The Recording and Manipulation of Natural Sounds into a Musical Work

by

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A thesis presented to the Honors College of Middle Tennessee State University in partial fulfillment of the requirements for graduation from the University Honors College

Fall 2022

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Dedication

To my wonderful family, who has supported and encouraged me to pursue my passions for as long as I can remember.

Acknowledgments

I would first like to thank my thesis director, Professor Michael Fleming, for his accommodating and enlightening approach to cooperating on this project. I would also like to thank my RIM department professors, Dr. Joseph Akins, Professor Misty Simpson, Dr. Michael Linton, and Professor Michael Hanson for teaching me about MIDI production, sound synthesis, music theory, and mixing, respectively. This project could not have been completed without the education and support of Blake Osborn, who has helped hone my outdoor skillset and provided me with backcountry essentials throughout my college career. In a similar vein, I would like to thank my good friend David Moore, who proved to be a phenomenal backpacking partner. I am also exceptionally grateful for the MTSU Honors College, Buchanan Program, and Laura Clippard for providing me with the extraordinary educational opportunity of being a Buchanan Fellow. I have much gratitude for Dr. Jamie Burriss and the URECA program for assisting me with the completion of my project and creating an opening to present my project to the public.

Abstract

In an effort to bring greater attention to the importance and diminution of natural soundscapes, I sought to record, compose, and mix musical works entirely from recordings of natural sound sources. This project embodies a study of the fields of biomusic, soundscape listening, field recording, audio production, and musical composition. The project resulted in musical works in which the listener may hear identifiable natural elements, elements that are highly reminiscent of natural sounds but have been clearly manipulated, and audio processed to the extent of loss of relation between the final sample and the original material. I discovered that variety of sound sources and ecology is important in creation of biomusic, the tools used to produce art influence the nature of the final outcome, and that properly conveying artist intention requires extensive planning and resources.

Preface

A couple elements of my life have consistently provided a great deal of inspiration and fulfillment. Music is one avenue through which I have found contentment, lifelong friendships, excitement, catharsis, and much more. My passion for the craft has brought me to MTSU to learn audio production and music theory.

Another facet of my life of which I never tire is exploring nature. My time in outdoors-related programs helped me develop a deepened connection and respect for the natural world. In my experience, I have found that nothing is quite as relaxing, refreshing, or spiritually fulfilling as spending time in the intricately beautiful outdoors.

When provided the opportunity to complete a creative thesis, I investigated ideas that would tie my education and personal interests into one. The idea that I found most promising was to make music out of nature. More specifically, I wanted to gather samples of natural sound sources then arrange and process these samples into three works of biomusic. While the main goal could be stated simply, this feat would require me to learn new skills in field recording and sample-based music production.

In a society that is consistently bombarded with the sounds of traffic, machinery, or corporate muzak, the richness of soundscapes has become flattened. Even in the realm of music, the advent of streaming services has increased the supply of music to an extent that the value of the art has diminished greatly. The purpose of this project is to bring greater attention to the depth of information that can be gleaned from natural soundscapes and how modern practices diminish the presence of these soundscapes. I strive to achieve this by providing a fresh auditory perspective on commonly heard sounds.

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List of Symbols and/or abbreviations

1. BPM - Beats Per Minute
2. DAW - Digital Audio Workstation
3. EQ - equalizer
4. LFO - Low Frequency Oscillator
5. Mic - microphone
6. PCM - Pulse Code Modulation
7. SNR - Signal to Noise Ratio
8. XLR - The original model series designation for a 3-pin circular cable connection created by ITT Cannon

List of Terms

1. Biomusic - a type of music in which sounds are generated or performed by a living non-human organism (plants, fungi, animals, etc.)
2. Binaural - Having or relating to two ears, allows us to localize sounds and perceive spatial information from sounds
3. Biophony - sounds produced by animals
4. Biphonic (audio) - term used to distinguish presentation of two-channel stereo information through headphones as opposed to speakers
5. Biphonic (music theory) - Two simultaneous melodies
6. Cents - a measure of musical pitch that is equal to one hundredth of a half step
7. DAW - Digital Audio Workstation, audio editing software that performs several necessary functions
8. XLR cable (colloquial)- one kind of electrical cable that can typically pass balanced signals through long distances and provide phantom power using a shielded twisted pair of wires, generally used for audio devices and has a circular 3-pin connector
9. Formant - collection of acoustical energy at consistent, specified frequencies that resonate based on the structure of the human phonatory system, musical instrument, etc.
10. Geophony - sounds produced by natural forces
11. Key - the basic tonal center of a piece of music
12. MIDI - Musical Instrument Digital Interface, a protocol that connects musical software and instruments in order to record, edit, and playback musical information such as pitch, note duration, and velocity

13. Modulation (audio) - when an acoustical transformation/distortion is applied at a specified interval or frequency; variation of one or more aspects of a signal, i.e amplitude or frequency
14. Modulation (music theory) - the process of changing key centers in a musical work
15. Monaural - Of or relating to one ear
16. Monophonic (audio) - Having one channel of transmission
17. Monophonic (music) - A single melody with no harmony
18. Musique Concrète - a musical composition technique that employs the use of recorded and manipulated sound (voices, machinery, musical instruments, random noise) rather than standard musical instrumentation containing strictly musical sound sources - typically produced in a recorded format, but can be produced live
19. Pad - a musical element that is characterized by long sustained notes
20. Panning - the act or state of moving to the left or right in the stereo field
21. Plug-in - a piece of software through which an audio signal can be routed in order to affect the signal in some controlled way
22. Pulse Code Modulation - a way in which analog audio signals are recreated and represented in the digital domain
23. Signal to Noise Ratio - the measure of the intensity of the desired signal as compared to background noise
24. Stereophonic - Using two channels of transmission, creating sounds that seem to emanate from multiple directions

Introduction

The goal of this thesis is to emphasize the importance of acoustic information in our daily lives, and to bring attention to the diminishment of natural soundscapes in modern societies. My approach to this issue is to present natural sounds in a unique, beautiful, and intriguing manner through the creation of biomusical works. In the first chapter, I provide background information on the studies of field recording, acoustic perception, and biomusical works. In the following chapters, I describe and analyze the technologies and methodologies used to gather, manipulate, and arrange audio material into musical compositions.

Chapter One: Background Information

While much of my thesis was experiential, experimental, and creative, a large portion of the project required academic research. Without the fundamental knowledge needed to complete an artistic goal, the end result falls flat. In this regard, the academic portion of my thesis has merit in its own scholastic qualities and the creative applications therein. My research concerned three topics; field recording, soundscape listening, and biomusic.

Field recording is a specific focus in the general practice of audio recording with the distinction that it takes place outside of acoustically controlled environments. Because of this distinction, there are elements of equipment and techniques that stray from the standard studio environment, which has been the primary focus of my Audio Production education thus far. Much of what I have learned, such as the basic principles of acoustics and sound capture, remain consistent across all recording environments, but additional resources were needed to fill in gaps specific to recording in uncontrolled environments. My knowledge of field recording was primarily built by reading *The Handbook of Field Recording*, by Frank Dorritie. In addition to

some helpful online materials, Dorritie's work helped me understand the basic history, equipment, and theory to the process of field recording.

The earliest known field recordings were captured by Ludwig Paul Koch in 1889.[1] The German eight-year old acquired an Edison phonograph and wax cylinders, onto which he recorded the call of the Common Shama bird.[2] This is widely regarded as the first bird recording, and the British Library preserves the original wax cylinder in the National Sound Archive.[3] At his young age, Koch likely did not anticipate the impact of his Shama recording, but his continued work throughout his life established a stable foundation upon which the practice of field recording could be expanded.

The innovations of field recording have been pushed forward by many factors through the years. The Lomax brothers, famous for their field recordings of American folksongs in the 1930s, used an acetate-disc phonograph that weighed 315 pounds.[4] Their work was groundbreaking, but the machinery was backbreaking. In order for field recording to become accessible to a wider range of applications, the technology needed to become lighter and more portable. The commercial use of tape recording in the mid-to-late 1940's provided a lighter alternative to disc cutting. Use of magnetic tape remained the most portable way to store high quality audio until the introduction of digital audio technologies in the late 20th century.

Since then, audio equipment developers like Zoom, Sony, and Sound Devices have focused on bit depth and sample rate capabilities, number of inputs, preamp quality, and ease of

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[1] Dorritie, *The Handbook of Field Recording*

[2] "Ludwig Koch - Master of Nature's Music"

[3] Dorritie, *The Handbook of Field Recording*

[4] "About the Lomax Collection"

user interface. While there are continued efforts to further size and weight reduction of field recorders, there appears to be a greater focus on increasing functionality of already highly portable packages. Microphone developments have broadened recordable frequency range, sensitivity, and have given recordists many varieties of polar patterns, filters, environmental protections, and modes of transduction with which to tailor their sound. In contrast to studio-based recording, development of hydrophones and contact microphones have granted field recordists new perspectives on previously untapped spheres of acoustic ecology.[5]

Nothing can supplement firsthand experience in a hands-on line of work, but *The Handbook of Field Recording* provides a wealth of valuable insight that can help avoid common missteps. Frank Dorritie is a highly qualified musician, recording artist, and educator, so his advice is credible.[6] Reference materials on equipment selection, recording techniques, and field recording tips enable beginner recordists to approach their first attempts at field recording with confidence. The publication of these materials allows a wider audience to get involved in field recording and develop a heightened appreciation for the recording arts.

In addition to field recording practices, another important part of my thesis is the communication of an aural message. Effective communication has several requirements involving the relationship between the signal, the listener, and extra input in the environment. Barry Truax's *Acoustic Communication* seeks to describe this relationship in all possible configurations. His communicational approach to acoustics emphasizes the understanding of sound, rather than direct transfer of energy or the cause and response approach to

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[5] The Underground Sound Project

[6] "Frank Dorritie Biography"

psychoacoustics.[7] Specifically, Truax describes the different types of sound and listening, the use of music, and the electrification of soundscapes.

Instead of thinking of every sound in an environment as an isolated collection of data and the human listener as a sort of bio-mechanical algorithm that decodes each signal, Truax seeks to understand the actual information being processed, the behaviors that follow, and the two-way relationship between the listener and the environment. Hi-fi listening environments, or environments with little to no acoustic masking and a wide SNR, allow for clearer communication. The listener has the ability to clearly receive and interpret acoustic messages. The listener also receives feedback from the environment as they generate sound themselves. Lo-fi listening environments, or environments with high amounts of acoustic masking, can lead individuals to feel isolated from their surroundings. The listener is discouraged from engaging with surroundings, and is instead forced to direct attention inwards. The idea of a hi-fi versus a lo-fi listening environment is a big motivating factor behind my project. Getting away from the constant noise of urban life reduces the overall amount of masking in a soundscape and allows the listener to clearly observe and gain a better understanding of the naturally occurring sounds of our environment.

Chapter 2 of *Acoustic Communication* focuses on the role of the listener and the various modes of listening. Truax identifies three main modes of listening; listening in search, listening in readiness, and background listening. The first mode is the most aurally attentive. Listening in search requires the listener to actively focus on the sonic characteristics of one particular sound and block other noises out. Attention is primarily guided towards interpreting the desired audio

[7] Truax, 11

cues when listening in search. In my travels, much of the time hiking was spent in this mode of listening. Because there are minimum distractions on a backpacking trip, it was easy to mentally engaged in the surrounding acoustic activity.

The second mode of listening indicates a middle ground, where listening is in the active consciousness , but it is not the primary focus of the listener. This mode is termed "listening in readiness," and Truax provides the example of a sleeping mother who is awoken quickly by her child's cry.[8] Listening in readiness requires a somewhat "hi fi" listening environment, one in which the SNR is high enough to allow the signal to be distinguished from surrounding noise. During my trips, there were several moments in which my focus was directed away from the critical listening space. In times that I was checking the trail map, getting a snack, or setting up camp, my primary cognition was dedicated to some other task, but I was still aware of the sounds around me. If something caught my ear in these moments, it was easy to redirect my attention to the sound and set up for recording.

The final mode of listening is referred to as "background listening." Background listening is what one experiences when completely absorbed in another realm of focus and is "tuning out" the sounds around them. This may not seem like listening at all, but the brain is still interpolating environmental cues subconsciously. When asked if someone heard a particular stimulus during their background listening period, most people are able give an accurate report if the sound "were not too distant in the past."[9]

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[8] Truax, 22

[9] Truax, 24

Chapter 4 reveals Truax's breakdown of the organization of different sound material. He begins with the statement that, in respective order from most to least structured, sounds can be categorized into speech, music, and soundscape. Speech is considered to be the most structured and information-rich form of acoustic communication. Strict rules must be followed in order for spoken messages to come across, lest meaning be misconstrued or completely bypassed. Next follows music, with a variety of organizational rules depending on culture and school of music theory. Although certain forms of music can be incredibly strict in their rules, when compared to speech, music as a whole is less information-dense. The structure of soundscape is a more ethereal concept to grasp. At its core, a soundscape is structured by, "not only the elements of the sound environment and their relationships, but also the pragmatic level of the context within which all of it occurs, and without which it cannot be interpreted."[10] The process of completing my thesis, in essence, is taking the least structured form of acoustic organization and transforming it into the second-most structured form. First, I further deconstructed environmental sound by isolating specific elements. Next, I reorganized these environmental elements into a musical form, following stricter rules of tempo, key, spectral bandwidth, and intensity. Finally, I deconstructed the musical work yet again in order to put it into words, both written and spoken.

Truax also notes that contemporary music has expanded its repertoire of possible instrumentation, including any real environmental sound or any "imaginary" synthesized sound.[11] With ever-expanding bounds, music and the rules therein have moved closer and closer to environmental structure as more experimentation takes place. Convergence of environment

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[10] Truax, 55

[11] Truax, 53

and music is exactly the goal of my compositions. Although Barry Truax explains that any expansion of the musical vocabulary will push musical structure further towards environmental structure, I set out to accomplish this goal in the most literal sense. I used both directly environmental sounds as well as "imaginary" synthesized sounds, but all with reference to natural phenomena and all created from originally natural material.

In Part II of *Acoustic Communication*, Barry Truax describes the impacts of the electrification of sound on soundscapes and communication. Much of the impacts described in this section are negative in nature. For instance, in Chapter 8 Truax delves into the idea of being able to sonically freeze something in time. Sound repetition makes it easier for the brain to process information. Harkening back to earlier in the book, this kind of repetition engages the background mode of listening. In order to counteract this in my works, I made an effort to create constant motion and development of the sound. I did not want any section of any piece to stagnate, as that is not how natural sound works and I wanted to engage the minds of the listener.

The electrification of sound also had an impact on musical instruments, namely with the inception of the synthesizer. In Chapter 9, Truax explores the topic of the waveform, the function that determines, in large part, the sonic output of synthesizers. He notes that, "Patterns of sound pressure, or waveforms, are constantly changing in the natural acoustic environment - no sound is ever invariant."[12] When one distances one's self from whining and whirring machinery, the fluctuations of natural sound become more apparent. The reverberations in between individual elements of the soundscape become audible, help define space, and the variety creates interest. Spatial cues and variety of timbres, dynamics, and timing are all things that I incorporated into

[12] Truax, 140

the compositions, but certain elements required a degree of homogenization. Elements such as the bass and pads from "Day" and the lead melodic element from "Night" necessitated the ability to sustain at a steady musical pitch. What was created was an oscillator based on looping portions of the sample. Truax states that this style of fixed-oscillator synthesis can be potentially boring, as the same material is being repeated over and over. A potential solution to this issue is using a different kind of synthesis: grain-based synthesis. Granular synthesis utilizes very short segments of an original sample crossfaded together, resulting in an entirely new waveform that can be modified by reconfiguring the individual grains in a variety of ways.[13] I did not personally have access to grain-based synthesis during the composition process, so I added LFOs that modulated timbre-shaping plug ins to create variation and evolution in otherwise stagnant oscillators.

Electronic sample-based music has a rich history and a large body of supportive work. Musique Concrète, a technique developed by Pierre Schaeffer (1910-1995) in 1948, was centered around the idea of splicing together recorded sounds in a musical way. Schaeffer began experimenting with sounds recorded on phonograph records, but later transitioned to working on magnetic tape. His first piece was entitled, "Étude aux Chemins De fer," and was entirely composed by arranging and manipulating train sounds. He went on to compose several more pieces, and he published several written works such as the *Traité des Objets Musicaux (Treatise*

[13] "The Basics of Granular Synthesis"

on Musical Objects).[14] Much like Barry Truax, Schaeffer emphasized the importance of the human perception of sound, and looked to explore such perception in his musical compositions.[15]

A more specific kind of sample-based music is biomusic. Biomusic is specifically an experimental form of music made from biophonic sound sources. Biophony is classified as sound that comes from non-human organisms. In specific cases, a piece can still harness human data for musical purposes and be considered "biomusic."[16] Because of the experimental nature of the genre, there are many accepted approaches to biomusic. One such approach is to create a natural ambience of biophony, on top of which a skilled musician would layer an instrumental track. One great example of this is Wendy Carlos's *Sonic Seasonings.* Based roughly on Vivaldi's *Four Seasons*, Carlos used a variety of natural ambiences atop which she played a Moog synthesizer.[17] Another great example of this is the 2005 release *Natural Imperfections* by Bernie Krause and Country Joe McDonald.[18] On this record, McDonald beautifully plays his acoustic guitar over top of, and in tandem with, a variety of natural soundscapes.

Another approach to biomusic is manipulating and warping natural elements into musical instruments of their own. This is the form of biomusic that I chose to create in this project. One example of biomusic similar in approach to my project is Graeme Revell's *The Insect Musicians*. Released in 1986, this album is entirely composed from insect sounds.[19] For a more modern take

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[14] Reydellet

[15] Valiquet

[16] Rosenboom

[17] Carlos - https://vimeo.com/428929978

[18] McDonald, Krause - https://youtu.be/UaOV5gDafdE

[19]Revell - https://youtu.be/6DVbfPq4B9Y

on the same concept, I turned to Cosmo Sheldrake. His use of natural ambience, rhythms, and synthesized natural elements is of extremely high quality. I highly recommend listening to his 2020 album, *Wake Up Calls,* for a fun and playful exploration into the possibilities of biomusic.

Comparing my personal works with that of past and current biomusic artists illuminated both the achievements of this project as well as areas of growth yet to come. One of the strengths of my works is the creative development between pure ambience and musical material. Many of the artists that I have listened to incorporated both of these sonic characteristics, but I really made an effort to telegraph the transformation of one into the other. This creates a unique flow throughout my pieces in which the listener is presented with alternating periods of organic ambience and musical composition. Another achievement of my efforts is the creation of harmonic material without the use of external instruments. While I find the music of *Sonic Seasonings* and *Natural Imperfections* to be very beautiful and inspired, I find that the additional challenge of only using sampled materials elevates the impressiveness of Revell and Sheldrake's works. Again, there is no universally correct approach to creating art, but I now have the skillsets to create biomusic both with and without traditional instrumentation; whereas if I had instead layered traditional instruments on top of natural ambiences, I would not have gained the sample-based synthesis skills that I developed.

Putting my work in context with the current repertoire of biomusic from several different artists allowed me the opportunity to critique my pieces alongside some of the best and brightest. In this critique, I found several areas that could benefit from additional practice. One area of improvement that became clear to me was my mixing ability. Although I have taken a course in mixing, I have not had many opportunities to mix compositions with a highly experimental

nature. Also, like many other skills, mixing is something that requires training and practice in order to accomplish at a high level. Unfortunately, focusing my efforts on sample collection and composition reduced the time I spent mixing over the course of the project. Another aspect of the pieces that I noticed in reference to the work of other artists was the focus. Most of the biomusical works I referenced had a tighter focus than concepts such as day, night, and dawn. Many of the pieces were centered around specific animals, specific geophonic sounds, or one distinct ambience. In each of my pieces, I combined several different kinds of sound sources from various locations. Neither of these approaches are inherently superior, but I do think having a narrower concept could have helped inspire more creative ways of representing said concept. The lesson learned here is that restrictions can be interpreted as a way of motivating ingenuity and critical thinking.

Chapter Two: Recording Phase

Field recording is a process and a study that can be explored in great depth, so I find it best to introduce the topic in the simplest way possible. When boiled down to its simplest elements field recording can be viewed in terms of location, sound source, recording goals, and recording method. A location without an artificially controlled acoustic environment is what defines a recording as a field recording. The sound sources at any given location serve as the muses of the field recordist who must carefully interpret the sounds via technologies and recording techniques to achieve their recording goals. Furthermore, these factors of field recording influence one another, and any one aspect of the system cannot be excluded. In this chapter, I detail the technologies, skills, and personal experiences of gathering nature-based samples.

Locations explored were concentrated in Middle and East Tennessee, with one location along the coast of Georgia.[20] Locations were picked with the primary goal of getting as far away from man-made sound as feasible. The fundamental sonic goal for each location was to capture high-quality recordings of as many bioacoustic and geoacoustic sources as possible. My procedure for sound source discovery was typically an on-the-fly approach, requiring active listening at all times while on location. Less commonly, a few locations were selected with specific geographic features that I planned to record going in. The final piece of the field recording equation involves the capture of the audio. Recording can be broken down into two main aspects: the recording equipment and the recording technique.

[20] See Appendix B for travel details.

My initial criteria for recording were low-noise, wide-bandwidth stereophonic recordings of animal and geophonic sound sources. At the start of the field recording process, I was interested in recording almost any sound that could be distinguished as natural. As I collected recordings and became more experienced, I realized that stereo recording techniques did not always best serve my purposes, and I also became more selective in the material that I recorded. I only sought after unique and distinctly musical sounds as I approached the end of the field recording phase of production. In order to capture the desired quality of audio recordings, I used an array of purchased, rented, and borrowed equipment.

With an ever-expanding array of options for the beginner field recorder, getting started proved to be a slightly overwhelming undertaking. Chapter 4 of *The Handbook of Field Recording* and the "Beginners' guide to wildlife sound recording" from the Wildlife Sound Recording Society helped define the necessary equipment for field recording. Dorritie offers detailed explanations and explores the available options for microphones, recorders, headphones, cables and connectors, accessories, storage devices, and supplemental gear. Because of the 2003 publication date of Dorritie's handbook, some of the information in this chapter is outdated by today's standards. For instance, instead of tape or MiniDisc audio storage, many modern recorders will use SD cards. That being said, the conceptual analysis behind gear choice remains relevant. Modern recording set ups have the same fundamental components, functionality, and signal flow that Dorritie details.

With the guidance of Professor Fleming and Dorritie's writing, I began assembling my collection recording utilities. The most integral device to the completion of my project was the

Zoom field recorder.[21] I purchased a Zoom H6 Pro portable field recorder, a compact six-channel PCM audio recorder. It is small enough to fit in one hand, and runs off four AA batteries. Capable of recording WAV files at sample rates ranging from 44.1 kHz to 96 kHz and bit depths of 16 and 24 bit, the Zoom H6 has professional-grade audio quality capacity. The H6 model has a connection on the front for interchangeable capsules, as well as four additional XLR inputs with built-in pre-amplification. An optional 24 or 48 volts of phantom power can also be supplied through the XLR inputs, which is needed to use condenser microphones. The four XLR inputs also double as quarter inch jack inputs. The Zoom H6 weighs 0.62 pounds.

My recorder shipped with the standard X/Y mic capsule, as well as a mid-side capsule. Both of these capsules utilize coincident stereo techniques to capture two-channel information, but use a different process to achieve the imaging. The X/Y mic uses two mics with cardioid polar patterns at an adjustable 90 or 120 degree angle. The mid-side mic uses a front-facing cardioid mic in combination with a bi-directional mic that is perpendicular to the axis of the front mic. Zoom incorporated an onboard mid-side decoder in the H6 that automatically matrixes the signals. A "dead cat"[22] style windscreen was also included, which helped reduce the effects of wind in gusty environments. The X/Y capsule weighs 6.4 ounces, and the mid-side capsule weighs 3 ounces.

In addition to the two stereo capsules for the Zoom, I also purchased a matched pair of Rode NT5 microphones. The mics are small diaphragm condensers, with a capsule diameter of 0.5". They feature a cardioid polar pattern and a flat frequency response from 20 to 20kHz

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[21] See Appendix A for recording equipment details

[22] These style of windscreens have been given this nickname due to having synthetic fur-like material that resembles a small animal.

Condenser mics need phantom power, and the Rode NT5's can run off of either 24 or 48 volts. The variable phantom power voltage is highly relevant to field recording, as running a lower voltage will allow for longer use of the AA batteries powering the recorder. Each mic weighs approximately 100 grams. My purchase came with a hardshell case with foam lining, two thin foam windscreens, and two mic clips. The whole set up weighs about 2 pounds.

One of the more specialized pieces of equipment I got to work with was the Rode NTG-2 shotgun microphone. I was fortunately able to borrow this, along with a short boom pole and a foam windscreen. Shotgun microphones are unique in their polar pattern. A long interference tube on the front of the mic captures sound from the sides and uses phase cancellation to attenuate noise that is not directly in front of the capsule. This provides the mic with excellent focus, and a recordist can capture clear sound at distance. Something to consider when operating this style of mic comes with the existence of two side lobes and one rear lobe in the pickup pattern. While less sensitive than the main front-facing lobe, these areas of sensitivity will still capture signal that may be undesirable. Another trade-off of shotgun mics comes with off-axis coloration. If the mic is not directly pointed at the center of the desired source, there will be a noticeable change in the timbre of the sound. One must listen and aim carefully when operating a shotgun mic to ensure the desired result. The NTG-2 weighs 5.7 ounces.

For monitoring recording in the field, I used Shure SE215 PRO Sound Isolating in-ear monitors. These allowed me to isolate myself from the noise of the environment and analyze the recordings as I captured audio. The eighth inch jack plugged directly into the bottom left-hand corner of the Zoom H6.

When I brought the Rode NT5's or NTG-2, I also packed a couple XLR cables. These were needed to connect the microphone to the Zoom. The three-pin connector allowed for balanced signal transfer that negated external interference within the cable run. The XLR cables also allowed me to supply phantom power from the Zoom in order to operate the microphones.

Recording equipment constituted half of my arsenal in acquiring recordings of natural sounds sources. For wildlife recording, Dorritie recommends putting thought into the items and equipment that will sustain the recordist in the field, so the other half of my equipment were things that ensured my safety and comfort during my outings. He suggests packing extra water and snacks, breaking in new shoes, getting adequate rest, and applying sunscreen and bug spray. These are all very important considerations for the health and safety of the field recordist, but also will result in an experience in which the recording focus will not be deterred by bodily discomfort. In attempts to capture natural vocalizations of animals, the ideal situation is to be undetected. Not only should sound emitted by walking or talking be reduced or eliminated as much as possible, but also olfactory and visual camouflage can help reduce the chances of being discovered.

As the Zoom recorder was the cornerstone of the recording set up, the backpack provided the foundation on which my camping gear was built. On Cumberland Island, I used an Osprey backpack rented from MTOP. For the subsequent backpacking trips, I used a Lowe Alpine Frontier 65-15 liter pack. Both packs shared many sizing features, like an adjustable torso harness, adjustable hip belt, and shoulder strap adjusters. They also included compression straps that allowed me to tighten the overall load of the pack and the center of mass as close to my body

as possible. The top pocket or "brain" of the packs offered a storage space for quick-access items, like extra batteries, snacks, and a headlamp among other things.

For overnight trips, my sleeping arrangement consisted of either a tent or hammock, a sleeping bag, and a sleeping pad. I brought a two-man North Face "Big Fat Frog 24" tent when I was backpacking with David Moore, and I brought a double-nest Eno hammock for the solo overnight trip. With the Eno, I also packed a bug net and hammock straps. A low-degree rating North Face sleeping bag was my go-to for warmth and padding. A thin foam Therma-Rest sleeping pad also provided some extra padding and insulation from the elements.

The Handbook of Field Recording also provides information about recording techniques for various purposes. Most relevant to the goals of this project, Dorritie elucidates the theory behind recording environmental and wildlife sounds. He explains that one must always consider what the desired recording is and for whom it is intended. Without understanding the specific goals of the recording, the field recordist's end result may lack the content needed to effectively communicate with the end user, or the listener. For example, a recording of a waterfall may be be mistaken for general wind ambience or white noise if it does not include the proper cues that the sound source is water-based. Dorritie reports the the basic purposes and methods of achieving ambient recordings. These methods include but are not limited to; a single omni microphones, spaced omni pair, XY coincident pair, mid-side coincident pair, and the baffled omni binaural mic technique. The final tip of the environmental recording section describes the differences between "good" and "bad" wind. Essentially, good wind is something that adds context and character to the recording, and bad wind is something that obstructs the capture of the desired source. Dorritie writes about wind screens and bodily shielding, two methods of limiting the

effects of bad wind at the microphone capsule. He also explains trip planning methods of avoiding wind, such as potentially avoiding recording around sunset. As the sun goes down, cooler air interacts with warm air causing breezes.

Shotgun mics or parabolic dish mics are ideal for capturing sound at-distance. In addition to directional mic pickup patterns, halving the distance between the subject and the mic will theoretically double the level of the recorded signal.

The gear at my disposal would serve no purpose if there was no accompanying technique to put it to use. I used a variety of microphones and miking techniques, but some processes were used consistently throughout every recording. Setting an adequate pre-amp level was necessary in order to capture a large enough SNR and to avoid clipping. Determining adequate placement of the microphone(s) was also needed for every recording. When a sound source was discovered, I used my psychoacoustic binaural perception to locate the specific direction from which the sound was emanating. When the sound source could also be seen, I used visual cues to note the direction of sound. Next, I would assess the distance at which I was recording. For sound sources like waterfalls or streams, I often wanted to record a wider image of the source. To achieve this, I would place myself close enough to the source that it became the foremost feature of the recorded signal, but at enough distance to allow the left and right channels to capture width of the source. The actual distance used depended on the size, level, and width of the sound source. Distance was also determined by physical obstacles, such as large bodies of water or dense foliage.

For more “point” like sound sources, namely animals, my primary goal was to get as close to the sound as possible without disturbing the animal. Birds were often high up in treetops,

so getting close recordings was rare and difficult. Still, any amount of distance closed between the recorder and the sound source resulted in a greater SNR. As I would approach, I would slow down my pace to quiet my steps. Then, once I felt the range was starting to become appropriate for recordings, I would stop and make a recording. I would only record for a few seconds before stopping the Zoom and taking a few more steps, repeating this process until I captured a very close recording with great level or the sound stopped.

I primarily used stereophonic miking techniques, as the Zoom capsules provided fast, easy, and lightweight ways to record with XY and mid-side configurations. Because I also had access to a matched pair of small-diaphragm condenser mics, I used them to experiment with spaced pair and other stereo configurations. Using a collapsable mic stand, a stereo bar, and two mic clips, I produced an NOS-style mic set up to capture daytime ambience. With the same set up, I produced a narrow spaced pair to capture the sound of a distant waterfall.

During the process of developing my thesis concept to propose to the Honors College, my advisor and I thought it would be beneficial to do some practice field recording runs. At the time of my first few practice runs, I had not acquired all of the equipment I would end up using on my project. For my initial recordings, I used the Voice memos app on my iPhone 11. While a limited set-up in terms of mic patterns, stereo capabilities, and directionality, using my phone to capture sounds of streams, waterfalls, katydids, and birds contributed insight into the practical methods that would be used throughout the completion of my thesis project.

On December 30th, 2021 I executed a solo hike at Frozen Head state park in Wartburg,Tennessee. I drove 38 miles from my family home in Knoxville to the trailhead. I hiked approximately seven miles, starting from the Panther Branch trailhead, traversing to Emory Gap

Falls, continuing on the North Old Mac trail, and looping around to my starting position. In the initial stretch from the trailhead to the falls, I captured a recording of a very small stream running across the trail. Once I made it to Emory Gap Falls, I captured two recordings of the ambience. The iPhone 11 without any additional attachments can only record in mono, so I specifically made two recordings to try to recreate a stereo image after-the-fact. After recording the waterfall, I captured a couple distant bird calls. Next, I sought a percussive sound by drumming a stick on a tree trunk near the Panther Branch campsite. Finally, I captured two birds chirping simultaneously and the sound of a leaf fluttering in the wind.

This first expedition was a great exercise in basic recording techniques and critical listening. I ensured that the Apple "Voice Memos" app was set to record lossless audio, rather than the compressed alternative. The iPhone 11 has three different mics for various apps and utilizations. The "Voice Memos" app uses the mic located on the bottom of the phone near the speakers. This mic is omnidirectional, so sound from any particular direction is free from timbral coloration or signal loss. That being said, both the phone and the recordist holding the device cast an acoustic shadow that can block higher frequencies. With each desired sound source, I held the bottom of the phone away from my body, pointing at the source of the desired signal. I was pleasantly surprised by the quality of the recordings on the phone. The iPhone had a better SNR than I had anticipated, and the mic had decent protection from the wind, which is a common issue in field recording. The animal life was rather dormant, given the season, so I made sure to listen with intent for any animal or insect noises, resulting in the few bird recordings that I did obtain. My experiment of recreating a stereo waterfall sound was not very successful. Because the two mono recordings were captured asynchronously, the signals were not correlated

enough to create a multi-dimensional sense of space when panned. Instead, I heard two similar yet distinct signals at the far reaches of the stereo field and perceived a sensation of a "void" or null pressure in the center of the stereo image. Physically, this trip was not as taxing as some of my latter adventures, as I only carried a small backpack with essential hiking items and did not have any recording gear other than the highly-portable phone.

The second trip I undertook also served as a practice run, as I still only had my phone to record. Through my employment at MTOP, I was assigned to co-lead a backpacking trip over spring break. I presumed that this trip would provide an opportunity to explore some foreign soundscapes, since I would be in a coastal environment compared to ecosystems with which I am familiar. A 560 mile van ride placed the group at Cumberland Island, Georgia. We stayed on the island from March 6-9th, 2022, and backpacked over 20 miles in that time span. Being a trip leader with a group of eleven people in a popular tourist destination, it was difficult to get enough isolation to record natural sounds free from human voices or noise. After the first night of the trip, I was provided with two days of clearer acoustic environments. During the first of these two days, I recorded an active dawn chorus and a nearby white-eyed vireo. On the second day, I was able to capture several interesting bird calls, an active avian chorus, a distant woodpecker, and leaf crunches on the 6.2 mile hike from Cumberland Island's Sea Camp to the Hickory Hill campsite. At the campsite, as my partner and I waited for the rest of the group, I was able to create more isolated recordings of another white-eyed vireo.[23]

The biodiversity of the island was astounding. Cumberland Island's vegetation and animal activity was remarkably different from that of Tennessee, and focusing on the acoustic

[23] BirdNET

activity allowed me to enjoy the experience on a deeper level. While I was still using barebones recording equipment, this trip prepared me physically for later excursions because I carried all of my backpacking supplies in an MTOP-provided Osprey backpack.The recordings from Cumberland Island illuminated the fact that though the iPhone 11 mic has an omnidirectional polar pattern, getting close to the desired signal is sometimes enough to capture good clarity and level. Halving the distance from source to recorder will double the level of the signal, so getting as close as possible to the sound source was a vital part of my recording technique.

The final outing that I completed before acquiring my Zoom field recorder was an overnight backpacking trip in Savage Gulf state park in Palmer, Tennessee. On May 13th, David Moore and I backpacked 8.7 miles from the Savage Gulf Ranger Station to Hobbs Cabin Campground. Pack-wise, we brought the overnight essentials, plus the extra 3 pound weight and bulk of a Super-8 VHS camera. Audio capture was limited on this trip, only ending with some distant bird calls and the sound of our backcountry meal sizzling in the fire. Hiking with a partner entailed both benefits and detriments to my project. On the positive side, the gear load could be split up between the two of us, there is safety in numbers, and the overall experience is a bit more enjoyable. On the downside, great conversations make for bad listening environments. It is more difficult to hear more distant sounds when they are being masked by nearby talking, and using brain power to respond detracts from the attention to listening. Animal vocalizations also become suppressed as loud hikers pass through their field of sonic perception. Finally, it may also be more difficult to stop and wait in silence for several minutes when there are two personalities in the mix.

The day after returning from South Cumberland, my Zoom handheld field recorder arrived in the mail. Eager to put the device and its accessories to use, I returned to South Cumberland State Park on May 19th. This time, I started my solo hike at Stone Door Ranger Station and hiked to Greeter Falls. Although this was just a day hike, I brought a backpacking pack to carry my equipment. I brought along the Zoom field recorder with mid-side and XY capsules, a short telescoping mic stand, a stereo bar, two Rode NT5 condenser microphones with foam windscreens, two XLR cables, snacks, and water. I kept both the Zoom and the microphones in their hardshell cases. The increased amount of equipment allowed me greater freedom of experimentation in my recording. Through this experimentation, I ended up with good and poor quality material.

Paradoxically, the "failures" of this hike proved just as useful as the capture of desired materials. The blown-out sub frequencies caused by turbulent airflow over the directional microphone capsules in the Rode NT5 recordings taught me that, even with the foam covers, those mics were not meant for windy environments. The unnatural coloration of the sound in the recordings captured with the Zoom's mid-side capsule taught me that I was holding the device improperly. A simple angle shift of ninety degrees greatly improved my effectiveness with the mid-side capsule. From a physicality standpoint, the gear that I brought and the manner in which it was packed was not optimal. The overall load was bulky, heavy, and uncomfortable. It left little space for backpacking necessities if I were to camp overnight. Hardshell cases offer enhanced physical and elemental protection for costly equipment, but they also increase the amount of time needed to set up and record. I would have to come to a complete stop, remove my pack, unpack my bag, take all equipment out of the cases, repack the cases and bag after

recording, and put the backpack back on. This series of events was physically taxing and tremendously time consuming. Knowledge of these details were vital for my success in the following runs.

The solo hike from Stone Door to Greeter Falls was a turning point in the development of my thesis. This single hike refined large portions of my field recording process and the undertaking that would be sample gathering. One thing that I began to grasp early on in the recording process is that natural soundscapes often change rapidly. Sounds that can be heard one second will suddenly disappear for an undetermined amount of time. Also, animals will sometimes quiet down as someone approaches. On single-day hikes, when daylight is of utmost importance, the field recordist must sometimes cut their losses and move on.

On Friday, June 4th, David Moore and I traveled nearly 90 miles from our house in Murfreesboro to the Possum Creek Gorge section of the Cumberland Trail in Soddy Daisy, Tennessee. Because this section of trail was a one-way through hike, we each drove separately in order to shuttle back to our starting point after completing the section. The trail was 8.1 miles long and featured 2,000 feet of elevation gain. Due to hot, humid conditions, dense foliage on and along the trail, and considerable elevation gain, this hike proved to be physically challenging. With the missteps of the previous outing in mind, on this trek I took only the Zoom and its included capsules for recording. Unfortunately, this hike was less fruitful than some of the others. There were only a handful of moments in which I heard something that piqued my interest. The need to unpack my bag slowed me down to the point that certain sounds would already have disappeared by the time I was ready to record. Also, David and I got turned around on the trail at one point, because the available signage did not give a clear indication of where

the trail continued. After that point, because we had wasted a bit over an hour of daylight, I shifted my focus from recording to getting to our campsite.

On June 13th, I set out on my very-first overnight solo backpacking trip. I returned to Frozen Head state park, this time hiking the Lookout Tower West trail, staying at the Squire Knob campsite, and taking the North Old Mac trail back to my starting position. Storing the Zoom in a thrifted fanny pack proved to be an effective method of reducing the time and effort needed to begin recording. I also brought the Rode NT5 stereo pair, but packed them securely in my felt sleeping bag rather than the hardshell case. These small adjustments to my packing list made packing and recording much more efficient with the trade off of equipment protection. I captured over forty recordings on this outing, with several unique bird calls, a percussive rock sound, a trickling stream, and a nearly half-hour recording of the transition from dusk to night. For the nighttime transition recording, I used an unconventional method of tying the Rode NT5 mics to a tree in a spaced pair configuration.

On July 1st, David Moore and I backpacked in the Virgin Falls Designated State Natural Area. I brought the Zoom recorder and accessories. Because this was later in the sample collection process, I decided to exercise greater discretion in what I chose to record. Instead of stopping for every nearby avian or mammalian vocalization, I focused on getting a smaller number of higher-quality geophonic recordings. At the end of the trip, I had produced one recording of the Virgin Falls themselves, and one cave recording.

At Fall Creek Falls, I captured one recording of an unidentified animal that was making consistent grunting noises from the side of a rock face. At my home in Knoxville, I recorded two

night ambiences. One was filled with tree frogs, and the other was a clearer ambience with typical cricket, katydid, and other insect trills.

During Labor Day weekend, I traveled to Chilhowee Campground in Polk County, Tennessee to guide another MTOP trip. I packed the Zoom and the Rode NTG-2, with an XLR cable wrapped neatly in a gallon ziplock bag to prevent moisture damage. During this trip I was given the opportunity to record a group conversation around a campfire. I also took some time in the late night hours to walk around the campground and record night ambiences. During the night walk, I also captured some close-range toad and insect sounds, which were very useful for my "Night" composition.

The final location where I recorded was at my home in Murfreesboro. Although it is not isolated from road and airplane noise, I was still able to record some compelling material. It was here that I was able to utilize the borrowed shotgun mic, capturing sounds in the middle of the night and during sunrise. I also documented rain, thunder, night ambiences, and some long-form captures of dawn soundscapes at this location. Most of the "Dawn Chorus" audio was recorded here.

	Number of Recordings	Average Length of Cue	General Types of material
Location 1	8	21.63s	birds, waterfall, stick banging
Location 2	7	42.71s	birds, leaf crunch
Location 3	2	1:30	bird soundscape, fire
Location 4	19	58.84s	bird soundscape, stream, cricket, waterfall
Location 5	8	30.50s	stream, fire, waterfall
Location 6	37	58.98s	birds, dusk ambience, stream, bugs
Location 7	3	1:10	cave waterfall, cave dripping, waterfall
Location 8	1	42s	mammalian grunting
Location 9	2	47s	frogs, night ambience
Location 10	10	3:44	campfire chat, night ambience, night insects
Location 11	19	13:44	dawn ambiences, shotgun mic during night and dawn, night ambiences

Table 1: Recording Cue data based on Location

There were many successes of the field recording process. Starting out as a complete newcomer, my confidence in field recording grew significantly over the course of the summer months. First and foremost, my knowledge of the equipment and techniques increased by reading field recording materials as well as experiential learning. My efficiency with trip planning, packing, and recording greatly improved over the course of my outings. When I started out, recording necessitated a clunky and tiresome stop along the trail. By the time I was recording in

my final locations, I was able to identify a sound and have it captured in less than a minute. Another success of the field recording process was the amount of material I captured, especially for the “Day”composition. I captured a wide variety of samples: dozens of different bird calls, several unique water features, fires, leaf crunching and stick snapping sounds, and more. Among technical successes, I also deepened my connection with nature by executing my first solo overnight trip.

Several facets of the recording process I undertook could be improved in significant ways. One factor that could have improved the end result is selection of locations with a greater variety of ecology. As stated earlier, most of the locations were concentrated in Middle and East Tennessee, and furthermore; almost every location had the same general ecosystem. While I was still able to record a variety of species and geographic features, I think expanding the reach of my travel would have inspired more creation with a greater number of truly unique samples. Along these lines, I believe another area of improvement would be actually recording less overall material. Because each recording also underwent a post-production editing process, every sample recorded required more working time than anticipated. If I had limited my sample collection to only the best, most unique content, then I could have saved time in the recording and editing phase and allotted that time towards creative use of the material. Another thing that would have greatly improved efficiency in the creative process is better labelling and organization of my recordings. Although time and date material was built into the recordings’ metadata and I organized the files based on location, including information relevant to the content of the samples is a rather obvious tool that I overlooked. Data like location, time, date, and weather could have been easily logged via use of verbal slates or a written notebook. Finally, adding a

shotgun mic to my regular toolkit would have been a huge help. I eventually was able to borrow one, but it was later in the recording process. It was only then that I realized the true power of the shotgun's enhanced directionality, and I realized what I had been missing out on. I was able to edit and harness plenty of usable material from the stereo recordings, but holding the misconception that "stereo is better because it has *more* channels," definitely hindered my progress in the sample-harvesting phase of production.

Chapter Three: Composition Phase

At the outset this thesis, my primary compositional goal was to create musical works in which every element can be identified as being from a natural sound source. The deeper I got into composing and arranging the pieces, though, the more challenging this goal became. Either way, I wanted to show music lovers, nature lovers, and field recordists the possibilities of creating biomusic with modern software, as well as open the ears of potential listeners to the beauty and depth of natural soundscapes. In this chapter, I explore the concepts behind my musical arrangements and the tools and technologies I used to create them.

Composition of the pieces was a multi-step process. After recording the audio, every individual recording was reviewed and edited to selectively cut out individual sound sources from the surrounding ambience. To aid in this process, I first organized every file into folders based on locations and dates. The Zoom H6 automatically incorporated date and time metadata for each cue chronologically ordered the audio recordings. Alongside this, most of the audio required a high pass filter to get rid of undesired bass frequencies. Some recordings also needed additional spectral equalization in order to clear up high-end leaf rustling or otherwise undesired frequencies in the signal. “Izotope RX vocal de-noise,” an intuitive noise-reduction plug-in, also came in handy in isolating desired bird calls.

Once the original audio files were broken down into their most musical moments, they were exported from Pro Tools. Using the Finder file system, I then organized these files into categories based on their musical qualities. The categories I devised were as follows: Melodic, Rhythmic, Percussive, and Noisy. The “Melodic” category included samples that were tuneful, or

had clearly defined pitches. This category included many bird calls, as well as insects and water droplets. The “Rhythmic” category included samples that had a specific repeated pattern, metronomic-like rhythmic precision, or otherwise syncopated rhythms that could be placed in a musical meter. The “Percussive” category was populated with samples that had strong transients. The transient, or beginning of a sound, is what enables percussive instruments like drums to indicate the beats of a musical piece with precision. Finally, the “Noisy” category was filled with samples that had a wide spectral characteristic, such as waterfalls.

	Melodic	**Rhythmic**	**Percusive**	**Noisy**
Key Definition	Clearly defined pitches, tuneful	Repeated patterns, steady tempo	Strong transient qualities	Broadband spectral content
Total Number of Samples	158	60	47	50
Amount of material (min:sec)	7:52	5:25	2:08	13:55

Table 2: Recording Cue Data based on Musical Significance

The actual arrangement, musical processing, and composition of the pieces was done in the digital audio workstation Ableton. In my experience, Ableton provides a wider range of sound manipulation plug-ins, more accessible automation, and a more intuitive methods of warping and pitching audio than other DAWs at my disposal. The “Simpler” and “Sampler” MIDI instruments are two incredibly powerful tools, and they were integral to my success in creating melodic themes with my samples. Another advantage of working in this DAW comes from my familiarity with the software, which provided me with a faster-paced workflow and enabled me to stay in the creative headspace. It is much preferred to focus one’s entire efforts

into achieving musical and creative goals, rather than constantly needing to “switch gears” to troubleshoot technical issues.

Creatively, I set out to compose a three-part work, in which each of the three sections has a distinct and unique sound that relates to the concepts of day, night, and dawn, respectively. I wanted each of the three pieces to function both in context with the other two pieces and as a standalone work. Each piece has attributes that relate it to the portion of the 24-hour cycle that it represents. The overarching structure of the works flow in the day to night to dawn manner because that is how I have typically experienced nature. I would often begin an outing mid-day, stay overnight, and then wake up in the morning and return home. One might ask why dawn was included as a separate work and not dusk, to which I would answer that dawn has the unique characteristic of the dawn chorus. The dawn chorus felt so significant to the idea of nature ambience and natural soundscapes that I could not leave it out of the mix. Dusk elements do appear in the overall structure of my works as the transition from day to night, but I did not feel as though I had enough material to make it a separate work of its own.

In the "Day” piece, I wanted to start with a natural soundscape that seems realistic, although it would be composed of several different recordings from various contexts. This “natural” soundscape then morphs and modulates into something supernatural, transitioning into a musical work with a tonal center and steady tempo. The general arc of the piece starts at a low energy, peaks in the middle, and ends at a low point. This arc mimics the rising and setting of the sun, with its highest peak in the middle of the day at noon. I also observed that natural soundscapes tend to get busier around the middle of the day, so that influenced the arc of the piece as well. “Day” is composed loosely in the key of C major, but it modulates frequently to

Ab major as well as other keys. I didn't want to stick too heavily to one key center, as I felt incorporating a greater sense of surprise in the musical tonality is more indicative of the range of pitches heard in a natural environment. Birds, frogs, insects, and other animals tend not to "sing" in a specified key.

The beginning of the piece introduces a basic nature ambience, with some high frequency wind and distant bird calls. A low-end rumble can then be heard fading in, which is the result of an automated low-pass filter that affects several layered waterfalls. As the waterfalls get panned to the center of the stereo image, they also gradually widen from mono to full stereo. The low pass filter reveals more high frequency content during this move as well, mimicking the effect of "turning the corner" to a waterfall scene. The movement of the low pass filter evokes the acoustic reality that bass frequencies travel further and bend around obstacles while high frequencies tend to be absorbed by obstacles more readily. Some footstep sounds were incorporated to help place the listener within the artificial soundscape. In conjunction, all of these elements create a scene of hiking around a corner to reveal a waterfall.

As a stream and more active avian soundscapes get gradually introduced into the piece, I automated several parameters on time-based effects. A spectral time plug-in gave a glitchy, digital sound to the stream. Automation of the frequency of a phaser gave the avian soundscape a swirling, spinning effect. The phaser frequency was automated to the extremes, nearly self-oscillating at its peak. These effects raise the overall intensity of sound manipulation to an obvious and extreme level and cue the audience that there is something more at play than simple nature soundscapes. At the riser's climax, I dropped the signal and introduced the first musical elements.

The bass sound was created by resampling and pitch-shifting a bug flyby. A small fraction of the bug's buzz was captured and looped, and a resonant filter helped eliminate extraneous noise and define a pitch. Using the filter's "key" function on the "simpler" instrument at maximum amount allowed me to correlate the pitch of the resonant peak to musical notes of the twelve-tone equal-tempered tuning system. Additional processing helped dial in the tone, such as addition of harmonics with a distortion pedal plug in. Psychoacoustically, low frequencies can be difficult to localize as accurately as mid and high frequency sounds. Because of this, I chose to make the bass sound monophonic.

Two other elements of "Day" that carry a solid pitch are the organ-like pad that can be heard outlining the chords alongside the bass and the keyboard-esque dripping instrument. Both of these instruments were created from the same source, water dripping inside of a cave. The strong resonances of each water droplet and the sustain of the cave reverb made this sample a perfect candidate for melodic use. The sustained pad sound was created by taking a sample of a droplet and repeatedly looping the resonant portion of the sound. This way, when the key was struck, the initial attack of the droplet hitting the floor would sound, but as the key is held a steady pitch is sustained. The length of the looped portion factored into the tuning of this instrument, as fast enough loop times begin to increase the pitch. I used a tuner plug in to get the sample to a near-perfect musical pitch, with variations of only a few cents in either direction. The drip keyboard used a similar approach, but without the use of the loop function. With this instrument, the entire envelope of the sample would play at the same rate each time the key is struck or even held down. I selected and tuned multiple droplets from the original recording, and used Ableton's chain function to set the different droplets to trigger at different octaves of the

keyboard. Incorporating the chain function in this manner allowed the instrument to have a more natural sound with greater variation, rather than one sample warped and pitched to extremes at either end of the spectrum.

To create the drum sounds, I used a mix of campfire samples and bird samples. The original fire recording had some low-end whooshes that I harnessed for a kick drum. By pitching the sample down, equalizing the sample to isolate the low end and some high end “tap”, and adding distortion and compression, I was able to create a thick and punchy sounding kick sample. My campfire recording also included snappy, high-frequency pops that I was able to repurpose for a snare drum with very similar processes. Both the “kick” and the “snare” samples were ran through Ableton’s drum buss plug in, which provides compression, drive, and some extra low-end boom to the signal. For hi-hats and cymbals, I imported high-frequency bird cheeps and pitched them up so that they inhabited the very high frequency range..

I utilized Ableton’s follow action feature to randomly trigger rhythmic and melodic samples at regular intervals at the climax of the piece. Although natural soundscapes are not random, per se, I wanted to incorporate a sense of randomness to the work. I felt as though letting the program decide which samples to trigger and when during this section of the piece had a more natural flow than personally deciding location and timing of each individual sample. While the selection of sample played was determined by Ableton’s random algorithm, the timing of the sample triggers was locked to the bars and beats grid. This allowed me to generate random material that remained musically viable by providing an extra layer of rhythmic subdivision.

At the end of the piece, I warped the tempo of the snare and played an extremely loose part of the drip keyboard in order to have the musical elements “fall apart” and return back into

natural soundscapes. To give the listener a sense of conclusion, I reintroduced the footsteps and the waterfall that can be heard at the beginning of the piece. I introduced an ambient recording that I took during the transition from day to night, then gradually decreased the level of the daytime layers and faded in night sounds to emphasize the transition to the next piece.

Nighttime soundscapes are highly distinctive from that of day, as I observed over the course of the field recording process. While sounds during the day are sporadic, the soundscape at night forms consistent layers of tones that persist for long periods of time. With this in mind, I wanted the general energy level of "Night" to stay relatively consistent. Of course, I did not want to bore the listener, but I did not want the radical transformation of energy as was exemplified in "Day." Also, because night is when people typically settle down and go to sleep, I wanted the general atmosphere of "Night" to be gentle and soothing. I chose a minor key and used a lot of minor seventh chords in the composition, as I feel these types of chords to be very calming. The piece is centered around the key of F minor.

The beginning of the "Night" smoothly transitions out of the previous piece. The listener is first presented with a natural-sounding ambience as a kind of introduction to the musical material that is to come. As more organic layers are introduced to the ambience, I also faded in a pitch-shifted and warped rhythmic ostinato that plays a major role throughout the rest of the work. The definitive beginning of the musical material in "Night" is preceded by a reverse reverb effect stemming from the main synthesized instrument. This effect provides a slight build and smoothly establishes the primary component of the piece.

The melodic character of "Night" is defined by a single synthesized instrument. Using a toad sample as my foundation, I applied a highly resonant filter in combination with the looping

trick that I used in the "Day" piece to create a smooth synth that can sound a wide range of frequencies. For the hard-panned stereo ostinato, I experimented with Ableton's pitch and time warping to create ear-catching sonic artifacts. I then re-recorded the signal, and slowed it down by a factor of one half. At this point, the rhythms in the ostinato were distinguishable enough to quantize to align with the song's 4/4 meter.

When the score becomes biphonic, with both a bassline and a higher melody line, I also introduced a stereo katydid chorus with a heavy phasing effect. I automated the dry/wet blend of the phaser in order to add even more modulation and variation to the sound over time. The end result is a background texture that seems to swim and pulsate.

Halfway through the piece, I introduced a cricket sample. I created duplicates at one octave and one fifth below the original, and panned the duplicates out to the far left and right. I then automated the panning on the duplicates so that they would alternate between left, center, and right in a continuous motion. These cricket samples were quantized to the grid, but instead of evenly subdividing the measures, they are playing a subdivision of three. I altered the speed of the subdivisions so that the crickets are sometimes dividing the measure into six and sometimes three. Alongside the crickets, a frog chorus is introduced. I kept the timbre of the frogs relatively unaltered, but I arranged the croaks so that they synchronized musically with the timing of other elements. At one point, I dropped the frog croaks one octave, but otherwise, I left them as they were. During this section of "Night," the main synthesizer switches to a very fast arpeggiation of the chords, preceded by a reverse reverb effect much like in the beginning. There is essentially a role reversal that happens in the middle of the arrangement. In the beginning, the natural sounds served as supportive material to the synthesized instrument. Towards the middle, the synthesizer

drops back further and serves as the background to the natural sounds that are now creating the primary rhythm and "melodies."

Similar to the "Day" track, "Night" ends much like where it begins. I used the toad synthesizer instrument to restate the primary melody and chord progression that can be heard at the beginning of the piece, and the final note rings out into an organic-sounding natural ambience.

Creating the "Dawn Chorus" track presented unique challenges. In large part, this piece was difficult to compose because of the recording location of a lot of the material. Because the vast majority of the samples were collected at my residence in Murfreesboro, road noise and airplane flyovers were far more present in these recordings than in others. I used similar techniques as before to reduce these noises. Almost every track has an EQ that is filtering off low end frequencies. Izotope RX vocal denoise was used frequently on this piece as well. With these tools, I was able to remove a significant amount of the unwanted noise.

The primary concept behind "Dawn Chorus" is the rising of the sun causing a short-lived but dramatic reaction amongst birds. Remaining consistent with the other two pieces of this series, the third and final work begins with an organic-sounding natural ambience that transitions smoothly from the previous work. This ambience is comprised of crickets, insects, and birds that were recorded right before the sun came over the horizon. I represented the rising of the sun in several ways. The first way is a drastic tempo increase from 111 to 450.17 BPM. Although there is no steady rhythmic foundation at the beginning of the piece to define the tempo or meter, the increasing tempo does affect the warping characteristics of the ambiences and provides a sense of increasing tension towards the 55 second mark. Two of the ambience tracks were set to the

"Re-Pitch" warp mode, which caused a pitch increase that corresponded with the rising tempo of the session. To a similar end, another ambient track was modified with rising transposition automation while in the "Texture" warping mode. Another way that the rising sun was symbolized was the use of low-pass filter sweeps. One of the ambience tracks starts off with the high-end frequencies cut, and as the composition progresses, the high frequencies gradually become revealed to the listener. The final aspect of the rising ambience at the beginning of this arrangement is a bird call that I reversed, slowed down, and pitched down. When it is first heard, it almost sounds like a motor vehicle due to the gritty nature of the intensely warped and manipulated sound. Gradually, though, I replayed the same reversed sample again and again, each time coming closer to the pitch and speed of the original recording.

After the initial ambiences and samples build to their highest intensity, the tempo drops and several layered rooster calls are sounded. I thought this sample would highly fitting, as the rooster crow is often used to symbolize morning time. The tempo quickly drops down to 70 BPM during this moment, which further increases the tension and anticipation of the downbeat.

When the downbeat does come, the tempo jumps to 481.05 BPM. The perceived tempo of the latter portion of the piece is much slower than 481.05 BPM, because longer rhythmic subdivisions were used. The beat is actually felt around the 120 BPM mark, meaning that every measure serves as one beat. The downbeat is signified by a high-frequency wash created by applying filtering and reverb to a harsh, noisy bird call. Several synthesized instruments can be heard at this point in the piece as well. I used many similar techniques as the other works in this series, such as creating defined resonant frequencies and looping small portions of material to create stable pitches. I also utilized an arpeggiator MIDI effect with modulation on the "rate"

control. The arpeggiator take in MIDI chord information and plays the material back in a note-by-note sequence at a specified rate. By modulating the rate control, I was able to create a unique pulse through each perceived measure. I emphasized this pulse in another synthesized instrument derived from a goose sample. Instead of using a MIDI arpeggiator, the goose instrument's rhythmic pulse was modulated in accordance to the sample's looping length. A smaller loop length resulted in faster repetitions, and vice versa.

Aside from the synthesized instruments in this track, there are several layers of various bird calls. I focused heavily on the rhythmic arrangement of these calls, as well as emphasizing the call and response technique by using left and right panning in the stereo field. For samples that had a melodic quality to them, I also changed pitches between individual clips to create further melodic interest. Some of the more transient bird chirps were utilized for percussive purposes. These elements help define the rhythmic feel of the composition and support the harmonic rhythm displayed in the synthesized instruments. The multiple layers of bird calls resulted in an uproarious, cacophonous chorus that is an extreme exaggeration of a natural dawn chorus.

The end of the piece is characterized by further exploration and play with soundscape work. As the chorus of birds continues to grow in intensity, the listener hears footsteps walk by. These footsteps are followed by the sound of a closing door. At the moment the door closes, many of the elements drop in level or disappear completely. Other elements become heavily filtered and muffled. This all works together to create a sense of literally closing a door on a soundscape, which isolates the listener from the natural ambience and muffles whatever is loud enough to still be heard. I then used this low point in the piece as an opportunity to crescendo

into one last final major chord, signifying the end of the piece and the end of the three-part series.

Composition of the pieces left me with mixed feelings. On one hand, there are several things about the pieces that I take pride in. First of all, the entire process from start to finish was very rigorous. Secondly, I find the pieces to be generally sonically pleasing and musically interesting. The thing that I consider to be the greatest success about the pieces are the sheer uniqueness of their sounds. I have heard very few pieces like "Day," "Night," and "Dawn Chorus," and I have definitely never created anything of this manner before. That being said, I fell short of my original intentions to create musical works in which every element can be identified as natural. In order to get consistent musical pitches out of some of the samples I gathered, I had to manipulate the material beyond recognition. Also, composing the pieces in Ableton pushed me closer to electronic dance music than I originally intended. I am not saying that I think the pieces are bad or of poor quality, but they did not turn out as I had once envisioned them.

My musical materials may be accessed here: **Google Drive - The Recording and Manipulation of Natural Sounds into a Musical Work**

And here: **OneDrive - The Recording and Manipulation of Natural Sounds into a Musical Work**

Conclusion

Throughout the course of completing this honors thesis, I have gained an immense amount of knowledge of field recording and sample-based synthesis relative to where I began. The sample editing and composition process taught me even more about field recording, specifically pitfalls to avoid. Because this was my first experience with field recording and biomusic composition, inefficiencies in the recording and composing processes were inevitable. I am glad to have made the mistakes that I did, which widened my view of field recording and music production.

The final results of my process are encouraging, at the very least. While there is still plenty of room to grow in recording, composing, synthesizing, and mixing, the fact that I was able to create pieces of music from nothing other than natural sound is something I take pride in. Although I did not have the knowledge or resources to directly achieve my goal of creating music in which each element could be identified as a specific natural sound source, I have grown stronger physically, creatively, and mentally in my attempts to accomplish something significant and unique. On top of that, I was able to create several pieces within the span of a year, having known little about field recording prior. At the end of the day, no musical work will ever be more indicative of nature than natural soundscapes themselves, and I realize that my unique process of transforming natural acoustic material was not meant to simply recreate what nature has already provided to humanity. Instead, I offered my own perspective on these concepts. I think these pieces definitely have a spot in the current collections of biomusical works. My work definitely illuminates a highly experimental approach to biomusic, and I hope other artists and listeners can

gain something from listening to my works. I would love to continue on the journey of gathering natural recordings, and I am excited to see how greater levels of experience effect my results. I have found that there are so many opportunities to take appreciation in things that are consistently overlooked, and there is so much depth to explore in the fields of sound and music. With that in mind, I look forward to continuing my biomusical journey and discovering new sonic lenses through which we may view the Earth's soundscapes.

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Appendix A: Recording Equipment

Figure 1: Zoom H6 portable recorder, shown with XY stereo mic capsule attached

Figure 2: Zoom mid-side stereo mic capsule

Figure 3: Zoom “dead cat” style windscreen

Figure 4: Zoom H6 and accessories in hardshell case

Figure 5: Rode NT5 microphones matched stereo pair, mic clips, foam windscreens, and hardshell case

Figure 6: NT5 mics in hardshell case

Figure 7: Rode NTG-2 shotgun mic and foam windscreen

Figure 8: Small boom pole for shotgun mics

Figure 9: XLR cable connectors

Figure 10: Shure SE215 PRO

Sound Isolating in-ear monitors

Appendix B: Recording Locations

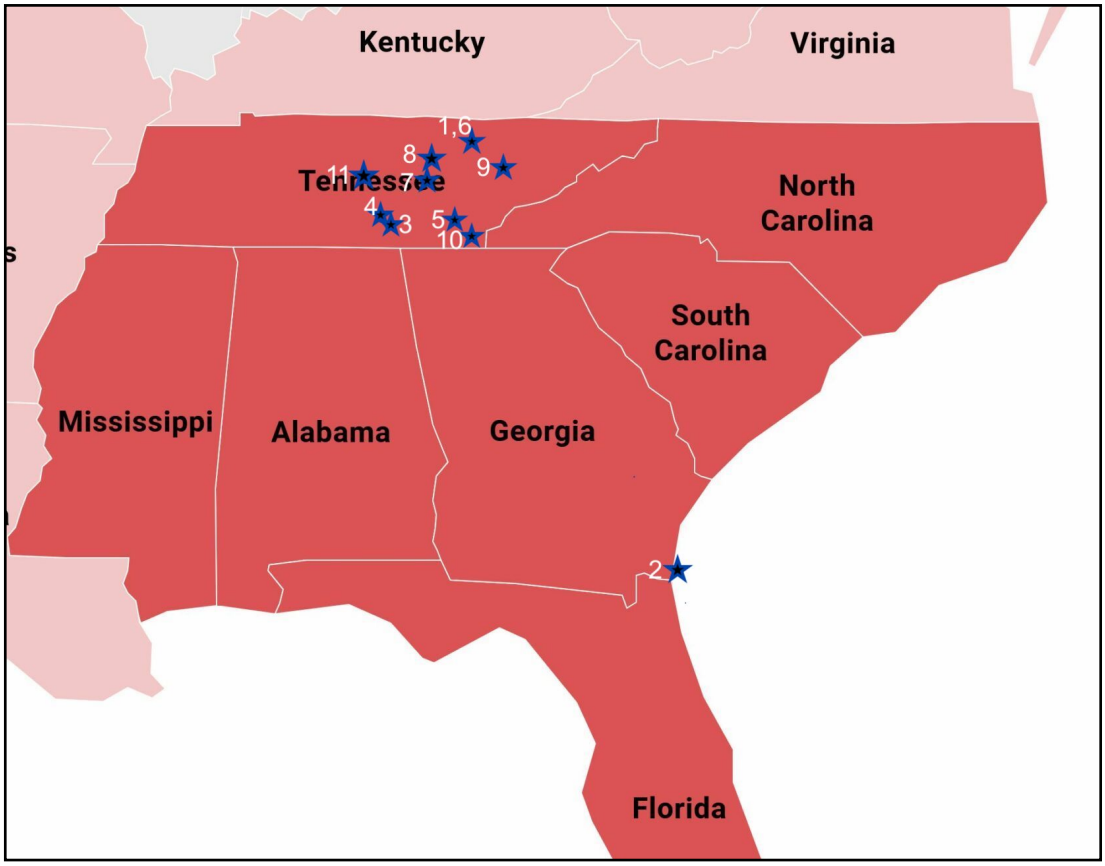

Figure 11: General overview of recording locations

Figure 12: Frozen Head State Park

Wartburg, TN

December 30th, 2021

Approximately 7 miles hiked

Figure 13: Cumberland Island

Camden County, GA

March 7-8th, 2022

20+ miles hiked

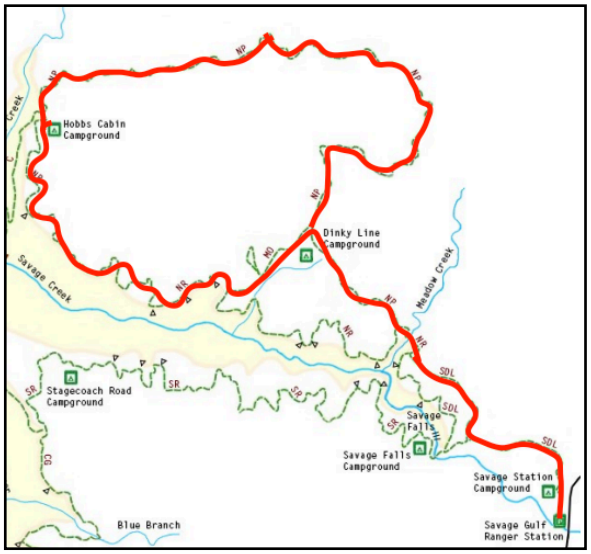

Figure 14: East Savage Gulf

Palmer, TN

May 13-14th, 2022

8.7 miles hiked

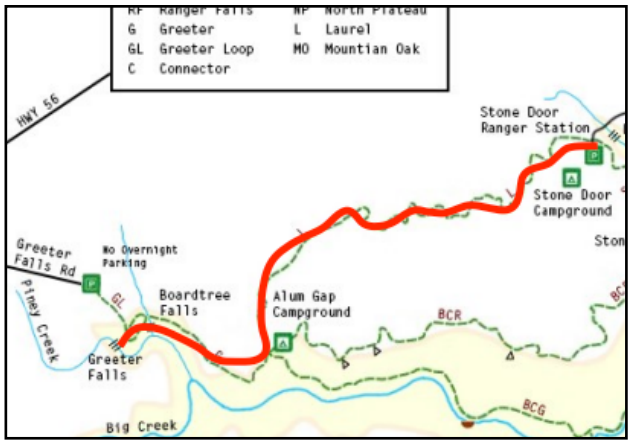

Figure 15: West Savage Gulf

Altamont, TN

May 19th, 2022

8 miles hiked

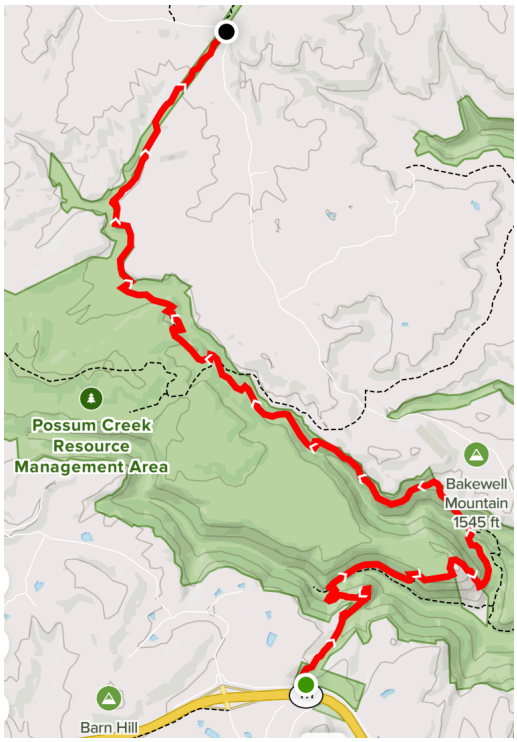

Figure 16: Possum Creek, Cumberland Trail

Soddy Daisy, TN

June 3-4th, 2022

8.1 miles hiked

Figure 17: Frozen Head, Squire Knob Campsite

Wartburg, TN

June 13-14th, 2022

9.1 miles hiked

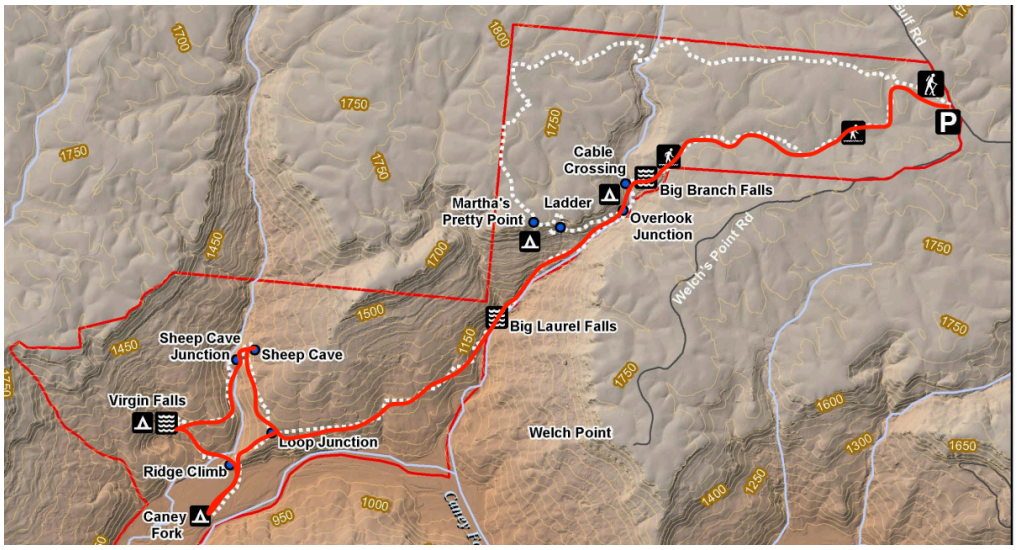

Figure 18: Virgin Falls State Natural Area, Caney Fork campsite

Sparta, TN

July 1-2nd, 2022

9.1 miles hiked