors are likely to be residents of Worcester, Massachusetts, Quinsigamond Village, and various local colleges (Devon Kurtz Interview, 2015). He also shared his vision for the cultural value of the establishment. Mr. Kurtz believes the Visitor Center will provide a special informative educational experience that contributes to the natural and aesthetic nature of Worcester as a whole (Id.). It will have a new city park, host large festival events, and essentially be a destination in and of itself (Id.).

## 4.2 Assess Current Trail User Perspectives

Finding 2: *Our findings were that although user perspectives were helpful in theory, their feasibility was less than we had anticipated, and as a result they took a back seat to factors more crucial to trail design.* The main portion of this section entailed creating a survey, distributing it to the trail-goers, and gathering information from it. Not only was our sample size rather small, but those we interviewed often gave subjective opinions rather than adhering to the format of the survey. The information we gathered was helpful, but difficult to assess objectively. And once

we had, much of the information we intended on accounting for was simply unusable. Once we narrowed down our trail sections into specific possibilities (see 4.6), deciding the ideal trail became a matter of assessing priorities on which features mattered, rather than the cookie-cutter approach we created the survey to undergo. In short, the information acquired was subjective and immaterial once we narrowed down our options.

We also met with Howie Fain, an educator who walks the trail every year with 8$^{th}$ grade students from Worcester East Middle School. Last year, he got lost on the trail, which led him to support clearer trail markers wholeheartedly. He also emphasized the value of improvisational education when taking groups of students out on nature walks, allowing for them to explore on their own and ask questions about what interests them most (Howie Fain Interview, 2015). Although his opinions as an educator were valued, the information we obtained contributed more to trail design than educational methods.

This finding was constructed with high aims, but resulted in weak support and very little context for the whole of the project. Because of small sample size, and how little the opinions translated into the final product, this portion of our project hardly impacted the final trail design. Instead we relied upon environmental and topographical factors to determine the recommended path (4.6).

## 4.3 School Integration

Finding 3: *Schools in close proximity will use the trail more frequently if they can easily connect and align nature with their curriculums.* Through interviews with school officials from the Vernon Hill School and Holy Name Junior/Senior High School, we found that both schools would be interested in using the trail once it has been formalized.

### Vernon Hill School

As Vernon Hill is an elementary school, we were eager to integrate their educational needs with the trail as much as possible. Elementary school education more free-flowing and less complex than high school education. Therefore, it lends itself towards field trips much more than a high school. As such, we made integration with Vernon Hill a priority, especially since there is a path connecting the school to the 'informal' trail.

On November 16th, we met with Vernon Hill Elementary School Vice Principal, Patti Murphy-Brown. Vice Principal Murphy-Brown said that Vernon Hill has no after school programs to speak of, so she supports and seeks any cross-curriculum education opportunities (Patti Murphy-Brown Interview, 2015). The Vernon Hill School is also eager to advance its science program, and while Massachusetts is currently updating their elementary school curriculum (as of Fall 2015), the value of 'thinking like a scientist' was sincerely encouraged by the state (Id.). In short, the school was eager to extend student hours and educate them in an engaging and cost-effective manner. Vice Principal Murphy-Brown was eager to integrate classes with the new trail through field trips, in-class experiments, or any way the school deemed appropriate (Id.).

### Holy Name School

We met with both Edward Reynolds, Headmaster of Holy Name High School and Jim Manzello, Athletic Director for Holy Name, regarding the integration of the trail with the school. Mr. Manzello and Mr. Reynolds felt that for their students, the trail's best use was exposing them to nature, rather than creating a focused educational experience. As we were still formulating the ideal route at the time of our meeting, it was important that they gave us the opportunity to pass through their land. They were very willing to give us that permission, provided that Broad Meadow Brook puts signs up for 'race days', four days each fall (Manzello and Reynolds

Interview, 2015), so that the cross-country team can hold ‘meets’ there without interference. The permission to use their land gave us the flexibility in trail design that we had desired.

## 4.4 Most Feasible and Effective Education Method

Finding 4: *Although interpretive signs are effective, self-guided brochures and guided nature walks are better options for this trail.* In an interview with Deb Cary and Martha Gach, we learned that interpretive signs and other physical structures along the existing trails at Broad Meadow Brook have been vandalized in the past, particularly along trails located further from the wildlife sanctuary (Cary and Gach Interview, 2015). Due to these past acts of vandalism, BMB chose not to invest in interpretive signposts or other large, physical structures along this trail.

As a result, we researched the effectiveness of other educational methods, such as brochures and guided nature walks, along trails. Through an interview with an environmental educator and analysis of nature trail case studies, we determined that guided nature walks are most effective, more so than interpretive signs and brochures, and are preferred by environmental educators. In this section, we will discuss the results from interviewing Ms. Melinda Learning, a well-recognized environmental educator, and the results from the development of the five case studies, introduced in Chapter 2.4, on the effectiveness of various educational methods along nature trails.

### R. Stewart Esten Elementary School in Rockland, Massachusetts

Ms. Melinda Learning is an elementary teacher from R. Stewart Esten Elementary School in Rockland, Massachusetts. In 1997, she began to develop a nature trail on school grounds with the hope of creating a “place where kids could go outside and learn something every day” (Melinda Learning Interview, 2015). Over the span of about 15 years, her trail became something she never could have envisioned. It began as a trail beaten down by animals and has

developed into a 2 mile trail network that students use each school day. In 2014, President Barrack Obama recognized Ms. Learning for her exceptional work as an environmental educator and the success of her trail (Id.). Ms. Learning was able to "learn alongside the students" and create a registry of species with over 180 identified species in the first year. She also used the trail as teaching grounds for multiple school subjects and incorporated school curriculum in her lessons.

Ms. Learning used her trail to develop lessons in math, science, art, writing, and reading. For example, Ms. Learning and her students published a book in the town library on "number and line patterns in nature," which incorporated math and geometry in the lesson (Id.). She had her fourth grade students publish a book describing many of the plant species along the trail. She had her students go out and draw pictures of what plants they saw. Then they would go into the classroom and conduct research on what they saw. Finally, they wrote a description of the plants. This exercise incorporated art, reading, and writing. Ms. Learning believes the research component of her trail lesson plans is one of the main reasons why it became nationally recognized (Id.).

Although Ms. Learning incorporates school subjects into her lesson plans, she does not use interpretive signposts along her educational, nature trail. When asked about interpretive signposts along her trail, Ms. Learning said she did not see a necessity for them and thought they may even "limit people's imaginations" (Id.). She feels that students learn best when they are free to explore on their own with her there to answer questions and guide them because "kids are naturally curious about plants and animals" (Id.). She emphasized, however, that she did not come from a scientific background and that she was not an expert when she first developed the trail (Id.). Therefore, according to Ms. Learning, students learn best when they are free to

discover what interests them, with the help and guidance of an adult, experienced or inexperienced with environmental education. Ms. Learning's educational style resembles guided nature walks, where she is there to guide her children along the path, point out unique features, such as plants or insects, and answer questions. Guided nature walks provide a unique experience and force people to be curious. Ms. Learning believes her trail walks are "more authentic for the kids when they are free to explore and imagine" (Id.). This sparked curiosity, especially in children, can lead to a lifelong, caring relationship with the natural world (Cross, 2012).

This confirms our finding that guided nature walks, or less formal walks with someone capable of answering people's questions, can be an effective education method along a nature trail, especially among children of elementary school age. The next section discusses two additional case studies, including one that provides statistical data echoing Ms. Learning's findings.

### Additional Case Studies

We developed additional case studies to examine the effectiveness of education methods along nature trails, understand unique ways to increase trail use, and understand the features people should consider when developing a trail. These case studies are discussed in detail in Chapter 2.4. The Palisades Interstate Park and Estuary Nature Trail cases are the most relevant when discussing the effectiveness of educational methods.

To understand the origins of interpretive signposts, we first examined the Palisades Interstate Park, or the first known trail to use interpretive signposts, or "friends" to help tell the story about the wildlife along the trail (Lutz, 1931). This case study shows that interpretive signposts have been an effective educational tool along nature trails since the early 20$^{th}$ century.

The Estuary Nature Trail study reiterates this finding that interpretive signposts are an effective method. However, it introduces two other methods, namely brochures and guided

nature walks, which prove to be more effective. Irene Ostermann-Sussman, a graduate student from Oregon State University at the time, conducted a study in 1993 on the effectiveness of interpretive signposts, self-guided brochures, and guided nature walks. To assess the effectiveness of the education, Osterman-Sussman administered a knowledge test of comprehension of the trail's educational points. The study purposely did not expose the control group to any interpretive signs, trail brochures, or guided naturalist walks. The results show that people exposed to the three educational programs scored significantly higher than the control group on a written exam about estuary wildlife (Ostermann-Sussman, 1993). Osterman-Sussman also made sure the people in these groups, including the control group were demographically similar, in terms of age, gender, educational background, residence proximity, and number of repeat visitors. The study looked at about 900 participants, which evenly made up the three groups.

Osterman-Sussman concluded that all three educational programs at the Estuary Nature Trail effectively educate visitors from all educational levels and backgrounds with guided naturalist walks being the most effective (Id.). While she concluded guided naturalist walks were the most effective, she found self-guided brochures to be effective as well, in fact more effective than interpretive signposts. Her study shows that people scored about 4% higher on the same exam when the information was presented through a brochure rather than on signposts and about 11% higher when information was presented through a guided naturalist walk rather than on signposts (Id.). Figure 12 shows her findings and the exam results. She believes one of the reasons for the exam score differences was that people do not actually read all the signs or read them fully. She observed over 300 people from a distance, recording the times they took to read the signposts. Although people could have learned all the information necessary to answer the

questions on the exam through the signposts, Osterman-Sussman believes it was because people found them less interesting and did not read them thoroughly (Id.). Instead, she believes people were more intrigued and engaged in the self-guided brochure, and especially along the guided nature walks where they could even ask questions about anything that particularly interested them (Id.).

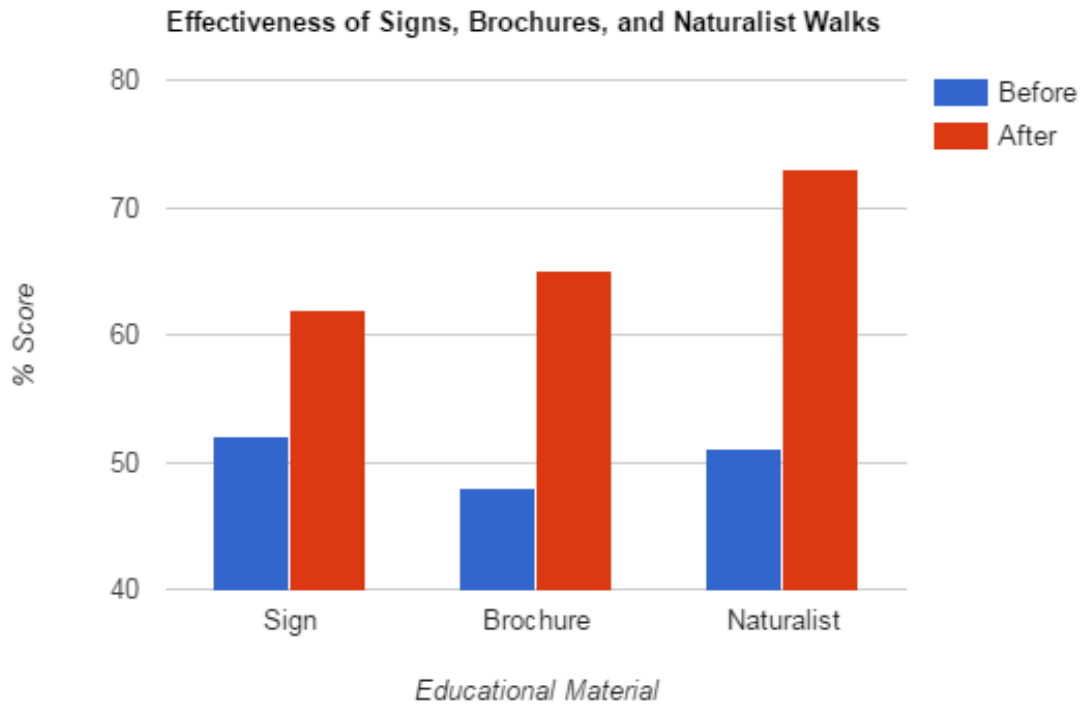



**Figure 12: Estuary Trail Case Study: Exam Results Before and After Being Exposed to Signposts, Brochures, and Guided Naturalist Walks (Osterman-Sussman, 1993)**

Osterman-Sussman's study confirms Ms. Learning's findings. Both argue that the most effective educational method includes a person who guides a group of people along the trail, allowing people to explore and to have their questions answered. Osterman-Sussman introduces an additional method, in the form of a brochure, which also proves to be more effective than interpretive signposts.

Initially, we viewed the decision to not invest in signposts along this trail as a limitation and therefore we began to look into other methods. However, after our research and findings

discussed above, we determined that interpretive signposts are not the best option along this new connector trail. Although very common along nature trails and traditionally effective, interpretive signposts are often not read, steer people to specific points along trails, and can be easily damaged or vandalized. While the information on them can be important and interesting, Ms. Learning and Osterman-Sussman argue guided nature walks are more effective because they bring out the imagination and curiosity in people and let them ask questions (Osterman-Sussman, 1993; Learning Interview, 2015). Self-guided brochures also offer a substitute to signposts. Brochures are inexpensive and people cannot vandalize them like signposts. The combination of a brochure and guided nature walks provides trail users with the option to view features and facts about things other people think are interesting, and also ask questions about what interests them.

## 4.5 Interpretive Material along a Connector Trail

Finding 5: *To capture the interests of potential users on a connector trail linking Broad Meadow Brook Wildlife Sanctuary with the new Blackstone Visitor Center, the interpretive material should highlight the focus of both endpoint destinations: nature and history.* According to Joe Choiniere, the Property Manager at BMB, "every trail has a purpose" (Joe Choiniere Interview, 2015). BMB intends for this trail to connect the wildlife sanctuary at BMB to the future Blackstone Visitor Center, providing visitors at both centers with the opportunity to walk to the other Visitor Center while experiencing nature. A trail "should not be too long or too straight", meaning that trail users should be able to get from one Visitor Center to the other and back easily. But because this is meant to be a nature trail, it should also include simple curves, giving users the feeling of an aesthetically pleasing trail rather than a roadway leading somewhere (Rathke, Baughman, 2007; Deb Cary Interview, 2015). The features highlighted along the trail should focus on the environment and the history of the area to capture the interests of trail users coming from the trail's two endpoints (Cary and Gach Interview, 2015).

Table 7 summarizes our findings of the unique environmental features along the trail and history of the region based on our research and interviews with wildlife experts at BMB, Devon Kurtz from the Blackstone Visitor Center, and Robyn Conroy, the librarian from the Worcester Historical Museum. These features include the Black Oak Savanna area, the views of the historic Blackstone River Valley and wind turbine at Holy Name, the pond, and the history of the region. Ms. Cary and Ms. Gach recommended we highlight various habitats as a way to group environmental features (Id.). The information in Table 7 represents all of the interesting information we found through our research. From this list of features, we eventually chose a select few to present along the trail. Please see Section 4.7: Environmental and Historical Features for the justification for which features we recommend.

| Historical Features | Environmental Features |
|---|---|
| **Immigration** – The construction of the Blackstone Canal and the Irish potato famine encouraged many Irishmen to immigrate to the Blackstone area around 1828. They became the primary immigrant force in the region at approximately 1850.<br><br>Starting at around 1870, Swedish workers were specifically recruited to work in the steel and wire industries in Worcester, and Providence. | **Black Oak Savanna** – A Black Oak Savanna is an area in which Black Oaks stand several feet separated from each other, surrounded by short plants. This is because wildfires kill the less durable plants so only the Black Oaks and small grasses remain. The Black Oak survives because its bark is resistant to fire, and thickens for years after exposure.<br><br>Sassafras is a short green plant that often appears after a wildfire.<br><br>By searching for widely distributed Black Oaks, short grasses, and sassafras, you can find a Black Oak Savanna, however the infrequency of wildfires has made this environment rarer and harder to find than it was years prior. |
| **Settlers** – William Blackstone was the first European settler of the Blackstone Valley in 1635. The first group of settlers arrived with Roger Williams in 1636 to found Providence, Rhode Island. | **Plain under Power Lines –** Regulations imposed under the power lines has resulted in a unique natural environment. The power company frequently trims the area, making it impossible for any trees to grow.<br><br>The area is rife with 'Little Bluestem', a tall clumping grass spread across the plain. |
| **English colonist takeover** – As a result of King Phillip's War, Native American tribes lose control of the Blackstone River Valley to English settlers. | **Deep Marsh** – The 'Deep Marsh' is a pond area near the trail path. The area is a probable home to beavers who are definitely local to the pond. It also contains 'Cinnamon Fern', a plant found in marshes that can be used to precisely trace the line of wetland as it meets the dry soil. |
| **Native Americans** – Blackstone Valley was originally occupied by the Narragansett, Nipmuc, and Wampanoag tribes. | **Various Animals** – Broad Meadow Brook is home to deer, who often scratch their growing antlers against hard tree trunks.<br><br>It is also home to beavers and several diverse species of birds. |
| **Industrialization** – The Blackstone River was a useful recourse utilized for grist mills and iron forges.<br><br>The Blackstone Canal was built in 1828 and the Railroad in 1835. These massive projects made the Blackstone Valley and Worcester an industrial hub which encouraged a great deal of immigration. | **Various Plants – '**Climbing poison ivy' grows in the area as a thick rooted vine instead of its more well-known leafy alternative.<br><br>Black Oak, White Oak, Scarlet Oak., and Red Oak all grow in BMB, and are easily distinguishable by their leaves. Collecting leaves from all four and distinguishing between them makes for an entertaining activity. |
| **Mass Audubon's Founding** – Mass Audubon was founded in 1896. | |
| **Broad Meadow Brook's Opening –** Broad Meadow Brook Wildlife Sanctuary was opened to the public. | |

**Table 7: Unique Environmental and Historical Features (Blackstone Heritage Corridor, 2015; Worcester Historical Museum, 2015)**

## 4.6 The Ideal Trail

Finding 6: *A trail's best path is determined by pre-existing land features and intended use. No formula exists for an ideal trail. Instead, a trail must be blazed taking into consideration its unique features, environment and users.* The existing trail network of Broad Meadow Brook consists of trails of varying makeups and difficulties. The connector trail connecting the existing trail network to the Blackstone Heritage Corridor Visitor Center could take many different shapes. In order to identify the best possible trail, we separated it into four distinct sections as seen in Figure 13. Each section has unique characteristics that create the opportunity for different paths. Ultimately, because of existing land conditions, each section has potential for various options.

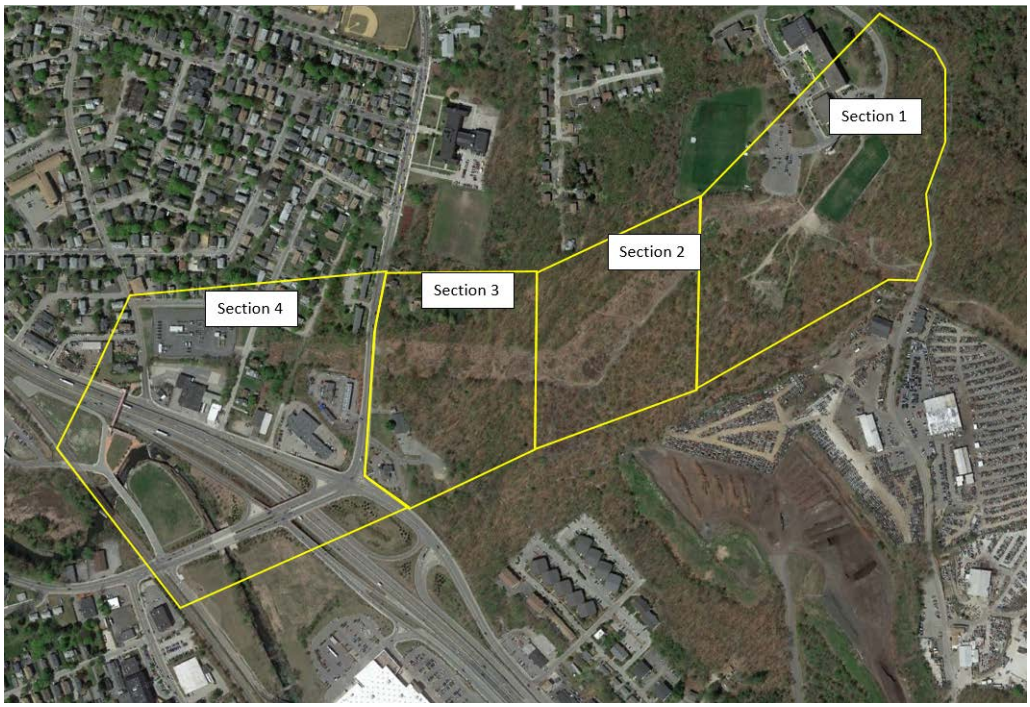
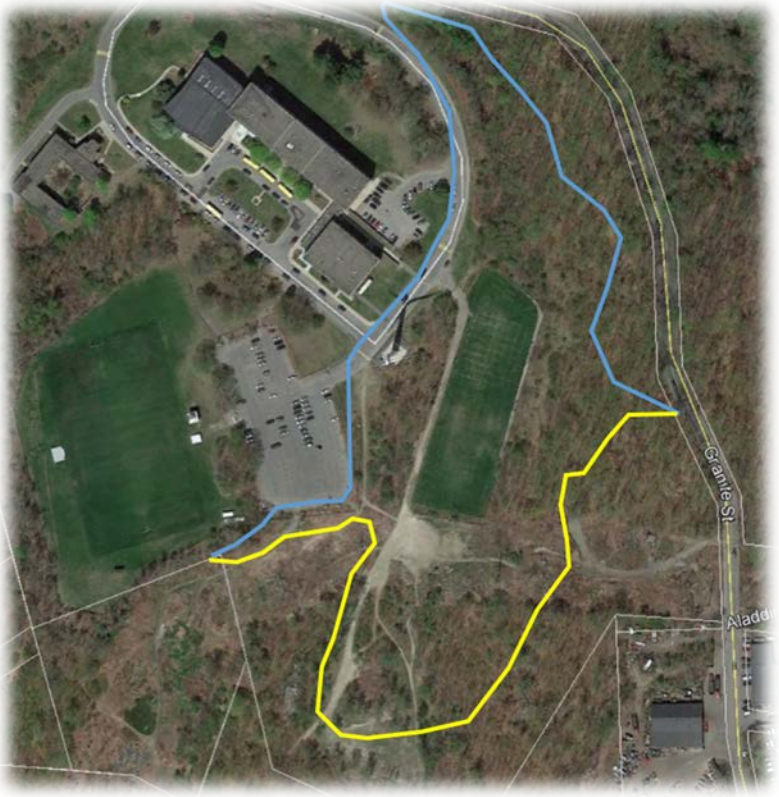



**Figure 13: Trail Sections**

### Section 1

Section 1 begins at Granite St. near Holy Name High School and extends west. For this section of trail, there are multiple options. Regardless of the path within section 1, the entrance to the trail always begins in the same spot, just off of Granite St. The trail can take two paths from

this point. It can begin by heading north and then traveling to the Holy Name driveway before passing the wind turbine. This section is thickly wooded and offers the opportunity to pass the wind turbine. This option can be seen in the map below, outlined in blue. The second option begins by heading south, crossing underneath the power lines and then continuing through the trees to section 2. This potential path can be seen outlined in yellow in Figure 14.



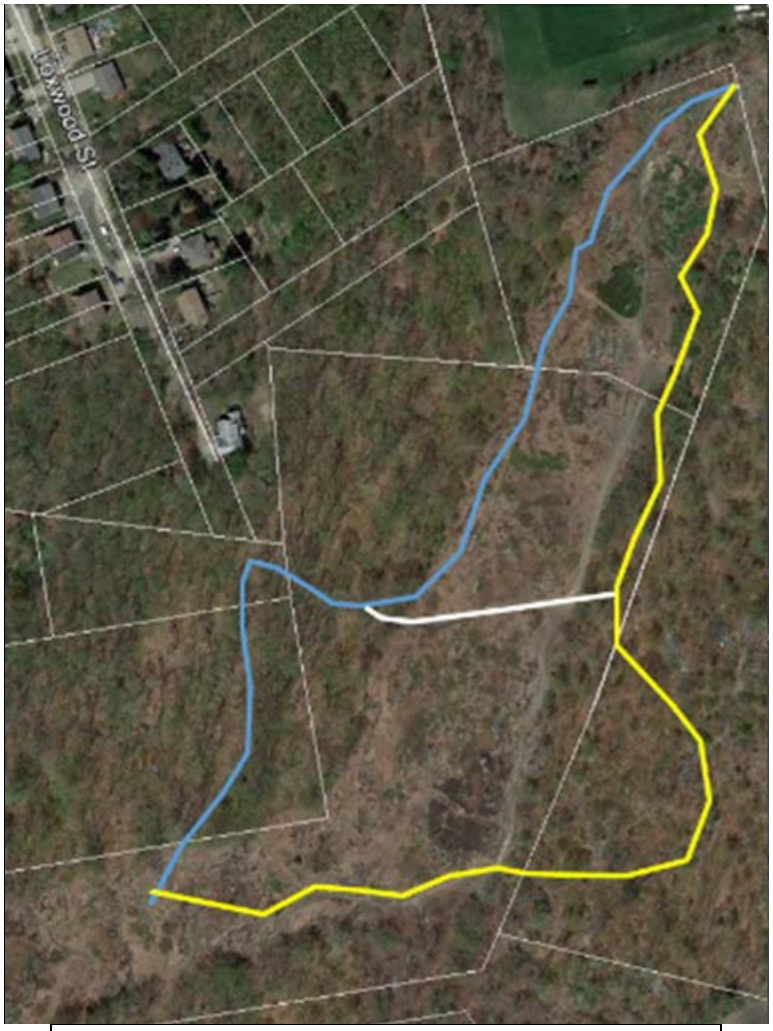

| Legend | |
|---|---|
| **Blue** | • Travel North<br>• Pass Wind Turbine |
| **Yellow** | • Travel South<br>• Cross Underneath Power Lines |

**Figure 14: Trail Options in Section 1**

## Section 2

Section 2 begins at the west end of the section 1 trail. There are also multiple options to move the trail through this area. The first option follows the north side of the power line. This trail is outlined in blue in Figure 15. This option stays primarily under the power lines, peeling

off into the woods to find a safe descent down the hill. The second option follows the southern side of the power lines, staying in the trees the entire time. This route can be seen in yellow in the figure below. This option has the potential to highlight part of the Black Oak Savanna as well. The second section could also feature a combination of the two trails. Figure 15 shows the two options that could feature a connection outlined below in white.




| Legend | |
|---|---|
| **Blue** | • Stay North of Power Lines |
| **Yellow** | • Travel South of Power Lines<br>• Stay in Thickly Wooded Area |

**Figure 15: Trail Options in Section 2**

## Section 3

Section 3 begins at the end of the section 2 trail and continues to carry the trail west. The first option for section 3 is to stay on the south side of the power lines, ultimately traveling south of the American Legion building before approaching the road. Figure 16 shows this option outlined in blue. This option features rocky terrain that provides an erosion-resistant surface, but can be steep at times. The other option is to stay on the north side of the power lines, coming near the small pond before crossing underneath the power lines and approaching the road. The second option is outlined in yellow. This option could highlight the pond as an opportunity to teach about the importance of wetlands, while also providing trail users with a destination. A destination is an important feature that will attract casual trail users (Deb Cary, Interview, 2015).

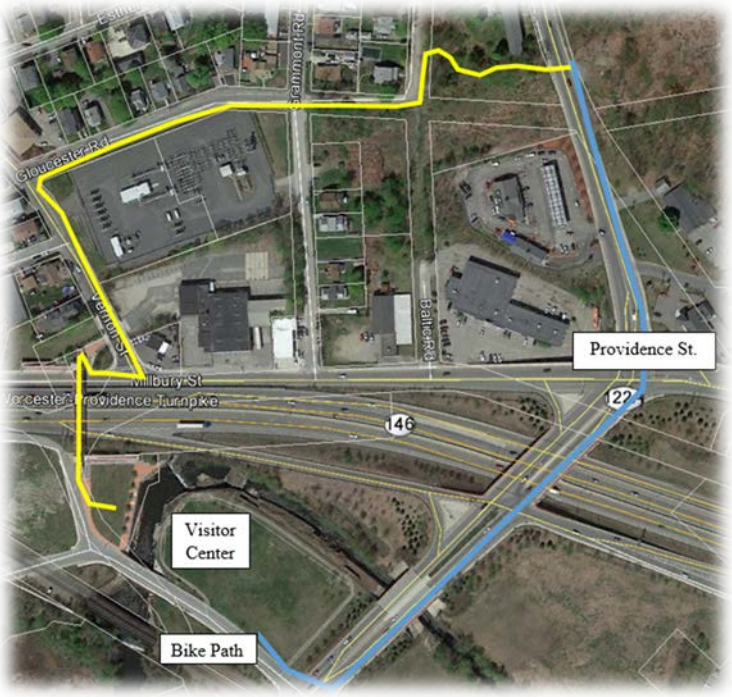

| Legend | |
|---|---|
| **Blue** | • Travel South Down Rocky Slope<br>• Exit to Providence St. Near American Legion |
| **Yellow** | • Travel North of Power Lines by Pond<br>• Exit to Providence St. in Open Area |

**Figure 16: Trail Options in Section 3**

## Section 4

Section 4 is the portion of the trail that covers the most urban and developed land before coming to the Blackstone Heritage Corridor Visitor Center. The first option is to travel south down Providence St., crossing to the Visitor Center at the bike path. Option one can be seen outlined in blue in Figure 17. The second option is to cross Providence St. immediately at the end of section 3. After crossing the road, the trail would cut through a small section of woods before coming to Baltic Rd. Then after traveling south on Baltic Rd., Gloucester Rd. would be followed to Vernon

St. and the trail user would ultimately cross the pedestrian bridge, arriving at the Heritage Corridor Visitor Center. Figure 17, shows this option outlined in yellow.




| Legend | |
|---|---|
| **Blue** | • Travel South down Providence St.<br>• Cross to Visitor Center at Bike Path |
| **Yellow** | • Cross Providence St.<br>• Travel Down Gloucester Rd. and Vernon St.<br>• Cross Pedestrian Bridge to Visitor Center |

**Figure 17: Trail Options in Section 4**

## 4.7 Recommendations

From the findings previously discussed, we have created detailed recommendations for the best possible trail route, options for trail improvements, specific environmental and historical features to highlight along the trail, and the methods by which to present these features to trail users. The pros and cons for each of the options in the four trail sections described in the previous section are shown in Table 8. The sections highlighted in green are the sections we recommend for this trail.

| Trail Section → | Section 1 | Section 2 | Section 3 | Section 4 |
|---|---|---|---|---|
| **Blue** | **Pros:**<br>• Small Section of Oak Savanna<br>• Gentle Slopes<br>**Cons:**<br>• Barren Dirt Area<br>• Would Require a Spur Trail to Turbine | **Pros:**<br>• Establishes Gentle Slope Towards Pond<br>• View Back Up of Turbine<br>**Cons:**<br>• Time Spent Under Power lines | **Pros:**<br>• Exit Closer to Blackstone Visitor Center<br>• Primarily Rock Foot Bed<br>**Cons:**<br>• Legion Land<br>• Steep Slopes | **Pros:**<br>• Less Time on Urban Trail<br>• Sidewalks and Crosswalks<br>**Cons:**<br>• Aesthetically Boring |
| **Yellow** | **Pros:**<br>• View of Wind Turbine<br>• Densely Wooded Area<br>**Cons:**<br>• Walk Along Driveway<br>• Wind Turbine Project | **Pros:**<br>• Black Oak Savanna<br>• Not Underneath Power lines<br>**Cons:**<br>• Does Not Set Up Section Three for the Pond | **Pros:**<br>• View of Pond<br>• Potential Viewing Platform<br>• Trail Head in Open Area<br>**Cons:**<br>• Wetlands<br>• Some Steep Slopes | **Pros:**<br>• Trail Users Cross Footbridge<br>**Cons:**<br>• Longer Portion of Urban Trail<br>• Aesthetics<br>• Sidewalks |

Table 8: Pros and Cons of Trail Options in Sections 1-4

## Trail Route

From the different trail options previously outlined, we have created a recommendation for the best possible trail. Please see Figure 18.

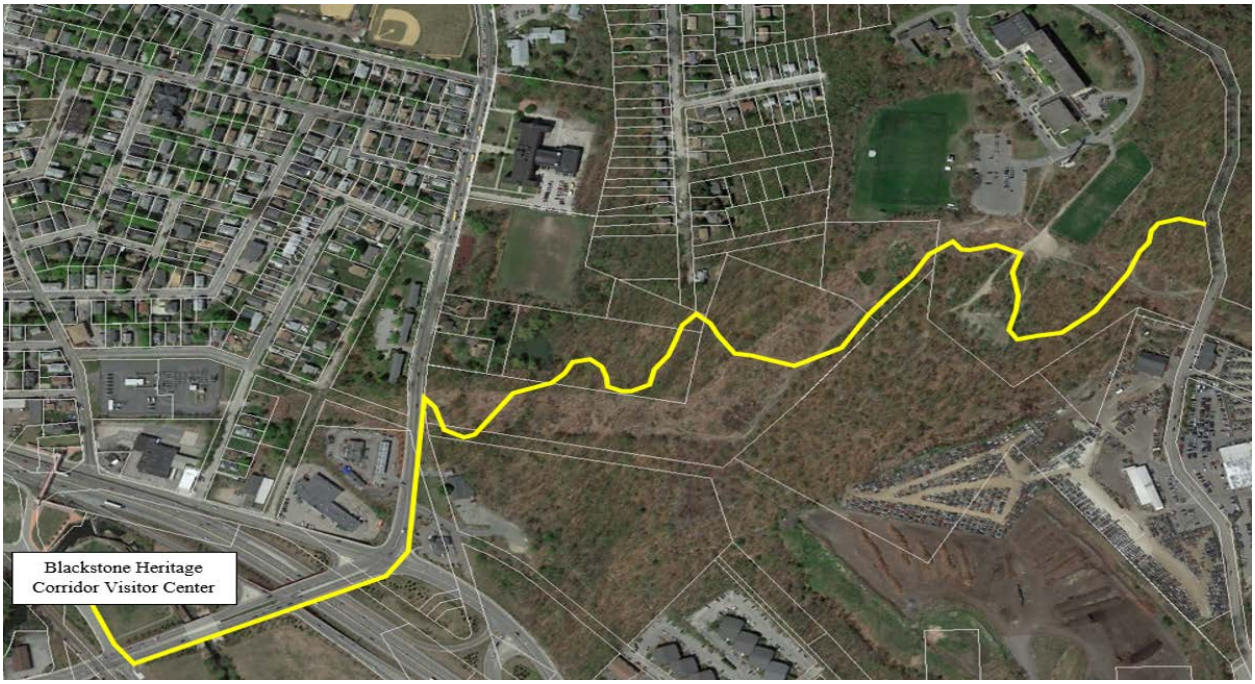



Figure 18: Recommended Trail Route

For section 1, we have chosen to recommend the path outlined in yellow, option 2 in Chapter 4.6 Section 1. This route was chosen because it is a more direct route through the area, and a large portion of the trail is through nature, while much of the other option is spent walking along Holy Name's driveway. Although this trail does not directly pass the wind turbine, it offers the opportunity for a spur trail to the wind turbine. A spur trail is a trail that connects from the primary trail to an additional point of interest. Also, in 2016, a two-year or longer study will be conducted at the base of the wind turbine to determine the feasibility of storing the energy that the turbine creates (Manzello and Reynolds Interview, 2015). A trail would likely be affected by the study, creating another reason to propose the other path.

While traveling through section 2, we recommend taking the yellow path, and then crossing at the white before continuing along the blue path. This route would allow a trail user to remain under tree cover until crossing underneath the power lines. The initial tree cover would allow for a trail user to learn about the Black Oak Savanna. A portion of Black Oaks, however, is

on land owned by Linder's Auto Sales, and difficulty in contacting the land owner has left the availability of this land uncertain. Please see Figure 19 for the area's land owners.

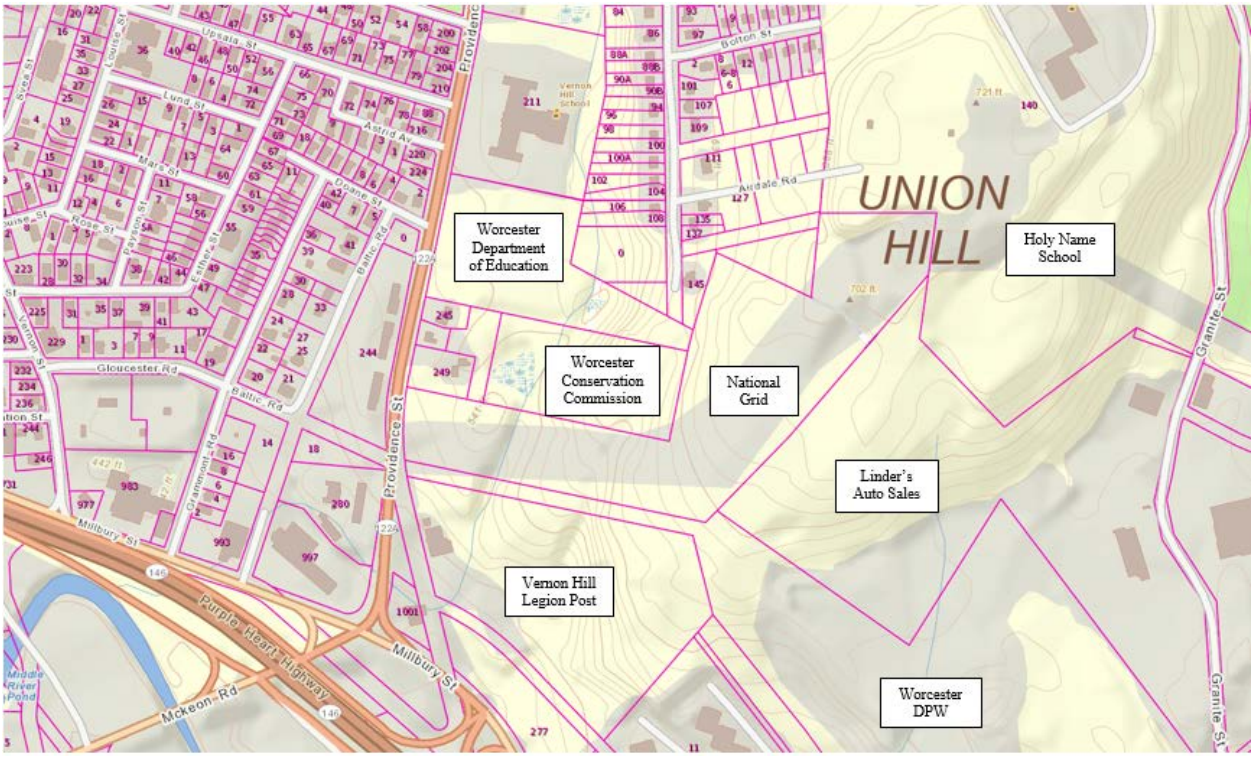



Figure 19: Land Ownership

This offers further justification for crossing underneath the power lines at this point. Crossing underneath the power lines would offer a trail user a spectacular view of the Blackstone River Valley, including the College of the Holy Cross and Worcester's Quinsigamond Village. After crossing underneath the power lines, the user would return to tree cover, setting them up for the third section of trail.

For section 3, we recommend the path outlined in yellow. This trail offers a user the opportunity to visit the small pond, seen in Figure 20, creating an opportunity to learn about the importance of wetlands. The pond represents a destination for potential trail users, which is something that casual trail users seek (Deb Cary Interview, 2015). The pond not only serves as a destination, but as a point to connect with the Vernon Hill School. There is an existing small path that connects the school to the pond, providing incentive to follow a path in that direction. In addition, the other option demonstrates several inadequacies. The terrain is extremely steep, and although rocky terrain is typically desired for its resistance to erosion, the rocks in this area can create a slick surface when combined with the steepness. Also, this option is located on land owned by the Vernon Hill American Legion Post and in the past they have demonstrated desires to develop the land, which makes the longevity of a trail uncertain.

**Figure 20: Small Pond**

Section 4 presents a number of difficulties in proposing the best route. In 2015, the trail represented in yellow is likely not a feasible option. While it offers a trail user the opportunity to cross the pedestrian bridge, a destination, the area as a whole is not desirable for a trail. The area is not aesthetically appealing, and in its current state, there are no sidewalks or crosswalks to make the path safe for users. However, the trail outlined in blue is extremely user friendly, as there are sidewalks and crosswalks all along the trail path. However, as the Blackstone Heritage Corridor Visitor Center is built, the Vernon Hill region will likely undergo a neighborhood restoration project, making a trail through that area much more appealing (Devon Kurtz Interview, 2015). This area is highlighted in the Figure 21. Also, the Heritage Corridor has proposed a bridge that crosses the Blackstone River, offering trail users another potential destination (Id.). If the trail was to be completed by 2015, we recommend using the trail outlined in blue, but as the Visitor Center is built and the Vernon Hill neighborhood is revitalized, the urban portion of the trail, section 4, should be revisited.


Figure 21: Vernon Hill Neighborhood

In addition, the trail should be marked in the same way the existing Broad Meadow Brook trails are marked. More specifically, because this trail is a continuation of the Sagatabscot Ridge Trail, it should follow the same system of blazes, a yellow diamond. On the wooded

portion of the trail, these blazes would be located on trees, but on the urban portion, telephone poles could serve as a substitute.

## Recommendation for Trail Improvements

The route previously outlined could be made into a better trail with a few improvements. Figure 22 shows a map labeled with points for improvement.

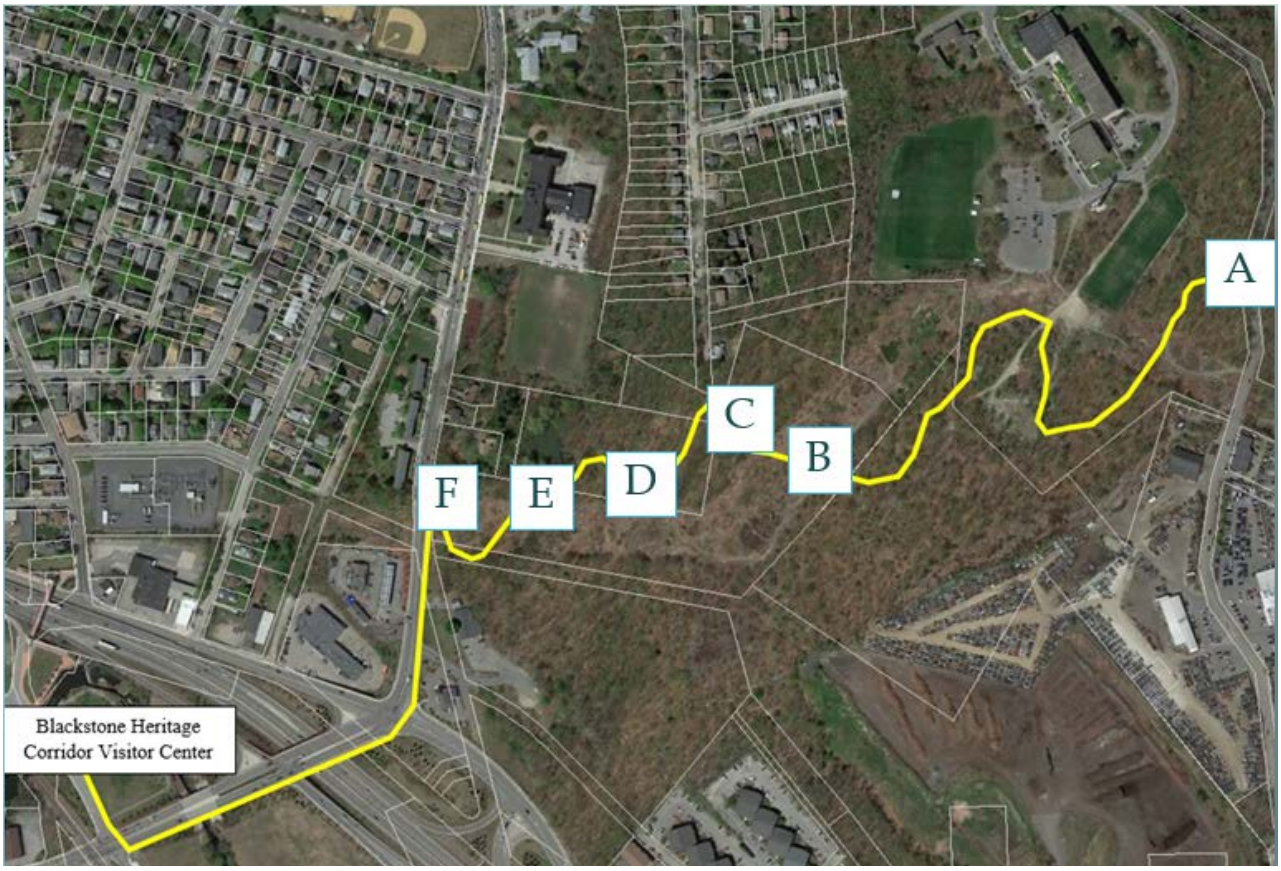



**Figure 22: Points for Improvement**

At point A, a crosswalk is needed on Granite St. This is necessary as a way for trail users to access both the existing Broad Meadow Brook trails and the new trail. To propose a new crosswalk, Broad Meadow Brook must submit a petition to the City Council. The petition is then referred to the Traffic and Parking Subcommittee. If the crosswalk is approved, it is then

scheduled on the pavement marking program (J.F. Borbone, Personal Communication, November 19, 2015).

At point B, there is the opportunity for a platform that would allow for better viewing of the Blackstone Valley. This platform offers trail users an opportunity to view the valley from a unique vantage point, and the abundance of large rocks in the area can provide hikers with a potential resting area. The view from this point can be seen in Figure 23.

**Figure 23: View of Blackstone River Valley**

Figure 24: Area Needing Rope Railing

At point C, the trail's path is relatively steep, rocky terrain. A picture of this area can be seen in Figure 24. To improve this area, a rope railing could be introduced to offer increased stability for trail users. Projects like this are often completed by volunteer groups, lowering any installation costs to Broad Meadow Brook or Mass Audubon (Joe Choiniere Interview, 2015).

Figure 25: Area Needing Water Bars

At point D, there is steep, worn terrain. Because of the steepness, the likelihood of continued erosion from rain water is increased. This area could be improved by adding water bars. Merriam-Webster defines a water bar as "a ridge made across a hill road to divert rain water to one side" (Merriam-Webster, 2015). These would make the trail easier to navigate and maintain. Much like at point C, this type of project is often completed by volunteers (Joe Choiniere Interview, 2015). This area can be seen in Figure 25.

At point E, there is a small stream that is difficult to cross in its current state. This area, pictured in Figure 26, could be improved by adding a small wooden foot bridge or perhaps a

Figure 26: Stream Crossing

stone crossing. A shallow stream ford would provide a crossing that is virtually maintenance free and capable of lasting for decades. See Appendix U for more information on how to build shallow stream fords. A crossing of this type could be built using the rocks adjacent to the stream and would likely provide a low-cost crossing that could be built by volunteers (Joe Choiniere Interview, 2015).

Point F represents a portion of the trail that could be made handicap-accessible. This would allow someone to come from the street to see the pond, creating a destination that is available to everyone.

## Environmental and Historical Features

In this section, we discuss our recommendations and justifications for the selection of the specific historical and environmental features we have chosen to highlight from those outlined in Table 7 from Section 4.5. We recommend educating trail users with features we highlight below mainly through a self-guided brochure. For discussion of this brochure and the additional interactive components we recommend, please see Section 4.7: Interactive Components.

### *Historical Features*

The Blackstone Valley Visitor Center is intended to, at its core, enhance the 'Worcester' experience. With the new Visitor Center, nearby park, and close by Revitalization Project, it is meant to bring a new natural experience to the city of Worcester, and thereby improve the quality of the city as a whole.

Much of the target audience of the trail and Visitor Center includes local Worcester residents who would benefit from being drawn into nature. As such, our historical approach is

two-pronged. Firstly, we recommend including the history of the Blackstone River Valley in both recommended and alternative educational components since the Visitor Center is a major portion of the trail's attraction. Secondly, we recommend including the history of Worcester as a draw for its residents. The educational material should focus on the city's heritage, and contain a positive tone indicative of its revitalization.

The historical approach is divided into three sections that describe the history of Worcester and the Blackstone River Valley. The first section is called 'Founding', where we describe the original Native American occupants, the first European settlers, and their eventual takeover. This is meant to evoke the nostalgia of historical reflection, and include the 'beginning' necessary when starting a historical account. The second section is 'Rise', when we detail the rise of Worcester and the Blackstone River Valley as an industrial power. This section focuses on immigration, industrialization, and most of all, progress! It is meant to evoke positive feelings of momentum for Worcester's citizens, and detail the most dynamic time in Worcester's history. The third section is 'Modern'. It details the most recent history contributing to the trail itself. It pertains to the history of Mass Audubon and Broad Meadow Brook. It should also include the history of the Blackstone Visitor Center if it is completed by the time a new educational component is developed (Worcester Historical Museum, Blackstone Heritage Corridor, 2015). This serves as both a justification of our educational content, and a guide for future educational materials.

### *Environmental Features*

The environmental portion of the recommended educational component is divided into four 'Habitats'. The purpose behind this format is to engage trail users, especially students, with the educational opportunities on the trail. They were also recommended by Martha Gach and Deb Carey (see Findings 4.5). Habitats are clear, and easy to engage with. We predicted that

since they are always in the same place, simple to notice, and dense in educational material, they are optimal materials for engaging children. We chose the following 'habitats' because they exhibit unique environmental features. The habitats we recommend include, firstly, the 'Deep Marsh' (or 'Pond'). We included this habitat because the body of water at its center provides a unique natural experience not found in any other area along the trail. This habitat includes the 'Cinnamon Fern'. A plant whose special properties inspire simple and engaging activities. It grows precisely along the line where the wetland meets the dry soil (Joe Choiniere Interview, 2015). Students can trace this line to uncover exactly where the wetland begins and dry land ends. For both the spectacle of the pond, and its natural uniqueness, we recommend the Deep Marsh as a habitat to be included in future educational components.

The second habitat we recommend is the 'Plain under the Power Lines'. While this habitat is not entirely 'natural', its distinctiveness provides a unique experience for trail users. It also shows how nature can adapt to human interference. In this case, the trees stop growing, and as a result of the free space, 'Little Bluestem' plants flourish throughout the area (Id.). The third habitat we recommend is the 'Black Oak Savanna'. This habitat is more subtle than the first two, and requires more searching to find. However it certainly redeems itself with its 'cool factor'. We believe that trees which adapt to wildfires provide a unique educational perspective that makes one rethink nature's capabilities, since it can adapt to something as universally destructive as fire.

The fourth habitat, 'The Woods' is the most general and common environment of the area. It should be included because it is the most prevalent. It possesses diverse forms of wildlife such as many species of birds and butterflies, and its trees are often scratched by deer or nibbled on by other wildlife. These diverse types of trees lend themselves to the most interactive activity.

Broad Meadow Brook staff often employ an activity where children identify Black Oak, White Oak, Scarlet Oak, and Red Oak by their leaves. This entails walking, searching, and a proactive attitude towards discovering nature (Id.). In summary, the pond, plain, savanna, and woods are all interesting and engaging habitats, and we recommend they are utilized in future educational components along the trail.

## Interactive Components

The interactive, educational components we recommend to accompany this trail are detailed in the following sections. Based on our research and findings, we recommend a self-guided brochure, an information kiosk, a viewing platform, a geocache, and eventually, as the trail becomes more popular, guided nature walks.

### *Self-Guided Brochure*

We recommend a self-guided brochure to go along with the trail because we found that it is an effective and low-cost educational method that does not have the potential to be vandalized as signposts do. Figure 27**,** Figure 28**,** and Figure 29**,** show a draft brochure BMB might use. For a more detailed view of the brochure, see Appendix V.

The brochure is an 11" x 17" tri-fold which includes a map, detailed information about key wildlife and historical features along the trail, and information about both the BMB Wildlife Sanctuary and the Blackstone Visitor Center. It includes a Quick Response (QR) Code for visitors to access it on their Smartphones. The electronic version also has the potential to be easily updated and include more detailed information for those that want it. We recommend that copies of this brochure be kept at both Visitor Centers.

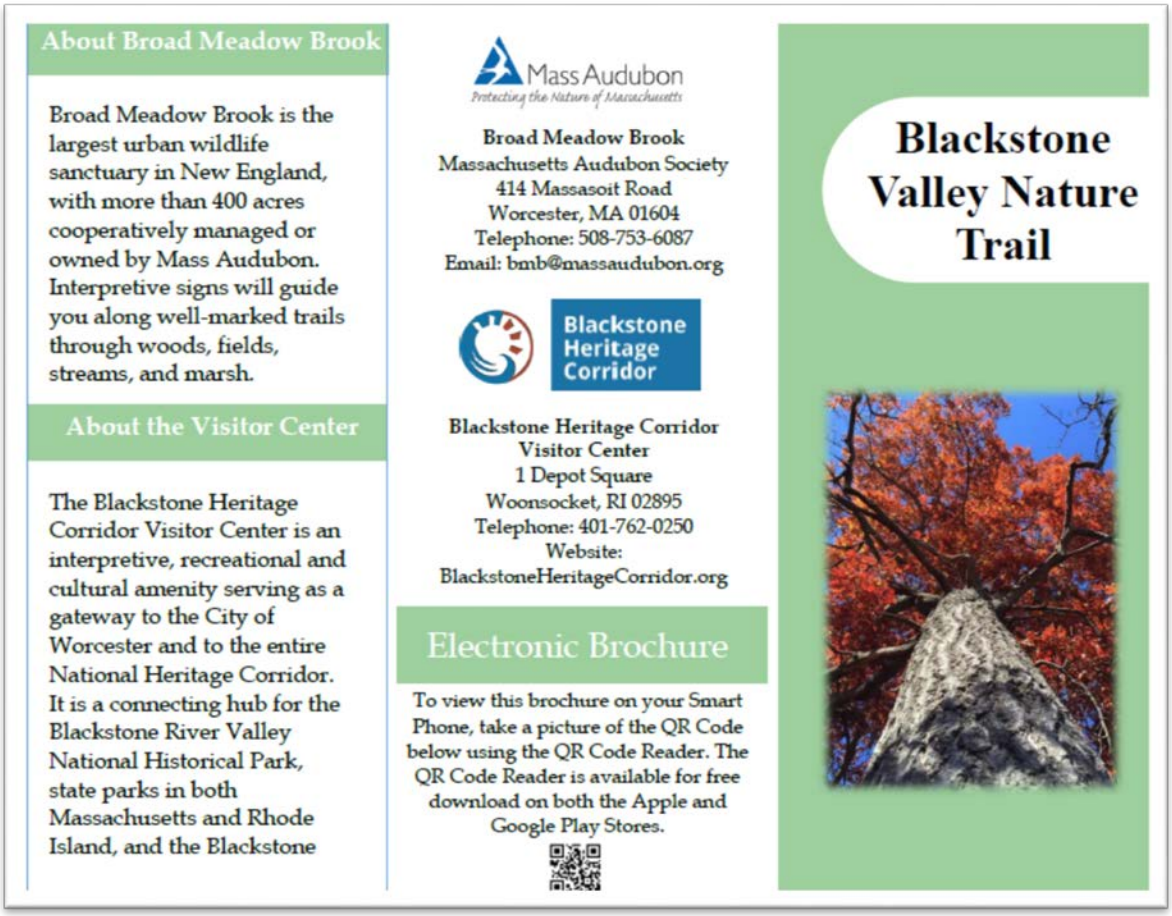



Figure 27: Brochure Cover, Back, and Side Panels

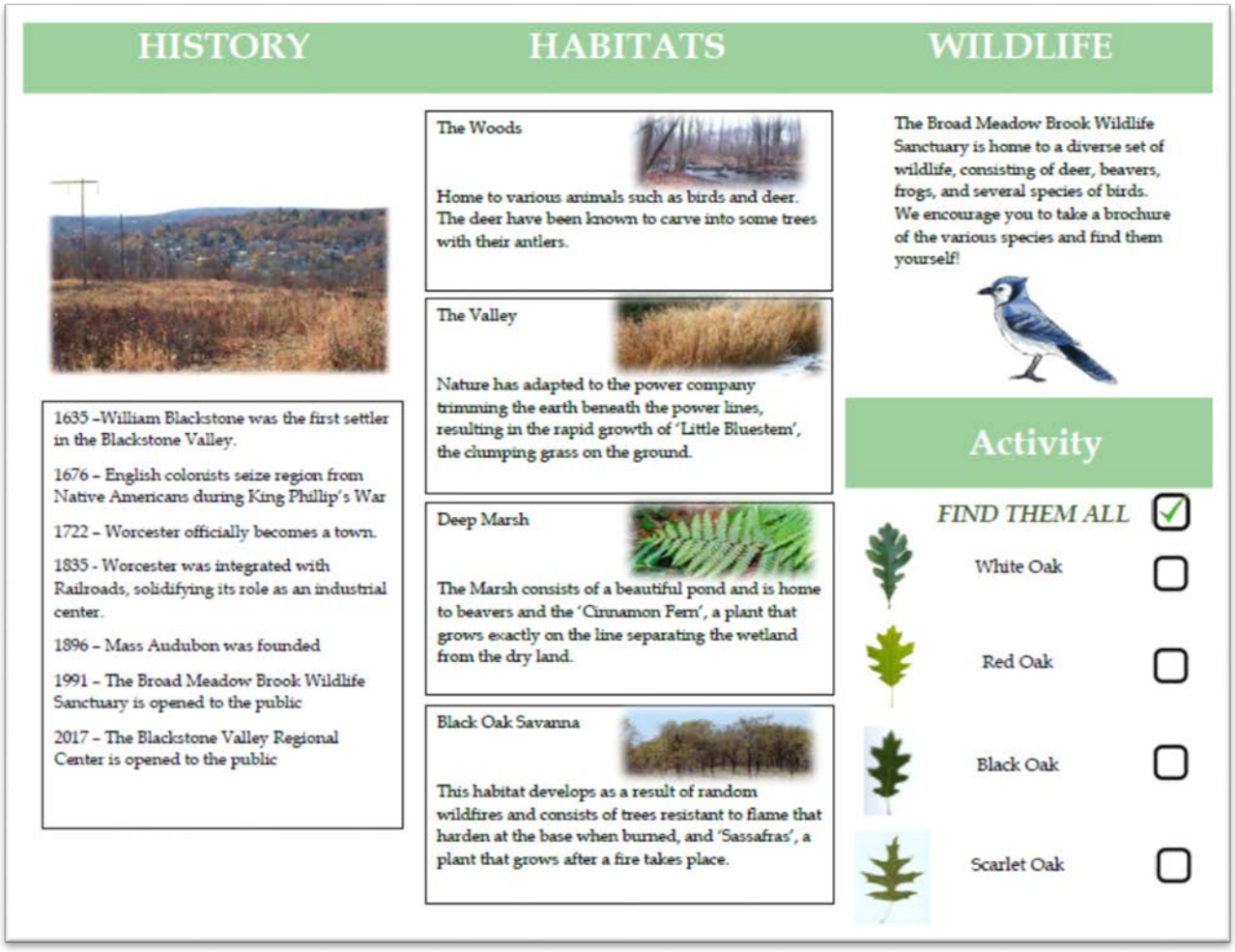



Figure 28: Brochure Interior Panels


**Figure 29: Brochure Trail Map**

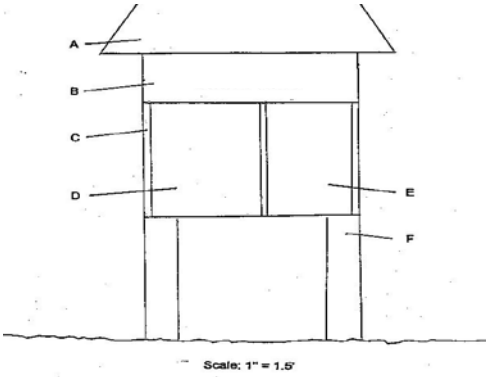
### *Guided Nature Walks*

Once the Blackstone Visitor Center has been built and is open to the public, there may be potential for guided nature tours along this trail starting from the Blackstone Visitor Center. We recommend these walks start at the Blackstone Visitor Center as this center will potentially attract more visitors due to the bike path, museum, and state park. As discussed in the sections above, we found that guided walks are the most effective education method. Tour guides would walk a group of people along the trail, highlighting its key features and answering questions people have about things they see. This recommendation component is dependent on the popularity of the trail once the Blackstone Visitor Center is open. Broad Meadow Brook would also have to hire staff or volunteers to guide these walks to make this component a reality. As discussed in the findings above, guided nature walks are a worthwhile investment and an

excellent way to expose people to nature and to use children's curiosities to let them explore, question, and learn. The incorporation of guided nature walks, along with the brochure, would be ideal.

### *Kiosk*

We also recommend a kiosk at the trailhead where the street trail meets the natural surface trail on Providence St. (where section 3 transitions to section 4). This kiosk will inform people of the trailhead and where the nature trail begins. The kiosk will have a picture of the map and a description of the trail, some of its features, and both visitor centers. Figure 30**,** shows what this kiosk might look like. Appalachian Trails use this type of kiosk and attempt to develop and implement standards for signage and kiosks along hiking and biking trails (Appalachian Trails, 2015). For a more detailed description of the materials and costs of this type of kiosk, please see Appendix T.




A. Roof
B. Nature Trail Heading
C. Information Board
D. Trail Map behind Plexiglas
E. Area for information about

**Figure 30: Sample Kiosk (Appalachian Trails)**

The chosen location is right next to a bus stop and across from a gas station. People getting off the bus or stopping at the gas station will see the kiosk and become interested, potentially increasing the amount of people who use the trail. The kiosk also has less of a chance for vandalism because it is out in the open in a busy area on Providence St. (Devon Kurtz Interview, 2015).

### *Viewing Platform*

We also recommend a viewing platform made of rock or concrete where the trail crosses under the power lines. We recommend using a granite slab to tie in with the history of the granite quarries along the trail. This platform would most likely only be found by those looking for it while walking the trail and therefore, has little potential to be vandalized. The viewing platform would be flush to the ground and have arrows on it pointing up and down the power lines in the directions of the wind turbine and the view of the valley, respectively. Figure 31 shows what this viewing platform might look like.

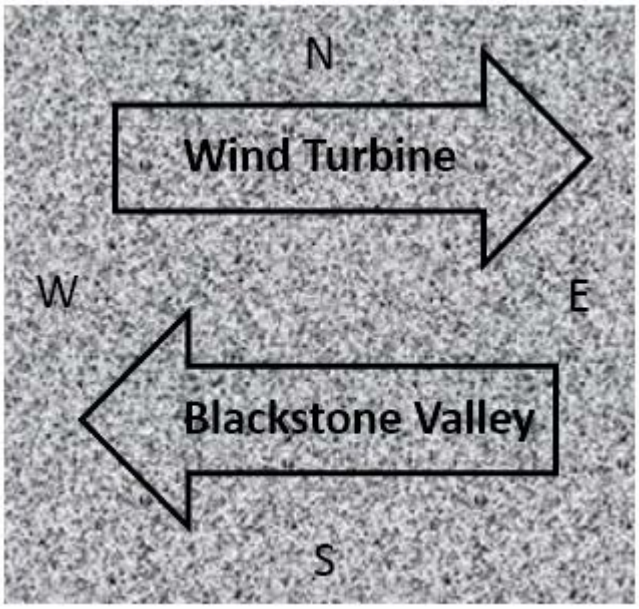



**Figure 31: Granite Viewing Platform**

This platform will be located in an area where there are multiple large rocks, providing people with the opportunity to take a break and children to play or climb on the large boulders.

### *Geocache*

There is also an opportunity to incorporate a geocache along the trail. A geocache is a small waterproof container with a logbook and small items, such as matchbox cars, a deck of cards, or small toys (Geocaching, 2015). Geocachers can obtain the box coordinates from the Geocaching website or mobile app (Id.). In order to set up the geocache container, we recommend using a Garmin eTrex HCX Vista, the same Global Positioning System (GPS) we used to map the trail, because it has a feature that allows you to upload geocache coordinates directly. The geocache activity acts as a similar scavenger hunt activity to that described in the Gruffalo Trails case study (described in Chapter 2.4), which attracted children and families to the trails in the United Kingdom. We believe the best location for this geocache would be somewhere in the northern section of the power lines, as you enter the woods when coming from Granite St. This is one area that we have not proposed as a destination, like the pond or black oak savanna, and the geocache has the potential to add excitement to this section of the trail. We recommend a small plastic box or an official geocache container which can be purchased on Geocaching.com to act as a geocache box. Figure 32, shows a sample, Official Geocache container set.


**Figure 32: Official Geocache Containers (Geocaching)**

## 4.8 Conclusion

Mass Audubon tasked us with examining potential trail routes connecting the existing trail network of the Broad Meadow Brook Wildlife Sanctuary to the future site of the Blackstone Heritage Corridor Visitor Center in Worcester, Massachusetts. This trail would be used to educate residents and visitors, alike, of the nature and history of the region. We determined the area's landowners and physical features to determine the best possible trail route and interpretive aspects. A trail connecting the two locations would help connect the people of Worcester to the world around them.

As a result of research, we have determined that the ideal way to connect residents and visitors with the natural areas surrounding Worcester is through the trail outlined in Section 4.7. We recommend that this trail feature multiple scenic view points and an accompanying brochure to educate the trail's users of the nature and history around them. In addition, connections can be made to the surrounding schools as a way to build community partnerships through the trail.

Because the Blackstone Heritage Corridor will not to be complete until 2017, the urban area of the trail will likely undergo changes. As such, the trail, too, should allow for change. A crucial element of the trail's success will be how user-friendly it is. Although the trail cannot be made entirely handicap-accessible, certain portions of the trail could be modified to accommodate certain needs. A trail capable of adapting to meet the changing needs of the user will be most successful in educating the residents and visitors of Worcester as well as connecting them to the community. We recommend an adaptable trail that can change and adapt over time. The trail we proposed is the first step and conduit in improving and developing the city of Worcester by integrating it with nature and the future Blackstone Valley Visitor Center.

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# Appendices

## Appendix A: Description of Different Trail Grades

**Table 9: Description of Different Trail Grades (Rathke, Baughman, 2007)**

| Percent Grade | Description |
|---|---|
| 0 to 2 | Nearly level |
| 3 to 6 | Gently sloping |
| 7 to 12 | Moderately sloping |
| 13 to 18 | Moderately steep |
| 19 to 25 | Steep |
| 26 and greater | Very steep |

## Appendix B: Soil Textual Classes

**Table 10: Soil Textual Classes (Rathke, Baughman, 2007)**

| Soil Texture | Identification |
|---|---|
| Sand | Loose and gritty. Will not form a ball. |
| Loam | Smooth (flour-like), but slightly gritty. Forms a ball, but ribbon usually breaks easily. |
| Silt | Smooth like flour, no grittiness. Forms ribbon that breaks under its own weight. |
| Clay | Smooth and sticky when wet. Forms ribbon that is long and pliable. |
| Organic (peat, muck) | High amount of decomposed material and water. Black to brown colors. Wetlands, low areas. |

## Appendix C: Filter Strip Width Guides for Trails

**Table 11: Filter Strip Width Guide for Trails (Rathke, Baughman, 2007)**

| Land Grade Between Trail and Body of Water (percent) | Recommended Filter Strip Width (feet) |
|---|---|
| 0 to 1 | 25 |
| 2 to 10 | 30 to 50 |
| 11 to 20 | 51 to 70 |
| 21 to 40 | 71 to 110 |
| 41 to 70 | 111 to 170 |

# Appendix D: Recommended Trail Standards

**Table 12: Recommended Trail Standards (Rathke, Baughman, 2007)**

**Hiking**

- **Trail Layout**
  Trail patterns vary depending on the expectations of the trail user. Day users tend to favor a loop or a series of loops. Design trails to cover a variety of vegetation, land forms, and sights. Frequently occurring curves and grade changes will add interest. Short spur trails may be used to access waterways and summits.
- **Length**
  Hikers travel at 1 to 3 miles per hour depending on the terrain and their ability. Hiking trails should be long enough to afford a meaningful recreational experience and short enough to suit a hiker's ability. Internal connector trails and cutoffs can be used to offer different trail lengths.

  Day use: 1/4 to 5 miles (1/2 day)
  5 to 15 miles (full day)

  Backpacking: 25 or more miles

- **Clearing Width**
  Vary clearing widths to avoid the tunnel effect and promote a variety of trail environments such as woodland flowers, meadow openings, and woodland edges. Trails generally should narrow on steep slopes to a minimum width of 3 feet.

  Light use: 4 to 6 feet (one-way traffic)

  Heavy use: 7 to 10 feet (two-way traffic)

- **Clearing Height**
  8 feet. Additional clearance may be needed to compensate for extended backpacks and branches drooping with heavy rain or snow.
- **Tread Width**

  Light use: 2 to 3 feet (one-way traffic)

  Heavy use: 4 to 6 feet (two-way traffic)

- **Trail Surface**

  Light use: Natural with gravel or corduroy used in wet areas

  Heavy use: Natural if possible; woodchips or gravel

- **Turning Radius**
  Turning radius is not critical; however, gentle curves are aesthetically pleasing and easier to maintain. Shortcut trails often will develop prior to sharp-angled turns. Straight sections usually should not exceed 100 feet.
- **Percent Grade**
  Grades exceeding 10 percent are difficult for hikers to sustain and, without additional protection, erosion problems often will develop. Steps, switchbacks, or water bars may be needed on slopes over 25 percent. Occasional grade changes and dips should be incorporated into the trail layout to promote user interest and facilitate natural drainage.

  Desired: 0 to 5%

  Maximum: 15% (sustained)
  40% (shorter than 50 yards)

  Outslope: 4% (maximum)

- **Sight Distance**
  Sight distances are not especially critical on hiking trails. However, motorized road crossings must be carefully located and designed to ensure that trail users and vehicle drivers have good sight distances in all directions.
- **Water Crossings**
  Structures for crossing water depend on the flow and length of the crossing and expectations of the hiker - almost all methods will accommodate foot traffic.

  Bridges: Must be located above ordinary high water mark or cabled at one end to prevent washout.

  Width:

  2 to 4 feet (light use)
  5 to 6 feet (heavy use)
  8 feet or more (maintenance vehicles)

  Weight capacity:

  Variable depending on maintenance equipment, bridge length, and alternative trail uses

  Fords: Slow moving water less than 24 inches in depth may be forded. Rocks and stepping stones may be used to assist hikers.

## Appendix E: Accessible Trail Standards

**Table 13: Accessible Trail Standards (Macdonald, 2014)**

| | |
|---|---|
| **Clear Tread Width** | 36" minimum |
| **Tread Obstacles** | 2" high maximum (up to 3" high where running and cross slopes are 5% or less) |
| **Cross Slope** | 5% max |
| **Grade** | Meets one or more of the following:<br>- 5% or less for any distance.<br>- up to 8.33% for 200' max. Resting intervals no more than 200' apart.<br>- up to10% for 30' max. Resting intervals 30'.<br>- up to 12.5% for 10' max. Resting intervals 10'.<br><br>*No more than 30% of the total trail length may exceed a running slope of 8.33%. |
| **Passing Space** | Provided at least every 1000' where trail width is less than 60" |
| **Signs** | Shall be provided indicating the length of the accessible trail segment. |

## Appendix F: Common Trail Construction Tools

**Table 14: Common Trail Construction Tools (Bike Fat, 2012)**

| Tool | Description/Typical Use | Picture |
|---|---|---|
| **Chainsaw** | Power tool for cutting through heaving brush; can be a dangerous tool and a bit noisy; remember to wear proper protective gear |  |
| **Pruning Shears** | Great for maintenance along a trail for cutting back overgrown brush |  |
| **Pulaski** | Tool with axe blade on one side and a grub hoe on the other; great for breaking dirt, cutting roots and stumps, cutting logs, and carving out a trail |  |
| **Bow Saw** | Good for cutting logs and clearing brush; a quiet substitute for a chainsaw |  |

| | | |
|---|---|---|
| **Rock Bar** | Great for prying out rocks, logs, and stumps |  |
| **Shovel** | Simple tool used to dig and move dirt |  |
| **Macleod** | One of the most popular for trail building; usually used last to go over the trail tread |  |
| **Pick Axe** | Great for loosening up soil and scooping it out with the scoop end |  |
| **Wheelbarrow** | Great for moving dirt, rocks, or other things while working |  |

| | | |
|---|---|---|
| **Flagging Tape** | A great way to mark the proposed route of the trail |  |
| **Clinometers** | A tool used to determine the slope or grade in percent between two points |  |
| **GPS Receiver** | A great tool for mapping out a trail using technology |  |

## Appendix G: Conditions for Departure from ADA Rules

**Table 15: Forest Service's "Conditions for Departure" from ADA Rules (Forest Service, 2006)**

| | |
|---|---|
| **Condition 1** | Where compliance would cause substantial harm to cultural, historic, religious, or significant natural features or characteristics. |
| **Condition 2** | Where compliance would substantially change the physical or recreation setting or the trail class, designed use, or managed use of a trail or trail segment or would not be consistent with the applicable land management plan. |
| **Condition 3** | Where compliance would require construction methods or materials that are prohibited by federal, state, or local law, other than state or local law whose sole purpose is to prohibit use by persons with disabilities. |
| **Condition 4** | Where compliance would be impractical due to terrain or prevailing construction practices. |

## Appendix H: Determining Trail Features during Development Process

**Table 16: Matrix for Determining Trail Features during Development Process**

| Features | Feasibility | Cost | Likelihood of increasing use |
|---|---|---|---|
| Length | | | |
| Width | | | |
| Surface | | | |
| Grade | | | |
| Roundness | | | |
| Same Start/End Location | | | |
| Wheelchair Accessible | | | |
| Educational/Interactive Components | | | |

## Appendix I: Interview Questions with Broad Meadow Brook Staff to Determine Trail Demographic

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Educational Material as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. Who currently uses Broad Meadow Brook trails the most?
2. Do you anticipate these same people will use this new trail?
3. Do you anticipate any new groups of people using this new trail due to location?
4. Would you like us to choose a trail route that meets the needs of a specific audience?
    a. Children
    b. Experienced hikers

**What we hoped to find out:**

- Current trail users
- Target demographic for new trail

Appendix J: Survey

# Worcester Polytechnic Institute Survey of Broad Meadow Brook Trail Users

We are a group of students from Worcester Polytechnic Institute (WPI) in Massachusetts. We are conducting a survey of Broad Meadow Brook trail users to learn more about their opinions of existing trails. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this survey is completely voluntary and you may withdraw at any time. Please remember that your answers will remain anonymous. No names or identifying information will appear on the questionnaires or in any of the project reports or publications. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study.

If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu

You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu

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1.) How old are you?

◯ 18-24 ◯ 25-34 ◯ 35-54 ◯ 55-64 ◯ 65+

2.) Which trail(s) have you walked at Broad Meadow Brook? (Please check all that apply)

| | | |
|---|---|---|
| ☐ Blue Well | ☐ Cardinal | ☐ Enchanted Forest |
| ☐ Frog pond | ☐ Holdredge | ☐ Lady Slipper |
| ☐ North Link | ☐ Piggery | ☐ Power line |
| ☐ Sagatabscot Ridge | ☐ Sensory | ☐ Smiley Face |
| ☐ Sprague | ☐ Troiano Brookside | ☐ Wilson Meadow Link |

Questions 3 and 4 relate to your most recently hiked trail.

Most Recently Hiked Trail: _____

3.) How clear were the start/endpoints of the trail?

◯ Very Clear ◯ Clear ◯ Somewhat clear ◯ Unclear ◯ Very Unclear

*Please continue on back…*

4.) How clear were the markers throughout the trail?

◯ Very Clear ◯ Clear ◯ Somewhat clear ◯ Unclear ◯ Very Unclear

5.) What would you like to learn about while you hike on trails? (Check all that apply)

Wildlife ☐

Plant Life ☐

History of the Land ☐

History of the Area ☐

Other: _____

6.) How would you like to obtain trail information (maps, educational info, etc.) in the future? (Check all that apply)

☐ Guided Audio Tour ☐ Personal Tour Guide ☐ Brochure

☐ Interactive Signs ☐ Other: _____

7.) Would you recommend Broad Meadow Brook to your friends?

◯ Yes

◯ No

Why or why not?

_____

Any additional comments/suggestions?

_____

**Thank you for your participation in this survey!**

## Appendix K: Interview Questions with Melinda Learning, Teacher and Environmental Education Expert

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to learn about educational methods as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. Start with brief elevator pitch of our project
2. We saw that you won an award for your efforts in Environmental Education. Congratulations!
3. What methods do you think work best when teaching children about the environment?
4. Are there any specific environmental issues you suggest focusing on for including along a nature trail?
5. Based on your experiences in the past, how would you recommend we go about developing educational material for our trail?
6. Could you discuss your past projects with the students on the trail?
7. How much has the trail changed over time?
8. Do you have any recommendations for any sources we should look into or any people we should contact?
    a. Would you mind us using your name when contacting them?

**What we hoped to find out:**

- Ideas for unique educational methods
- Ideas for areas of focus
- Potential new contacts/resources

## Appendix L: Interview Questions with Howie Fain, Teacher from Worcester East Middle School

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Educational Material as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. Tell us about your experience on the trails last year.
2. How many students did you bring along with you?
    a. How old were they?
    b. Did they volunteer to walk the trail or was it part of a class?
3. We understand you may have gotten lost while walking. Could you explain where you think you began to stray off the trails?
4. Was there anything in particular that the students seemed interested in while walking the trail?
5. Did you think the trail was too easy or too difficult to walk for yourself or the students?

## Appendix M: Interview Questions with Surrounding School Officials to Connect Trail to Students

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Educational Material as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. We believe that a trail near your school could help connect your students with nature. Is there any environmentally based curriculum you currently teach?
2. Do you think that your students would be interested in using a trail to discover nature?
3. Would your teachers be willing to use the trail to educate students beyond the classroom?
4. What do you think the students would be interested in learning on a trail like this?
5. Do you have any concerns about the trail being so close to your school?

## Appendix N: Interview Questions with Broad Meadow Brook Staff to Determine Most Effective Educational Method

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine the most effective educational methods as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. We understand a big component of many of the trails at Broad Meadow Brook is education. Could you talk about some of the ways you educate here at Broad Meadow Brook?
2. From your experiences here, what methods do you think work best?
3. We understand signposts are not a feasible option due to possible vandalism. Are there any other educational methods you think we should stay away from for this trail?
4. What do you think might be the most effective for this new trail (brochure, scavenger hunt, etc.)?

What we need to know:

- Educational methods to avoid
- Methods currently used at Broad Meadow Brook
- Most successful methods on other trails

## Appendix O: Interview Questions with Melinda Learning, Teacher and Environmental Education Expert

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to learn about educational methods as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. Start with brief elevator pitch of our project
2. We saw that you won an award for your efforts in Environmental Education. Congratulations!
3. What methods do you think work best when teaching children about the environment?
4. Are there any specific environmental issues you suggest focusing on for including along a nature trail?
5. Based on your experiences in the past, how would you recommend we go about developing educational material for our trail?
6. Could you discuss your past projects with the students on the trail?
7. How much has the trail changed over time?
8. Do you have any recommendations for any sources we should look into or any people we should contact?
    a. Would you mind us using your name when contacting them?

**What we hoped to find out:**

- Ideas for unique educational methods
- Ideas for areas of focus
- Potential new contacts/resources

## Appendix P: Interview Questions with Broad Meadow Brook Staff to Determine Educational Material

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Educational Material as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu

**Interview Questions:**

1. Could you talk briefly about some of the unique wildlife features in Worcester, MA and particularly the area of this new trail?
2. Are there any insects, animals, or plants that people may be interested in learning about?
3. What other environmental features do you think we should try to highlight along the trail?
4. We are planning to visit the Worcester Historical Museum to find out the history of the land along the trail. Do you think this is something people might enjoy learning about?

**What we hoped to find out:**

- Unique wildlife features that might interest people
- Areas to highlight along the trail

## Appendix Q: Interview Questions with Devon Kurtz, Project Manager of Blackstone Visitor Center

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Educational Material as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. Trail – talk about our proposed trail
    a. Do you know about Mass Audubon's plans?
    b. What is your relationship with Mass Audubon?
    c. Interest in interview for video
    d. Interest in providing him with our video to play in visitor center
2. Plans for visitor center
    a. We heard that the historical museum was involved with the visitor center. What is going to be inside?
    b. We noticed there is no crosswalk currently from the site of the visitor center across the street to Wal-Mart. Do you know if there are any plans to put one in there?
    c. Who do you hope will use the visitor center?
3. We understand that construction is set to begin in 2016. Do you have an updated timeline for building and opening the visitor center?

## Appendix R: Interview Questions with Broad Meadow Brook Staff to Determine Mass Audubon's GPS Methods

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Mass Audubon's GPS methods as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. We know you have maps of all the trails here at Broad Meadow Brook. How do you typically GPS the trails here?
2. Should we use the same method and equipment you currently use here for the new trail?
3. How long do you think it will take to GPS map our trail?
4. Do you have any recommendations for overlaying GPS trail routes with property maps?

**What we hoped to find out:**

- Current GPS method
- Do we need to figure out how to GPS on our own or can we use Broad Meadow Brook's methods and equipment
- Time estimate for GPS'ing new trail

## Appendix S: Interview Questions with Joe Choiniere, Property Manager at Broad Meadow Brook

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting this interview to determine Educational Material as a way to create a strong foundation for the establishment of a new trail. We strongly believe this kind of research will ultimately enhance the trail users experience and the long-term success of future trails. Your participation in this interview is completely voluntary and you may withdraw at any time. If you desire, we will keep your identity confidential. This is a collaborative project between Mass Audubon and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study. If you have specific questions about this research please feel free to contact us at: audubon-15b3@wpi.edu. You may also contact our WPI project advisors, Corey Dehner and Melissa Belz, at cdehner@wpi.edu and mbelz@wpi.edu.

**Interview Questions:**

1. Can you talk about your role at Broad Meadow Brook?
2. How much maintenance is required on the trail?
3. What type of trail markers (blazes) do you typically use?
4. Does that change as you get farther from the sanctuary?
5. What type of information do you think people like to learn about on the trail?
6. Do you know of any significant features of the trail past Granite St. that you think are important to note?
7. Are there any features you particularly look for on a trail?

**Other we planned to discuss:**

- The stream near the pond (Potential for a small bridge)
    - The change in the pond as the result of weather
- Clearing Paths vs. Adjusting Path to follow existing trails

## Appendix T: Kiosk Design Option

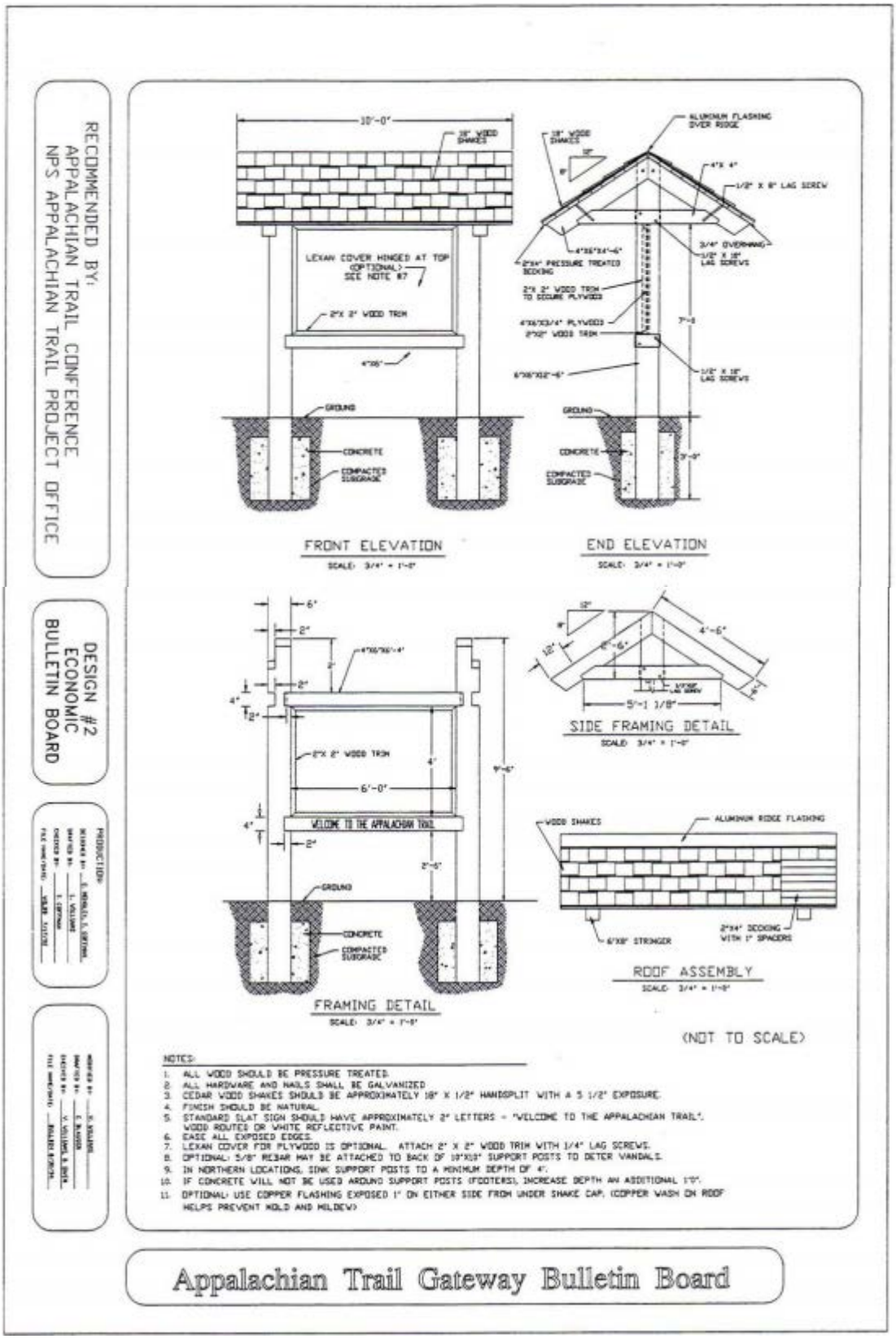


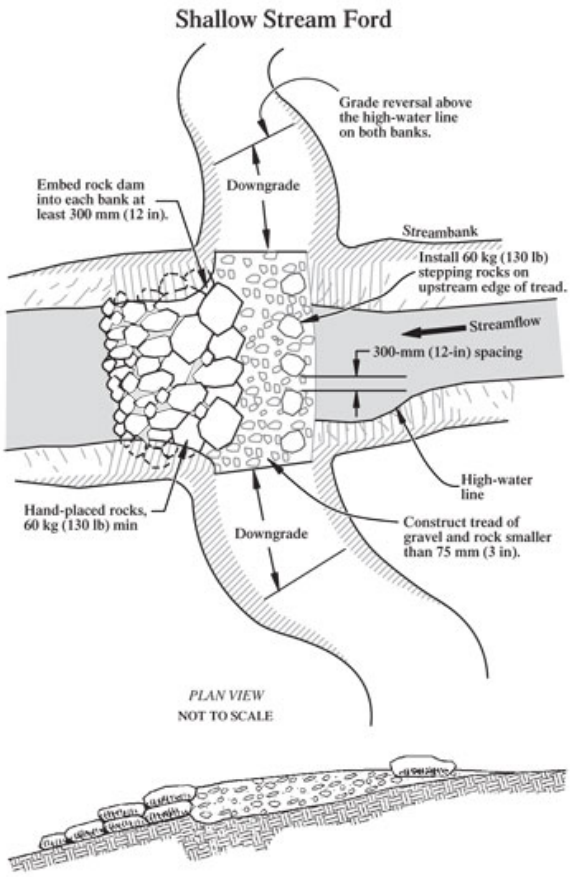

**Figure 33: Sample Kiosk Design (Appalachian Trails, 2012)**

| # Needed | Material | Approximate Cost |
|---|---|---|
| 2 | 6"x 6" x 12'6" pressure treated lumber (support posts) | 70.00 |
| 4 | 4" x 6" x 4'6" pressure treated lumber | 60.00 |
| 2 | 4" x 6" x 5' pressure treated lumber (rafters) | 30.00 |
| 2 | 4" x 6" x 6'4" pressure treated lumber (horizontal beams) | 30.00 |
| 1 | 6' x 4' x ¾' plywood panel | 28.00 |
| 1 | 6' x 4' x ¼" Lexan® | 240.00 |
| 2 | 2" x 2" x 4' pressure treated board (panel frame) | 7.00 |
| 2 | 2" x 2" x 6' pressure treated board (panel frame) | 7.00 |
| 1 | 15" (minimum) x 10' aluminum ridge flashing | 27.00 |
| approx. 18 | 2" x 4" pressure treated boards (roof frame) | 70.00 |
| as needed | Wood shakes, triple overlay, approx. 5" – 6" exposed (100 sq. ft.) | 600.00 |
| 12 | ½" x 10" lag screws | 60.00 |
| 18 | ¼" x 4" lag screws (panel frame) | 18.00 |
| 8 | ½" x 8" lag screws | 24.00 |
| 2 | 5/8" x 3' rebar minimum (optional; to attach to back or side of posts to deter vandals from using chainsaw on support posts) | 13.00 |
| as needed | Galvanized nails to attach 2" x 4" roof frame | 5.00 |
| as needed | Galvanized nails to attach wood shakes on roof | 5.00 |
| 12 | 60-pound bags of ready-mix concrete (optional; can be poured dry or wet around base of support posts to add stability) | 50.00 |
| 8 | 12" bridge spikes or lag bolts (optional: can be pounded or nailed near base of support posts, below grade, to add stability) | 7.00 |
| | **Total Cost** | **$1,351.00** |

Note: Costs are estimates only, based on 2012 pricing; prices may vary significantly by locale.
Note: Larger-dimension lumber may have to be special-ordered from a sawmill.
Note: Taxes are not included in this estimate.

Figure 34: Sample Kiosk Bill of Materials (Appalachian Trails, 2012)

## Appendix U: Shallow Stream Ford




Drawing of a trail that uses a ford in order for hikers to cross a stream entitled 'Shallow Stream Ford'. The drawing is a plan view and is not to scale. Various items are labeled in the drawing which are as follows:

- The 'Downgrade' of the trail going into the stream is labeled on both sides of the stream with arrows showing the length of the downgrade.
- The top of the downgrade is labeled with the text 'Grade reversal above the high-water line on both banks.' and an arrow is used to show the location.
- Rocks that were stacked to create a dam are labeled with an arrow and the text 'Embed rock dam into each bank at least 300 mm (12 in). The rocks for the dam are also labeled with the text 'Hand-placed rocks, 60 kg (130lb min).
- The bank of the stream is labeled with the text 'Streambank'.
- The 'Streamflow' is labeled with text and an arrow showing the direction of flow.
- The 'High-water line' is labeled with text and an arrow.
- The bottom layer of rocks for the ford are labeled with an arrow showing their location and the text 'Construct tread of gravel and rock smaller than 75 mm (3 in).'
- Larger rocks are used as stepping stone for hikers to get past the stream. They are shown with an arrow and labeled with the text 'Install 60 kg (130 lb) stepping rocks on upstream edge of tread.

**Figure 35: Shallow Stream Ford (Forest Service)**

## Appendix V: Self-Guided Brochure

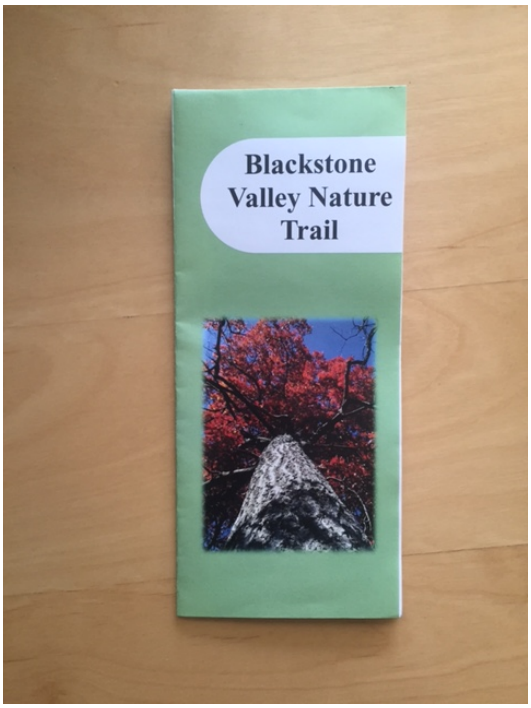



**Figure 36: Brochure Cover**

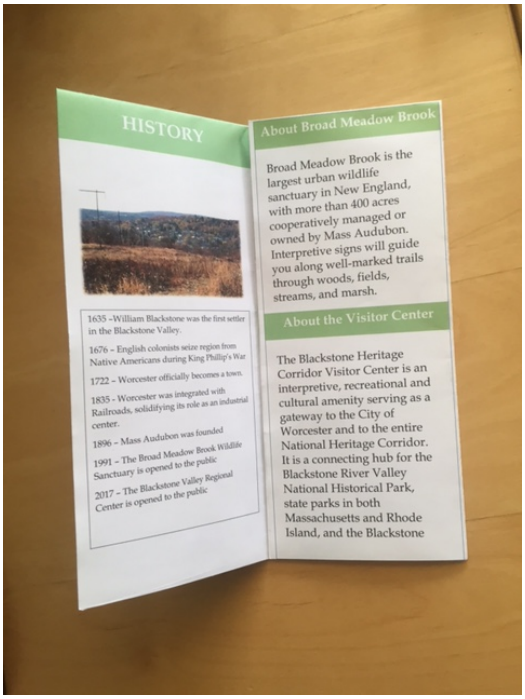



**Figure 37: Brochure One Open**

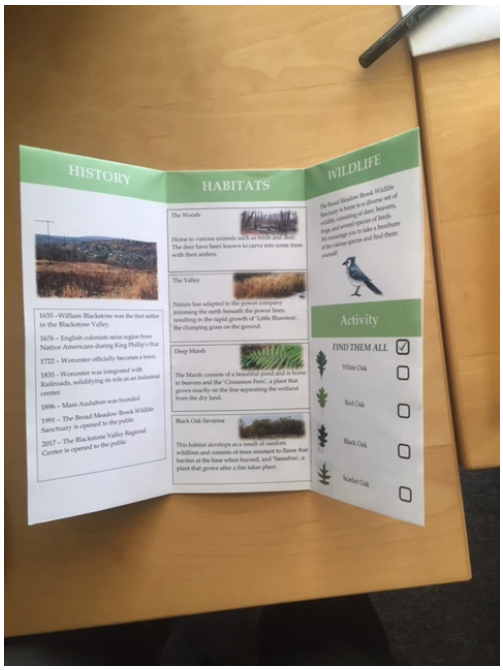



**Figure 38: Brochure Two Opens Inside**

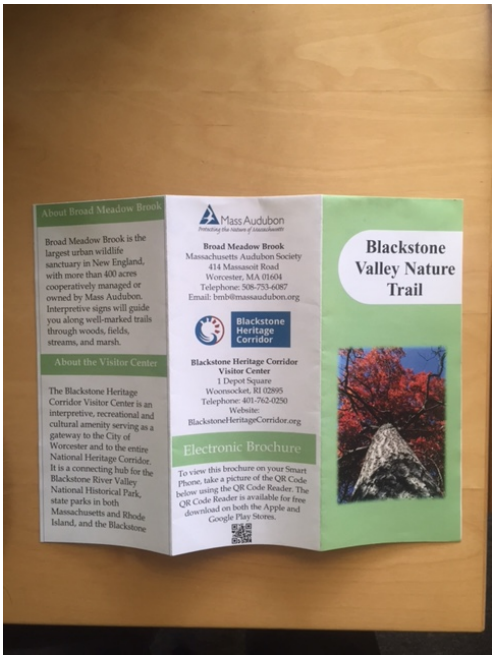



**Figure 39: Brochure Two Opens Backside**

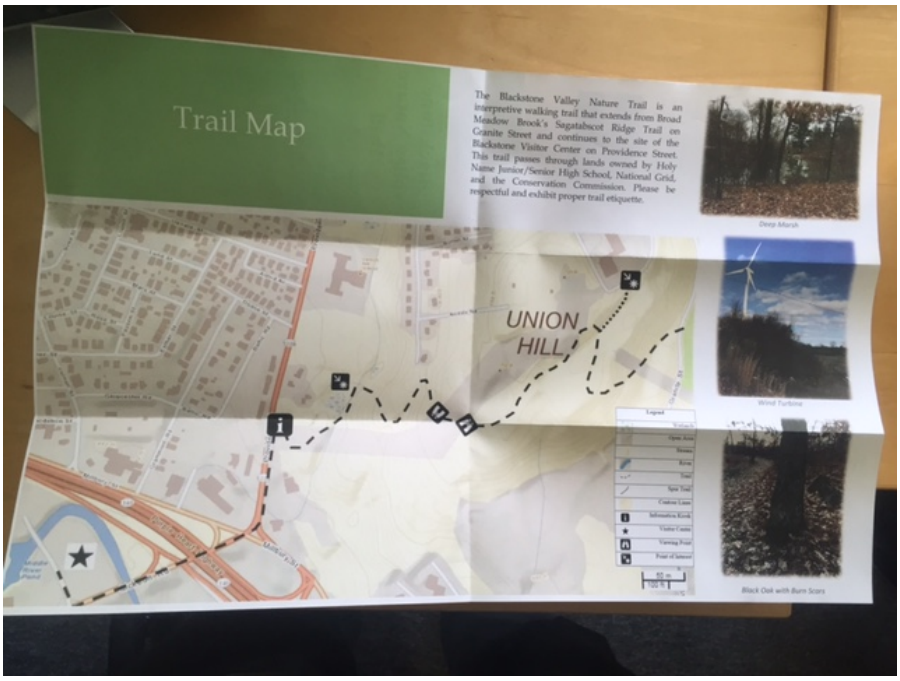



**Figure 40: Brochure Fully Open**