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Sound Archive: Acadia National Park
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Abstract

The purpose of this project was to collect audio recordings of Acadia National Park. With these recordings, the team designed an archive that makes the recordings accessible to the general public. The audio recordings include important sounds that are signature to Acadia. These "sound marks" illustrate the unique attributes of the park to the general public. This project is of importance to groups that do not have direct access to the park. People who want the Acadia experience, but cannot physically traverse the terrain will now have the opportunity to do so through audio. Researchers and artists who are looking for sound clips to capture and display the history of Acadia can also find use in this archive. It will preserve and present the natural sounds and environment of Acadia National Park for many generations to come.

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Executive Summary

The purpose of this project was to collect and archive audio recordings of Acadia National Park. The six major acoustic zones that compose the majority of Acadia National Park determined the recording locations. These acoustic zones are Alpine, Evergreen Forest, Hardwood Forest, Mixed Forest, Shrubland, and Wetlands. Each acoustic zone had sounds that were signature to the vegetation and biodiversity that was present in those areas.

In order to record and document the environment, a shotgun microphone, preamplifier, recorder, and headphones were brought into the field. The equipment was set up with the microphone on a tripod for stabilization. Recording of birdcalls, cicada sounds, oceanic waves, chipmunks, squirrels, and insects moving was commonplace. A hydrophone was used to document the movement of water and other underwater sounds. External hand-held equipment was also brought into the field for the purpose of documenting the surrounding area, time of day, exact location, and visual representation.

The raw recordings were then entered into an audio processing software so that they could be edited to provide the best quality possible. The edits included noise cancellation, normalization, and clipping. After editing, the sounds were tagged in increasing numerical order for organization, as well as with GPS coordinates and their source file number.

With these recordings, the team then designed an archive that makes the recordings accessible to the general public. The audio recordings included important sounds that are signature to Acadia. These “sound marks” illustrated the unique attributes of the park to the general public.

This project is of importance to groups that do not have direct access to the park. People who want the Acadia experience, but cannot physically traverse the terrain will now have the opportunity to do so through audio. Researchers and artists who are looking for sound clips to capture and display the changes of Acadia's soundscape will also find use in this archive.

The sound archive and associated metadata will be posted on the National Park Service's website IRMA for easy accessibility. A GIS rendering will be put online with locations pinpointed that will allow users to listen to the sounds recorded at each location. The archive will preserve and present the natural sounds and environment of Acadia National Park for many generations to come.

Table of Contents

Abstract 2

Acknowledgements 3

Executive Summary 4

List of Figures 8

Authorship 9

Introduction 10

Literature Review 12
- **2.1 Audio Presence in National Parks** 12
- **2.2 Audio Recordings in National Parks** 12
- **2.3 Recording Techniques** 13
- **2.4 Archiving Strategies** 14
- **2.5 Accessibility Techniques** 15
- **2.6 Connection to Acadia National Park** 16

Methodology 17
- **3.1 Criteria for Recording** 17
- **3.2 Recording Equipment & Technique** 18
- **3.3 Archiving Sound** 19
- **3.4 Accessibility of Sound Marks** 20
- **3.5 Ethical Considerations** 21

Discussion and Results 22
- **4.1 Recording Setup and Equipment** 22
- **4.2 Acoustic Zones** 26
  - *4.2.1 Evergreen Forest* 27
  - *4.2.2 Hardwood Forest* 28
  - *4.2.3 Mixed Forest* 29
  - *4.2.4 Wetlands* 30
  - *4.2.5 Alpine* 31
  - *4.2.6 Shrublands* 32
- **4.3 Technical Considerations** 33
  - *4.3.1 Mid-Side Conversion to Left-Right Stereo Audio* 33
  - *4.3.2 Noise Cancellation in Recordings* 35
  - *4.3.3 General Editing in Recordings* 36
  - *4.3.4 Storage of Archive and Metadata* 37
  - *4.3.5 Integrated Resource Management Applications (IRMA) and WPI Website* 39

Recommendations 40
- **5.1 Continue Documentation** 40
- **5.2 Geographic Information System (GIS) Availability Online** 40
- **5.3 Parabolic Dish Microphone** 40

Conclusion **42**
References **43**
Appendix A **47**
Appendix B **48**
Appendix C **49**
Appendix D **51**
Appendix E **52**

List of Figures

Figure 1. Recording Equipment General Setup 22
Figure 2. Microphone Stand for Audio-Technica BP4027 Shotgun Stereo Microphone 23
Figure 3. DolphinEar DE200 Series Hydrophone Setup 24
Figure 4. Handheld Devices for Metadata Recordings 25
Figure 5. Canon EOS Rebel T3 Digital Camera 26
Figure 6. Cadillac Mountain South Ridge Trail – Evergreen Forest 27
Figure 7. Beehive Trail - Hardwood Forest 28
Figure 8. Bald Mountain Trail - Mixed Forest 29
Figure 9. Bass Harbor Marsh – Marshland 30
Figure 10. Cadillac Mountain Peak - Alpine 32
Figure 11. Schooner Head Coastline - Shrublands 33
Figure 12. Archive Metadata for First 23 Recordings 37
Figure 13. More Archive Metadata for First 23 Recordings 38

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Introduction

The National Park Service's responsibility is to protect nature in America. The United States government, through the support of U.S. citizens, mandates this responsibility. The government's mandate outlines the National Park Service's (NPS) *Call to Action*. The parks' *Call to Action* is twofold: the NPS must steward nature and simultaneously engage the public in its work. Through promoting these principles, the National Park Service hopes to protect the natural beauty of America's parks.

An often-overlooked aspect of a park's natural beauty, as well as its inherent value to people, is its soundscape. A soundscape is the combination of all sound in a particular area. For example, Old Faithful erupting is a commonly admired sound in America. Recordings of soundscapes, such as this one, document the natural ambiance of the park and make it accessible to the public.

Audio recordings are necessary to capture the soundscapes of locations. As a national park, Acadia's sounds are a large part of its natural ambiance. From the mountains to the coast, sounds emanate throughout the park. However, many of Acadia's sounds have been diluted by the increase in human activity on Mount Desert Island. This dilution compromises the aesthetics of the park. A way to steward this problem was to document the sounds as soon as possible. Documentation included multiple recordings of sound-rich areas in order to capture a small snapshot of the parks' environment. Making these sounds accessible to the public through archivization promoted further public engagement with the park.

The process of archiving is a well-known method of data organization that is intended for public use. It results in preservation and easy access to the investigated subject. However, not many archives have documented and presented naturally occurring sounds in national parks.

Through the work of our project, environmental audio recordings have been collected in order to preserve the natural sounds of Acadia. These audio recordings include important sounds that are exclusive to Acadia. These “sound marks” are unique attributes of the park and required preservation. We archived these recordings so that they are accessible to the public, including researchers and artists who may need to listen to and study the sounds of the park.

Literature Review

In the past, written words, pictures, and art preserved nature. However, not much was done to document the naturally occurring sounds. Sounds are just as much a part of the environment as light, water, and wildlife. Because the audio of an environment changes over time, there is a need to record it. The following chapter reviews literature that acknowledges these special sounds of national parks and how to document and make accessible a baseline system of recordings, such as those at Acadia National Park.

2.1 Audio Presence in National Parks

Every national park has unique sounds (Ambrose & Burson, 2015). Yellowstone National Park has the hissing famous geyser, Old Faithful (National Park Service - Department of the Interior, 2015). Lassen National Park in California has bubbling hydrothermal features – the numerous fumaroles and burping mud pools (U.S. Department of the Interior, 2015). Acadia National Park is no exception. Thunder Hole, a small cave at the tidal edge where waves drive in then blow back with percussive force, creates a sound distinctly similar to thunder (Hartford, 2015). Special sounds, like those at Thunder Hole, present an opportunity for documentation.

2.2 Audio Recordings in National Parks

Since sound changes can indicate improvement or deterioration of the environment, the National Park Service made it mandatory that all national parks conduct sound studies by recording unique audio specific to that park (United States National Park Service, 2001). For example, one sound study conducted at Sequoia National Park demonstrated variation in

seasonal sounds through a series of soundscapes (Krause, Gage, & Joo, 2011). A different sound study, currently underway in Denali National Park, establishes a soundscape baseline that can illustrate the sound of the park before it is further interrupted by human-generated noise (National Park Service - Department of the Interior, 2015). Similarly, a sound study conducted in Canyonlands National Park created a baseline as well. It is noteworthy that the National Park Service utilized this baseline to denote Canyonlands one of the quietest national parks (Montana State University, 2015). The Canyonlands' recognition was a direct result of the national park's successful recording technique.

2.3 Recording Techniques

Recording techniques utilize a mix of new and old approaches. One of the earliest efforts to record sound utilized equipment that is no longer useful, but established a great strategy of how to record audio. Some of these strategies appear in the work of Bernie Krause. Using the idea that our brains hear selectively, he arranged microphones to collect sounds that will immerse the listener. To achieve this effect, he used a high-quality hypercardioid condenser, a microphone design that is still in use (Oppenheimer, 1989). A more recent expert, Chris Watson, has adopted newer equipment and developed more effective techniques (BBC Radio excerpt, 2015). His approach gives a good strategy on how to conduct sound recordings. One example is the use of very low-tech structures for omnidirectional recording. Chris Watson uses an omnidirectional microphone and connects it to a coat hanger to create a good lightweight stereo (Gallagher, 2011). For overall sound production, he uses an omnidirectional microphone to record the ambiance, and a hypercardioid to pick out key sounds. Known as layering, this

process blends multiple sounds into one sound scene. Watson's techniques use more modern equipment. Watson's microphone of choice for his sound recordings is any in the HKN series. Specifically, he uses the MKH 50 microphone to record directional sounds (Tv-bay, 2015). These approaches to recording have been brought together by Damon Joyce. He studied the rise of noise levels and their impact on national parks (Lynch, Joyce, & Fristrup, 2011). He also studied bioacoustical activity within national parks to find patterns between the many different national park sites. His research creates a map that predicts bioacoustical activity throughout the United States (McKenna, Mennitt, Lynch, Joyce, & Fristrup, 2013). This kind of mapping makes it possible for people to find the optimal place to listen to or record the most ecologically active sounds.

2.4 Archiving Strategies

In order to systematically archive the collected data, a few modern archiving techniques exist. One example appears in Cornell University's Macaulay Library. This database, developed by Cornell University's Lab of Ornithology, is now considered the world's largest collection of digitized wildlife recordings (Leonard, 2013). It contains approximately 150,000 digital recordings, representing approximately 9,000 species from around the world. Cornell's archiving system utilizes the outline provided by the Association for Recorded Sound Collections (ARSC) Technical Committee. This outline contains relevant information that must be included for completeness when making sound recordings (Ross, 2009). The descriptive information categories, also known as metadata, contain the important facts that archive users seek. The system uses metadata categories like location of recordings, the equipment used, and the name of

the animal or object recorded to help users identify a particular recording for further investigation.

Western Soundscape Archive uses another technique. This organization designed and implemented a system similar to the one used by Cornell University. This archiving system differs, however, because it contains not only the animal sounds that were recorded, but also spectrograms, maps of where the animals were recorded, and pictures that demonstrate the terrestrial areas in which the recording took place (Collections, 2009). Archiving systems like these provide necessary organizational techniques for accessibility purposes.

2.5 Accessibility Techniques

A concern with archiving is the strategy for making certain sounds easily accessible. One way to make sound recordings accessible is through a GIS. A GIS, or Geographic Information System, is a technology that captures, stores, retrieves, displays, manipulates, and analyzes spatial data (Fotheringham & Rogerson, 1994). Data used by the GIS is then geographically referenced to the coordinates of a given area. As a result, features on the earth's surface can be located and the spatial relations between these features can be mapped (Scurry, 2015).

Many things have been accomplished through the use of a Geographic Information System. Two famous examples are Google Maps and Apple Maps. These two mapping applications give the public access to enormous amounts of geographical data. Besides giving people directions from point A to point B, they can also give the user information about traffic and even a street view of a given area. A GIS was also used to document a range of information about the Ashepoo, Combahee, and Edisto (ACE) Basin, one of the largest undeveloped estuaries

on the Atlantic Coast. The information of the ACE Basin is layered upon a map of the area in the GIS. Each layer addresses historical resources, environmental conditions, biological resources, societal demographics, recreation and tourism, resource management, and county infrastructure (Scurry, 2015). With these layers, the GIS is a user-friendly interface for navigating and visualizing sources of sound.

2.6 Connection to Acadia National Park

The audio presence in Acadia National Park is diverse and ever changing (Ambrose & Burson, 2015). As such, there is a need to record this presence and preserve it for future generations. Sound marks, as well as other biodiverse areas, dictated the audio recording locations that took place in Acadia. The recording techniques developed by experts were applied to Acadia's environment in order to properly document the national park. This documentation was used to establish a sound archive of Acadia. Portions of Acadia's sound archive will be made accessible through a geographic information system, or GIS. Both the sound archive and GIS are accessible on the Internet.

Methodology

The goal of our project was to protect a natural feature: sound. Sound is a key aspect of Acadia National Park. The audio of Acadia needed to be documented to ensure that it is never lost. Documentation required recording sounds, archiving them, and making them accessible. In order to document the audio of Acadia, we needed to first identify locations that demonstrate sound marks[1].

3.1 Criteria for Recording

The locations that we recorded included tourist-favorite regions and areas that demonstrate the characteristic ambiance of Acadia. The locations were selected by obtaining information from tourists and park officials through the use of a survey. In order to acquire the opinions of tourists, we provided a copy of a park map with all major locations marked on it. We asked tourists to identify all the locations they have visited, star the locations with their favorite sounds, write any suggestions that we may have missed on the map, and write how many times they visit the park annually. This survey is located in Appendix A. To locate sound marks in Acadia, we held two different focus groups. One was held with the Science Coordinator of Acadia National Park, Dr. Abraham Miller-Rushing. The other focus group was held with park rangers. We asked these focus groups which locations they think should be documented. The structure for the focus groups is located in Appendix B. The input from these qualitative research methods assisted in updating the list of locations, listed in Appendix C, which were recorded.

[1] A sound mark is a sound that is characteristic of a particular location.

At these locations, we recorded distinct sounds. In some regions, there were sound marks. The most pertinent example is Thunder Hole, whose well-known "booming" sound is signature to that location. However, if a location did not have a specific sound, it may have had a specific ambiance that was characterized by animals, bodies of water, or even wind that required documentation. In order to capture these many different aspects of nature, appropriate equipment was utilized.

3.2 Recording Equipment & Technique

The three pieces of equipment that were used are a microphone, a preamplifier, and a recorder. An Audio-Technica BP4027 shotgun microphone was used with a windscreen attached to record sound. The microphone recorded with a dynamic range of 101dB and in two polar patterns: cardioid and figure-of-eight. A cardioid polar pattern orientation picked up sounds directed at the front of the microphone. Meanwhile, a figure-of-eight polar pattern was an orientation that picked up sounds on the sides of the microphone, namely the right and left channels. Both polar patterns had their strengths and weaknesses. A cardioid pattern was intended to pick up sounds in front of the microphone while ignoring the rest of the area. This was advantageous for picking up specific sounds, such as a bird chirping.

However, a figure-of-eight pattern was designed for picking up sounds around the microphone. This was especially useful for picking up ambient noise. A combination of cardioid and figure-of-eight made the microphone ideal for our use. The BP4027 picked up key ecological sounds and simultaneously recorded ambient noise that represented the atmosphere in the area. The BP4027 provided a variety of information that produced an analog signal through

signal processing. Signal processing is the removal of noise and interference from a recording. This occurred in the Sound Devices 302 preamplifier.

The Sound Devices 302 preamplifier receives a dynamic range of 115dB through its input. This preamplifier adjusts the gain, channels, and filtering in order to modify the input. For example, the location determined the settings needed. One such setting was the mid to high gain with a low-pass filter of 80 Hz. The low-pass filter was used to filter the sound of wind out of recordings. A second setting was the channel, either channel 1 or 2, which corresponds to the mid and side channels, respectively. The mid channel picked up the cardioid pattern of the microphone, while the side channel picked up the figure-of-eight pattern. Another setting was the combination of the fader and the pan switch. By dropping the fader of the side channel and setting the pan switch to center, only the mid channel was active. Now very specific sounds with low background noise were recorded by using only the mid channel.

After the preamplifier processed the signal, the signal was recorded. The TASCAM DR-40 4-channel recorder was used to record audio. The recorder uses a 24-bit, .wav file format with a sampling rate of 48KHz per second. This was advantageous for acquiring raw, detailed sound files that were then preserved and stored onto hard drives.

3.3 Archiving Sound

These sound files are preserved in an archive. Because an archive presents organized information, there were organizing criteria. The first organizational technique was to arrange the sound files in increasing numerical order by recording date, beginning with number one. This system was recorded in a Microsoft Excel data sheet. For simplicity, the numbering system was made the first column.

The next columns in this Excel sheet contain twenty-seven other categories in which recorded sounds were categorized for identification. In total, there are 28 specific categories including, but not limited to: name, description, length, location recorded, environmental factors, equipment, associated pictures, and general comments. This is the data that we collected for each of the recordings. These categories were chosen because they are similar to already established classification systems, such as those used by Cornell's archive (Leonard, 2013). Another reason for this system is that it ensures easy access for a wide range of users.

Users of this archive are able to search for a particular recording by typing in any of the words or phrases associated with the categories mentioned above. The complete list of categories that were filed in the archive system is listed in Appendix D. A link to each individual recording is present next to all of the information. The classification of the records with this metadata tagging system significantly enhances the ability of researchers to identify one sound from another.

3.4 Accessibility of Sound Marks

In order to make the recorded sounds accessible to the general public, a select few were posted onto the team's website, WPI Sound Archive 2015. The sound marks will be layered into a geographical information system, GIS, using a program called QGIS. To layer the sounds in QGIS, the coordinates for each sound file will be mapped to the corresponding audio. The GIS that will be created by using this program will give viewers a way to locate the source of the sound marks in terms of the geography of Acadia National Park. When users select a particular sound, they have the option to listen to it, as well as retrieve useful information about it.

3.5 Ethical Considerations

Being aware of the potential ethical issues that arose when interviewing human subjects was imperative. All subjects interviewed were allowed to stop their interview if at any time they felt uncomfortable answering. Lastly, the anonymity and confidentiality of all individuals who agreed to participate was ensured.

There were also ethical considerations that were taken into account when engaging in sound recording in a biodiverse area such as Acadia National Park. The natural environment that we documented was not disturbed by our work.

Discussion and Results

4.1 Recording Setup and Equipment

Figure 1 demonstrates the recording setup that was used in the systematic collection of audio recordings in Acadia National Park. The diagram displays the Audio-Technica BP4027 Stereo Shotgun Microphone connected through XLR cables into the input of the Sound Devices 302 Preamplifier. It also depicts the output of the Sound Devices 302 Preamplifier connected with XLR cables into the Tascam DR-40 4-Channel Recorder. A pair of studio-quality Yamaha headphones was inserted into the preamplifier so the recordist could hear the sounds being recorded. The microphone was situated on a generic microphone stand for stabilization while recording, as shown in Figure 2.

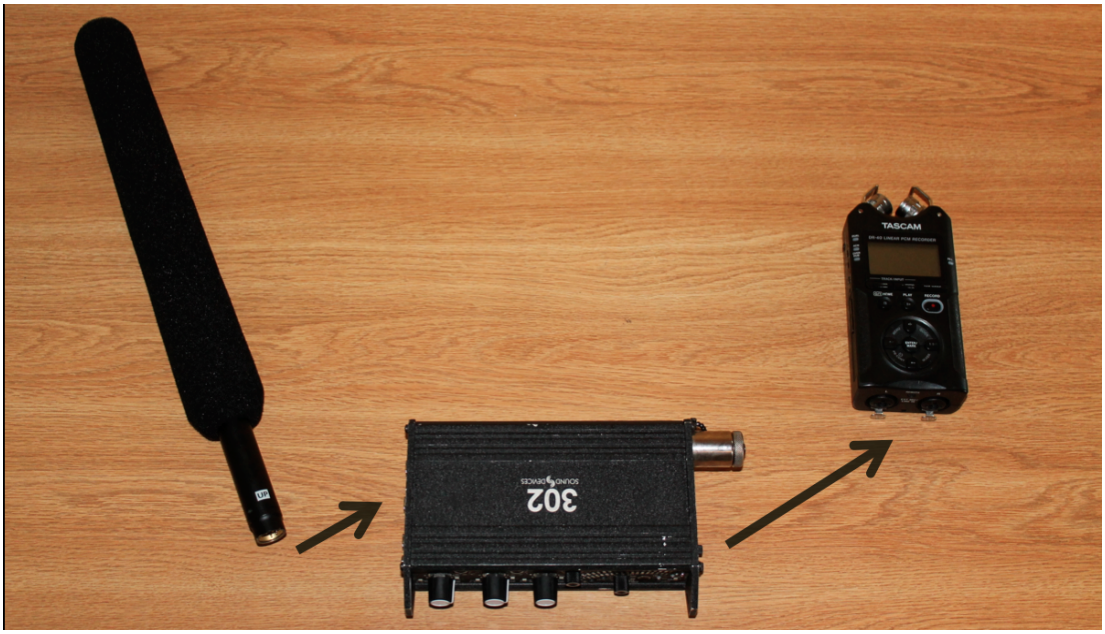

Figure 1. Recording Equipment General Setup

Figure 2. Microphone Stand for Audio-Technica BP4027 Shotgun Stereo Microphone

The DolphinEar DE200 Series Hydrophone and associated amplifier are shown in Figure 3. This hydrophone was used to capture underwater sounds in a variety of locations in Acadia National Park. The recordings documented the sound of flowing streams, brooks, and rivers. Recordings taken in locations such as Valley Cove also demonstrate the sound of slight movements of water in tidal pools. The hydrophone was also immersed in The Tarn, an ecologically active area of the Cromwell Brook Watershed. The recordings documented the current water level of the area, which can be used for future comparison.

Figure 3. DolphinEar DE200 Series Hydrophone Setup

Aside from the recording equipment shown above, other equipment was carried into the field for the purpose of metadata collection at each recording location. This equipment includes three handheld devices used in attaining the metadata for the archive, as shown in Figure 4. A Garmin etrex High Sensitivity GPS (left) was used to document the longitude and latitude of the locations recorded. An iPhone 6 Application called "Coordinates - Calculate and Convert a Position" was used to document the more exact longitude and latitude coordinates when possible. A Google Maps application provided the altitude of each location by pinpointing GPS coordinates on an online map. A Speedtech Instruments Skymate SM-18 Wind Meter (center) was used to take the average wind speed reading in each location. A generic temperature and humidity sensor (right) was used in order to record the respective aforementioned readings.

Figure 4. Handheld Devices for Metadata Recordings

Figure 5 displays a Cannon EOS Rebel T3 digital camera that was used to visually document the vegetation and weather of each area, shown in Figure 5. A collection of photos was taken at each location. At the summit of a mountain, a photo was taken of the summit's sign with the elevation and name of the trail for completeness of the archive. The photographs of each day's recording sessions were removed from the Secure Disk (SD) card, placed on an external hard drive, and tagged with the location at which they were recorded. This location correlates with the Microsoft Excel spreadsheet of recordings. The photographs were then organized into folders named with the locations that the team recorded.

Figure 5. Canon EOS Rebel T3 Digital Camera

4.2 Acoustic Zones

Sound in Acadia National Park can be divided into six acoustical zones, based on the type of vegetation and biodiversity present in an area (United States DoT, 2007). These six acoustical zones cover approximately 97% of Acadia National Park, based on the United States Department of Transportation study. The same study also determined the vegetation of each area in Acadia. The map that displays this data is included in Appendix E. The six acoustical zones outlined by the study are: Evergreen Forest, Hardwood Forest, Mixed Forest, Wetlands, Alpine, and Shrubland. The team took multiple recordings in each acoustic zone by hiking trails in Acadia National Park that contained these acoustic zones. Each acoustic zone is examined in the sections below.

4.2.1 Evergreen Forest

A prevalent acoustic zone present in Acadia is the Evergreen Forest. The Evergreen Forest acoustic zone is denoted by the presence of Evergreen trees and shrubbery around the recording location. This usually includes pine trees, as a fair amount of Acadia's forests and trails are populated with pine trees. The Evergreen Forest locations afforded the ability to record a variety of birdcalls, insects, and occasionally the scurrying of chipmunks or squirrels on the forest floor. An example of a prominent Evergreen Forest in Acadia that was recorded is Cadillac Mountain's South Ridge Trail. The acoustic nature of an Evergreen Forest is specifically denoted by dark and damp trails. Figure 6 shows Cadillac Mountain's South Ridge Trail and the associated vegetation.

Figure 6. Cadillac Mountain South Ridge Trail – Evergreen Forest

4.2.2 Hardwood Forest

Another acoustic zone present in Acadia National Park is the Hardwood Forest. Characteristic of the Hardwood Forest recording locations is specifically the presence of broad-leaf spruce trees, which are the main type of hardwood trees that cover most of Acadia. The Hardwood Forest afforded the opportunity to record and document the sounds of chipmunks and squirrels, as well as a plethora of birdcalls. On a rare occasion, the team was able to record the sound of a squirrel building its home by gathering leaves and pushing them into a hole. An example of a Hardwood Forest that the team documented is the section of Beehive Trail before the rocky climb to the summit. Figure 7 below shows this section of trail and the associated vegetation.

Figure 7. Beehive Trail - Hardwood Forest

4.2.3 Mixed Forest

A ubiquitous acoustic zone present in Acadia is the Mixed Forest, denoted by the presence of a mix of birch, cedar, pine, and spruce trees. As the name implies, a Mixed Forest includes a mixture of Evergreen, broadleaf, and deciduous trees. Characteristic biodiversity of the area includes a variety of birds, as well as chipmunks, squirrels, mosquitoes, and other insects. A prime example of a Mixed Forest that the team recorded is Bald Mountain, which is located in the southwestern section of Mount Desert Island. Figure 8 below shows the vegetation and surrounding biodiversity along Bald Mountain Trail.

Figure 8. Bald Mountain Trail - Mixed Forest

4.2.4 Wetlands

A different acoustic zone present in the park is that of Wetlands. The Wetlands zone is denoted by the presence of small shrubs, small bodies of open water, and a large number of mosquitoes. Swamp-like and marshy wet ground, bog-like conditions, and unique birdcalls are also present. The Wetlands are also home to a large amount of land- and ocean-dwelling creatures such as bullfrogs and leeches, as well as dragonflies and small fish. An example of a well-known wetland in Acadia is Bass Harbor Marsh, located on the southwestern-most edge of the island. Bass Harbor Marsh and other wetland areas tend to be most biologically active at the early hours of the morning. As such, the team recorded these locations between six and seven o'clock in the morning. Figure 9 demonstrates the vegetation and surrounding landscape of Bass Harbor Marsh.

Figure 9. Bass Harbor Marsh – Marshland

4.2.5 Alpine

Another acoustic zone present in Acadia is called Alpine. Alpine refers to an area that contains exposed bedrock and minimal plant life. This bedrock is generally composed of granite, although Gabbro-diorite sections exist in the park as well. An alpine area is generally found before the summit of a mountain, as the exposed bedrock often leads directly to the summit, which is often alpine in acoustic nature as well. The team traversed a number of these sections of trails. Small shrubbery and other plant life, such as ferns and grasses, were often found to grow in and around the exposed bedrock. The acoustics of the biodiversity in alpine areas is fairly similar to other locations in Acadia; birdcalls are abundant, as well as the scurrying of squirrels and chipmunks. Occasionally cicada calls could be heard. However, the wind in these locations, due to the increased altitude, often decreased the clarity of the recordings. A section of Acadia that is most recognizable as an Alpine zone is the summit of Cadillac Mountain. Cadillac Mountain Summit contains all of the vegetation explained above, along with foot trails for a higher volume of traffic. The audio recorded at this location includes birdcalls and wind gusts. Figure 10 shown below displays this location and its associated vegetation.

Figure 10. Cadillac Mountain Peak - Alpine

4.2.6 Shrublands

Another acoustic zone present in Acadia National Park is called a Shrubland. Ferns, grasses, shrubs, and other small plant life characterize a Shrubland zone. Boulder sized rock and pieces of gravel intermittent with these small plants are also common in Shrubland areas. The biodiversity present in a Shrubland is a bit different than the other acoustic zones, due to the increased number of insects that often flew past the microphone during recording. An example of a Shrubland that the team documented is Schooner Head on the easternmost coast of Mount Desert Island. The high number of mosquitoes, black flies, and bees in the area were recorded bountifully. Birdcalls were still audible, as well as coastal waves crashing against the granite

rock coastlines below the location. Figure 11, below, demonstrates the vegetation and surrounding area of Schooner Head.

Figure 11. Schooner Head Coastline - Shrublands

4.3 Technical Considerations

4.3.1 Mid-Side Conversion to Left-Right Stereo Audio

The following section details the step-by-step process that was used to convert raw analog audio recordings in mid-side stereo format into smooth digital files that could be listened to properly through headphones, played-back in left-right stereo audio. This process was carried out on a Macintosh laptop with version 2.1.0 of Audacity on every recording taken in the field.

A Secure Digital (SD) card containing the audio files was removed from the TASCAM DR-40 4-Channel Recorder and inserted into the SD card slot on the laptop. The recordings were placed in a folder on the computer's hard drive so that edits could be made to them, and so that

the original files could be retained. The files were opened chronologically in Audacity. When the file was first opened, the audio was presented in mid-side format. Upon viewing the sound wave, the mid channel was set to the left channel, and the side channel was set to the right channel by default. As mentioned previously, the mid channel corresponds to the cardioid pattern on the microphone, while the side channel corresponds to the figure-of-eight pattern on the microphone. In order to achieve a left-right stereo audio recording, the following steps must be followed.

The audio tracks are first split into their respective left and right channels. Clicking the drop-down arrow next to the source file number and clicking the "Split Stereo Track" option accomplishes this. The user must then set the track to be of mid-side setting temporarily; this is done by clicking the pull down menu on the mid channel and selecting the "Mid Channel" option. The next step is to change the track to the correct channels. Mid-side recordings require three separate channels for the resulting recording to sound proper. The mid channel acts as the front area of the recording, the inverted side channel acts as the right side of the recording, and the non-inverted side channel acts as the left side of the recording. The user must simulate the above breakdown in Audacity by duplicating the side channel and inverting it to create both a left and right channel. To accomplish this task, the user must have the side channel highlighted, and click "Edit" and the "Duplicate" option. Then the user must take the newly duplicated channel and click "Effects" and "Invert" in order to invert the track. The inverted audio track should be set to the right channel, and the non-inverted channel should be set to the left channel. This can be done with the pull down menu discussed above.

The side channels need to be combined together in order to create a complete side stereo channel. Highlight one of the side tracks and, while holding the "Shift" key, click the other side

track. Click the pull-down menu and select the “Make Stereo Track” option. If the user listens to both channels at this point, he will notice that both side channels average together into one mono track. The gain can be changed at this point if desired; a more ‘wide’ sound will be obtained if the gain is increased, and a more ‘narrow’ sound will be obtained when the gain is decreased.

After the gain is set to the user’s preference, the last step is to mix the tracks together to create the desired left-right stereo channel. The user should hold the “Shift” key and click on both tracks, ensuring that all work to this point is highlighted. Under the toolbar menu “Tracks”, the user should select the “Mix and Render” option. This will create the left-right stereo audio track that can be listened to properly through headphones. The conversion process is now complete.

4.3.2 Noise Cancellation in Recordings

Noise cancellation is a process by which unwanted sound is removed from a recording. Unwanted noise includes: mechanical noise from the internal microelectronics of the preamplifier, construction beeping, wind, car ignitions or movement, and even people speaking. The process isolates one particular sound, while muting or removing all the rest. This process was useful if, for example, a specific birdcall was the only desired sound from a recording. All noises except the birdcall were removed to make it easily recognizable.

In order to accomplish the noise cancellation, Audacity’s built-in noise cancelling software was utilized. To begin the process, the user must select five seconds of a recording that he wishes to have “noise cancelled”. The user should select this section of the recording by highlighting it. If five seconds total is not present in the recording, the user can “Copy” and

“Paste” a small section of unwanted sound to the end of the file to create the five second minimum length.

In order to remove the undesirable section of sound, the user should select the “Effects” option from the toolbar, and select the “Noise Reduction” option. They should next click “Get Noise Profile” and select the five seconds of unwanted noise. Lastly, they should select the entire file and again select “Effects”, but this time set the “Noise Reduction”, “Sensitivity”, and “Smooth Bands” to their maximums. Hitting the “OK” option will complete the process. The recording is now free of unwanted noise, with only the desired sound left over.

4.3.3 General Editing in Recordings

General editing of audio included the deletion of sounds that were unnatural in the environment from the recordings. Examples of unnatural sounds include the microphone being touched, the movement of a team member in the recording area, or the XLR cables hitting the preamplifier. Sections of the recordings that were deemed excessively loud were removed if it hindered the quality of the rest of the recording. It was typical for a section of this type to be comprised solely of wind gusts.

The last step in general editing was altering the maximum amplitude of each recordings sound waves to be within the desired range of -.5 dB to -3 dB. This was accomplished by normalizing the recordings. To do this, a user would select the “Effects” option from the toolbar, and select the “Set Maximum Amplitude” under the “Normalize” heading. They would then enter the above values.

4.3.4 Storage of Archive and Metadata

The signal-processed field recordings are numbered in increasing numerical order. The first recording was labeled with the number 1, and the last recording in the archive is labeled 186. All of the data collected for each recording was placed in the proper Microsoft Excel column and row, corresponding to the headings. The source file number corresponding with each signal-processed recording was also documented. This represents the original recording name from the SD card of the Tascam Recorder, before the sound was processed. This information is recorded in the event an interested party needs access to the original, unprocessed sound file.

The figures below demonstrate a fraction of the archive, and its associated metadata for a select few recordings.

Archive File #	Source File #	Description	Recording Length	In Acadia?	Park Vegetation Designation
1	150428_0267	Boat Sound	19 Seconds	No	Tidal Zone
2	150428_0268	Waves with Boat	32.5 Seconds	No	Tidal Zone
3	150428_0269	Deckhand Chores	31.5 Seconds	No	Tidal Zone
4	150428_0270	Dock Waves	19 Seconds	No	Tidal Zone
5	150429_0271	Crashing Waves	27.5 Seconds	Yes	Tidal Zone
6	150429_0272	Crashing Waves	1 Minute 32 Seconds	Yes	Tidal Zone
7	150429_0273	Crashing Waves	1 Minute 22 Seconds	Yes	Tidal Zone
8	150429_0275	Crashing Waves w/ Bird	23 Seconds	Yes	Tidal Zone
9	150429_0277	Coastal Waves	2 Minutes 4 Seconds	Yes	Tidal Zone
10	150429_0278	Coastal Waves	1 Minute 13 Seconds	Yes	Tidal Zone
11	150429_0280	Coastal Waves w/ Wind	1 Minute 19 Seconds	Yes	Tidal Zone
12	150429_0282	Coastal Waves	1 Minute 18 Seconds	Yes	Tidal Zone
13	150429_0283	Coastal Waves	41 Seconds	Yes	Tidal Zone
14	150429_0285	Coastal Waves	1 Minute 14 Seconds	Yes	Tidal Zone
15	150429_0286	Coastal Waves w/ Plane	1 Minute 29 Seconds	Yes	Tidal Zone
16	150429_0289	Coastal Waves	3 Minutes 0 Seconds	Yes	Tidal Zone
17	150429_0290	Bird Sounds	4 Seconds	Yes	Residential Land
18	150429_0291	Chipmunk Sounds	.7 Seconds	Yes	Residential Land
19	150429_0292	Wind and Bird Sounds	1 Minute 35 Seconds	Yes	Residential Land
20	150429_0293	Waves, People, and Seagulls	3 Minutes 1 Seconds	Yes	Conifer Woodland
21	150429_0297	Bird Sounds	2 Minutes 35 Seconds	Yes	Decidious Woodland
22	150429_0299	Wind with People Talking	3 Minutes 12 Seconds	Yes	Mixed Woodland
23	150618_0301	Birds and Construction Beeping	1 Minute 1 Second	Yes	Conifer Woodland

Figure 12. Archive Metadata for First 23 Recordings

Acoustic Zone Designation	Site Name	Latitude	Longitude	Date	Time - EST Zulu	Weather Conditions	Average Wind Spe
Coastline	CoA Dock	44.395405	-68.219648	6/16/15	11:45	Cloudy/Drizzle	5.5 MPH
Coastline	CoA Dock	44.395405	-68.219648	6/16/15	11:47	Cloudy/Drizzle	5.5 MPH
Coastline	CoA Dock	44.395405	-68.219648	6/16/15	11:50	Cloudy/Drizzle	5.5 MPH
Coastline	CoA Dock	44.395405	-68.219648	6/16/15	11:53	Cloudy/Drizzle	5.5 MPH
Coastline	Thunder Hole	44.320992	-68.188624	6/17/15	9:10	Sunny	2.8 MPH
Coastline	Thunder Hole	44.320992	-68.188624	6/17/15	9:12	Sunny	2.8 MPH
Coastline	Thunder Hole	44.320992	-68.188624	6/17/15	9:14	Sunny	2.8 MPH
Coastline	Thunder Hole	44.320992	-68.188624	6/17/15	9:15	Sunny	2.8 MPH
Coastline	Otter Point	44.307171	-68.189575	6/17/15	9:39	Sunny	3.0 MPH
Coastline	Otter Point	44.307171	-68.189575	6/17/15	9:40	Sunny	3.0 MPH
Coastline	Otter Point	44.307171	-68.189575	6/17/15	9:51	Sunny	3.0 MPH
Coastline	Otter Point	44.307171	-68.189575	6/17/15	9:57	Sunny	3.0 MPH
Coastline	Otter Point	44.307171	-68.189575	6/17/15	9:58	Sunny	3.0 MPH
Coastline	Schooner Head	44.340443	-68.176775	6/17/15	11:05	Sunny	5.0 MPH
Coastline	Schooner Head	44.340443	-68.176775	6/17/15	11:08	Sunny	5.0 MPH
Coastline	Schooner Head	44.340443	-68.176775	6/17/15	11:13	Sunny	5.0 MPH
Shurbland	Schooner Head	44.339533	-68.176615	6/17/15	11:36	Sunny	0.0 MPH
Shrubland	Schooner Head	44.339533	-68.176615	6/17/15	11:36	Sunny	0.0 MPH
Shrubland	Schooner Head	44.339533	-68.176615	6/17/15	11:47	Sunny	0.0 MPH
Beach	Sand Beach	44.329237	-68.181866	6/17/15	12:18	Sunny	9.5 MPH
Beach	Sand Beach/Great Head	44.328562	-68.178717	6/17/15	12:36	Sunny	1.5 MPH
Coastline	Great Head	44.327092	-68.175731	6/17/15	12:56	Sunny	2.4 MPH
Mixed Forest	Champlain Mtn. Northridge Trail	44.362112	-68.192674	6/18/15	9:01	Sun/Clouds	.25 MPH

Figure 13. More Archive Metadata for First 23 Recordings

The complete list of archive metadata categories is as follows: Archive File Number, Source File Number, Description, Recording Length, In Acadia?, Park Vegetation Designation, Acoustic Zone Designation, Site Name, Latitude, Longitude, Date, Time – EST Zulu, Weather Condition, Average Wind Speed, Altitude, Humidity, Temperature, Microphone, Type of Recording-Setup, Preamplifier, Recorder, Editing Software, File Format, Bit Rate, Sampling Rate, Pictures?, General Comments, and Recordist Name. This information is also available in Appendix D.

After the recordings were entered in the archive, they were renamed with their corresponding chronological number, and moved onto a final hard drive for storage. The final Microsoft Excel file containing the archive is stored on this hard drive as well, along with a Read-Me file containing instructions for correlating sounds to their rows in the archive for ease of use. The Read-Me file also contains instructions for finding photographs of a particular recording location. This hard drive was supplied to Professor Bianchi so a copy could be made,

and then it was delivered to Dr. Abraham Miller-Rushing, Acadia National Park's Science Coordinator, for use by Acadia National Park in their visitor center.

4.3.5 Integrated Resource Management Applications (IRMA) and WPI Website

The Microsoft Excel sound metadata, along with the corresponding field recordings, will be uploaded to the National Park Services' Integrated Resource Management Applications (IRMA) website. IRMA is a tool that the general public, researchers, teachers, or other interested parties can use to find relevant information related to the National Park Service, its mission, research, and work. IRMA is a database system with advanced searching capabilities. As such, a separate page will be made for Acadia National Park's sound archive so that this work can be easily retrieved in the future. It is important to note that the raw .wav recordings are too large to be uploading online; as such, they will be converted to .MP3 format for ease of accessibility.

Aside from the National Park Services' IRMA, a select few processed sounds were also uploaded to the teams website, WPI Sound Archive 2015: Acadia National Park. These sounds demonstrated a variety of different acoustic zones, as well as a range of biodiversity. A recording from the underwater hydrophone was also included.

Recommendations

5.1 Continue Documentation

Acadia National Park's natural soundscape is continuing to change. As such, further documentation is needed to ensure that Acadia's sounds are well preserved. Though this project has filled a gap in Acadia's documentation, more locations in the park should continue to be audio recorded and archived. Such locations would include the Cranberry Isles, Porcupine Islands, and others, which would result in a more complete and accurate representation of Acadia's natural soundscape. Acadia National Park strives for thorough audio documentation that only can be accomplished by a continuation of this project.

5.2 Geographic Information System (GIS) Availability Online

A geographic information system is an online, user-friendly application that can be used to visualize the locations at which audio has been recorded in Acadia. The user would be able to click on a location in Acadia and hear the audio at that location. A GIS map located online would interest and engage the public. A GIS map located in the Visitor Center would provide tourists an easy way to plan which locations in the park they would like to visit.

Using the data recorded in this project a GIS layer of Acadia could be created. With the latitudinal and longitudinal coordinates, the audio files can simply be overlaid on a map of Acadia.

5.3 Parabolic Dish Microphone

Parabolic dish microphones have great sensitivity to sounds along the axis of the dish, similar to the shotgun microphone used in this project. Parabolic dish microphones are mainly

used for nature sound recording. The microphone works by reflecting the sound waves into a concentrated center, or focal point, of the dish where a recorder is located (Wildtronics, 2014). This method provides a noise-free gain of the analog audio signal.

Though the shotgun microphone used in this project worked flawlessly, it is recommended to try a parabolic dish microphone in order to limit noise pollution from tourists on the trails. Parabolic dish microphones limit the amount of unwanted sounds from directions in which it is not pointing, whereas the shotgun microphone is vulnerable to these sounds.

Conclusion

The National Park Service (NPS) has a responsibility to protect nature in America. Their *Call to Action* states that the NPS must steward nature while simultaneously engaging the public. Our project assisted in both goals: stewarding nature and building a foundation for future engagement.

The team preserved the natural recordings of a range of areas across Acadia National Park. From the windy summits of the highest mountains to the murky lowlands and swamps of Acadia, recordings of a very biodiverse ambiance were documented. The many locations can be broken down into six acoustic zones: Evergreen Forest, Hardwood Forest, Mixedwood Forest, Wetland, Shrubland, and Alpine. Each zone has a distinct acoustical sound. The recordings were then edited with audio software in order to remove unwanted noise. Next, the sounds were metadata tagged and placed into the archive.

The team's foundation for future engagement was accomplished through the use of developing a metadata system to tag all of the sounds in the archive. The metadata system consists of twenty-eight categories that characterize each audio recording. This system exists to engage the public by providing easy access to scientists, researchers, teachers, and others. This archive has the potential to encompass the whole park and document the entirety of Acadia's natural sounds in the following years.

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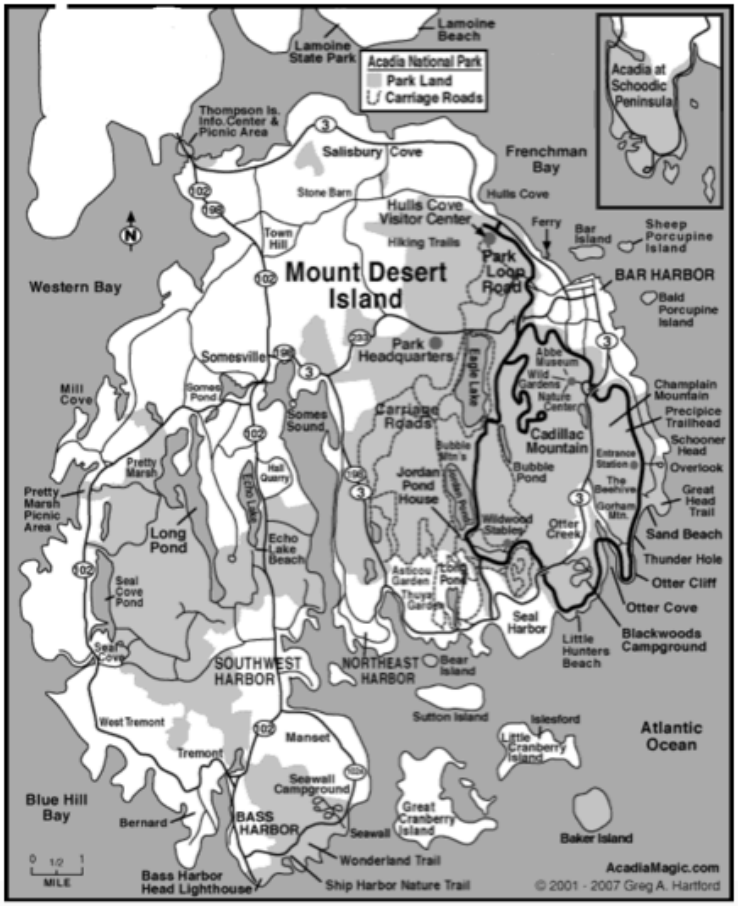
Appendix A

WPI Sound Archive 2015 – Visitor Survey

On the map below, please circle all the names of the locations that you have visited on Mount Desert Island, and then put a star next to the locations that you think had distinct sounds.



We are a research team from Worcester Polytechnic Institute. We are conducting this survey in order to configure a list of places to record for the creation of a sound archive of Acadia National Park.

How many times have you visited Mount Desert Island?_____

Are there any locations with distinct sounds that aren't on the map? If so, please list them here:

_____

_____

_____

At each specific place you starred, what sounds did you hear? (e.g. Thunder Hole: booming waves)

_____

_____

_____

_____

_____

Appendix B

Interview Questions for Park Officials and Rangers

Thank you for taking the time to meet with us today. We are a research team from Worcester Polytechnic Institute. We will be recording sounds in Acadia National Park for the next two months. We are conducting this interview in order to configure a list of places to record for the purpose of creating a sound archive and interactive map of Acadia. We would like your input on determining some locations to record.

1. Are there any places you would like to add to our list of places to record?

   (A list will be provided to the interviewee.)

2. Are there any specific things, not places, that we should record in the park?

3. Are there any specific locations that you would like to see on an interactive map of Acadia?

   (We will describe GIS if necessary.)

4. Should we visit certain locations at any specific time of the year?

5. Is there anything else that you would like to add?

Appendix C

Locations Recorded

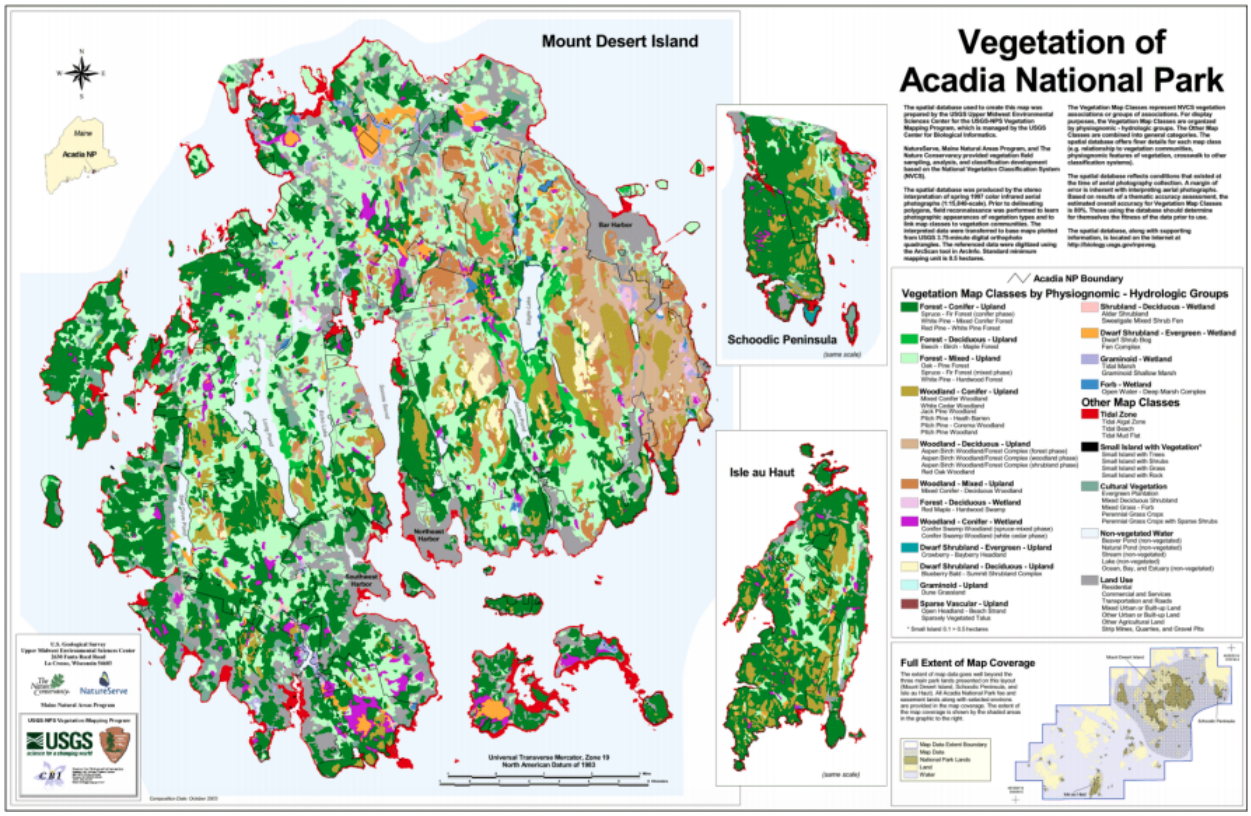
Recording Location	Sounds Recorded
CoA Dock	Boat sounds, crashing waves
Thunder Hole	Crashing waves
Otter Point	Waves
Schooner Head	Waves, Airplanes, Birds, Chipmunks
Sand Beach	Waves, People, Birds
Great Head	Wind, People
Champlain Mountain	Wind, Construction, Birds
Otter Cove	Wind, Birds
Pretty Marsh	Birds, Insects, Wind, Waves
Cadillac Mountain	Wind, Birds, Airplanes
Bald Mountain	Insects, Birds, Bugs
Seal Cove Pond	Waves
Bernard Mountain	Cicada, Birds, Airplanes
Flying Mountain	Birds, Trees, Children
Valley Cove	Waves
Valley Peak	Stream, Mosquito, Birds, Cicada
St. Sauveur Mountain	Mosquito, Birds
Acadia Mountain	Stream, Squirrel, Birds
Beech Cliff	Birds, Squirrels
Beehive	Birds, People, Bugs
The Bowl	Birds, Water

Gorham Mountain	Leaves, Hikers, Horn, People, Birds, Airplane
Klef Pond	Birds, Frogs, People
Breakneck Road Trail	Pond, Bug, Birds
Carriage Roads	Birds
Paradise Hill	Birds, Airplane
Bar Island	Birds, Music
The Tarn	Stream
Bass Harbor Marsh Road	Birds, Generator Noise
Wonder Land	Birds, Mosquitoes, Boat, Airplanes
Pemetic Mountain	Raindrops, Birds
Bubble Pond	Birds
Parkman Mountain	Birds, Cicadas, Mosquitos
Grandgent Trail	Birds, Mosquitoes
Gilmore Mountain	Birds, Mosquitoes, Airplane
Sargent Mountain	Wind, Birds
Cedar Swamp Mountain	Birds, Cicadas, Cars
Sunken Heath	Birds, Cars, Stream
Beach Croft Trail	Birds
Fresh Meadow	Birds
Jesup Path	Birds

Appendix D

List of Archiving Categories

Archive File Number	Altitude
Source File Number	Humidity
Description	Temperature
Recording Length	Microphone
In Acadia?	Type of Recording / Setup
Park Vegetation Designation	Preamplifier
Acoustic Zone Designation	Recorder
Site Name	Editing Software
Latitude	File Format
Longitude	Bit Rate
Date	Sampling Rate
Time - EST Zulu	Pictures
Weather Conditions	Comments
Average Wind Speed	Recordist Name

Appendix E

Vegetation Map of Acadia National Park