Keynote Sounds in the Tryon Creek Soundscape:

A battleground in the deep[1]

Nathaniel Stoll

Thesis Submission for Environmental Studies Major

Lewis & Clark College, Spring 2012

Concentration: Music – Making connections with our surroundings

[1] Some of the writing from this paper is taken from the project entitled, "Soundscapes in Tryon Creek," which is also authored by Nate Stoll and is available on the Lewis & Clark College Environmental Studies Program SGE website (https://sge.lclark.edu/project-mashup/soundscapes-in-tryon-creek/).

Faculty Mentors:

Professor of Environmental Studies, Jim Proctor

Professor of Music, Jeff Leonard

Professor of Geological Sciences, Liz Safran

Acknowledgments:

First and foremost, I would like to thank the Lewis & Clark Environmental Studies Department, including all the staff and students, for the guidance and help I have received throughout this study. I would especially like to thank Professor Jim Proctor for his careful attention to my project and Professor Jeff Leonard for his inspiring ideas. I also would not have been able to dream up such a project if it weren't for the careful advising and long discussions with Professor Liz Safran. The comments provided by my peers—Tara Brown and Zach Holz—were also invaluable. Lastly, I would like to thank Patrick Ryall and Lewis & Clark Instructional Media Services for the use of their recording equipment.

Abstract

This study is situated in Tryon Creek in Southwest Portland, Oregon. The aim of the study is to analyze the keynote sounds of the Tryon Creek soundscape by manipulating the frequency and duration of 15 field recordings taken at five different sites along the creek. Keynote sounds are sounds ubiquitous to the soundscape that are highly influential to the other sounds occurring around them. These sounds lay the foundation for all other sounds in the soundscape. Furthermore, keynotes are often unconsciously listened to by humans. The keynote sounds found in Tryon Creek are airplane sounds, traffic sounds, and creek sounds. These keynotes all occur in low frequency ranges. As a result, the keynotes compete with one another for acoustic space. An in-depth analysis of the field recordings is coupled with a survey issued to Lewis & Clark College students in order to assess how the keynote sounds of Tryon Creek are perceived. This study avoids the false dichotomies of human-created and natural sounds found in much of the research done within the field of soundscape studies. Furthermore, the methodological analysis accounts for variations in perceptions of time, which has also been significantly neglected in soundscape studies. The variable of time within the field recordings is manipulated by speeding up and slowing down the recordings in order to reveal patterns that might not be apparent upon a listening at regular speed.

Table of Contents

I. Acoustic ecology – An introduction

> If soundscape study is to develop as an interdiscipline, it will have to discover the missing interfaces and unite hitherto isolated studies in a bold new synergy. This task will not be accomplished by any one individual or group. It will only be accomplished by a new generation of artist-scientists trained in acoustic ecology and acoustic design. (Schafer 1977: 134)

The above is taken from one of the seminal works in acoustic ecology, R. Murray Schafer's *The Soundscape*. While the field of acoustic ecology and related fields like soundscape ecology and bioacoustics are finally starting to gain traction (Tingley 2012), this "new generation of artist-scientists" is emerging amidst a society that consistently neglects auditory information. The visual mode of interpretation dominates current environmental and social discourse (McLuhan 1989). Arguments are more often presented using papers, maps, tables, graphs, photographs, or mathematical models rather than with speakers and audio recorders. Everyday language usage is filled with phrases dominated by references to the visual rather than the aural world. Acoustic ecologists—myself included—are not guilt-free either. In the field of soundscape studies researchers often describe sounds using visual aids. Why have we put such an emphasis on our eyes over our ears? One possible reason is that our eyes can be much more selective than our ears. For instance, our eyes have eyelids. Aside from throwing our hands up and plugging our ears, we have no "earlids." As Mark Slouka crudely puts it, "Lacking money, I've lived with noise—with the sounds of fucking and feuding in the airshaft [and] MTV and Maury Povitch coming through the walls" (Slouka 1999: 45). In other words, we have much less control over our aural environment than our visual environment. Do we really have less control though? While it is true that we don't have earlids, there is still a way to block out sound. That is, we can cover up sound with other sounds. There are a variety of instances where sounds are mitigated, controlled, curtailed with curfews, blocked out with headphones, or compartmentalized within walls (Schafer 1977). Sound plays a huge role in our environment, and it's about time we get our eyes unglued from books, charts, and graphs and stop to listen for a while.

So what are we listening for? The field of acoustic ecology sheds some light on this question. The object of much aural attention within acoustic ecology is the soundscape. Much like the term landscape, a soundscape can be defined according to many different spatial scales. A soundscape could be delimited by the confines of a city, the borders of a lake, the interior of a car, or the boundary of a forest. In essence, the soundscape is a unit of scale used to encompass differing acoustic environs. According to Schafer, a soundscape is defined by three key features: 1) keynote sounds, 2) signal sounds, and 3) soundmarks. Keynote sounds are sounds ubiquitous to the soundscape that are highly influential and often unconsciously listened to. Signal sounds are more apparent and listened to more consciously. In a sense, keynote sounds can be thought of as background sounds, whereas signal sounds can be thought of as foreground sounds (Project and Truax 1978). Lastly, soundmarks—much like landmarks—are sounds that are somehow unique and highly prized or well-noticed within a community (Schafer 1977: 8). Schafer's use of visual terminology to describe aural events is made readily apparent by his references to foreground versus background dichotomies as well as landmarks. It is hard to escape a visual bias when there is significantly less readily understandable terminology available to describe aural events than visual events. Nonetheless, Schafer's soundscape framework provides a useful platform with which to build further studies.

II. Situating soundscapes – Tryon Creek keynotes

Each of Schafer's three sound categories provides a different perspective for analyzing soundscapes, and each comes with its own limitations and advantages. Much like the charismatic mega-fauna phenomena used in environmentalism to garner support for species conservation, the soundmark approach champions certain sounds over others. While this might be useful to gather support for the preservation of a soundscape, such a perspective does little to strengthen our understanding of the inner workings of the soundscape. Before we can argue for any policy objectives concerning soundscapes, we must first better understand how particular soundscapes function. Analyzing soundscapes through signal sounds is certainly useful, but it leads to a very basic understanding of the soundscape. Such an analysis could be done simply by taking a walk through a particular soundscape and writing down the sounds most obviously occurring. In this instance, a rich understanding of the soundscape gained from the sheer magnitude of details is buried underneath the façade of signal sounds. The features of the soundscape that provide the most useful information—features which take the most time and care to analyze—are the keynote sounds. Keynote sounds highlight the subconscious and unnoticed aspects of soundscapes, and they set the stage for all the other sounds occurring in a soundscape. Uncovering these often-ignored yet ever-present sounds leads to a greater understanding and appreciation of our aural environment.

In this study, the emphasis is put on keynote sounds. While it would be ideal to address all three sound features of a soundscape, such an approach is beyond the scope and means of this particular study. Murray Schafer writes, "To give a totally convincing image of a soundscape would involve extraordinary skill and patience: thousands of recordings would have to be made, tens of thousands of measurements would have to be taken; and a new means of description would have to be devised." (Schafer 1977: 8) As this is the case, the most effective approach to gain a deeper understanding of the inner-workings of a soundscape is an approach that analyzes keynote sounds.

Great work has been done in the field of soundscape studies on a large scale like that of Jian Kang in *Urban Sound Environment* and the work completed by the team comprising The World Soundscape Project. However, there is an increasing need for work done on a smaller scale that can relate back to and inform such large-scale studies. This particular study is situated in the soundscape of Tryon Creek, a tributary of the Willamette River located in Southwest Portland, Oregon. This creek was chosen because it runs through a varied urban landscape including residential streets, main highways, backyards, and Tryon Creek State Park. The study includes a methodology that is interdisciplinary and integrates field recordings, studio manipulations, and survey feedback in order to identify and assess the keynote sounds of Tryon Creek. Five well-spaced sites were chosen along the creek varying from the terminus of the creek to the creek's beginnings in residential neighborhoods. Three recordings of half an hour each were taken at every site during the morning, afternoon, and night. These samples were then analyzed and condensed using the studio software Ableton Live to reveal patterns within each soundscape recording. A survey was also conducted with students from Lewis & Clark College where respondents were asked to identify significant sounds occurring at one of the Tryon Creek recording sites. Inherent within the framework of an urban aural environment like Tryon Creek is a hybrid manifestation of nature and culture. Taking a small step back to see the overarching picture, it is crucial for fields within the environmental realm to address this hybrid system in order to move forward to positively confront environmental issues. In this case, Tryon Creek's keynote sounds—creek sounds, airplane sounds, and traffic sounds—play a dominant role within the soundscape. All three of these sounds occupy a low frequency range, and as such these sounds compete with each other for acoustic space in the low register. The clarity of the low frequency range of the soundscape of Tryon Creek often suffers from this competitive relationship.

III. The aural environment – A place for sound in environmentalism

The topic of sound is situated to play an exciting new role within environmentalism. Many works within the environmental movement have argued in varying degrees that humans have transformed the earth (Marsh 1874, Turner 1990, Meadows, Rome, and Associates 1974, and many more), and there is no doubt about this. However, such views create a false dichotomy between humans and nature. Modern environmentalism has outgrown this simple dichotomy of humans versus nature. The two are integral parts of one another. In order to recognize this, studies must integrate humans into the concept of the environment to avoid false dichotomies. The environment as we know it is not found in nature reserves and zoos. Instead, it is found in the mixed up hybrids lurking between biophysical processes and society like an axe protruding from a tree stump or the sound of snowshoes crunching through a forest. Soundscapes offer a perspective well-suited to such hybrid environmentalism.

An illustration may prove useful in discussing how this type of environmentalism applies to soundscapes. Think of a spectrum of sound sources. On one end there are the natural sounds as exemplified by birds tweeting, leaves falling, and water dripping. On the other end of the spectrum there are cultural sounds as exemplified by the low humming of airplanes and the sound from the friction of tires on pavement. In our urban aural environment these two rather useless constructs of nature and culture fall apart. Leaves fall into the creek and onto the street. The creek gurgles past trees, by industrial plants, under roadways, and across backyards. The low roar of airplane engines is able to penetrate homes, parks, and streams. Sounds blur together no matter what their source. There is no way to separate the natural sounds from the sounds created by our culture. The sounds exist together, and must be analyzed as one whole soundscape, especially in instances like that of Tryon Creek. Approaching the environment through soundscapes avoids simple dichotomies and instead emphasizes heterogeneity.

Such a hybrid environmental approach to soundscape studies is greatly lacking in the field. Going back to Schafer provides a clear example that is by no means exceptional in the literature. Rather, it is part of the norm. According to Schafer, “keynote sounds of a given place are important because they help to outline the character of men living among them.” (Schafer 1977: 9) Gender insensitivity aside, this statement is oozing with anthropocentrism, and sadly it is a common feature of acoustic ecology (Pijanowski et al. 2011). Schafer takes the backwards position of analyzing keynote sounds in terms of their importance to humans rather than focusing on the reciprocal relationship between humans and the soundscape. *A priori* judgments about relationships between sounds and sources—and more importantly judgments about the value of sounds in relation to their sources—leads to a misunderstanding of environmental processes that can in turn lead to false environmental solutions. Inherited aesthetic values have historically been known to cause many environmental problems (Robbins 2007). As Schafer’s anthropocentrism illustrates, sound is just as much a candidate for these aesthetic *a priori* judgments as sight. As many of the previous studies within the field have misrepresented the environment, this study aims to adapt old tools and uncover new tools to analyze soundscapes in a manner more consistent with modern environmentalism.

IV. Setting the sounds apart – Progressive soundscape studies

Since Murray Schafer's 1977 primer on acoustic ecology, *The Soundscape*, three troubling themes have arisen in soundscape studies. In this study, these themes will be identified and avoided. The first and most prevalent theme is that of noise pollution. While the exact start of the noise pollution movement is hard to identify, some of its first champions were the World Soundscape Project headed by Schafer and Barry Truax. This project worked to document and preserve dying soundscapes across the globe and to combat noise pollution. One of the most comprehensive studies done on noise pollution to date is Kang's 2007 work, *Urban Sound Environment*. Kang uses a very technical approach to document soundscapes and to argue for the negative impacts of human-created noise (i.e. noise pollution). He argues that noise pollution can cause speech interference, cardiovascular disturbance, sleep impairment, absenteeism, increased drug use, and many others (Kang 2007). The National Park Service (NPS) has followed up on such studies with research and policy of their own. According to the NPS management policy guidelines:

> The National Park Service will preserve, to the greatest extent possible, the natural soundscapes of parks…The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts. (National Park Service and U.S. Department of the Interior 2006: 56)

To follow through with this policy, a recent study was conducted at Crater Lake National Park in Oregon which found that 15% of the time noise caused by humans is present in the park like overhead airplane noise and propeller noise (Templeton 2011). Similar findings have also been observed in Alaska's Denali National Park (Tingley 2012). At the Olympic National Park in Washington, a project has been implemented in the Hoh Rainforest called "One Square Inch" to preserve one square inch of silence free of human-caused noise. This is done by managing the surrounding soundscape up to 20 miles away from the silent site. All of the aforementioned studies concerning noise pollution operate under the assumption that human-created sounds are inherently bad, hence the term "noise" instead of sound. With this underlying assumption, the goal of such studies is sound preservation, soundscape restoration, and the mitigation of anthrophony (i.e. human-created sounds). Common methodologies to address noise pollution include mapping decibel levels of noise using GIS, identifying sound sources, analyzing sound quality with measures like a sound's pleasantness, and calculating how often anthrophony occurs (Yu and Kang 2006; Kang 2007; Miller 2008; Templeton 2011).

However, such studies fail to grasp the complexity of the term "noise." Within the literature there has been much debate over how to define noise. An example of three different definitions of noise will clearly illustrate this point. Murray Schafer defines noise as follows: "Noise pollution results when man does not listen carefully. Noises are the sounds we have learned to ignore" (Schafer 1977: 4). John Cage makes a further distinction. He argues that unpleasant noise is that which we ignore, and pleasant noise is that which we listen to (Cage 1961). Barry Truax disagrees that noise is unwanted sound. Instead, he argues that noise covers up other sounds. Most commonly, Truax argues that noise "simply reduces the meaningfulness of the aural experience and the sense of self and place" (Truax 1988). These three differing perspectives on noise illustrate the discrepancies among conceptions of noise. The vague character of the term noise makes it a poor candidate to ascribe to the entire category of sounds that are human-created, but this is exactly what is done in noise pollution studies. Keeping this in mind, the ideological foundations of research on noise pollution are questionable at best. In this study, no such misleading assumptions will be made concerning which sounds are noise or not.

The second troubling theme in soundscape studies is an emphasis on visual interpretations of data. Such methodologies include visually representing characteristics of sound like frequency, duration, and amplitude using computer graphing technology. These methodologies are very commonly used in national park studies as well as by other soundscape researchers (Tingley 2012; Pijanowski et al. 2011). Despite the warnings of Murray Schafer and Barry Truax, many researchers are currently emphasizing the importance of their eyes over their ears. However, soundscapes are not experienced through eyes, they are experienced through ears. It is this emphasis on the aural experience that this study attempts to regain. The aural emphasis will be coupled with alterations of time within the soundscape in order to uncover patterns among keynote sounds.

Before moving on to the last troubling theme, a few more examples within soundscape studies must be discussed. Most soundscape studies work within a rigid disciplinary framework. For example, in an article entitled, “Soundscape Ecology,” Pijanowski et al. separate their own studies from other soundscape studies. The authors coin the term “soundscape ecology” because they believe that their methodological approach to soundscape studies creates a new subsection of ecology. Soundscape ecology tends to emphasize scientific theory. In Tippecanoe County, Indiana, some soundscape ecologists adapted the terms of diversity and evenness (normally used in reference to biodiversity) to illustrate that natural landscapes farther away from human disturbance were richer in soundscape diversity and evenness (Pijanowski et al. 2011). Soundscape diversity refers to the amount of different sounds occurring in a soundscape, whereas soundscape evenness refers to how often each sound occurs. As another example, in Sequoia National Park, soundscape ecologists worked to gather data on the acoustic niche hypothesis. This hypothesis argues that some species develop their own unique acoustic niches that vary in frequency and/or time interval in order to differentiate their own communications from other biophony and geophony (Pijanowski et al. 2011). The term biophony refers to biological sounds like birdsong or the croaking of frogs, whereas geophony refers to geophysical sounds like that of water or wind.

In acoustic ecology, there has emerged an academic interest in the intersection of music and the soundscape. Musical compositions that include soundscape recordings—like that of composer-ecologist Francisco López—push the boundaries of what is considered music and probe listeners to create their own music out of the sounds in their own environment. Save for the machine-laden "noise-sounds" of Luigi Russolo, most of these composers emphasize what they call "natural" sounds (Russolo 1986). This is done to the point of glorifying soundscapes relatively free of anthrophony over other soundscapes using only the criteria that anthrophony is *inherently* a negative impact on soundscapes.

This leads to the last troubling theme in soundscape studies. That is, there is a presupposed divide between anthrophony, geophony, and biophony in much of the literature concerning soundscapes, whether in the field of ecology, noise pollution, national park management, philosophy, or music. In fact, the very existence of such categorical terms like anthrophony illustrates this point. In order to stay clear of the false dichotomy between human-created sounds and natural sounds, no such distinctions will be assumed to automatically have significance in this study. It is a shame that so many previous studies have overlooked the hybridity of interactions between nature and human culture. Making distinctions between humans and nature immediately decouples such an environmentalist approach with the reality of our world. The reality is that freeway sound is just as much a part of the natural soundscape as birdsong in the middle of the Amazon Rainforest. Making arbitrary dichotomies between nature and humans often leads down a falsified path where environmental solutions are unfeasible, uninspiring, or under-endorsed. This study aims to raise awareness of our environmental soundscape, illustrating the inescapable fact that humans play an important and integral role within that soundscape. The human factor within the equation of our environmental soundscape is not going to disappear anytime in the foreseeable future. Many environmentalists outside the field of soundscapes have recognized this fact (Marris 2011), and it is time for soundscape studies to catch up. We must learn to move forward with this knowledge rather than regress by putting up boundaries and restrictive policies in order to preserve a pristine nature that no longer exists.

V. Time – The ever-present variable

The variable of time plays an integral role in properly situating this soundscape study apart from others. Time is a variable often overlooked in visual mediums, but it is absolutely essential to any understanding of aural environments. Not only is time a defining characteristic of sound (i.e. duration), but time is also inextricably linked to a sound's frequency. Sounds do not exist outside of the time they are created in. A striking example is illustrated by comparing aural and visual environments. It would be easy to take a fallen branch from a tree and transport it to a different location for visual presentation. However, taking the sound of the same branch falling and transporting it anywhere outside of the time in which it occurred seems near impossible. Of course, we could record the sound of the branch falling, but this is not the original version of the sound. Such recordings—however precise—are interpretations of the soundscape. In other words, microphones impart their own sound characteristics onto the recording much like the exposure of a camera colors a photograph. The importance of time within the soundscape offers a variety of ways in which time can be manipulated to uncover the finer details of the aural environment.

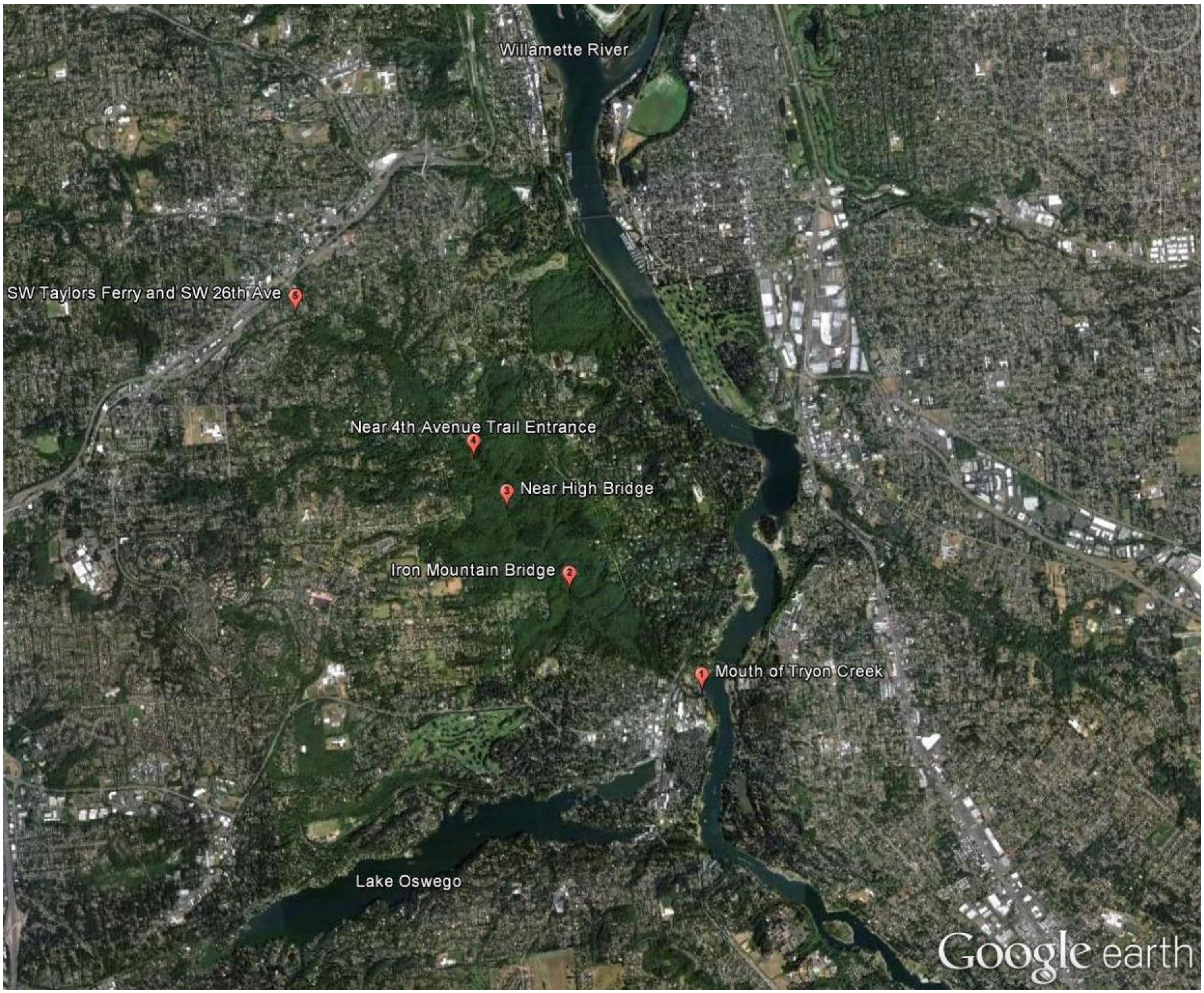
The importance that the perspective of time imparts on a soundscape has hitherto been almost completely ignored by other soundscape studies. Most studies simply catalogue sounds occurring without paying much heed to time's effect on the perception of sound. Altering time within a soundscape can reveal patterns that would not normally be perceived by the human ear because some patterns occur too quickly or too slowly. However, these patterns are essential in understanding the soundscape. By emphasizing the importance of time within this study, the soundscape will be analyzed in much greater depth.

The primary focus of this study is to analyze connections between time and space in the Tryon Creek soundscape in order to reveal the soundscape's keynote sounds. There may be patterns within Tryon Creek's soundscape occurring spatiotemporally that the typical listener would never realize due to logistical reasons (e.g. not having the ability to put our ears in two places at once). In order to uncover these sounds an interdisciplinary approach blending ecology with acoustics and sound engineering is essential. Soundscapes are dynamic and ever-changing due to the constant flow of time. Yet, given enough patience, careful listening, and a situated place and time, certain patterns will begin to arise. The bottom line is twofold. Take the *time* to *listen*. Our aural environment is far too important to take for granted so frequently.

VI. Methodology – From morning till night, from backyards to the mouth

The first section of the methodology is geared towards answering two questions: 1) what types of keynote sounds exist in Tryon Creek, and 2) how and why do keynote sounds vary across different sites and different times of day along the creek? The locations of each of the five recording sites help to account for a diverse array of sounds from the soundscape (see Figure

Figure I – Recording site locations



I). The first site is located at the confluence of the Willamette River and Tryon Creek. The next site is located further upstream at Iron Mountain Bridge in Tryon Creek State Park. Continuing upstream in the park, the third site is near the High Bridge on a bank off the foot trail. The last site in the park is further upstream near a drain pipe next to the 4th Avenue trail entrance. The final site is located at a bus stop at the intersection of SW Taylors Ferry and SW 26th Avenue. All sites are located within six feet of the creek.

Three half-hour recordings were taken at each site—one in the morning between 9am to 11am, one in the afternoon between 2:30pm to 4:30pm, and one at night between 8pm to 10:00pm. All the field recordings were taken with a battery-powered Zoom H2 Handy Recorder. Due to concerns for the equipment, I observed each recording at a distance. This may have had some impact on the sounds occurring in the environment, but because human presence is common in all the recording locations such a methodological practice was not completely out of the ordinary for this soundscape. Furthermore, I was unable to record during inclement weather, which happened often during the sampling period. This is certainly a limitation of this study as the sound of rain and wind is integral to the Tryon Creek soundscape. However, this circumstance was unavoidable due to the high cost of weather-resistant recording equipment. As season also plays an important role in the soundscape, the recordings were all gathered from late October 2011 until early January 2012 to conform to the winter season common during this time in Tryon Creek.

Tryon Creek's keynote sounds were identified and compared across sites and times of day with the aid of modern audio analysis tools. Ableton Live was used to manipulate and highlight the three primary characteristics of sound in each recording: frequency (i.e. high or low pitch), duration (i.e. how long the sound lasted), and amplitude (i.e. loudness). Each recording was split into low (30hz-1,000Hz), middle (1,000Hz-5,000Hz), and high (5,000Hz-22,000Hz) frequency ranges along with the original (unaltered) frequency range. These ranges were chosen because they correspond approximately with the optimal (and non-optimal) hearing ranges of the human ear. The human ear hears best along the middle range of roughly 1,000Hz to 5,000Hz, which is the most common frequency range of the human voice. Outside of this range, the ear hears at lower decibel levels depending on the specific frequency. Using these ranges highlights audio that is relatively harder for humans to hear while at the same time analyzing audio that—in loudness terms—is most present to our ears in aural environments. It is important to note that an individual's ears may vary from these approximations.

In addition to singling out these different frequency ranges, the recordings were also sped up and slowed down. The recordings were sped up by a factor of 16 times and slowed down by a factor of 8 times. In essence, this altered the temporal and frequency resolution at which the sounds were heard. These factors (e.g. 16 and 8) were chosen through trial and error within the constraints of the audio software. For lack of better aural terminology, such alterations were a way of viewing the soundscape with a magnifying glass. This magnifying glass may have distorted the aural image at times, but the increased magnification was invaluable to evaluate aural patterns and frequencies that normally go unheeded. In the sound engineering field, such distortions are called artifacts, which are not present in the original recording. These artifacts may have affected the aural analysis of the recordings. However, these distortions are becoming less and less with modern improvements in technology that stretch or condense the time of recordings. This leaves hope for further refinements of future implementations of this methodology with technological improvements of audio manipulation and increased funding. Altering the temporal resolution illuminated patterns and highlighted sounds within the soundscape that could not be easily detected by listening to the recordings unaltered. Hidden rhythmic and temporal patterns found in the soundscape were more easily detected. The human ear may often fail to perceive certain aural patterns because these patterns occur too quickly or slowly for proper aural comprehension.

Each sound in the altered recordings was analyzed and catalogued according to relative fidelity, frequency range, duration, loudness, possible source, and transients. The cataloging was done on a relative scale in order to avoid visual representations of the data. Soundscapes function through aural pathways, so it follows that aural modes of analysis are most appropriate. In other words, listening to the recordings in detail is more effective than portraying the recordings through visual representations. To clarify the relative nature of the cataloguing method, sounds were always taken in context with the other sounds occurring in the recording. For example, the duration of a bird call may have been three seconds. However, in relation to the continuous occurrence of creek sounds this is a relatively short duration. To explain some of the more technical terms, fidelity is a measure of the clarity of audio. In other words, fidelity is a measure of the amplitude ratio between a signal sound and all other sounds occurring in the soundscape (Truax and World Soundscape Project 1978). In practice, fidelity was assessed by listening to the clarity of the recording. If one sound dominated over the other sounds, this would be considered more low-fi than a recording where all sounds were well-differentiated. Transients are fluctuations in dynamics and frequency that occur throughout the body (i.e. middle) of a sound. However, the data on transients was not very useful in drawing conclusions about the soundscape.

The last question addressed by this study is: what are some of the ways in which listeners perceive the keynote sounds of Tryon Creek? This was answered by conducting a survey of

Lewis & Clark College students. Students first visited one of the recording sites near the High Bridge and then listened to the analyzed field recording taken at this site. The respondents were asked to write about the sounds they heard during each of these experiences. While the sampling strategy was not random or representative of the whole Lewis & Clark population, the respondents' insights provided useful data on how the Tryon Creek soundscape might be perceived, and more importantly how the manipulations implemented by this methodology increase understanding of a soundscape.

VII. Keynote sounds – Water, planes, and cars

While a seemingly endless catalogue and description of the sounds occurring in the Tryon Creek soundscape could be included here, writing about sounds is very different from actually listening to sounds. All of the sounds and phenomena that are discussed in the following can be found at https://sge.lclark.edu/?p=13104 where a map of the recording sites in Tryon Creek is accompanied by all 15 of the analyzed soundscape recordings. Referring back to these recordings occasionally for clarification to supplement the written descriptions and analysis is invaluable to understanding the aural processes that are occurring in Tryon Creek (this should be done with good headphones or speakers). I can talk about the soundscape all I want, but if you don't actually listen to what is going on there is little point in my ramblings.

To begin, I will briefly describe the aural environment found at each site. However, before continuing it is important to note that the following results and analysis are constrained by the methodology previously discussed. In other words, the results are limited by the time of year in which the recordings were taken and by the sites where the recordings were taken. However, the scope of the sampling site methodology does account for the various differences that are commonly found in the soundscape along Tryon Creek. Unsurprisingly, water running from the creek was present in every recording. At the mouth of Tryon Creek, airplane sounds were present in both morning and night recordings. Songbirds, seabirds, geese, wind, and insect stridulation were also common features at the mouth of the creek. The sounds that were unique to this site were sounds made by industrial plants. These sounds included engine hum and machinery hammering. This makes sense as large rivers like the Willamette have a history of providing shipping lanes for industry. Also, the wide expanse of the river allows for these industrial sounds to travel upstream and downstream by echoing along the river banks.

Moving upstream, the next site was the Iron Mountain Bridge. Airplane sounds were found during all times of day at this site, but they were quieter during the night recording. Songbirds sang morning and evening choruses, whereas during the afternoon the sound of human traffic and voices along the bridge were more prevalent. A train horn that rang out during the night recording provided a clear instance of a signal sound at this site. The location of this site at the bridge created an interesting environment for hearing the sound of footsteps. When visitors to Tryon Creek State Park walked across the bridge a rhythmic thumping was added to the soundscape. When this sound is sped up, the striking rhythm of footsteps on the bridge becomes inescapable (listen to the afternoon recording of the Iron Mountain Bridge at 3:26 for an example).

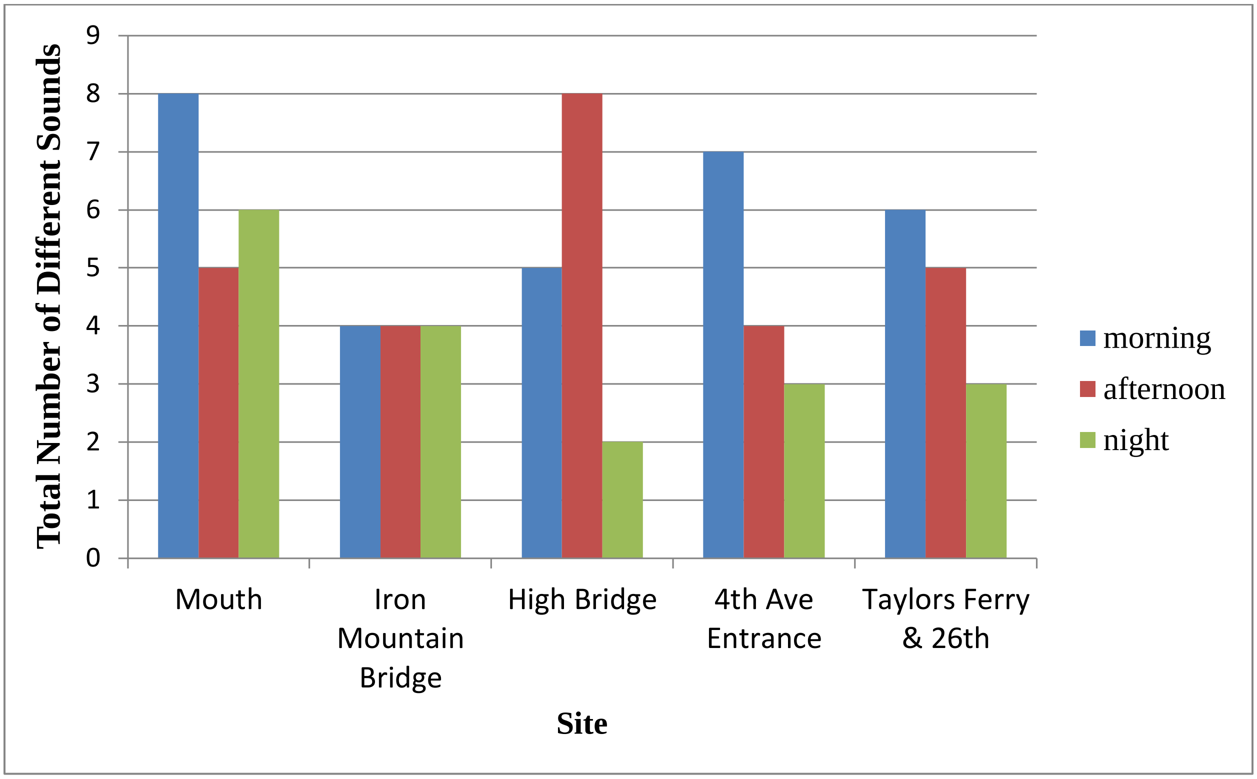
The third site located near the High Bridge included many of the sounds already discussed like songbirds and insect stridulation. Like the previous site, airplane sounds occurred during all times of day, and again, the airplane sounds were significantly quieter during the night recording. Human voices, a twig crack, and a dog bark added a lot of sound diversity to this soundscape. One of the most unique sounds I encountered in all of the 15 recordings occurred during the morning recording at this site. Throughout the whole recording there is a soft falling of leaves, which sounds a lot like rain when the visual component of the landscape is taken away from the listener. The falling of leaves on this scale happens only a few times a year, and even then such occurrences have to coincide with days where rain isn't covering up this constant soft rustling.

Continuing on, at the site near the 4th Avenue entrance to Tryon Creek State Park, airplane sounds occurred in all recordings except during the night. The morning recording at this site had quite a few more sounds than the afternoon and night recordings like the sound of a garbage truck at work in the distance, a train horn, and twigs cracking (see Figure II). Songbirds and crows were also calling in all the recordings. The sound that really set this site a part from the others was the sound of a drain spilling into the creek, which continued constantly throughout every recording. This sound was especially loud during the night recording.

The last recording was particularly different from all the rest. It included many of the sounds already discussed such as songbirds, crows, and dogs barking. However, unlike many of the other sites, airplane sounds were only found audible in the morning recording. As the recording was located very close to the street corner of SW 26th Avenue and SW Taylors Ferry, the sound of traffic was also very prevalent in all three recordings. The relationship between traffic and airplane sounds will be discussed in greater detail momentarily.

So which of all these sounds are the keynote sounds? By far the most ubiquitous sounds in the recordings are the running water of the creek (rather obviously) and the sound of airplanes which is found in all but four of the recordings. Bird calls are also very ubiquitous to the

Figure II – Sound diversity in each soundscape recording categorized by site and time of day



soundscape, but these calls occur with infrequency. The duration of the creek sound is continuous in all the recordings, and airplane sounds occur relatively frequently and last for minutes. In other words, creek and airplane sounds are very present in the recordings in terms of how often they occur and the duration for which they occur. However, there is still one more keynote sound of the Tryon Creek soundscape: traffic. Even though traffic sounds only occurred at one of the sites, this sound played a prevalent role at this site. Other than creek water sounds, traffic sounds occurred by far the most frequently at this site. The traffic serves as a constant whoosh in the background, which sets the tone of the soundscape. Furthermore, there are many other intersections where Tryon Creek passes under roadways, and there are also many drainage ditches where the creek runs along roadways. It is most likely that traffic sounds are at a similar or greater consistency in these other places. In this way, traffic can be considered a significant keynote in Tryon Creek. The other sounds occurring in the soundscape can be categorized in terms of either signal sounds like dogs barking or soundmarks like birdsong.

VIII. Competing low frequencies – The battle of the keynotes

There are a number of features of the soundscape which point to significant relationships within the soundscape. Table I points to relationships between the keynote sounds of Tryon Creek. The first and most interesting feature of the keynote sounds is that they all contain a very significant amount of low frequency data. This makes perfect sense with Schafer's definition of keynote sounds as often unconsciously listened to. In a way, the human ear is similar to a high pass filter. That is, the human ear begins to roll off (i.e. make increasingly quiet) frequencies below 1,000Hz. These sounds are more often than not present in the soundscape, but the human ear does a great job of acoustically filtering out this low frequency information (Moore 2007). Unfortunately, because these sounds occupy similar frequency ranges, competition for acoustic space is bound to occur.

While the running creek is present in every recording, the loudness of the creek in relation to the other sounds in the soundscape varies according to the time of day. This is a very interesting observation because the only time of day when the creek actually gets louder is during the night. As is illustrated by the "Creek Loudness" column of Table I, the creek was louder during the night than in the morning and afternoon at the Iron Mountain Bridge, near the High Bridge, and at the intersection of SW 26th Avenue and Taylors Ferry. Furthermore, Figure II shows that the three recordings with the lowest sound diversity all occur during the night.

Table I – Relative loudness of low frequency keynote sounds

Site	Time of day	Creek Loudness	Airplane Loudness	Traffic Loudness
Mouth	morning	soft	moderate	n/a
Iron Mountain Bridge	morning	soft	moderate	n/a
Near High Bridge	morning	soft	moderate	n/a
4th Avenue Entrance	morning	soft	soft	n/a
Taylors Ferry & 26th	morning	soft	very soft	loud
Mouth	afternoon	soft	n/a	n/a
Iron Mountain Bridge	afternoon	soft	soft	n/a
Near High Bridge	afternoon	soft	moderate	n/a
4th Avenue Entrance	afternoon	soft	soft	n/a
Taylors Ferry & 26th	afternoon	soft	n/a	loud
Mouth	night	soft	soft	n/a
Iron Mountain Bridge	night	moderate	soft	n/a
Near High Bridge	night	moderate	very soft	n/a
4th Avenue Entrance	night	soft	n/a	n/a
Taylors Ferry & 26th	night	moderate	n/a	moderate

These findings challenge the common assumption in acoustic ecology that night is often higher fidelity than other times of day (Schafer 1977).

In the case of Tryon Creek, the loudness of the creek during many of the nighttime recordings actually covers up many of the other sounds occurring in the soundscape making them seem quieter—an example of acoustic competition in action. This is clearly illustrated at the site located near the High Bridge. Airplane sound is relatively moderate in loudness compared to the softer creek sounds in both the morning and afternoon recordings. However, in the night recording these roles switch as the creek becomes louder and the airplane sounds become quieter. This relationship is further emphasized at the site near the 4th Avenue entrance to the park. At this site, airplane sounds are only present in the morning and afternoon recordings. The sound of running water coming from the creek is reinforced by the sound of the drain pouring into the creek providing further low frequency data to compete with airplane sounds at night. Figure II also illustrates this general trend of the creek competing with more sounds when it is louder at night because the night recordings near the High Bridge, near the 4th Avenue trail entrance, and at the intersection of SW 26th Avenue and Taylors Ferry have the least number of differing sounds.

The biggest issue raised by these keynote sounds all occupying the low frequency range is that they oftentimes cancel one another out or cover each other up. This is most easily illustrated with an example taken from the musical world. How many times have you seen a band with three different bass players? Probably never. That's because when you have three actors playing in the same frequency range the sounds tend to get very muddy and confusing. In application to the Tryon Creek soundscape, this occurs most obviously when traffic is present. Listen to the beginning of the morning recording of site five at SW Taylors Ferry and SW 26th Avenue, and notice how the sound of the creek fades away when cars pass by. Furthermore, this is the only site where airplane sounds were noticeable only during one time of day. It is very possible that the low traffic is covering up the airplane sounds in the afternoon and night recordings. Going back to Table I, in many instances if the creek is soft, then the airplane sounds are louder in comparison. If the creek is louder, than the airplane sounds are quieter in comparison. If traffic is loud, then it is likely that the traffic will make the creek seem quieter or even cover up some of the creek and airplane sounds.

The site at the mouth of the creek also provides a powerful demonstration of the way in which low frequency sounds compete with one another. This site includes a constant engine hum from an industrial operation which is present in every recording. However, the engine hum is high-pitched during the morning and night recordings, whereas it is much lower-pitched during the afternoon recording. The afternoon recording is also the only recording at this site that does not have perceptible sound from airplanes. In this way, the lower-pitched engine hum, which is very prevalent in the afternoon recording, could be covering up the sound of airplanes. At every other site where airplane sounds were present in the morning and at night, airplane sounds were also present during the afternoon. This makes it unlikely that the airplanes heard during the morning and night recordings simply stopped during the afternoon. Furthermore, the only other afternoon recording that shows no evidence of airplane sound is site five at SW Taylors Ferry and SW 26th Avenue. As previously discussed, traffic is a heavy influence on the soundscape near this intersection. This points to the possibility that the low-pitched traffic is masking airplane sounds in a similar frequency range as the low machinery hum.

Any possible alterations to the Tryon Creek soundscape must first consider the competition of low frequencies. There is a great deal of overlap in this soundscape within the low frequency range between water, traffic, and airplanes. As this competition is three ways, any attempt to clean up the soundscape's muddy low frequency range by singling out only one of these three sounds may simply reveal a new competition between the other two actors. For instance, if the sound from traffic is minimized in an area, this may reveal a significant amount of low airplane sounds that also battle with the low creek sounds. This relationship may have been relatively unnoticed when traffic was present.

IX. Perceptions of keynote sounds – The ghost of noise pollution

Seven survey respondents visited the Tryon Creek High Bridge during the afternoon throughout the month of February 2012 and recorded the sounds they heard there for a 10-minute period. Respondents also recorded notes on the sounds they heard while listening to the analyzed soundscape recording taken in the afternoon near the High Bridge. It is important to note that respondents have a bias as they were asked to sit and listen to the soundscape intently for 10 minutes, which is probably not a common activity for park attendees. The intent of the survey was to gather data on the keynote sounds of Tryon Creek and how they are more often than not unconsciously present to the listener. However, in hindsight this might not have been the best way to go about this since the process of sitting and listening quietly in Tryon for 10 minutes is an atypical experience in the park. That is, such an experience makes people hear things they normally wouldn't. A further study could better fulfill this intent by administering an exit survey to Tryon Creek State Park attendees. In such a case, park attendees would not be actively listening during their park experience.

Nonetheless, the responses from the survey provide interesting data that supplements and corroborates the data collected throughout this study even if the survey data did not support the intended conclusion. It is heartening that many of the same sounds that were catalogued in the recording were also heard by the respondents while they visited the site. These sounds include humans talking, the running of the creek, footsteps, songbirds, twigs cracking, and airplanes. In addition, respondents also heard rocks falling into the creek, rain, wind, and surprisingly even a gunshot.

Some respondents naturally picked up on the competing keynote sounds in the soundscape. One respondent wrote about the sound of the creek, "This was the dominant sound when the planes weren't passing." Another wrote that the sound of airplanes "overruled all other sounds and felt very close." Following the general, but certainly not necessarily true, assumption that human-caused sounds are inherently negative to the soundscape, some respondents categorized airplane sounds as "noise pollution" and "disrupting of the environment." In contrast, some respondents characterized the sound of the creek as "comforting" and "blissful." Previous work in soundscape studies has certainly left its mark on the way some listen to the Tryon Creek soundscape. Automatically dividing airplanes into the realm of noise pollution presupposes that the sound of airplanes is not a natural part of our aural environment. In practice within Tyron Creek, it seems that the opposite is true. It is harder to find areas where airplane sounds are not present in Tryon Creek. However, it is perfectly understandable for respondents to hold such a view as the term "noise pollution" has become a part of our everyday vocabulary. Overall, respondents' analyses of the soundscape further illustrate that the competing keynote sounds of the Tryon Creek soundscape have a significant effect on the Tyron Creek soundscape.

X. Moving forward, not back - Creating a sense of space and place with our ears

How do we move forward within the Tryon Creek soundscape now that we have illuminated the competing nature of keynote sounds? If this study was within the traditions of soundscape ecology or noise pollution studies, it might be enough to document the significant presence of anthrophony (e.g. planes and cars) and discuss further study into the possible effects this might have on the local fauna. However, any hope of actually getting rid of these human-created sounds in Tryon Creek is slim to none. Who is going to tear down the streets that run by the creek? Who is going to stop airlines from flying planes into and out of Portland International Airport? If such events transpire, our culture will be in shock on a scale that is far beyond the impacts such actions would have on soundscape studies. Contemplating such fanciful events is far beyond the scope of this study.

Unlike what many soundscape researchers believe, the greater message to take from a study like this one is not: sounds made from combustion engines are bad. Rather, such a statement should be revised to: sounds made from combustion engines *interact*. That is, they are an integral part of many soundscapes, including Tryon Creek. The implications of this study, which reveals the interactions between low keynote sounds in Tryon Creek, are that the low frequency range of the Tryon Creek soundscape is off-limits to any actor who wants acoustic space. This could mean that the local fauna will adapt (or already have adapted) by vocalizing outside of low frequency ranges. This could also mean that humans have to talk louder in lower registers to be audible.

Such findings are not necessarily new. In *The Soundscape*, Schafer extensively documents the transition from rural high fidelity soundscapes to urban low fidelity soundscapes, especially in the lower frequency ranges. There are many more possible implications of such findings, but it is not necessary to theorize about all the possibilities to discuss how to deal with such competing low frequencies within a soundscape. The absolutely critical question is this: what are we left with when the low frequency range of a soundscape is dominated by keynote sounds like water, cars, and planes? The answer: all of the other frequency ranges. It is the clarity of these other frequency ranges (i.e. the middle and high) that we must work to preserve. In Tryon Creek, it is within these ranges that humans are able to understand each other through speech; birds are able to call to each other; insects are able to communicate with one another by rubbing body parts together; dogs are able to proclaim that this backyard is their land. Within these boundaries, the diversity of Tryon Creek's soundscape—from gunshots to the constant soft rustling of leaves—is able to thrive. Above this consistent muddle of low frequencies, there are sounds to preserve. Within this space, actors are filling in new acoustic niches.

In the broader field of environmentalism, our sense of space and place is very important. When applied to visual realms, space and place are relatively easy to comprehend. There is the space where you place your feet in a car. There is the space where you ride your bike along the road. There is the place where you grew up. However, aural space and place are much more difficult to comprehend, and as a result they are more often ignored. The competing keynote sounds in Tryon Creek illustrate the importance of becoming more aware of the acoustic *space* within an environment. There is only so much acoustic space to go around, and actors must either adapt to make room for one another, or get lost in a series of competitions.

This application of place to the acoustic realm is an important notion for our environment. It is through acoustic place and space that soundscape researchers can learn to grapple with our hybrid environment. This is because space and place offer avenues where research methods and policies can be formulated which do not hinge on the assumption that human-caused sounds have an inherently negative impact on the soundscape. Instead, soundscapes should be analyzed in terms of how much space is left for acoustic actors of all types. Leading from this, the policy goal for a healthy soundscape is not how can we get rid of human-created noise pollution, but rather how can we create more acoustic space and sense of place for all acoustic actors? It is not the place of soundscape researchers to determine exactly how a soundscape should sound. Allowing for the greatest amount of space for acoustic actors to have their own freedom to interact is a much better goal for soundscape research than imposing value judgments on which sounds should be considered noise. To further clarify, the space of a soundscape can be thought of much like a recording done in a professional studio. Recording engineers often speak of acoustic space in terms of the lows, the mids, and the highs. Only with very careful planning and skill can more than one or two sounds occur in the same frequency ranges. Such space evokes a sense of place within any given aural environment. In the Tryon Creek soundscape, if we are to preserve the clarity of the middle and high frequency ranges, similar planning and skill are necessary.

XI. Further research – Urban/suburban soundscapes and flowing bodies of water

In order to truly asses the health of the Tryon Creek soundscape and to draw connections to other urban and suburban soundscapes, it is necessary to move beyond the identification of competing low keynote sounds. Analyzing the soundscape's keynote sounds was a crucial first step. However, much more research is needed in order to properly analyze the full soundscape and the implications to soundscapes in other urban contexts. One avenue for further research could look into the question of why Tryon Creek gets louder at night. Is this due to increased stream flow or some other factors of the urban environment? While this study did a good job accounting for temporal aspects like time of day and rhythmic patterns, much is still lacking in terms of temporal relationships that might occur across the seasons. An analysis of such patterns would be necessary for drawing implications to other urban contexts. The limitations of this study make it hard to apply the findings of the urban/suburban soundscape of Tryon creek to other urban and suburban soundscape contexts. This is especially true considering that the influence of rain on the soundscape was not analyzed in this study, and rainfall could certainly be a contender for another keynote sound in the Tryon Creek soundscape. Weather-resistant equipment would be needed for such an undertaking, and significantly more data storage and battery power would also be necessary. However, such requirements are not unthinkable. Soundscape researcher Davyd Betchkal works in Alaska's Denali National Park taking continuous audio data for months on end using solar panels and special weather-resistant recording gear able to withstand extremely cold temperatures in the winter (Tingley 2012). With equipment such as this, it would be much more feasible to take consistent recordings of the Tryon Creek soundscape during all times of year and all types of weather. This would allow for a more comprehensive assessment of the soundscape outside of keynote sounds.

However, as the budget for such equipment is rather astronomical ($10,000 and farther upwards would not be an unreasonable estimate), why not think on a larger scale than just Tryon Creek? The feature that makes the relationship between Tryon Creek's keynote sounds unique is the triangulation between the sounds of water, cars and airplanes. This trifold relationship could be occurring in many other soundscapes where a flowing body of water is present along with the low hum of combustion engines. Further solidifying the competitive relationship among these low keynote sounds in other urban and suburban contexts is essential in delimiting the amount of acoustic space soundscape researchers and aural actors have to work with. One of the most fascinating questions for further research would be whether there are places where all three of these keynote sounds exist, but the competition among these sounds is minimized. Such an occurrence could be due to a number of factors like a very fine and minute differentiation in sound frequency characteristics, or possibly landscape characteristics that channel sounds into different spaces. This research would be the most useful in terms of finding solutions to create more clarity in the low frequency ranges of a soundscape. A great place to start further research like this would be in the greater Portland Metro area as there are plenty of bodies of flowing water to choose from (e.g. the Willamette River, the Columbia River, and creeks aplenty). The identification of relationships among acoustic actors will be critical for future soundscape studies. It is crucial to remember that such relationships should be defined without a priori assumptions about which sounds are noise or not. In other words, a solution to an issue of competing low frequencies should not start with the premise that getting rid of anthrophony is always a positive and feasible option.

XII. A reflection – On soundscape studies

The analysis of Tryon Creek's keynote sounds is certainly a worthy endeavor, which has been discussed at length. However, if all of the conclusions about competing keynote sounds and hybrid interactions between biophysical and cultural aural actors go unheeded, there is one particularly simple point which this study—and all other soundscape studies for that matter—would like to stress. Our aural environment is important, and it would behoove society to take greater note of the acoustic surroundings that affect so many of the interlinking processes of the earth. You do not need to spend a year developing a soundscape study and recording hours of field data to recognize this fact. As the survey respondents who participated in this study would surely testify, simply going out into your environment and quietly listening with keen attention for ten minutes can do wonders to open up your mind's perception of its aural environment. Do this a little more than once a year, and then you're way ahead of the majority of our visually-dominated society. In addition, experiencing the aural environment doesn't just have to happen on occasion. Simply becoming more aware of the sounds that occur in our everyday lives will cultivate a finer appreciation for the significance of soundscapes. That said, making an outing of an aural experience is certainly worthwhile. Sitting for long stretches of time and simply listening to your surroundings can be an absolutely enlightening experience. Try sitting in a forest at night and listen to the owls talk back and forth while train horns echo in the distance and a creek gurgles past your ears. Better yet, close your eyes and listen to the freeway sounds in the distance blend into a wash of acoustic waves. Such experiences are just as awe inspiring as some of the greatest paintings on display at any fine museum. If you don't believe me, please, go out and try it.

XIII. References

Cage, John. 1961. "The Future of Music: Credo." In *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner. Continuum International Publishing Group.

Kang, Jian. 2007. *Urban Sound Environment*. Taylor & Francis.

Marris, Emma. 2011. *Rambunctious Garden: Saving Nature in a Post-Wild World*. Bloomsbury Publishing USA.

Marsh, George Perkins. 1874. *The Earth as Modified by Human Action*. C. Scribner's Sons.

McLuhan, Marshall. 1989. "Visual and Acoustic Space." In *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner. Continuum International Publishing Group.

Meadows, Donella H., Club of Rome, and Potomac Associates. 1974. *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. Universe Books.

Miller, Nicholas P. 2008. "US National Parks and Management of Park Soundscapes: A Review." *Applied Acoustics* 69 (2) (February): 77–92. doi:10.1016/j.apacoust.2007.04.008.

Moore, Brian. 2007. *Cochlear Hearing Loss Physiological, Psychological and Technical Issues*. Chichester ;;Hoboken, N.J. :: John Wiley & Sons,.

National Park Service, and U.S. Department of the Interior. 2006. "Management Policies 2006: The Guide to Managing the National Park System". U.S. Government Printing Office. http://www.nps.gov/policy/mp/policies.html.

Pijanowski, Bryan C., Luis J. Villanueva-Rivera, Sarah L. Dumyahn, Almo Farina, Bernie L. Krause, Brian M. Napoletano, Stuart H. Gage, and Nadia Pieretti. 2011. "Soundscape Ecology: The Science of Sound in the Landscape" 61 (March): 203–216.

Truax, Barry, and World Soundscape Project. 1978. *The World Soundscape Project's Handbook for Acoustic Ecology*. A.R.C. Publications.

Robbins, Paul. 2007. *Lawn People: How Grasses, Weeds, and Chemicals Make Us Who We Are*. Temple University Press.

Russolo, Luigi. 1986. "The Art of Noises: Futurist Manifesto." In *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner. Continuum International Publishing Group.

Schafer, R. Murray. 1977. *The Soundscape: Our Sonic Environment and the Tuning of the World*. Destiny Books.

Slouka, Mark. 1999. “Listening for Silence: Notes on the Aural Life.” In *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner. Continuum International Publishing Group.

Templeton, Amelia. 2011. “Documenting the Sound of a Fallen Tree (and Planes).” *Weekend Edition Sunday*. NPR.

Tingley, Kim. 2012. “Whisper of the Wild.” *The New York Times*, March 15, sec. Magazine. http://www.nytimes.com/2012/03/18/magazine/is-silence-going-extinct.html.

Truax, Barry. 1988. “Electroacoustic Music and the Soundscape: The Inner and Outer World.” In *Companion to Contemporary Musical Thought*, ed. John Paynter. Routledge.

Turner, Billie Lee. 1990. *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*. CUP Archive.

Yu, C., and J. Kang. 2006. “Comparison Between the UK and Taiwan on the Sound Environment in Urban Residential Areas.” In *The 23rd Conference on Passive and Low Energy Architecture*. Geneva, Switzerland. http://www.unige.ch/cuepe/html/plea2006/Vol2/PLEA2006_PAPER632.pdf.