Bar Harbor Project Center
Trail View: Acadia National Park

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

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August 2nd 2013

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Methodology: Rachel, Tim, Cam

Results: Cam, Laura, Tim, Rachel

Recommendations: Laura, Rachel, Tim, Cam

Conclusions: Laura

Works Cited: Rachel

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Abstract

In recent years, the National Park Service has been looking for more ways to incorporate technology into the preservation, research, and enjoyment of nature. Trail View serves as a way to close the gap between humans and nature by offering an interactive virtual tour of Acadia National Park's hiking trails. Similar to the concept of Google Street View, Trail View is an interconnected series of panoramic photos. It is further expanded into an educational tool by displaying information about natural phenomena alongside the trail. Its intended use is to increase interest in Acadia, educate people on environmental and conservation issues, and create a database of relevant trail information.

Executive Summary

As the National Park Service nears its hundredth year of operation, it calls for a recommitment to the exemplary stewardship and public enjoyment of its parks. The National Park Service was founded to conserve natural and historic landscapes, while allowing the public to enjoy the environments it was sworn to protect. Throughout the National Park Service's history, it has battled to find equilibrium between preservation and accessibility. As applied science grows, so too does the opportunity to safely allow increasing numbers of people access to the most secluded and fragile environments in the country. Through the use of technology, the National Park Service hopes to increase the availability of its areas while at the same time carefully conserving environments with constant monitoring.

WPI Trail View is an interactive program that allows users to virtually travel on trails using a series of linked panoramic pictures. Using panoramic technology similar to that of Google Street View, Trail View focuses on more natural landscapes, specifically that of hiking trails within Acadia National Park. The unique spherical panoramas (known as 360x180 panoramas) capture pixels from every direction. When the panoramas are viewed in a spherical projection, the user can enter into the center of the photosphere and get a first-person look around that location.

During the course of this project, similar programs were launched or improved upon. Nature Valley Trail View has mapped 65 trails in 4 National Parks over the past 3 years, and the Google World Wonders project has started to map locations ranging from the Grand Canyon to the Great Barrier Reef. While both of these projects are impressive, the Trail View team found that they focused more on picturesque views and were lacking in certain areas. The WPI Trail View program would be more tailored towards the needs of Acadia National Park.

WPI Trail View was developed to meet certain goals set forth by the National Park Service in “A Call to Action”. These action points include reaching younger generations through citizen science programs, visual arts, and social media (Action Points 7 and 10). The National Park Service also called for advancements in educational programs, allowing kids K-12 to take virtual field trips using interactive, digital experiences (Action Points 16, 17, and 19). While a virtual hiking trail would meet some of these action points, the program needed to be further expanded to create an even better educational and interactive experience.

In addition to showing the incredible views that Acadia has to offer, the program also shows documented flora, fauna, landmarks, trail projects, sound recordings, and weather data. To successfully exhibit all of these features, the Trail View team created “Points of Interest.” On the righthand side of the website is a series of collapsible accordion menus. Each menu has a specific point of interest that can be expanded. As the user clicks through the trail, the information in each box changes based on the location of the viewer. For example, if there is a large glacial erratic rock visible in the panorama, the “Landmarks” tab will include a link to an enlarged photo of the rock. In addition, a brief description about how it was deposited on the trail, by melting glaciers over tens of thousands of years ago, would be available in that same window. For animals and plant species that span large areas, such as locations of bird species and certain plants, strings of panoramas would show the information in the approximate sections where they could be found on the trail.

The WPI Trail View team was successful in mapping the entire South Ridge Trail of Cadillac Mountain. This 3.5 mile trail required over 1500 individual pictures captured with a fisheye lens. These photos, taken in groups of 5 at each trail location, were stitched using a program called PTGui to create the 313 panoramas leading from the base of the trail to the

summit of Cadillac Mountain. Trail headings and GPS coordinates were also recorded at each of the 313 panorama locations. Panoramas were taken every 20 yards give or take, depending on the different corners and turns of the trail. This ensured that the next panorama position could be viewed from within the current location. In addition to taking photos, the Trail View team also collected, logged, and wrote brief descriptions for each of the 44 points of interest.

Google Maps Application Program Interface (API) was used to create the actual trail view application. The API allowed the user to look around the spherical panorama and navigate between panoramas using arrows at the bottom of the window. Several custom programs were created to link each of the 313 panoramas with GPS coordinates, insert points of interest, and tile each picture to reduce bandwidth and loading times.

Due to financial constraints, the Trail View website interface was not able to go live on the internet. Instead, it was built to be locally hosted on a single computer. Locally hosting was the best option for this project because it was free and would have the ability to show the program in its highest quality. With the project still in its proof of concept phase, both cost and quality were major factors in determining what would be done to the final product.

Users were very impressed with the final Trail View application; navigating the website was intuitive, the points of interest were educational, and the trail was documented fastidiously. Hikers could preview the trail to determine the difficulty of the terrain, bird watchers could survey bird species to search for on specific areas of the trail, and hikers could learn about low impact hiking through projects such as cairns and drainage areas that help prevent trail erosion. In addition, information about glacial erratic rocks served to inspire the next generation of geologists through the Trail View application.

Researchers had the ability to give data to the Trail View team to upload into the program. For example, Caitlin McDonough, a graduate student from Boston University researching plant degradation within Acadia, contributed a list of all the plants on the South Ridge Trail to the team. This list proved valuable in identifying flora that the team integrated into the points of interest section of the website. The digital trail acted as a central hub for data, with an endless possibility of information to be added.

The points of interest sets the Trail View application apart from current projects such as Nature Valley and Google World Wonders. Trails are no longer simple strings of pictures, but instead turn into educational resources with an ever increasing database. The Trail View team recommends an addition of user uploaded data in the future, so climbers and hikers can become citizen scientists. Ordinary hikers turn into ornithologists by uploading bird sightings and song recordings. Hikers become civil engineers by monitoring sections of trail susceptible to erosion. Artists and photographers can upload creative photography. As next year's Trail View team creates maps of new hiking trails, older trails can continuously be updated and built upon through user created data.

The Trail View interface was an exemplary project for the National Park Service. This application allowed for a hiking trail to become highly accessible, and successfully served to monitor flora, fauna, and trail conditions. Additionally, this application met the National Park Service’s action points of attracting new audiences through digitally interactive experiences including sound recordings and scenic photography. With over 110 miles of hiking trails left to map in Acadia National Park, the Trail View project is not close to being completed, but it is definitely off to a strong start.

Chapter 1: Introduction

The purpose of the National Park Service (NPS) is “to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (The National Park Service Organic Act). As the NPS nears its centennial anniversary, it must “recommit to the exemplary stewardship and public enjoyment of these places” ("A Call to Action: Preparing for a Second Century of Stewardship and Engagement"). It is essential for the National Park Service to expand its services into its second century, both in terms of the technology and the experience given to its patrons. While applied science grows, so too does the opportunity to allow increasing numbers of people access to the wonders of the world. The Trail View project supports the goals of the NPS by allowing people to virtually visit Acadia National Park in an interactive first-person view of its hiking trails.

Mount Desert Island’s Acadia National Park plans to answer the Department of the Interior’s “Call to Action” by incorporating new technologies and programs into its agenda. Acadia, offering a diverse collection of hiking, biking, and kayaking trails, plans to broaden its user base by offering a new and more technologically interactive park experience. Through panoramic imaging, the mapping of three-dimensional space onto a single image, Acadia National Park can both show and advertise the beauty of the island, while at the same time monitor and minimize the risk of destroying what it was sworn to protect.

Since May of 2007, Google Maps has offered “Street View,” a panoramic viewer linked with GPS and maps to show first-person view of streets throughout the world ("Street View – Google Maps"). This application has many functional uses for people, including navigation, exploration, and data collection. Companies, including Google and Nature Valley,

have recently begun to broaden the use of such panoramic projects to include more artistic purposes, such as displaying the natural beauty of National Parks and other world wonders. To date, Nature Valley Trail View has mapped trails in the Sequoia, Grand Canyon, Yellowstone, and the Great Smokies National Parks ("Nature Valley Trail View"). The Google World Wonders Project has mapped well over 100 wonders ranging from the Palace and Park of Versailles to the Great Barrier Reef ("Google World Wonders Project").

Although these previous projects have taken great strides in developing panoramic techniques and mapping strategies, they have only successfully documented sections of the Sequoia, Grand Canyon, Great Smokies, Yellowstone National Parks. These are just four of the fifty-nine National Parks in the United States, just a small taste of what this country has to offer. The tasks at hand are very large, and it is not likely that a single organization will be successful in mapping all of America's parks.

The Trail View project contributes to the mission of world mapping by covering one small corner of America, Acadia National Park. As the first National Park east of the Mississippi, Acadia embodies the ruggedness of the east coast, with its rocky granite coastline and thick, old forests. Because Mount Desert Island is a fairly secluded location and Acadia is currently facing budget cuts, helping raise interest in Acadia is a particularly worthy goal ("Facing Cuts, Acadia Outlines Potential Effects").

The goal of the Trail View project was to capture the beauty of Acadia through panoramic photos and use of an interactive display of its hiking trails. After careful research of various panoramic photo taking and stitching techniques, these methods were applied to over 300 individual locations along the trail in Acadia. Spherical panoramic photos were then

integrated into a Google Street View interactive display and embedded in a local website for easy access.

Through use of the website interface, the Trail View project serves to increase the availability of technology and information to the public. Showcasing the natural beauty of Acadia sparks people's interest, sending the Park's visitation rates soaring. Integrating data and information on hiking trails ties into the education aspect of this project. Placing "Points of Interest" alongside the trail map allows users to read about different flora, fauna, weather data, and special trail features specific to certain locations on the trail.

Chapter 2: Background

In the upcoming years, the National Park Service will be looking for new ways to incorporate technology into its parks. The purpose of this integration is to provide a more interactive experience for park visitors and to make the parks more accessible to the public. Every National Park and monument across the United States is unique, so various options to preserve and display park beauty will be explored. A virtual tour composed of panoramic mappings of Acadia National Park's hiking trails give users a glimpse of the beauty that is Mount Desert Island. In addition, the Trail View provides a foundation for achieving park goals, including education, trail and wildlife preservation, and data collection. This section will examine the specific characteristics of Acadia National Park that must be considered in the effort to make an interactive and educational Trail View experience. It reviews the history of National Parks, Acadia's hopes for the future, and how technology can aid in reaching those goals.

2.1: National Parks

As stated in the United States' Organic Act, National Parks were created "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (The National Park Service Organic Act). The National Park Service (NPS) is in a constant struggle between making the natural wonders of the United States accessible to all, while at the same time preserving them for future generations to enjoy. It is important to study the history and creation of National Parks when looking into the future to gain a good understanding of their goals and purposes.

2.1.1: History

Before the National Park Service, parks created in the United States were privately owned and operated. The history of the NPS began in 1916 with the establishment of The National Park Service Organic Act (16 U.S.C. 1 2 3, and 4). President Woodrow Wilson signed the Act so that the American government could oversee the management of each park, and unite their individual goals related to preservation and education. With the passage of this Act, the Secretary of the Interior could now make rules and regulations for all National Parks, monuments, and reservations. In addition, this Act also set aside land for the first National Parks, including the Sieur de Monts National Monument on Mount Desert Island. In 1919, after the acquisition of more land, President Wilson signed 16 USC § 341, turning Sieur de Monts National Monument into Lafayette National Park. This was later renamed Acadia National Park (National Park Service).

2.1.2: Purpose

National Parks provide a window into the timeless history of the American landscape. Through parks and monuments, the NPS teaches of the natural history of the United States and also shows the effects that people, throughout history, have had on these lands.

The land protected by the National Parks serves as prime real estate for endangered plants and animals. By preserving the environment for human enjoyment, the Parks also preserve countless creatures' habitats.

2.2: Acadia National Park

Acadia National Park offers an astounding collection of geographical formations, diverse species of flora and fauna, and a rich cultural history spanning back to Native American settlements over 5,000 years ago. Acadia currently has a prominent tourist industry, is thoroughly involved in scientific research, and is dedicated to protecting countless endangered species by preserving their habitats.

Acadia only spans 45,000 acres, making it one of the United States' smallest National Parks. However, it is also one of the top ten most popular due to its spectacular views, unique coastal landscapes and scenery, and proximity to large population centers ("Friends of Acadia - Maine Nonprofit, Conservation Organization, Acadia National Park, Bar Harbor").

2.2.1: Needs and Goals

One major goal that all of the National Parks share is increasing accessibility for all people. An internet presence is helpful to this end as it allows people to visit parks remotely if they cannot visit in person. At the same time, the internet raises awareness for Acadia, bringing in more visitors than would otherwise be possible.

Without the help of its volunteers, workers, and visitors, Acadia National Park would not be as successful as it is today. If trails and roads are left without people to work on them, then hikers and visitors will not be able to enjoy the aspects of Acadia that make it so special and different from other National Parks.

2.2.1.1: Friends of Acadia

Acadia is home to numerous support groups, most notably Friends of Acadia ("Friends of Acadia - Maine Nonprofit, Conservation Organization, Acadia National Park, Bar Harbor"). This

private, nonprofit organization aims to preserve and protect both the natural and cultural aspects of Acadia and its surroundings. Through various projects and volunteer efforts, Friends of Acadia has been dedicated to serving both the community and Park since 1986.

Just a few of the beneficiary efforts of this organization include: “making crucial conservation grants to the park and communities, recruiting and leading a corps of dedicated volunteers, defending the area against threats, and advocating for Acadia before Congress and the Maine legislature” ("Friends of Acadia - Maine Nonprofit, Conservation Organization, Acadia National Park, Bar Harbor"). With over 3,000 members and countless volunteers, this organization’s efforts can be seen throughout Acadia. Without such a dedicated group, the trails and carriage roads would not be as clean and visitor friendly as they are now. People would also not be as aware of or educated on the importance of conservation and preservation techniques.

2.2.1.1.1: Acadia Trails Forever

Acadia National Park is home to over 130 miles of hiking trails. The hiking trails are one of the favorite aspects of this National Park to visitors and locals alike. It is important to keep the trails maintained and cared for to prevent erosion that makes them unmanageable and difficult to hike. At the start of the new millenium, Acadia National Park and Friends of Acadia worked together to create Acadia Trails Forever, with the purpose of both restoring and maintaining the trails. Acadia Trails Forever is America’s first “endowed trail system, and today serves as a model for other national parks and their partners.” Acadia Trails Forever’s impressive restoration and rebuilding projects would not be possible without the strong bond between Friends of Acadia and the National Park and the impressive dedication and devotion of its members and endorsers

("Friends of Acadia - Maine Nonprofit, Conservation Organization, Acadia National Park, Bar Harbor").

2.2.1.1.2: Rec Tech

Acadia National Park is constantly working to improve its connections and involvement with technology and science. It is for this reason that the Rec Tech was established. This is a group of college-age students who work with park rangers and staff to research and study the recreational use of the park. The Rec Tech does a number of different research and monitoring tasks, including but not limited to: setting up trail counters on hiking trails and carriage roads, using GPS coordinates to map and record the conditions of hiking trails and other points of interest, and gathering valuable information through visitor questionnaires ("Friends of Acadia - Maine Nonprofit, Conservation Organization, Acadia National Park, Bar Harbor").

2.2.1.2: SERC Institute

Another nonprofit organization, the Schoodic Education and Research Center (SERC) Institute of Acadia National Park, is the largest of 20 National Park research learning centers in the nation. Its mission is to provide education and research opportunities for people of all ages. Created in 2004, the Institute has been working hard to close the gap between humans and nature, and hopes to inspire people to work on developing ideas for nature conservation and preservation.

Located at Schoodic Point, the SERC Institute and Acadia National Park have created a great learning experience, unique to Maine’s special qualities and offerings. Specifically, the SERC Institute supports scientific research in Acadia, and hopes to spread the spark for

innovation throughout its visitors and community in order to ensure nature conservancy and care for generations to come. To accomplish these goals, the Institute raises money for research support, provides educational programs offered by Acadia, and directs a professional development program for educators and teachers on integrating research and science into the classroom ("SERC Institute").

2.3: Technology in Parks

The National Park Service works very hard to keep its visitors up-to-date on park information and all it has to offer. Acadia currently hosts a well-designed interface made available to the public via the NPS website. The purpose of this program is to “present natural, historical, and cultural wonders associated with National Parks and provide opportunities for people to discover why national parks are special places” ("NPS: Explore Nature » Views of the National Parks"). These modules allow people from all over the country to explore the National Parks in detail and learn what makes every park so valuable to the rest of the nation.

Acadia National Park currently has a “Photos & Media” tab on their website ("Home - Acadia National Park”). There are many interesting links and resources available there, including “PanoramAcadia” ("Photos & Multimedia - Acadia National Park"). There, one can view various photographs of Acadia including Dorr Summit and Dancehall Rocks.

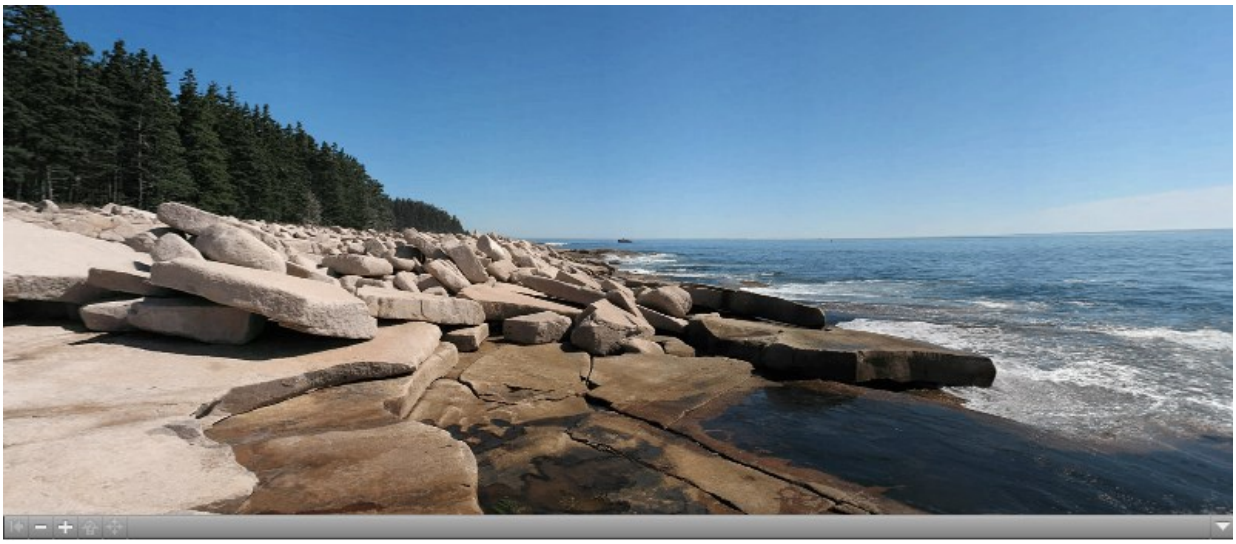

Figure 1: Screenshot of "PanoramAcadia" - Dancehall Rocks ("Photos & Multimedia - Acadia National Park")

"Acadia eCruise" is a virtual tour that offers twenty different scenes from around the Park ("Virtual Tours - Acadia National Park.") Audio clips of wildlife and videos narrated by park rangers make this feature an interactive experience for the user. Some photos in this online exhibit have a 360 degree panorama option. This allows the user to view the same scene at different angles. There are also areas on some scenes, such as the tidepool exhibit, that allow the user to zoom in on images of various flora and fauna. Videos of park rangers give information about different wildlife creatures, ranging from birds to bugs and plants. There are also videos containing information on the tides in Acadia, an analysis on night skies in the Park, as well as hiking and basic park safety tips.

The Frenchman Bay Camera, updated every fifteen minutes, provides viewers with different views of the water as well as detailed meteorological conditions and levels of pollution ("Acadia National Park, Maine - Camnet"). These views of the Acadia include relevant information and facts about the different features of Mount Desert Island. Although the range of places and accessible knowledge is widely diverse and gives a small preview of every part of Acadia, there is little to no information on the hiking trails.

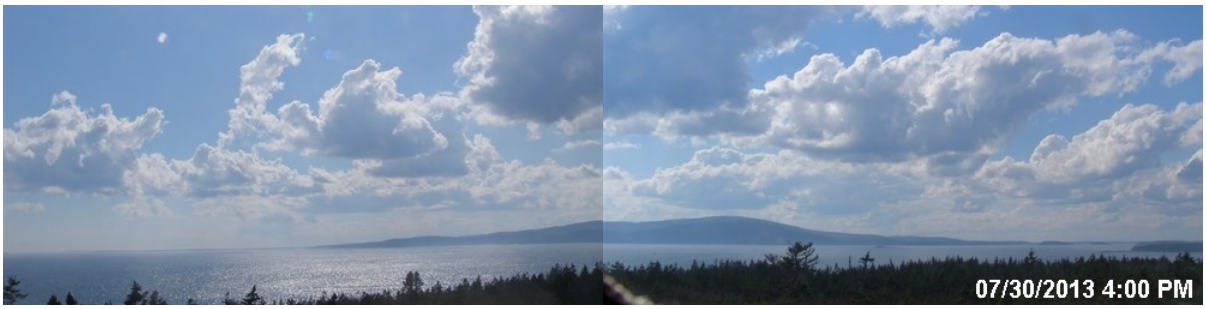

Figure 2: Camnet view of Frenchman Bay ("Acadia National Park, Maine – Camnet")

The National Park Service is currently working to expand the reach of its mission in order to better involve communities all over the country. The Trail View project helps with some of the designs listed in their proposal, specifically those connecting people to the parks and educating its visitors on park phenomena.

The NPS hopes to implement methods for students to learn about various topics such as the history and nature of its parks. According to its Call to Action, the NPS hopes to "accomplish this by reaching 25 percent of the nation's K-12 school population annually through real and virtual field trips" (Action Point #16). Interactive media and technology will make this possible. The NPS also hopes to "reach new audiences...by transforming the NPS digital experience to offer rich, interactive, up-to-date content from every park and program" (Action Point #17). By helping visitors engage in these online experiences, these unique parks will be "accessible to the broadest range of the public" (Action Point #19). Designing user-friendly web sites and features will allow the NPS to reach out to more audiences, including those who do not have easy access to the National Parks ("A Call to Action: Preparing for a Second Century of Stewardship and Engagement").

Through the addition of updated exhibits and media, new ideas and information will be easily spread across the nation. Expanding the use of technology in the National Parks will ultimately lead to an increase in park visitation and attendance. The NPS wants to engage not

only its visitors, but also the general public, in its efforts and passion for nature preservation. Spreading awareness and information through interactive media will help to spark interest in the parks and nature. Increasing support will allow for further advancements in park technology and preservation.

2.3.1: University of New Hampshire Picture Post Project

The University of New Hampshire produced a concept project for Acadia National Park called the Picture Post Project (“Picture Post: Home”)("Picture Post: Home"). There will be numerous posts laid out along trails and other popular areas. Atop the post is a small raised octagonal shape. The idea is for hikers to take six pictures with their camera backed up against each of the eight sides. Doing so will, ideally, create a panorama of the surrounding area, albeit one with a limited vertical view. The purpose of the project is to essentially recruit hikers to take photographs of the designated areas, giving Acadia a means of tracking information and patterns over time.

Figure 3: Example of a Picture Post in Menotomy Rocks Park ("Picture Post: Home")

Acadia National Park is currently planning on placing these posts along popular hiking trails and tourist destinations within the Park. However, the usefulness of the project is diminishing. With more and more people using smartphones as cameras, the hexagon placed atop the post is no longer useable in the intended fashion. Many smartphones now include features to automatically take comprehensive panoramas, rendering the manual mode encouraged by the post obsolete. Nevertheless, the fundamental idea of having set points at which hikers and tourists take images to provide Acadia with necessary information is one that can be implemented in current and future projects.

2.3.2: Nature Valley Trail View

One project that used technology to map natural landscapes was Nature Valley Trail View ("Nature Valley Trail View"). Nature Valley, best known for its snack food, started its

Preserve the Parks program roughly three years ago. In addition to offering support for nature conservation and park preservation, this program was created to help fundraise and organize restoration efforts for National Parks. The ultimate vision of Nature Valley was to share the beauty of nature and National Parks through an interactive and user friendly service via the internet. Similar to that of Google Street View, the Nature Valley Trail View project would help people from all over the country see, firsthand, the hiking trails in National Parks.

This project has allowed people to experience National Parks like never before. Nature Valley has successfully mapped trails in four National Parks so far: the Sequoia, Grand Canyon, Yellowstone, and Great Smokies. However, the United States has 59 National Parks, and Nature Valley has only focused on parks located in the western part of the nation.

With interactive, virtual trails, users can navigate easily through nature via the internet. Nature Valley Trail View is the “first nature-based integrated technology platform that marries 360 technology with the National Parks” ("Nature Valley Trail View – Think Insights – Google"). Without this platform, many people would not be exposed to the various conservation efforts and inspiration that encourages involvement with the National Park Service.

2.3.3: Google World Wonders Project

A similar project has been created by Google. Google has recently begun to expand its Street View section in its Google Maps application to map different monuments and world wonders. Google World Wonders offers users a closer look of many different monuments and unique international locations ("Google World Wonders Project). The Great Barrier Reef, Leaning Tower of Pisa, and the Palace of Versailles are just three of the 132 sites of Earth’s

treasures that have been uncovered and explored by Google. These sites offer a close, three dimensional look into these monuments via 360 degree panoramas.

Google World Wonders offers a future educational experience like no other, promising “a much more fascinating, hands-on approach than a dry textbook, and it’s a unique way of bringing encyclopedic knowledge to an era of Chromebooks and the cloud” ("Google World Wonders Project Takes You to Earth's Treasures in Glorious Street View Vision" 2012). Google World Wonders is working on doing for the world what Nature Valley Trail View has done for National Parks; allowing the public a closer look into nature and helping to inspire interest in preservation and conservation of both the world and the nation’s natural wonders and treasures.

2.4: Panoramic Photos

One concept that was essential to all of these previous projects, and the current Trail View project, was that of the panoramic photo. Also referred to as a panorama, a panoramic photo is a loosely defined term referring to depictions of a wide angle of space. The term originated in the late 1700’s with the artist Robert Baker. He captured a large swath of Edinburgh, Scotland in a single painting (Lippman. et al.). The medium with which panorama is most commonly associated today is photography.

Even though panoramic photography is not a new technology, its implementation has evolved over the years and such photos are continually being used in new ways. People began shooting panoramas nearly as soon as photography was invented. In these early days, there were no cameras specialized for this purpose; the effect was achieved with film development techniques. These extensive landscape depictions were used by militaries to analyze terrain ("Panoramic Photographs - a Brief History").

Figure 4: View from the top of Lookout Mountain, historical panoramic photograph by George Barnard ("Panoramic Photographs - a Brief History")

2.5: Interactivity on the Internet

Interactive media is a growing set of tools designed to give people an autonomous experience within a virtual world. This category extends from video games to "choose your own adventure" stories. Most relevant to parks and the Trail View project, many of Google's services fall under the category of interactive media, including their maps and street view interfaces.

2.5.1: Cyber Tourism

One form of interactive media is cyber tourism; a branch of tourism that involves "visiting" a location remotely through interfaces such as panoramic tours. It is commonly used for such applications as real estate and college campus advertisement. One of the main goals of this development is to entice people to visit an area in person after receiving a virtual glimpse of

what it has to offer. It can also serve as a showcase to make a location available to people who are unable to travel there.

2.5.2: Google Street View

Google's Street View ("Street View – Google Maps") project has been an enormous undertaking. Attempting to map approximately 50 million miles of road in the world (Anguelov et al.) is a process that cannot help but take significant amounts of time, money, and energy. Street View started as an attempt by Google cofounder Larry Page to expand Google's wealth of knowledge to something that had never quite been done before. The goal of this project was to create high resolution images of streets all around the world, and make them readily available to everyone. During the initial phase of the project, Google used an SUV equipped with cameras, lasers, and a GPS mounted on the roof. However, this was not sustainable on a larger scale, so the decision was made to switch to "lightweight" vehicles, with lower resolution cameras and a single computer.

Over the years, Google has iterated through many different systems, but all of them share some commonalities. They all consist of a small rosette of approximately fifteen cameras that can easily capture a nearly 360 degree image in one shot. More recent apparatuses now include lasers that can accurately map building facades (Anguelov et al.). Google has amassed an enormous arsenal of complicated, expensive equipment. Their extensive resources make it easy to gather the vast quantities of data that comprise Google's Street View.

Chapter 3: Methodology

A key objective for the 2013 Trail View team was to solidify an effective methodology for constructing panoramic mappings. Leaving behind a comprehensive framework will allow Acadia, or future IQP groups, to easily expand upon the project by adding more trails or new functionalities.

From March 11, 2013 through April 30, 2013, the team prepared for the project by researching the theory behind panoramic technology and developing a tentative methodology.

The project started on June 17, 2013 and continued through August 2, 2013. Going out in the field allowed the team to solidify its understanding of what worked and what did not. The framework that the Trail View team recommends is based on what was learned, and will serve to assist in the further expansion of the project.

3.1: Equipment Selection

There are many ways to achieve a panoramic effect, but methods vary in the quality of resulting products. Most smartphones can run applications that aid in the creation of panoramas. Many modern cameras also come equipped with special modes to perform similar functions. One such example is Easy Panorama Mode by Nikon. This mode gives users thirty seconds to rotate the camera 360 degrees and automatically stitches a panorama from the resultant images (Nikon). However, panoramas created with these easy methods do not capture a full sphere containing the sky and ground, but instead result in a cylindrical strip.

Fisheye lenses ease the creation of panoramas by bending light such that wide fields of view are captured in a single photograph, thereby decreasing the number of photographs necessary to depict an expansive space ("How to Shoot Panoramic Photos Easily - Camera, Lens,

Tripod, Panohead, Software"). Software, some of which is free, exists to automate the stitching process. The end product is essential to creating virtual tours of real spaces, such as the service provided by Google Street View, and is used extensively in fields such as real estate and advertising.

The process of creating a panoramic photo differs based on the equipment employed. Any equipment setup needs to ensure that the point of rotation is at the camera's point of no-parallax. This is the point at which objects are not perceived to move relative to one another when the angle of viewing changes. It is also universally important to make sure that adjacent photographs contain overlap if the user hopes to automate the stitching process. Stitching software works by identifying pixels that two or more photos have in common. This information is then used to determine where the photos connect. Since ordinary cameras do not have lenses that enable the capture of a wider angle, users of these devices must take a large number of photographs in order to capture a complete 360 degree panorama with sufficient overlap.

3.1.1: Choosing a Camera

With a standard camera lens, at least twenty photos are required to capture a 360 degree view with sufficient overlap to satisfy the stitching software. Built-in features such as Nikon's Easy Panorama mode remove much of this hassle, but still only achieve a 360 degree cylinder, not a complete sphere. One alternative option that the team found was the use of a fisheye lens, a convex lens that captures light from a wide angle. These lenses capture an entire half-sphere in a single photo. A higher quality option would have been to use an expensive DSLR camera with an internal fisheye lens ("How to Shoot Panoramic Photos Easily - Camera, Lens, Tripod,

Panohead, Software"). However, due to budgetary constraints, the team was confined to using a point and shoot camera with an external fisheye lens adapter.

After researching and comparing various lenses online, it was found that the majority of them produce photos with blurry edges ("How to Shoot Panoramic Photos Easily - Camera, Lens, Tripod, Panohead, Software"). This is unacceptable for creating panoramas; edges must be crisp because the stitching software uses common edge pixels to identify adjacent photographs. The only affordable fisheye lens adapter that was not reported to have this undesired effect was the Nikon FC-E9. This lens is capable of capturing 183 degrees of space and is directly compatible with only a select few Nikon cameras. One such camera is the Nikon Coolpix 5700, available on loan from the WPI Academic Technology Center.

Figure 5: Nikon Coolpix 5700 digital camera and FC-E9 fisheye lens

3.1.2: GPS and Points of Interest Data

For every panorama taken, it was necessary to record the location's GPS coordinates for later use with the Google API. Since a few yards' precision was required, a cell phone GPS was not sufficiently accurate. Therefore, the team used a handheld GPS, often referred to as a "hikers' GPS." The specific model was a Garmin eTrex.

Figure 6: Garmin eTrex GPS ("Garmin | eTrex")

In addition to GPS coordinates, headings were necessary for the Google API so that when the user clicks to progress to another panorama, the new view is always pointed towards the head of the trail. A smartphone application known as GPS Status was used for this purpose. Keeping the view when you enter a new panorama consistent helps make the program feel organized and keep the user oriented when moving between panoramas.

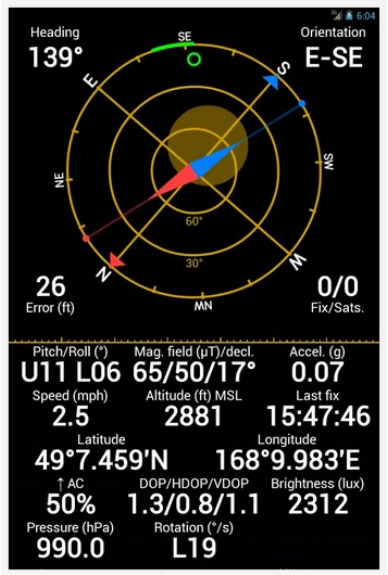

Figure 7: GPS Status app ("GPS Status & Toolbox - Android Apps on Google Play")

The points of interest recorded alongside the Trail View included atmospheric data, audio recordings, and close-up photos of special trail features. The equipment used to gather all of this data was a Weatherhawk Skymate SM-18, a Tascam DR-40 Linear PCM Recorder, and a Canon PowerShot SX150 IS, respectively.

Figure 8: The Weatherhawk Skymate SM-18 ("SM-18 Skymate Wind Meter W/Temp & Wind Chill")

Figure 9: Tascam DR-40 Audio Recorder ("Product: DR-40 | Tascam")

Figure 10: Canon Powershot SX150 IS ("Canon U.S.A.: Support & Drivers: Powershot SX150 IS")

3.2: Trail Selection

There was a lot to investigate when choosing an appropriate trail to map. Each trail in Acadia National Park is a unique exhibit that presents different traits of the area. The chosen trail should represent many different characteristics of Acadia National Park, while offering an easy platform for the team to develop proper panoramic techniques. When choosing a trail, the team investigated a range of characteristics including trail history, accessibility, trail quality and difficulty, and variety of landscape and habitat.

Each section of trail has its own history, ranging from old goat paths and Native American sections to well-maintained Civilian Conservation Corps (CCC) created sections. The team planned to find a trail with a varying history. This would give the interactive trail map an opportunity to teach about the histories of the different cultures that have inhabited the area and created the trails that are used today.

Trail accessibility was an extremely important aspect to consider when selecting a trail to map. Throughout the project the group carried equipment back and forth from the College of the Atlantic to the trail. There are trails throughout Mount Desert Island and the surrounding areas. Transportation to the trails could vary from a 10 minute drive down Park Loop Road to a ferry ride across Cranberry Cove. Considerations were made to select a trail that is easily accessible.

In addition to a trail that is easily accessible, the team considered a trail that is easy to hike. The daily hikes and carrying of equipment was a strenuous task. A difficult or poorly maintained trail will only make this task more demanding. Also, the length of the trail was a factor in determining how many pictures are collected. The number of pictures taken would greatly increase the amount of time spent on the trail, time used to process panoramas, and programming time.

A goal of the interactive trail map is to represent the beauty and variety of Acadia. The chosen trail should try to best represent everything that Acadia has to offer. Panoramas on the peaks of mountains and next to bodies of water capture the idyllic character of Acadia and be a great representation of this majestic park. In addition, trails with known, rare, flora and fauna provide a teaching opportunity for the interactive map.

Many considerations can be made on trail selection through reading. However, the group didn't select a trail until after they arrived in Bar Harbor. They hiked the different trails during the first days of the project. This firsthand experience provided information no book or website could provide. They took notes on each trail, critiquing each of the areas aforementioned.

3.3: Taking Panoramas

After selecting equipment, it was necessary to fully understand the panoramic photography process with the specific, chosen setup. Creating a panorama consists of two distinct phases. The first is taking the individual photos. This process differs depending on the equipment used. The team considered these varying levels of difficulty when making equipment selections and chose to use a fisheye lens because it was the least time-intensive setup. Doing so reduced the number of photos necessary to achieve a single panorama from more than twenty down to five. It was only necessary to take four images at ninety degree angles to one another, followed by one straight up at the sky. Ideally, a sixth photo aimed straight down would have been included, but the lens captured such a wide angle that it was impossible not to get the team's feet in the photo. Because of the wide angle, however, the ground was almost fully captured within the other photos anyway.

When taking the photos, one very important consideration was the point around which the camera was rotated. For best results, the point of rotation should be the camera's point of no parallax, which is located just behind the lens. This made the use of a tripod less than ideal, as the tripod's point of rotation was located too far behind the lens. Leveling the tripod was also a very slow process and greatly reduced the amount of photo-taking that could be accomplished in one day. The team instead decided to maintain the point of no parallax by hanging a weighted string behind the camera lens. Keeping the string above one point on the ground during the full 360 degree rotation ensured that there was no parallax error.

One consequence of the processes required to make panoramas was distortion of the depicted space. Since panoramas are a projection of three dimensional space onto a two dimensional surface, landscapes look warped. It is especially apparent when one displays a line that is straight in three dimensional space; such a line will appear very curved (see Figure 11).

Figure 11: Panoramic photograph that demonstrates the distorting effects of panorama. The rows in this field are straight and parallel ("Panoramic Photographs - a Brief History")

This effect was mostly a non-issue for the Trail View team because it is largely mitigated when panoramas are viewed in an environment using spherical projection, like that of Google Street View. This means that the user's point of view can be thought of as being the center point of a sphere, with the panoramic photo information projected onto the inside walls of the sphere.

This more closely simulates the actuality of the real landscape depicted, and therefore appears more natural. The team used a program called FSPViewer to preview images in spherical projection before loading them into the Google interface ("FSPViewer").

The second phase was stitching the resultant photos together into a panorama, the process of which again varies based on equipment. Smartphone users can find applications to do this automatically, and certain cameras come equipped with specialized modes that achieve the same end. For the best results, the team loaded photos into a computer program that did most of the work automatically, as discussed below.

3.4: Software

In addition to the equipment required to create panoramic photos, there was a fair amount of software that was used to help complete the Trail View project. After taking multiple photos in a single position, they were stitched together into a comprehensive image. Once that was done, each image was then "tiled" into many smaller sub-images. Ultimately, each image was loaded into Google Maps through JavaScript interaction with the Maps API.

Figure 12: Five photos taken at one location

Figure 13: The resultant panorama post stitching

3.4.1: Stitching Photos into Panoramas

Many programs exist with the purpose of automating the process of stitching together adjacent photos to form a panorama. The software achieves this work by identifying commonalities between the edge of one photo and the edge of another to identify photos located adjacent in space. It then stitches these photos at the point of overlap.

There were several free options. The two leading free programs were Hugin and Microsoft Image Composite Editor ("Hugin - Panorama Photo Stitcher;" "Microsoft Research Image Composite Editor"). The team installed both and tested them in two separate proofs of concept. The first proof of concept was completed early in the planning process before a camera was chosen. Sixteen photos were taken in a circle using a Canon PowerShot SX150 IS point and shoot camera. The resultant images were fed into both of the program options to compare the two pieces of software on several criteria. The results were as follows:

	Hugin	Microsoft ICE

Time required	~5 minutes	~5 minutes
Ease of use/automation	Fair, some user input required	Very easy, fully automated
Product quality	High	Fair; wavy edges

Table 1: Round 1 of Software Testing

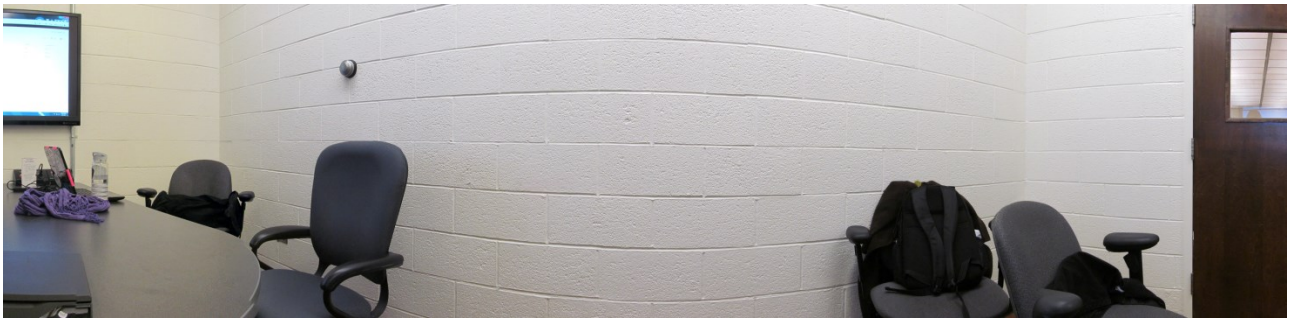

Figure 14: Hugin round one stitch

Figure 15: Microsoft ICE round one stitch

Because these factors were subject to change due to modifications in the methodology when the actual equipment was used, the team held off on making any final decisions until the second proof of concept was completed in Maine. Upon beginning these tests, it was immediately apparent that Microsoft ICE was not customizable enough for the team's purposes. The program assumed it would be given rectangular images, but since the images produced by a fisheye lens are circular, ICE was unable to stitch the photos together correctly. Therefore, the

team had to disregard this program as a viable option. Hugin performed mediocrely in the second test, quickly and successfully stitching the photos but with fairly low quality. “Warping” effects were very significant in the final product.

At that time, the team began considering commercial software, including one called PTGui ("Photo Stitching Software 360 Degree Panorama Image Software"). They ran the same set of photos through the free trial of PTGui and found that much higher quality results were obtained.

	Hugin	Microsoft ICE	PTGui
Time required	~5 minutes	~5 minutes	~5 minutes
Ease of use	Good, comparatively well automated	Fully automated	Fair, some user input required
Product quality	Fair, some “warping”	Unusable	Good

Table 2: Round 2 of Software Testing

Figure 16: Hugin round two stitch

Figure 17: Microsoft ICE round two stitch

Figure 18: PTGui round two stitch

3.4.2: Tiling Process

When an application uses images that can be enlarged by the viewer, those photos are put through a process known as tiling. During this process, the image is expanded and cut into smaller sections. These smaller images can then be loaded into the map individually as needed. Memory, processing power, and bandwidth are conserved, both on the user side and on the server side. There are no issues of consequence that might discourage the use of tiles. In fact, it is the default for the panoramas used by Google in their Street View service. Given its benefits, the team was very interested in tiling the photos that were processed into panoramas.

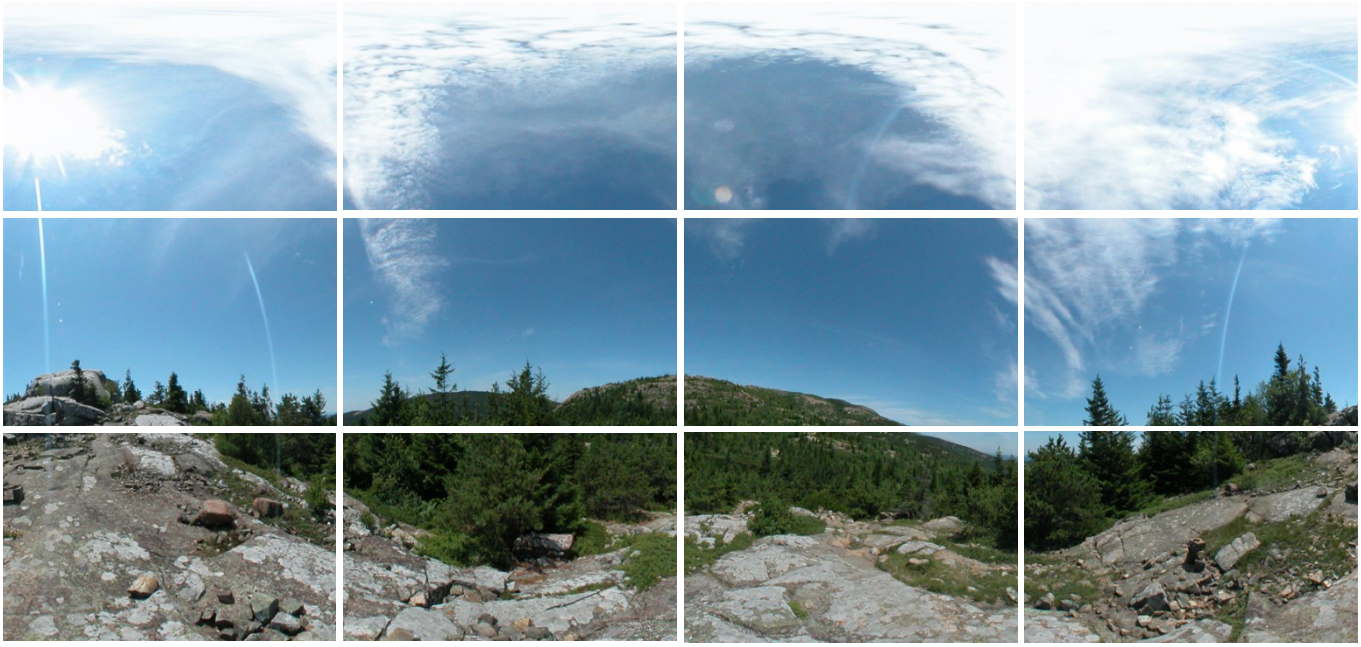

Figure 19: A tiled panorama

The team found an open source program, TilesGenerator, written by Mike Gleason Jr and licensed under the GNU Public License v3 ("Create Zoomable Images Using the Google Maps API"). The program was free to use and modify provided that it remained licensed under GPLv3. After attempting to use the program, it became apparent that modifications would be needed. The program was written to work with square images, but our images were in a 2:1 ratio (360° by 180°), so it required some modification to how the tiles were created. Once the modifications were finished, the program was more relevant to the specific needs of the Trail View project.

Tiling the photos involved calling the executable from the command line with two extra parameters, the level of zoom to be used, and the path to the photo to be tiled. The overall process was extremely simple and ran with satisfactory speed. Once the images were tiled, they could be loaded into the map application through the Google Maps API.

3.4.3: Google API

For many years, Google has been a leader in technological innovations, and has provided many technologies and platforms for the open use of others. One such technology, and a focal point of this project, is Google Maps. This program digitizes traditional maps, enabling users to perform complex interactions. Since its inception in 2005 (Taylor), Google Maps has become an integral part of many people's travel routines, allowing route planning and directions. The only simple way for outside developers to interact with Google Maps is through its Application Programming Interface, also referred to as its API.

An API allows programmers to interface with an existing codebase without access to the source code. By doing nothing more than asking, the programmer is able to utilize data with minimal effort. The Google Maps API allows for anyone with the necessary skills to make use of Google's systems. Though this project solely used the JavaScript implementation of the API, Google provides numerous other means of interaction with the code base, from APIs for dealing with Android and iOS applications to the depreciated system using Flash.

Google offers two different types of APIs. The free version simply requires the generation of an API key. This is done by requesting one from Google, allowing the site owner to monitor requests from the page. The Business version of the API offers higher request limits, increased quality and services, as well as numerous other advantages for businesses (Google).

While the Business version of the API would offer some benefits to the Trail View project, these only matter for hosting a webpage with the map in it.

The team created a local page to demonstrate the Trail View interface. There were no restrictions as to what could be incorporated into the site once the API was obtained. With use of the API, anyone can access all aspects of Google Maps commonly available from its website (Google Maps), as well as provide custom contents in the form of custom panoramas and overlays.

Figure 20: Google Maps View of Mount Desert Island

After the photos were processed, the next step was to load them into an interface similar to that of Google Street View, using the Google API. The process of adding custom panoramas to Google Maps was relatively simple. The API needs to know the location of the panorama, defined by its GPS coordinates. Next, one must define where the images for the panorama are located on the local computer. Custom panoramas are then created with a few lines of code. The team only faced trouble because of the sheer quantity of photos that needed to be processed. The

solution was to programmatically load and link together each panorama so that they appeared to be one cohesive system.

3.4.4: Points of Interest

To meet Action Point #16, "Live and Learn," the Trail View program was designed for use as an educational resource ("A Call to Action: Preparing for a Second Century of Stewardship and Engagement"). Points of interest were developed to teach users about specific items on the trail, specifically plants, animals, sound recordings, landmarks, atmospheric data, and trail projects designed to prevent erosion. These points would be attached to specific panoramas and GPS coordinates to give the exact location. Often times the points were visible within the panorama.

The team met with Caitlin McDonough, a graduate student from Boston University researching plant degradation along hiking trails in Acadia National Park. Caitlin supplied the team with an archive of various plants found on South Ridge Trail. This list proved to be extremely beneficial to the team when it came time to identify the plants photos that were taken as points of interest. The team was also able to successfully identify birds, insects, and other animals on their own.

3.4.5: Website

The website was responsible for hosting one particular instance of Google Street View; the one that contains all of the custom panoramas and data that have been created and collected. The website was written ASP.NET MVC 4, using Microsoft's Visual Studio. In addition to ASP.NET MVC 4, the website included work in HTML, CSS, JavaScript, and SQL. It was

designed around having a clear and easy to use interface that made it simple for the user to find whatever he or she was looking for.

Chapter 4: Results

The Trail View team was successful in designing an interactive website that showcases an entire trail mapped with 360 degree panoramas. Through the user interface, the website also displays a variety of information that the team documented on the trail: flora and fauna, sound files, atmospheric data, landmarks, and other trail features that help reduce erosion.

4.1: Trail Selection

The team's first task upon arriving in Acadia was to choose the hiking trail that would be used in the Trail View interface. The first four days were spent evaluating different trails and rating them based on specific criteria. In order to showcase all of the special features that would be integrated into the website, the chosen trail would not only require visual beauty, but it would also need to include interesting features and landmarks, different species of flora and fauna, and varying soundscapes.

The team decided to start research by hiking the Beehive, a widely known and popular trail for hikers. Located across from Sand Beach on the Park Loop Road, this trail is easily accessible for visitors by car. Starting in a thick wooded area, the trail gradually rises upwards with large rocks, creating an easy pathway over small water runoffs and muddy sections. The trail comes to a fork that allows hikers to either take a right and follow the steep trail up the east side of the peak, or continue to go straight along the back bowl to the summit. The steep section of the trail has great views of Sand Beach, while the trail up the backside of the summit has a small pond, referred to as the Bowl, that hikers can walk around. In terms of variety, Beehive offers great views looking out to the ocean along the steeper areas, and provides natural diversity complete with different minnows and birds that inhabit the pond area.

The team also hiked up South Ridge Trail, a long 3.5 mile hike starting on Route 3 that brings hikers all the way to the summit of Cadillac Mountain. This trail has an excellent variety of natural landscapes complete with four distinct and diverse sections of terrain. The first section is a thickly wooded area that climbs gradually over tree roots, wooden foot paths with manmade steps, and drainage areas to help prevent trail erosion. The second section of trail begins after the Eagle's Crag where tall, coniferous trees give way to small pitch pines growing around large granite slabs. The first two sections of trail have glacial erratic rocks and varying species of birds specific to certain elevations. The third section of trail includes Featherbed Pond, where you can hear frogs croaking and see many different plant species that grow both in and near the water. The last stretch of trail travels along the exposed ridge, a granite spine with incredible 360 degree views. Hikers can see the Bubbles to the west, Cranberry Isles to the south, and the Champlain Mountain to the east.

The team visited Bar Island for the next hike. It was immediately discarded as an option for a few reasons, one being the amount of people. In addition, it would be hard to take pictures due to accessibility issues since Bar Island can only be reached by foot at certain times of the day - during low tide. The actual trail on the island is short, and the view is not as impressive as Beehive or South Ridge Trail.

The Asticou Terraces Trail was originally considered due to its expansive display of various plants and landscapes. These special features would bode well for the points of interest section of the Trail View website. After exploring the trail, the team concluded that it was too short and did not feel like a representative part of the park. Even though this trail would have provided the team with a lot of flora for use in the points of interest, it was not well-rounded enough to show off the other features that the website has to offer.

The Cadillac Mountain South Ridge Trail was immediately chosen as the best trail for the project. The ridgeline offers amazing views in every direction - perfect for 360 degree panoramas. The overall diversity of the trail provided a great variety of flora, fauna, landmarks, and soundscapes that could be incorporated into the website interface and successfully showcase the planned features of the Trail View project.

4.2 Panoramas

Taking photos to create a panorama was a process that the team spent a lot of time researching and practicing because it was such an important part of the Trail View project. The team aimed to achieve photos that were high quality in order to ensure that the interface would successfully capture the beauty of Acadia's hiking trails. After making minor changes to the methodology, this process was finally perfected to create panoramas worthy of being integrated into the Trail View interface.

The first picture was always taken pointed in the direction of the trail. The next three were taken while rotating around the point of parallax, every 90 degrees. The last photo was taken with the lens pointed at the sky. Each set of five photos was taken approximately every twenty yards. However, when the trail wound through the woods, photos were taken at each bend in order to ensure that the location for the next panorama would always be visible in the previous panorama.

As pictures were being captured at each location, one group member took notes and pictures of interesting birds, plants, and features along the path, in addition to recording audio clips. Two team members recorded GPS coordinates with the Garmin eTrex and took trail headings using the GPS Status smartphone application.

4.2.1: Determining Photo Quality

Both automatic and manual mode were tested to see which resulted in the best photos. In automatic mode, the panoramas had borders where the shading would change. For shooting manually, the pictures were checked to make sure that the exposure and shutter speed were correct. Although it took extra time to check camera settings, manual mode resulted in higher quality panoramas. After stitching, pictures that were overexposed or underexposed were either edited in Photoshop or retaken.

Weather was a factor in panorama quality. Clear, blue skies resulted in higher quality photos. Foggy and hazy days on the upper, exposed ridge section had obstructed views that resulted in lower quality panoramas.

4.2.2: Stitching Process

Since a fisheye lens was used to capture the five photos taken at each trail location, the resulting pictures were a set of circular images. The next step in processing these photos was stitching them together to create one 360 degree panorama. Using a stitching software program called PTGui, the team successfully stitched 1565 photos together into 313 panoramas. The lens type was specified in the PTGui software and the photos were circularly cropped to get rid of any surrounding black space. PTGui then aligned the images into a single panorama through the use of control points. The control points served the purpose recognizing similar objects in the photos to fasten edges together. In order to increase panorama quality, PTGui's optimizer was used to create panoramas that were less distorted and warped in the viewer. In addition, excessively dark or bright panoramas were then Photoshopped for editing and color correction.

Figure 21: Five photos taken at one location

Figure 22: The resultant panorama post stitching

4.3: Trail View Utilities

Three different programs will frequently utilized during the project. The first was a program called TilesGenerator, originally written by Mike Gleason and licensed under the GNU Public License v3 and modified by the group for the specific circumstances of the current Trail View project. The purpose of TilesGenerator is to take a stitched panorama and to tile it into smaller sub-photos. Each photo would then consist of multiple tiles at each possible zoom level.

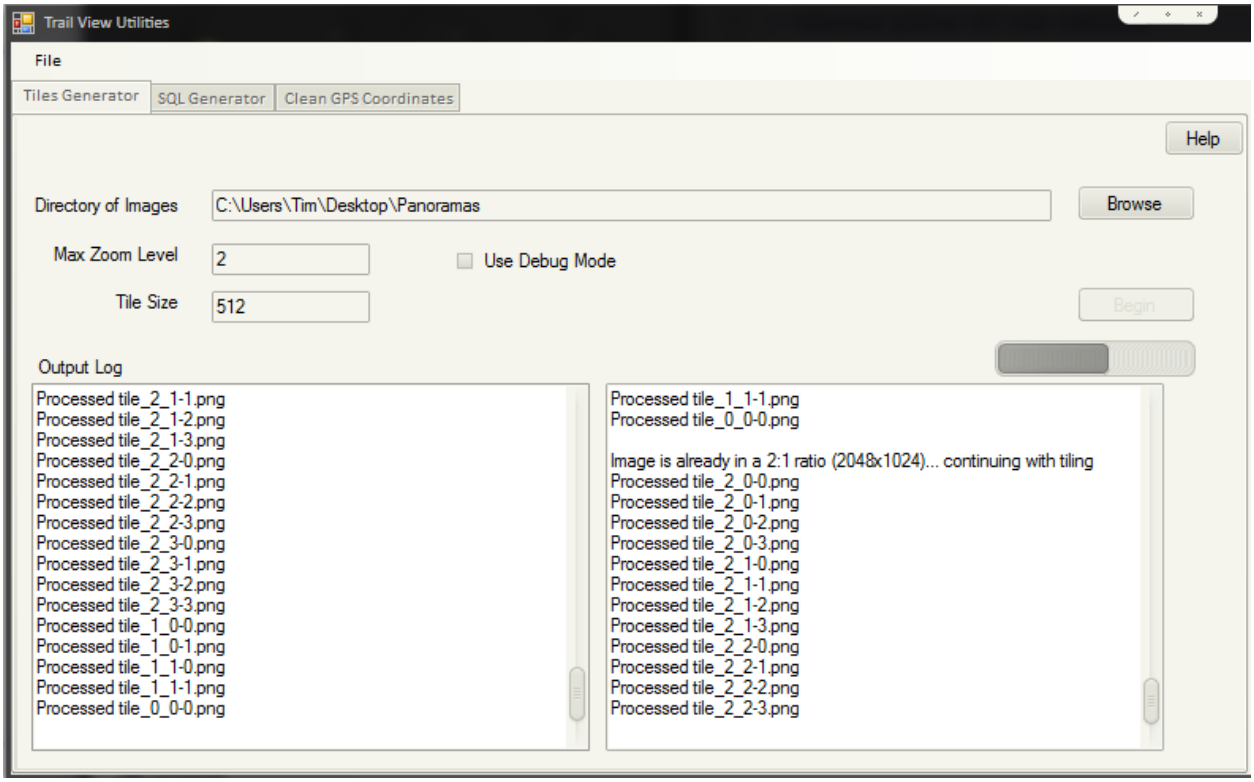

Figure 23: Tiling a set of photos

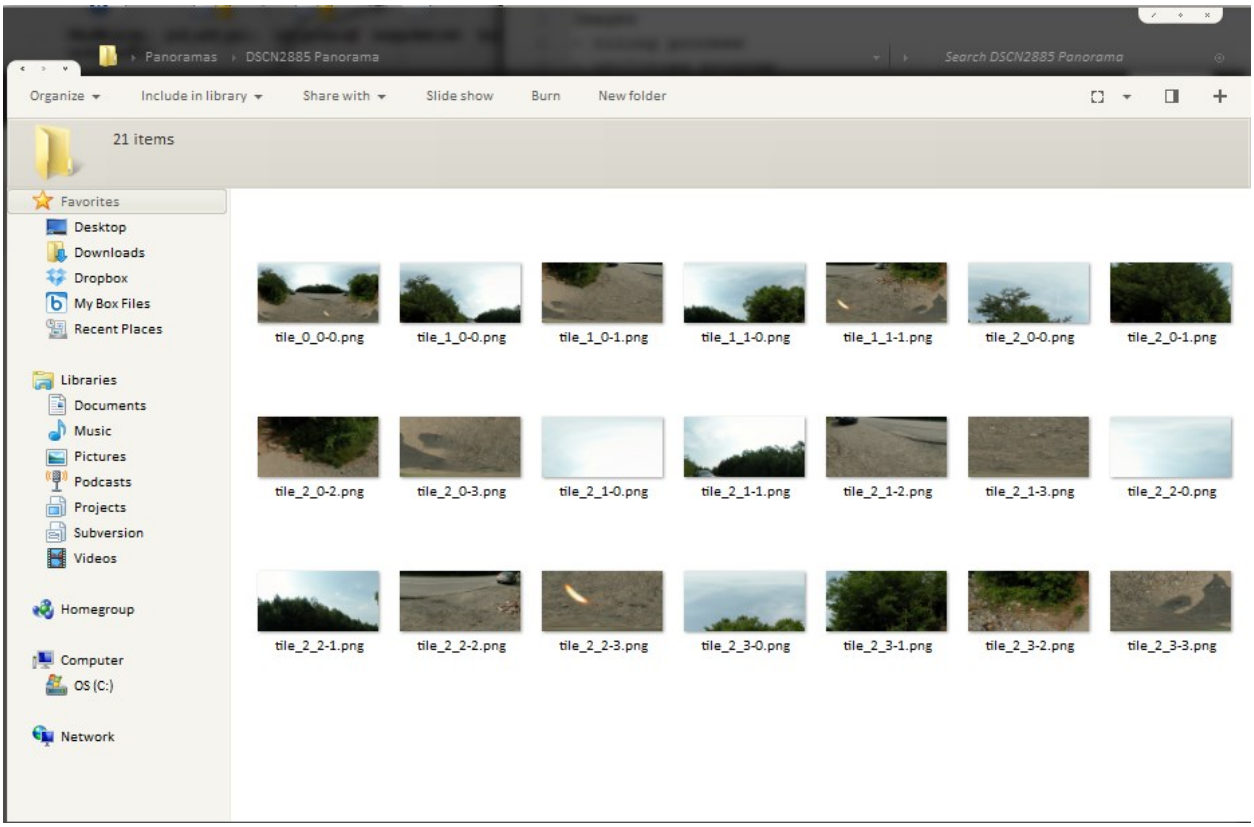

Figure 24: Tiled images resulting from running TilesGenerator

Another program was written to take tiled photos, GPS coordinates and headings taken from the trail, and to generate a SQL query that could be executed to add all of the necessary information for the website to display the panoramas.

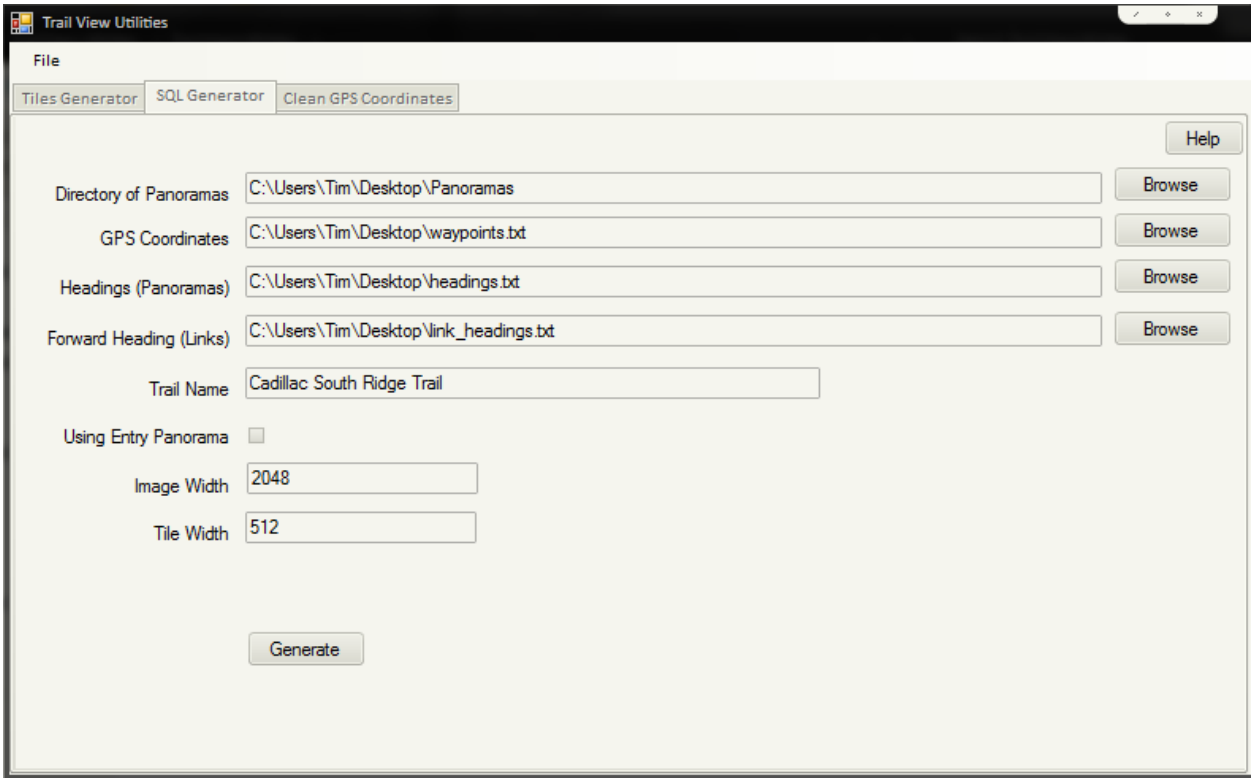

Figure 25: SQL Generator

The final program written was designed to take a file filled with data about waypoints as was output by the program Expert GPS and clean it up into a more manageable format, as well as the format that the previously mentioned program for generating SQL queries was designed to take.

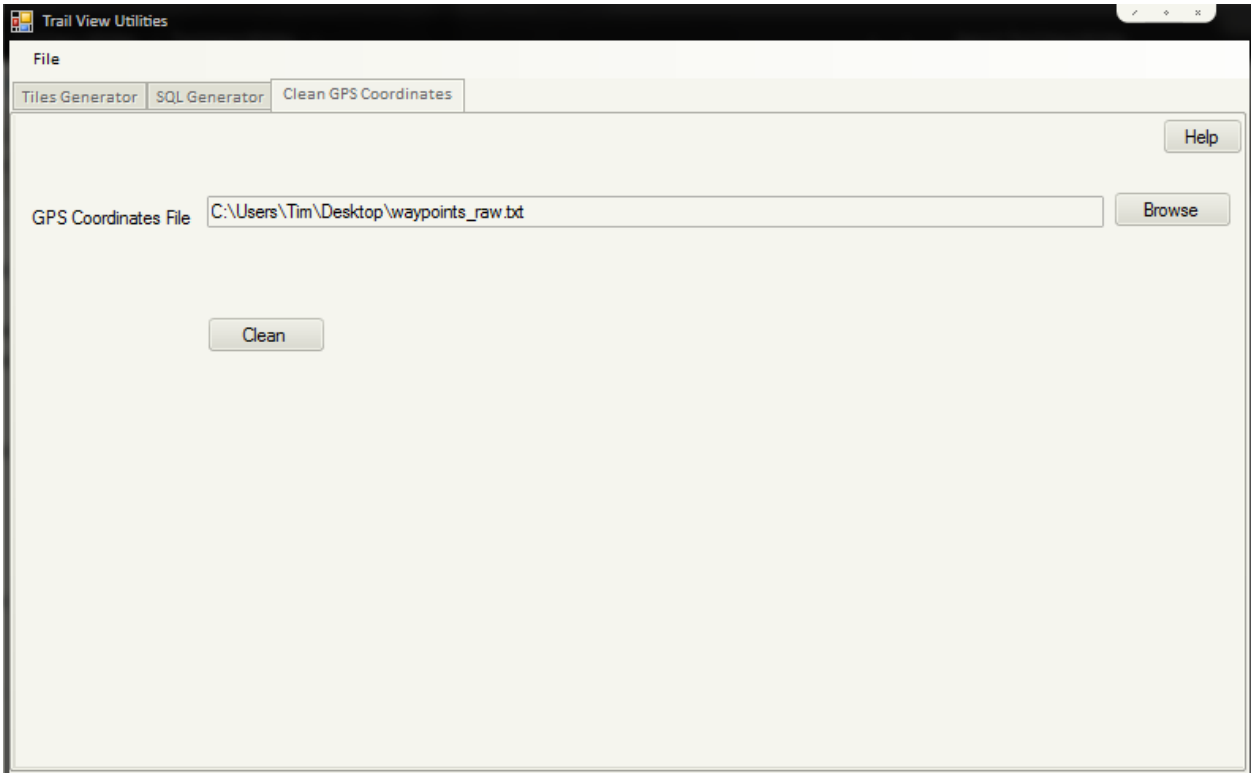

Figure 26: Cleaning GPS coordinates

A graphical user interface (GUI), called Trail View Utilities, was programmed specifically for the Trail View Project. The program was designed as an easy to use alternative to manually running the three previously mentioned programs. It included three tabs, one for each program. TilesGenerator took the path to a directory with all the images that needed to be tiles, as well as a maximum zoom level and the tile width for each tile. After pressing the begin button, the program would launch TilesGenerator to tile the photos, and continue to do so until all the images supplied in the directory were tiled. The tab for SQL Generator took a number of input. It requested a directory that held all of the tiles photos, a file with the GPS coordinates for each of the photos, two files representing the heading for each panorama and the heading of the forward link for that panorama. Finally, it took the name of the trail that these photos existed on, whether or not one of Google's panoramas was to be used as an entry point, and the image width and tile width. This information was then fed into the SQL Generator program, and one the query was

created, it was opened either in a program for .sql files or the default program associated with .txt files. The final tab for GPS Cleaner simply takes the file that was output by Expert GPS and, after running, returns a file with the pertinent information reformatted into a more useable file.

Each of the programs include a small help file that explains what the program is designed to do, and what is necessary for the user to supply in order to work correctly. Additionally, each program has a number of settings that the user can set in order to make using the program a simpler experience.

4.4 Website Interface and Points of Interest

The final panoramas were then integrated into the Google API together with corresponding GPS coordinates and trail headings. This allows the interface user to click through the panoramas of the trail, similar to that of Google Street View. The Google API is accessed through JavaScript.

The Trail View website was written in ASP.NET MVC 4 with additional work in JavaScript, HTML, and CSS. JavaScript libraries such as JQuery and JQueryUI were used to quickly added complex features, and increase the production quality of the website.

The Trail View window that displays the panoramic photos on the left hand side of the page is the focal point of the web interface. The window is the result of utilizing the Google API, and the various aspects of it are all handled by the API.

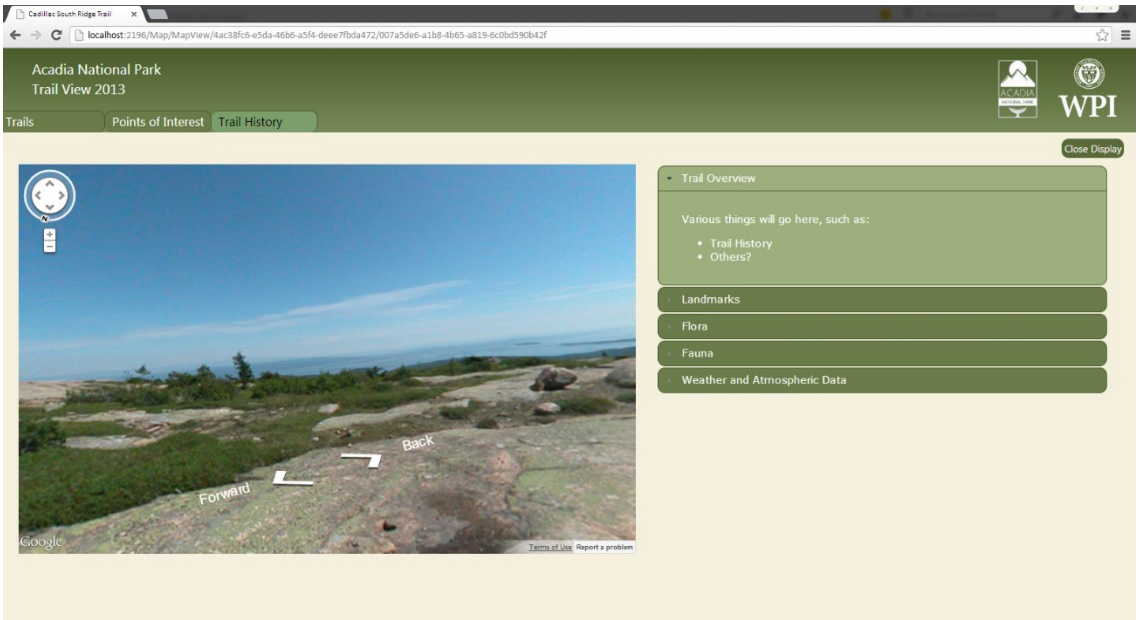

Figure 27: Main TrailView window

Users can select a point along the trail to jump to by requesting that a map, also created using Google Maps, be filled with markers of various categories. The user can select from multiple categories, from all of the points along the trail to individual categories of points of interest. After selecting the filter, the user clicks a button, and the map loads various markers along the trail. Each marker can be clicked by the user, and then that panorama along the trial is loaded for viewing.

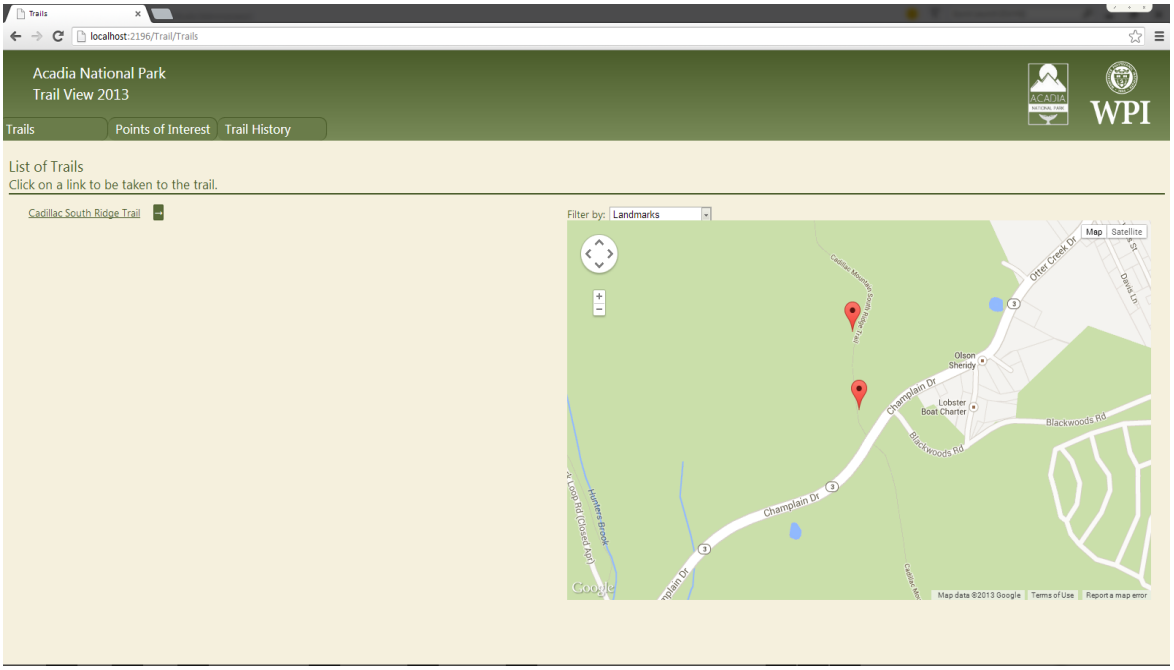

Figure 28: The page to select an entry point for a trail

On the website, various points of interest can be viewed on the right hand side in an accordion menu. This allows for content to be expanded and contracted based on the user's preferences. Points of interest are showcased through images and sound recordings. Displays of information on flora, fauna, and trail landmarks change based on the location of the panorama with respect to the trail. In addition to the accordion menu, points of interest are also available in a bar menu at the top of the webpage. Using the bar menu, people only interested in a certain category of point of interest can navigate to specific locations on the trial where they can be found. The bar menu is split into two sections. The user can view all points of interest listed alphabetically by category, or by selecting a category, they can view all those points of interest listed by the trail they can be found in. This two sided approach to presenting the points of interest allows people to conduct direct research on specific items using the bar menu, and also lets the user learn about the trail when navigating through the Trail View application.

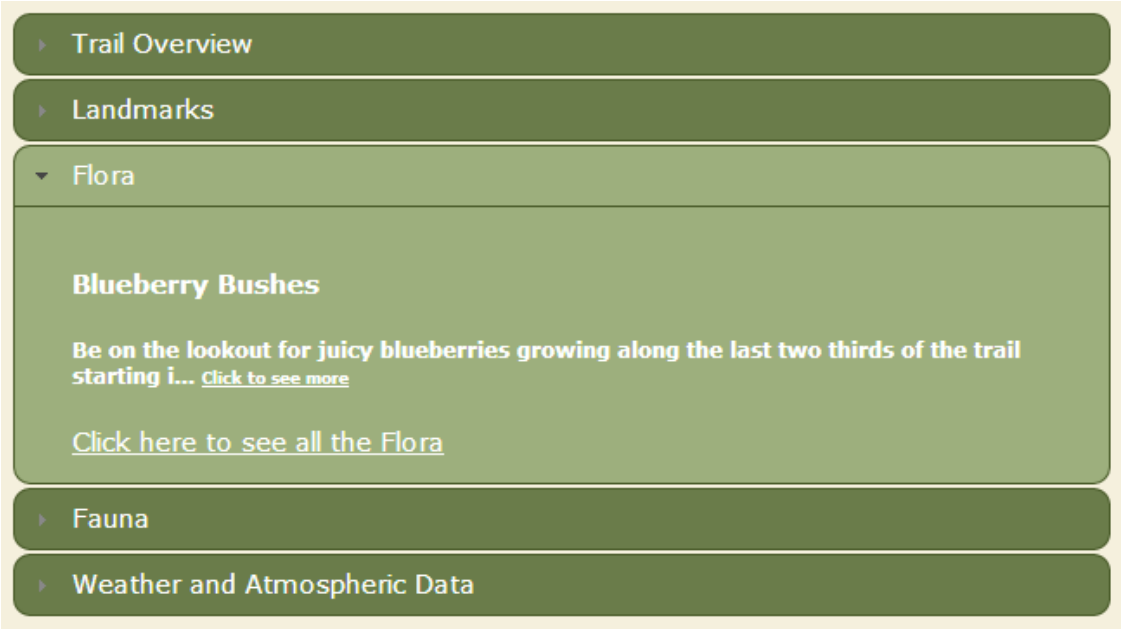

Figure 29: Accordion of Points of Interest

Locations along the trial for points of interest vary based on the category and exact point of interest. For example, a specific glacial erratic rock only exists on the sidebar in one panoramic location on the trail. A specific recording of a bird song, however, exists in a string of connected panoramas that cover the bird's known habitat.

The points of interest section of the interface also includes special features that can be found on the trail such as wooden walkways, staircases with manmade steps, and runoffs for water. These apparatuses serve to decrease the effects of trail erosion, both preserving and protecting the trail from excessive weather conditions that could damage the path. These impacts of destruction make it difficult for hikers to fully enjoy everything that the trail has to offer.

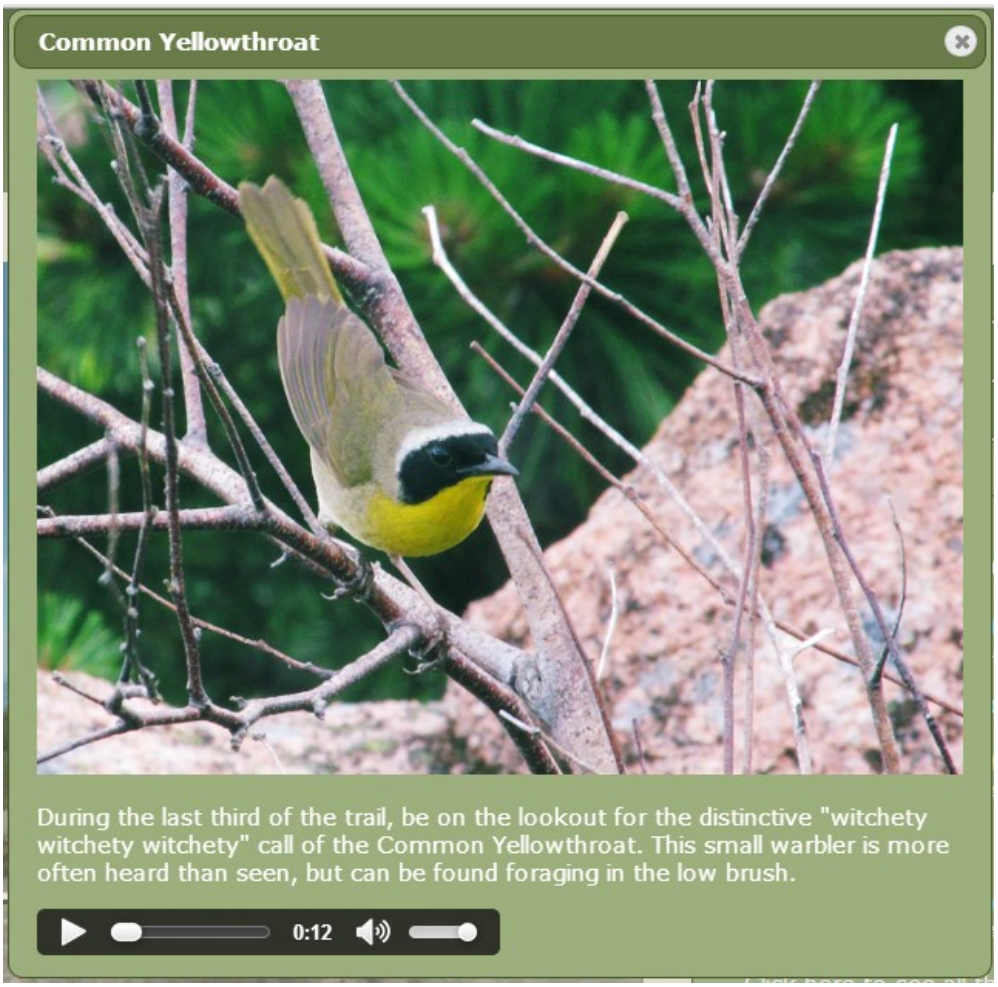

Figure 30: Popup window for a Point of Interest

The Trail View project increased the accessibility of Acadia by allowing people to virtually tour the hiking trails, opening the wonder of the Park up to people who may not be able to hike. It also served to advertise these trails to people who have not yet found another motive to visit the Park. If Trail View images are consistently updated in future years, it will serve as a log of the condition of the trail. This allows for park managers to monitor the trail erosion caused by hikers and take action when it is needed.

4.5: Social Media

The website interface that the team created successfully integrated the virtual Trail View and information to further educate viewers about trails in Acadia National Park. All that was missing was a means of reaching a wider audience to spark interest in the project. It is for this reason that the Trail View team turned to social media, allowing people to follow the developing project through its growth and expansion into a full, live website. Since the final product of the 2013 Trail View project will not be posted online, it is important to build a social media framework so that future groups will already have a following and public interest in the project. The Trail View team created a Google website and Twitter account and a Cadillac Mountain South Ridge Hiking Trail Facebook page was created.

The Google website was constantly updated with biweekly blog posts and various pictures and descriptions of equipment and the team's picture-taking process. This gave viewers a quick introduction and understanding of the Trail View project. A new embedded web based application from Google Developers, Photo Sphere, allowed the Trail View team to post newly created panoramas, in their highest quality, directly onto the website. Originally, the team did not plan on posting any panoramas online because the free version of the Google Maps API had very poor picture quality and bandwidth issues. The Photo Sphere panoramas were not linked to one another and did not have the Google Street View interface, but they proved to be useful in meetings with Dr. Miller-Rushing and the Acadia Youth Technology Team. The panoramas acted as a successful display to show the progress and work that had already been done on the project.

A Twitter account, @WPI_Trail_View, was created so that the team could upload updated pictures of the trail and equipment, and talk about the status and progression of the project. The Twitter was also used to direct people to the Google website in order to give viewers

more in depth information. In addition, the Twitter page allowed the team to follow organizations like Friends of Acadia and Acadia National Park, allowing the Trail View team to remain updated on other relevant projects and research.

One of the best methods of advertisement is through Facebook pages. The business style page for the Cadillac Mountain South Ridge Trail does much more than just let people "like" the trail. Facebook users are also given the option to "check in" to the area based on GPS coordinates. As a result, any pictures or statuses made in the geographical area of the trail contain a link to the Cadillac Mountain South Ridge Trail page. The "check in" feature of the page mirrors the data crowdsourcing goal of the project that will eventually let people post pictures of birds and plants, and provide weather data and conditions on certain areas of the trail. In addition, statuses and pictures that are "checked in" are available for a wide variety of people who might not have even known about the trail or project to begin with. The Facebook page is a great way to advertize the trail to the public, and help it reach a greater number of users through the use of social media.

4.6: Framework for Future Project Work

PTGui, the photo-stitching software used to turn sets of 5 photos into one complete panorama, was purchased to give the team three licenses. This allowed for more than one group member to stitch photos at a time, which was very time efficient. This software can be passed along to future project groups.

The Trail View team successfully created a variety of programs that can assist future groups in tiling photos, added information to the database, and other small tasks that would take a long time by hand. Additionally, a front end for these programs was created to make it easier for future groups to work with the programs in no modifications are needed.

The final web interface was structured so that future groups will only need to expand it when new content types are added, such as new categories for points of interest. Beyond this, the program was designed so that simply adding a trail is as simple as stitching and tiling the panoramas, and then running them through the supplied utilities and adding the information to the database.

Nevertheless, in the wholly expected scenario where future groups need to expand on the work completed, the code for the website has been added to SVN version control hosted on Google Code ("Google Code – WPITrailView"). Additionally, all programs and source code will be copied to a hard drive and supplied to future groups.

Chapter 5: Recommendations

The Trail View project was highly successful in achieving its goals, but as with any major project, there are some improvements that could lead to further advancements and enhance the overall quality of the final product. Furthermore, there are some possibilities for the future development of Trail View that were not fully explored in the past year and will require the attention of future groups.

5.1: Equipment

The research completed by the Trail View team prior to arriving in Acadia turned out to be highly successful in some ways and lacking in others. In practice, the equipment selected worked fairly well, but the team has recommendations on how to change it in the future.

The fisheye lens allows for a full 360 degree panorama to be captured in just five photos, an invaluable convenience when regular lenses require upwards of twenty photos in order to accomplish the same task. The lens was a very successful choice. Its only downside is that the final product includes some “warping” that would not exist in panoramas taken by a regular lens. These effects are not severe and, in the Trail View team’s opinion, the small drop in quality is worth the large increase in productivity that the lens provides.

The Trail View team was also very satisfied with the functionality of PTGui, the photo stitching software. It worked as desired and is both time-efficient and easy to learn.

The camera was chosen for price and convenience. It was available to the team for free from WPI’s Academic Technology Center, but it is an outdated camera from 2002. The project would benefit from a more modern camera capable of taking higher resolution photos.

For use with the Google API, photo width in pixels must be a power of two. The Nikon Coolpix 5700 is just barely capable of reaching the 4096 pixel benchmark if zoom is utilized to minimize wasted black space around the outside of the circular photo. Bandwidth issues with the final product require a reasonable balance between picture quality and loading speeds. Higher resolution photos would be of higher quality, but loading speeds would suffer if the resolution is too high. The 4096 size photos seem to walk that line fairly successfully, but quality would improve greatly if the camera was not strained to the edge of its capabilities.

A more modern camera with higher megapixel capabilities would have the luxury of taking photos larger than necessary and shrinking down to the 4096 size. Shrinking a photo generally eliminates some of the noise and other distortion that is apparent in full-size photos. Modern cameras are compatible with the fisheye lens, but further equipment is necessary to make the whole apparatus work. The threads on the lens adapter do not fit all cameras, but step-up and step-down rings exist for the purposes of creating compatibility. The Trail View team has several recommendations for future project groups depending on their budget.

If budgets remain small, the Trail View team recommends keeping the same fisheye lens and obtaining the Canon Powershot G7, which can be made compatible with the current lens through the use of a Canon LA-DC58H Conversion Lens Adapter and a 46mm to 58mm step-up ring. The estimated cost of this option is about $200. This camera is a viable option for project groups with a limited budget. However, should more money become available in the coming years for the Trail View project, there are several superior options.

The next step up would be a DSLR camera with an internal fisheye lens. This setup will create high quality images with little distortion and provides much user customization. This option is likely to cost at least $2000.

Finally, the ideal setup, given a large budget, would be to obtain a panoramic camera. Such cameras are designed for exactly this purpose and, as a result, create perfect depictions of the landscape with no distortion. One leading example in the field is the Panoscan MK-3 ("Panoscan Panoramic Camera for High Speed Digital Capture; Home of Panoscan Inc."). Such a camera cannot currently be found for under $10,000.

5.2: Going Live

The Trail View team's main task was to create a local draft of what will someday be an online-accessible website. There are many considerations that future teams will need to make in undergoing this transition.

5.2.1: Google Business API

In order to successfully host the large files associated with the Trail View project, a Google Business API key will be required. The free API simply does not provide the necessary bandwidth or resolution necessary for such an image-heavy project. Without it, the website will run very slowly and will not tolerate a lot of traffic. The Business API costs $10,000 per year ("Google Maps API for Business – Google Earth and Maps Enterprise").

The NPS already has a Business API that the Trail View team might be able to use. Nate Irwin and the staff at NPMaps have graciously offered assistance to future teams, both in terms of using the API key and general help in building the web application. Future groups should contact Mr. Irwin as soon as possible to begin discussions. He can be reached at npmap@nps.gov.

5.2.2: Server and Hosting

In order to successfully host the website, a server will have to be acquired. Since ASP.NET MVC 4 is a Microsoft language, the best system to use to host the website would be Microsoft Azure. Future groups should certainly look into the feasibility of hosting on a server running Azure.

5.2.3: Smartphone Application

This project has the capability of being expanded further into a smartphone application. Given that technology is constantly changing and upgrading, it is necessary that this project does as well. This will keep the project's technology up-to-date, while at the same time maintain people's interest in what the team is trying to accomplish for Acadia National Park.

Developing the online interface into a handheld media device will allow park-goers to become more interactive in park research. People will be able to input data and observations, such as weather and trail conditions, and record any flora or fauna observed. They will also have the option of uploading photos, videos, additional panoramas, and even audio clippings into the application.

Creating large amounts of data will be valuable for Acadia and other researchers who study climate trends, trail erosion, and species migration and survival on Mount Desert Island. This idea of crowdsourcing will allow for researchers to more easily spot and observe trends in data over time. These patterns and trends will help create methods and plans for the preservation of trails and wildlife, as well as point out problems and erosions that may not have been apparent before this application was launched.

Crowdsourcing will become a great asset not only to Acadia, but also to the National Park Service. Expanding this application even further in the coming years, to other National Parks, will be a step in the right direction for keeping the parks safe, clean, and protected.

Chapter 6: Conclusion

The Trail View team has successfully captured the beauty of Acadia National Park through panoramic photos, and has integrated these into a working web interface that showcases everything that the trail has to offer. This project goes hand in hand with the Department of the Interior's "Call to Action," which touches base on trail preservation, increasing tourism, educating park visitors, and incorporating technology into the National Park system (Action Points 7, 10, 16, 17, and 19).

Utilizing an external fisheye lens proved to be successful for the photo-taking process involving sets of five photos taken approximately every 20 yards on the trail. The team found a stitching software that was easy to both learn and use in order to put the photos together into one panorama. A website interface was designed to interactively include points of interest, pictures and information on flora and fauna, audio recordings, and special trail features and landmarks. For future progression, the Trail View team recommends use of a higher quality camera and purchase of the business version of Google API in hopes that the website interface will be hosted online for everyone to enjoy.

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