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Student Research Report

How Does Human Activity Impact Bird Song in the UBC Botanical Gardens?

Lia Newman, Robbie Lockyer, Shea McConkey, Severine Renard, Savannah Gladstone

University of British Columbia

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Abstract

The decline of biodiversity is an enormous issue that is undeniably prevalent on a global scale. This is often an intimidating concept for many due to its extensive prevalence, but studying distinct terrains on localised scales allows one to understand how this affects us all directly, and how humans have continued to contribute to biodiversity decline. Our immediate surroundings, the UBC Vancouver campus, offers a myriad of biodiverse species that has created miniature ecosystems across the University Endowment Lands, representing many of Canada's common maritime wildlife. The UBC Botanical Gardens equally hosts a diverse array of bird species that vary throughout the year, as it is a key location along a major flyway for migratory birds, the Pacific Flyway. However, it also renders a range of human activities; management, construction, trespassing, traffic and general recreation. The overall purpose of this study is to illustrate the relationship between human and non-human and bring light to a wider, more problematic issue of biodiversity, through examination on a smaller scale. Sonic geographies enables one to orchestrate this parallel while offering an alternative to common studies conducted in the field of urban ecology. Looking distinctively into birdsong and the biodiversity of bird species within this seemingly serene utopia using sound as a device has enabled us to scrutinize our initial perceptions of the gardens and compare it to our findings. Data collected using hyper-sensitive recording devices has allowed us to extract the prominent sounds in the Botanical Gardens during the winter. Key findings include: anthropogenic influences denying the garden of its assumed tranquility and disturbing the communication between bird species; vegetation associated to coastal maritime climates, such as rainforests, encourage a larger proportion of bird activity, compared to human-made green spaces; and sonic geography as an appropriate method in studies in urban ecology. Finally, the study of acoustic ecology can inspire further introspection on how sound impacts sense of place at UBC and beyond.

INTRODUCTION: THE IMPORTANCE OF LISTENING.

Urban ecology is the study of ecosystems that include humans actively living in urbanizing landscapes. It is an emerging, interdisciplinary field that aims to understand how human and ecological processes coexist in human-dominated systems and assists communities with their efforts to become more sustainable. We have partnered with said communities, namely SEEDS, a program that intends to advance campus sustainability by creating partnerships between students, operational staff, and faculty on innovative and impactful research projects. Our research mirrors this interconnection established by urban ecology by associating overarching themes to localised affairs, specifically our own UBC Botanical Gardens, Canada's oldest university botanical garden. This location acts as a microcosm for larger global anxieties surrounding diminishing biodiverse habitats attributed to anthropogenic disturbances. Analysing this parallel has been studied in a myriad of methodologies, but our chosen approach was sonic geographies.

Rarely does one enter a landscape and simply listen. Generally, we are accompanied by people, headphones, or distractions that push the environment to the background. However, if we listen, we may hear birdsong, frog choruses, the chatter of squirrels, or even the wind through the trees. Biophony, or the sounds of living organisms, is a measurable indicator of habitat quality, and a known benefit to human wellbeing. This project explores the human connections to sound ecology by creating an inventory of biophony on campus to be used in various sound installations. These installations will support connections between the campus community and our campus' biodiversity through community engagement. This contemporary research method has proven to illustrate the connection between humans and non-human nature, as well as sounds that are created by both parties and how they interlink. For the purpose of our research, we will be focusing on bird song. Measuring bird diversity, and biodiversity in general, has shaped the goal of our project. We hope to improve the socio-

ecological connection between the UBC community and the campus through recordings of the Botanical Gardens. A secondary goal is to use sound recordings to create a baseline of biodiversity on UBC campus.

STATEMENT OF THE PROBLEM

The main objective of our study is to represent the problems that lie within global anxieties surrounding biodiversity on a local scale. We use these to define exactly what anthropogenic influences are affecting birdsong in the Botanical Gardens. The global debate that encompasses biodiversity under threat is characterized by a number of ecological disruptions, for example extinction. Unlike previous mass extinction events in geological history, the current geological age, denoted the Anthropocene, is defined wholly by human being's impact on the Earth and biodiversity. These anthropogenic influences are arguably creating a 'tipping point' for our planet, in which the resources that we as humans need to survive, that is produced by these endangered ecosystems, will be exploited beyond repair.

Halting global biodiversity loss is central to the Convention on Biological Diversity and United Nations Sustainable Development Goals, but success has been very limited. When looking closer at the location of UBC itself in relation to global scale issues, it is important to note that it is along the Pacific Flyway. The Pacific Flyway is a major north-south flyway for migratory birds in America, extending from Alaska to Patagonia. Every year, migratory birds travel this distance both in spring and in fall, following food sources, heading to breeding grounds, or travelling to overwintering sites. True to the catastrophic scale of the Anthropocene, this too is under threat.

LITERATURE REVIEW

It is a self-evident fact that humans impact nonhuman nature significantly and constantly. The phenomenon of urbanization and the expansion of cities have particularly accentuated the interest of researchers in nature-human relationships in urban environments (Hebdom et al., 2014; Schwartz et al., 2014). In a paper by Cerulo (2011), this subjectively dialectical relationship is defined as one of great complexity, where humans and non-humans are both vital for social interaction.

Human-Nature Relationships

Human encroachment on natural ecosystems often results in high stress to the ecosystem flora and fauna, and can drastically change the ecosystem dynamics. In a paper by Rayner (2015), the author claims that the relationship between human encroachment and bird species occurrences is highly dependent on proximity of the ecosystem to the anthropogenic boundary, as well as change in human development in the ecosystem over time. In her study, she found that human encroachment effects were seen in avifauna species up to five kilometres from the urban boundary. She also determined that the rate of human development affects the intensity of human encroachment effects; the slower the onset, the less detrimental to ecosystem dynamics, and the faster the rate of development, the more bird species are found to be affected.

Researcher Bernie Krause emphasizes that natural soundscapes plays a determining role in the behaviour of otherwise wild creatures, with his paper focusing on the effects of human-induced noise (anthropogenic) in conveying aspects of the damage to flora and fauna. Avian vocalizations or ‘birdsong’ specifically, have evolved overtime to perform within the changing acoustic parameters of their specific habitat, due to the underlying fact of humans disturbing nature, especially in proximity to urban settings. With the notion that there is a

profound effect on biophony by the introduction of human-induced noise, Krause adopted the Niche Hypothesis to emphasize the correlation between birdsong and the sounds of their habitat. The origin of the Niche Hypothesis came about in the late 1970's when Peter Marler and Kenneth Marten where doing a birdstudy at a particular site (no other information). However, they "were unable to adequately quantify their observations with then-available technology or within the scope of their document" (Krause 1). With advancing technology, the scope of the Niche Hypothesis arose and has been used to acknowledge and understand the implications of anthropogenic sound on habitats, and avian vocalizations in particular.

The complexity of birdsong and other acoustic patterns can be utilized to determine the health of a biome, its size, its relative location to others and its age. Learning about the perspective of vocalizations in undisturbed habitats has allowed us "to observe the first direct correlation between human-induced disturbances" (Krause 2). An indicator of biodiversity that is often utilized by soundscape ecology are avian vocalizations. The amount and density of bird song is impacted by the level of anthropogenic disturbances in close proximity to the bird habitat. According to a study conducted by Benitez-Lopez et al, the main response of birds in close distance to human-made infrastructure (roads, buildings, construction) is to completely avoid the area, resulting in a declining population density in the area. The decreasing bird populations in proportion to infrastructure proximity is a widespread trend across climatic regions. Another interesting finding by the author concerns species variation in response to infrastructure disturbances. Certain bird species adapt better to urban landscapes compared to others, such as raptors, resulting in an "unnatural" predominance of certain birds and the abandonment of others. Another study conducted by Qin et al, describes the highway corridor effect. This comprises of the strong negative effects that road traffic has on birds, including noise and light pollution, high mortality rates, and stress on breeding and migrating birds. In general, there are higher levels of bird populations and biodiversity in

parks, and lowest along road strip corridors. This makes sense as proximity to road traffic increases, the disturbances are exponentially increased.

Catherine Ortega in her article “Effects of Noise Pollution on Birds”, referenced a study made in the Netherlands by Reijnen et al found that “the overall effect of traffic noise on nesting birds, measured through lack of habitat occupancy, may extend >300 m on both sides of roadways” (9). This is important to acknowledge for our study as the UBC Botanical Garden is surrounded by different roads, as seen in red in the map of the garden (Appendix A). NW Marine Drive, which loops around the campus, runs through the middle of the gardens and has generally the busiest traffic. The two roads running ‘east’ into the campus are quieter and the one travelling along the bottom of the gardens is only open during a certain time of the day, so doesn’t affect biodiversity, especially birds, as much as NW Marine Drive in terms of noise.

As well as Ortega, Kight et al in the article “Acoustic space is affected by anthropogenic noise” also are interested and address the implications of noise on bird song in addition to several mitigation strategies which gardens, like the UBC Botanical Garden’s, can adopt and practice. For example, they suggest reducing the amount of impervious surface cover (e.g. paved roads, buildings), as they can have “a disportionately large effect on signal efficacy”, which is really important as bird song is vital between bird species (Kight et al 57). Another strategy, which in turn the UBC Botanical Garden’s have, are strips of unmodified land which shield territories and “mitigate the effects of introducing anthropogenic features to the habitat” (Kight et al 57). Relating to our research statement, Kight et al emphasize that “habitat types should be considered along a continuous gradient, rather than dichotomous endpoints”, for example, closed/open and urban/rural (49). The UBC Botanical Garden is nestled between Pacific Spirit Park, several roads and university buildings, meaning avian species will live alongside anthropogenic noise and thus will be impacted directly. UBC, and

Vancouver, thrive in creating and maintaining a consistent fluid gradient between green and urban space which we have to acknowledge for our research as “avian populations will live between these extremes” and alter their behaviour accordingly (Kight et al 49).

Sound and Subjectivity

It must be noted that the effects of human-induced noise as a factor in natural soundscapes has been mostly a subjective endeavor, as both humans and non-humans “respond differently to the types, relative amplitudes and spectra of specific or combinations of introduced mechanical or human noises in relationship to the biophony” (Krause 4). While this is inherent to the practice of soundscape, it does not detract from the overall value and use of it.

Whitehouse (2015) adresses Krause’s concern that human activities are a source of habitat loss, causing ecological and sonic disruptions in the everyday experiences of birds and other wildlife. In his work, he highlights that the absence or change in bird sounds are a source of anxiety that are specific to the Anthropocene era, the geological epoch in which human activity has become the dominant force that shapes the Earth (53-56). These anxieties are further explored his “Listening to Birds project,” where he analyses the process of listening to birds, as well as the response to what is heard and not heard (53). In his research, Whitehouse brings up the idea of linking sounds to birds or naming birds is in itself an experience that is connected to other sets of relations, narratives and reflections which shape the way one listens to their surroundings. For example, bird sounds can be familiar, unexpected or exotic (69). He also argues that the way humans listen to birds is also grounded in their own, individual experiences, therefore the perspective from which every person listens to birds is fundamentally different. Furthermore, the results demonstrate how bird sounds are significant to how people understand their surroundings by impacting their

sense of place, time and season. Birds sounds are not only integral to how people experience their environment, but have also shaped how they want their relations of place to be, that is, conducting lives that resonate with the birds around them (53 & 70). For birds, sound-making is also a form of place-making. Sounds contribute to relationships with other organisms, and aids in being responsive to signs within their environment, therefore helping birds territorialize their space. As our study is conducted in a semi-public space, the UBC Botanical Garden in itself is integral to the sense of place of the visitors who have access to the space, as their experience of listening to birds within this location contributes to their relationships with them. However, the experience of public space can be hindered by the fact that there is a private component to the space, as the Botanical Gardens belong to UBC and thus it serves the interests of researchers.

The nature-human relationship can be explored by evaluating the biological diversity - or biodiversity - found in cities. The *United Nations Convention on Biological Diversity* (1993) defines the term as "the variability among living organisms from all sources [...] and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." A push towards sustainability trended worldwide. A crucial element of understanding what it means to be sustainable comes from studying human impacts on biodiversity. However, as Lindenmayer et al. (2011) discusses, global biodiversity monitoring has historically been inconsistent and highly variable in effectiveness, due to a range of factors, including the lack of global data standards and the lack of time and financial support to operate the monitoring. The authors suggest that there is substantial value in monitoring biodiversity electronically, as global data sharing is crucial for understanding humanity's relationship with nature, creation of mitigation techniques, and the process of environmental policy-making. Therefore, the use of sound ecology, defined below, may be a viable new approach to monitoring biodiversity globally.

Acoustic Ecology

A relatively recent and innovative method of measuring biodiversity utilizes sound. The use of sound was first implemented as a means of identifying and analyzing relationships between people and cities. Proving useful in the realm of urban planning, the soundscape approach has been adapted to biodiversity research. Soundscape ecology was first coined in the World Soundscape Project *Handbook for Acoustic Ecology* in 1978. This dictionary categorically defines all major terminology in this field. Soundscape ecology is the spatial-temporal integration of three basic sources of sound: anthrophony (human-produced), biophony (organism-produced), and geophony (Earth-produced sound such as wind and rushing water) (Tucker et al., 2014, p. 746). As many organisms have evolved and adapted to the sounds of their natural habitats, disturbances in soundscape patterns have significant ecological impacts. Pijanowski et al states the four measurable components of a soundscape, consisting of acoustic composition, temporal patterns, spatial variability and acoustic interactions, "Composition is the acoustic frequency (subjectivity what humans perceive as pitch) and amplitude (sound level) of all sounds occurring at the same time and location. Temporal patterns are numerous and reflect certain biological events (e.g. breeding) that occur in the landscape. Spatial variability results from the heterogeneity of biophysical landscape" (Pijanowski et al., 2011, p. 1214). Fluctuations in any of these components can change an ecosystem. Our research will pay close attention to these elements throughout the recording process and analysis.

Moreover, the relevance of how measuring bird diversity, and biodiversity in general, can be an important component that can improve human-nature relationships within green urban spaces has equally been demonstrated in relevant literature. Hedlbolm *et al's* study on how birdsong diversity influences young people's appreciation of urban landscape (2014).

The study found that participants not only enjoyed hearing birds in an urban setting, but equally the variety of sounds from different species. The study suggests that any loss in bird habitat or surviving habitat can affect where birds are located, and therefore the frequency of bird song. In this way, anthropological noises may aggravate the fragmentation of bird habitat and affect the landscape's ecosystem.

The Void

Although research on the key concepts highlighted above, such as sound ecology and biodiversity, have been tackled in academia, there remain voids in the literature that need to be filled. There remains a continued need for human and environment relationships, further development of our skills to listen to our environment, and work towards building an urban landscape that is compatible and supportive of biodiversity.

Following a survey on bird biodiversity perception and sensitivity to changes by locals in a Parisian city garden, researchers Shwartz et al (2014), call for "more experimental, interdisciplinary studies to further explore the people-biodiversity interactions." (580). This need is justified by the authors as it would help further knowledge of the role of urban biodiversity in people's daily life. Further research on human-biodiversity relationships would also highlight the importance and ubiquitousness of this interaction, and inspire the public to continue supporting conservation policies. Our research conducted at the Botanical Gardens directly contributes to this void, and specifically on the relationship between birds and humans in semi-public spaces or planned urban spaces such as a university campus. Collecting data on a diversity of bird songs and the different anthropogenic noises that can be heard in the garden (which includes passerbyers) will illustrate human's daily interaction with ecosystems. Further it will illuminate how prevalent birds are in our own lives, and how we impact birds as individuals and structurally. While many perceive ecosystem disturbance as

deriving from large-scale habitat changes such as deforestation, we often forget that even through our presence in the Botanical Gardens has an impact on birds.

In order to fully understand human-biodiversity relationships and interactions, we must improve skills in listening to the environment. Whitehouse argues that "listening to birds in the Anthropocene should not encourage a separation of human activities from those birds but should instead ground the development of relations in companionship" (Whitehouse,70). Through conducting our research in the Botanical Gardens, we will practice the art of listening to our environment. Society today places a heavy emphasis on visual awareness and understanding, while auditory skills are not as prioritized. Using soundscape ecology as our methodology of choice contributes to the validity and importance of using sound as an indicator of human-environment relationships. Additionally, we are exposing ourselves, as well as our audience to an entirely new method of experiencing the world.

Only through increasing the academic repertoire on human-biodiversity interaction, and improving our listening skills can we begin to build an urban landscape that is compatible to and supportive of biodiversity. Whitehouse promotes the idea of breaking away from the general narrative in the Anthropocene which emphasises on humans as threats to non-humans and switch focus on "how we listen to birds and the rest of the world, and how we learn to make ourselves, however uneasily, at home in it" (Whitehouse, 70). While our research project aims to uncover the extent to which anthropogenic noises impacts bird song in the Botanical Gardens through listening, our goal is to inspire positive change to better human relationships to birds at UBC, and beyond.

One drawback of soundscape ecology and particularly biodiversity monitoring using sound is the fact that it is inherently technological, that is, those undertaking monitoring through sound must have access to high-quality recording equipment, as well as a high-powered computer to store the sound data. If soundscape ecology is to be used globally as a

central biodiversity monitoring tool, it means all researchers must have access to high-quality equipment. This fundamentally limits who is able to contribute to soundscape biodiversity monitoring, depending on financial capabilities. As Turner (2018, 16) explains, "The need for a relatively high-powered computer is the main logistical barrier to this kind of monitoring being used for certification schemes or other environmental initiatives." This is important to think about, because it could mean that soundscape biodiversity monitoring is only able to be conducted in financially privileged locations.

METHODOLOGY

As our research lies within the cross-section of birdsong and anthropogenic impacts, conducting recordings at specified locations and times were of critical importance. We have mapped the main roads and highways surrounding the Botanical Gardens, in which are demarcated by a red line on the map displayed in Appendix A. We have also taken into consideration the numerous other human impacts within and surrounding the Gardens, such as visitors, horticulturists, varying transportation, and construction to name a few. Due to the multitude of variables in any given time or location of the Gardens, our approach must be systematic, organized, and consistent.

Our main method is conducting a variety of sound recordings across a range of days, times and areas within and around the garden. This will include not only the bird noises, but the anthropogenic noises around us. We will do this through a systematic, sampling approach. Zoom H5 recorders will be used to collect our samples and were provided by the UBC Geography Department. Upon recommendation of the director of the Botanical Gardens, three specific locations have been chosen to conduct these recordings: (1) the Moon Gate and tunnel access to the east gardens, (2) the Physic Garden and (3) the BC Rainforest Garden. As our goal is to reveal a coherent trend in our data, it is important to gather as much data on the

specific locations as possible. Our decision to choose three specific locations is not only feasible, but will allow more structure through this process. Not only do these locations represent some of the different types of flora found within the gardens, but different types of human and bird activities as well. One factor that caused an ethical dilemma in data collection was that we had a very rough estimate of the specific location *within* each research location where we would record. For instance, BC Rainforest is rather large, and different locations within this Garden could reveal varying sound intensities and frequencies. Had we had a more specific spot mapped out in each area, our data may have returned different results.

With the three locations decided, the next step was to establish a consistent timetable to conduct these sound recordings. The Botanical Gardens' director has granted us permission to record our measurements two days a week, at two different times of day. This schedule, while relatively consistent, could have been improved by ensuring the morning time slots on Wednesdays and Saturdays were the same time. The Saturday morning times are later than Wednesdays because we were restricted by the Garden's later hours of operation on weekends. In reality, 9:30 am is later than we hoped to record in the mornings because the morning chorus is what we hoped to record, and this tends to occur around sunrise. Below is the schedule:

	7:30-8:30 AM (Wed) 9:30-10:30 AM (Sat)	**1:00-2:00 PM**
WEEK 1		
Wednesday, Feb 7	Sev & Savannah	Lia & Robbie
Saturday, Feb 10	Lia	Shea
WEEK 2		

Wednesday, Feb 14	Robbie & Savannah	Lia
Saturday, Feb 17	Sev	Shea, Robbie
WEEK 3 (no Robbie, Lia)		
Wednesday, Feb 21	Sev	Shea
Saturday, Feb 24	Savannah	Shea
WEEK 4		
Wednesday, Feb 28	Robbie	Shea & Lia
Saturday, March 3	Sev & Lia	Robbie & Shea
WEEK 5		
Wednesday, March 7	Sev	Shea, Robbie
Saturday, March 10	Savannah	Lia, Robbie

These times were selected because there are different traffic patterns around and within the park during the morning and afternoon, as well as on weekdays versus weekends, and there are different bird behavioral patterns throughout the day. Anthropogenic sounds will likely vary throughout the day based on common commuting times (particularly around 7-9 am and 4-6 pm) as well as on working hours more generally (between 9-5 pm), and will also vary throughout the week, as we expect to hear more human sounds through the work/school week than on the weekends. UBC generally sees less foot traffic on the weekends than throughout the week, however it is fair to assume the Botanical Gardens themselves see more visitors on the weekends than through the week. Birds are more active in the mornings at dawn and evenings at dusk. In the afternoon, bird and human activity will probably be less prominent, and we foresee these natural patterns to present themselves in our sound data.

We expect the biophysical landscape of each research location to play an important role in the respective bird songs recorded. We assume that more bird songs will be heard in

areas where there are lots of trees, and where there is lots of canopy. Moon Gate is surrounded by many tall trees, including a tree that is home to an eagle nest. Considering the Physic Garden has no canopy cover and no immediately surrounding trees, we can expect to hear less bird songs here. In contrast, the BC Rainforest is densely populated with coniferous trees, there is lots of canopy cover and it is the most representatively "natural" location we'll be collecting data from. We expect to hear the most bird songs in the BC Rainforest.

We also strongly predict that the human landscapes of each location will play an integral role in the anthropogenic sounds recorded. The entirety of the Botanical Gardens are human-constructed/-maintained areas, and therefore we expect to hear humans wandering around the gardens. There are also major roads crossing through and surrounding the Gardens, and the distance to these roads is expected to be a contributing factor to the intensity of anthropogenic noises heard. The Moon Gate and BC Rainforest locations are both situated right next to busy roads, while the Physic Garden is found a little more on the interior of the Gardens. So, we think that the Physic Garden should be noticeably less loud in anthropogenic sounds.

We predict that factors beyond our control, such as weather, may influence the consistent and systematic nature of our data sampling. For example, there will be less visitors on rainy days compared to clear, sunny days. It can be noted that we will supplement the audio recording files with a table that will tally additional information on the samples (e.g.: date, time, weather and other personal notes). In addition, we have taken photographs at each location to ensure location specificity, as well as to provide a visual to the class for our presentation.

After data collection, we uploaded all of the sound files we collected onto a sound-editing program called *Reaper*. This computer program will enable us to manipulate and analyze files from our recordings. We originally planned to isolate any bird songs we could

hear in our recordings, and then use an online resource called *E-Bird* to match the songs we heard with the database of birds found in our geographic area, to identify exactly which species we heard and where. However, when the time came that we were ready to start manipulating our sound data, it became evident that our original plan was too ambitious for the amount of time we actually had to utilize the program (which was new to all of us) and produce the corresponding sound clips. Instead of isolating bird songs from all other noises, and then identifying specific species, we found that a more interesting and feasible final product would be to represent the more accurate relationship between anthropogenic sounds and bird songs. Therefore, we decided our final sound clips would feature the most prevalent bird and anthropogenic sounds we could hear in our data files, composed together in such ways that would reflect the relational noise patterns we observed in each location and at each time. In the end, we had six final one-minute sound clips, two per location, one from the morning data and one from the afternoon data.

This was the stage in which we encountered the most ethical dilemmas. By definition, sound editing is very subjective. It depends entirely on the person doing the editing, and what they want their data to present. In our case, we worked together on each sound clip to ensure a collective agreement, but ultimately, our final clips represent the narrative that we found through doing this research. The story we tried to tell is that anthropogenic noise in the Botanical Gardens is much louder than we were expecting it to be, but had another group worked on this same project, they would have produced completely different results. That is essentially the biggest problem of representing qualitative data using soundscapes. We tried our best to remain true to the patterns we heard in our data, but objective representation is inherently impossible using soundscape ecology. This is the underlying problem with soundscape ecology as a research method: while it can be a modern and useful tool to explore biodiversity, it does not produce adequately objective results. David et al (2014), came to this

conclusion and recommended that soundscape technologies, while working to provide qualitative evidence, should be used as a supplement to more empirical, scientific methods to assess biodiversity.

ANALYSIS

To much surprise, our main findings show that anthropogenic sound is the most prevalent sound in the UBC Botanical Gardens. Mostly, these consist of engine roars from boats, airplanes, buses, cars, or the occasional maintenance vehicle or chainsaw. Other anthropogenic sounds include conversations and cheering, footsteps and whistle blowing, and the occasional fumbling of keys. It soon became evident that anthropogenic related sounds became the baseline for all recordings, where the consistent monotone of car engines were most prevalent. This contrasted with the common geographical imaginations of gardens which associate this space to natural, serene and peaceful sounds with general silence and interruptions of birdsong, wind and the soft sound of human conversation from afar. Indeed, the amount of bird sound heard during the winter season met our expectations, but the extent of anthropogenic sound far exceeded them.

Data Analysis

After analyzing our data, we came to several conclusions. We determined that the most important factor for determining the varying frequencies/intensities of anthrophony and biophony was location. The different locations presented more obvious sound patterns than the different times or days. In the early stages of our research, we knew that we would be hearing more biophony in the mornings compared to the afternoons, so this pattern did not surprise us. However, what did surprise us was the amount of anthropogenic sound heard throughout the days and times and across all of the locations. There were different

anthropogenic sounds heard at each location, and some locations had specific human sound patterns. For instance, football practices were heard clearly from the BC Rainforest on Saturdays, and the maintenance vehicle was commonly heard at the Physic Garden due to the Garden Pavilion and the area primarily hosting man-made features of the gardens (such as the Great Lawn and Food Garden). Similarly, being a major road on the UBC campus, the flow of traffic heard along NW Marine Drive was much stronger on Wednesday mornings, than any other recording time, due to UBC being a workplace for many people.

Apart from the different anthropogenic landscapes at each location, the varying biophysical landscapes affected the amount of bird songs heard. We determined that the more canopy cover and the higher the tree density, the more likely we would be to hear bird songs. This was proven by the much higher frequencies of bird songs heard in BC Rainforest and Moongate (which are surrounded by tall coniferous trees), compared to the Physic Garden, which has no immediately surrounding trees and where we heard little to none bird song.

Another conclusion we came to was that not all bird species are affected equally by breaching human sounds. It became obvious that certain types of birds seemed unaffected by the amount of anthrophony. For example, crows, geese and eagles could be heard overtop of loud anthropogenic sounds (such as passing vehicles) and in these moments, it sounded like the birds were actively trying to sing louder than the anthrophobic features. Contrastingly, the birdsong from smaller species, such as finches, robins and hummingbirds could not be heard over the anthropogenic noise. As stated by Eric Stone, we are looking at short-term responses, as "the vocalizations of fauna cease for prolonged periods after the introduced noise has ceased" (225). Stone then goes onto state these short-term responses can lead to long-term effects, as "introduced noise can be documented by means of recording lower diversity species in areas where noise in present, as compared to less disturbed locations" (225). This can be linked to the Botanical Garden's, where the bird species recorded can

thrive elsewhere, such as Pacific Spirit Park, a natural forest surrounding UBC and the gardens. So through our research, we determined and grasped that sound is a good indicator for biodiversity, as birds are believed to be particularly sensitive to noise "since auditory communication is an important feature of several aspects of their development and mating and social behaviour" (Stone 225).

Transformation of Our Project

Throughout the collection process of our research project we found that certain factors began to transform it into something new. The volume and density of anthropogenic noise such as cars or airplanes, made this very much a study on anthropogenic sounds over bird biodiversity. The fact that the anthropogenic sounds were so prevalent and consistent led us to believe that there was comparably less bird song when this may not have been necessarily true. This impacts one's experience and sense of place in the Botanical Gardens. Anthropogenic sound became noise because it was unexpected, constant and pervasive throughout the gardens. Krause delineates the difference between noise, ("an acoustic event that clashes with expectation"), which has an inherently negative connotation, and sound, ("the product of activity") which has a comparably more objective meaning (Whitehouse, 58).

However, as humans have adapted to our urban environment, we have adapted to push many anthropogenic sounds to the background of our minds. While we may only subconsciously register anthropogenic sounds like road traffic, other layers of unexpected, sudden sounds such as a chainsaw or leaf blowers shock the observer. Our findings relate the anxieties caused by the absence and change in bird sounds that are experienced in a human dominated era, (Whitehouse 54). We discovered that human activity significantly impacts the sonic harmony of the Botanical Garden.

Our project transformed from initially perceiving soundscape ecology as a purely quantitative approach, to assessing biodiversity in the Botanical Gardens, to understanding our methodology as representing a subjective, qualitative approach to bird song in which we were able to utilize our artistic license. Our initial understanding of soundscape ecology in addition to our systematic approach to conducting our research led us to believe we would empirically analyze the soundscape data we collected throughout the five-week period of research. The director of the Botanical Gardens provided us with empirical tools such as eBird (an online database of bird species and sounds) that we presumed we would utilize in identifying bird species, and identify the density of bird song at each location. However, as our research progressed and we began to listen to our data, we realized how incredibly subjective the field of soundscape ecology, and more generally *listening* truly is. Equipped with this knowledge, we began analyzing our data with the understanding that a multitude of variables impacted our data collection. This includes uncontrollable variables such as weather and temperature, as well as small, unconscious variables including equipment positioning and length of recordings. Thus, listening and manipulating our data into a comprehensive sound bite required art-based techniques. As we, the researchers, were the sole collectors of our sound recordings, it was our responsibility to as accurately as possible portray the trends we discovered.

Ultimately, a large dosage of artistic license was required in creating our condensed sound bites for the presentation. First and foremost, we decided on an organizational framework to follow as we created our sound recordings. The patterns we discovered as mentioned previously relate primarily to location and time of day. Therefore, we organized our sound recordings accordingly: morning and afternoon recordings for each location. Subsequently, we decided on what story we wanted to tell through our recordings and an understanding of the trends. We aspired to place our audience in each respective location,

provide a realistic three-dimensional experience, and tease out the patterns we discovered. Thus, we manipulated our data to emphasize predominant sound patterns.

Through an auditory computer software program, Reaper, we uploaded and manipulated our collected recordings. In addition to the challenge of learning new technology over a short period of time, we had to make numerous executive, quick decisions regarding what to include, and what not to. Despite the confounding variables that compounded throughout conducting our research, and manipulating our data, we are satisfied the story our soundscapes portrayed because they represented the narrative we came to learn.

SIGNIFICANCE

Soundscape ecology as a research methodology illustrates the value of an often under-utilized and understated approach to biodiversity research. Typically, empirical biodiversity research, and more generally research as a whole, has depended upon data collected visually (whether through the installation, operation, collection, or analysis of data). Soundscape research has demonstrated that exploring other human senses that are constantly in operation whether subconsciously or consciously bring forth an equally valuable and vast amount of information. Inspired by Krause's work, it can be assumed that changes in the "animal orchestra" of a certain location is an indicator of environmental altercation. More specifically, the disappearance of certain sounds can indicate the exodus of a species within that habitat. According to Whitehouse, this loss of familiar sounds associated to species we are accustomed to hearing, such as birds, affects one's sense of place within their environment. It can be assumed that within a university setting, human activity is a major contributor to habitat disturbance. Therefore research on the current state of UBC's soundscapes can contribute to further introspection on the way humans impact environment.

Although we discovered through our own sound research that there are inherent drawbacks (notably, the potential for subjectivity obscuring our data through every stage of our research), the significance of the methodology and our results outweighs the qualitative nature of soundscapes. While our results do not provide a measurable indicator of bird biodiversity, they audibly display trends and patterns of birdsong and anthropogenic noise concomitantly. For future researchers, the birdsongs collected can be further dissected to identify individual species present in the months of February and March in the Botanical Gardens, providing an indicator of species presence and richness. If this research were to continue for multiple years, changes (or lack thereof) in bird song presence can reflect changes in anthropogenic influences. While there are multitude of directions future research can take, the data we collected offers an important baseline of ecological diversity in the Botanical Gardens.

FUTURE RESEARCH DIRECTIONS

While we did a good job of establishing a baseline for future biodiversity monitoring here at UBC, there is vast opportunity for expansion on this research. We were limited mostly by time, but if this was not a factor, a more thorough exploration of anthropogenic noise impacts on bird songs could be conducted. Specifically, we would have liked to collect data from more locations within the Gardens, and over a much longer time period. Realistically, we only collected data over 5 weeks, so a longer time scale would allow us to differentiate between seasonal patterns and other influencing factors. The UBC Botanical Gardens is an appropriate on-campus resource for directing human-nature relational research, and has not been taken advantage of within the UBC geographical research community. Through our research, we established that anthropogenic noise is most prevalent in the Botanical Gardens, but it would have been useful to be able to conduct a comparative study of a non-human-constructed (or “natural”) location, in order to better understand the impacts of the chosen

research location itself on our study. We originally thought it would be a good idea to conduct two identical studies in differing locations, one in the Botanical Gardens and one in Pacific Spirit Park, in order to compare the two soundscape ecologies. We thought it would be interesting to see if the fact that the gardens are human-made and regularly maintained would influence both the frequencies and intensities of anthrophony and biophony, which we concluded that it would.

Another aspect of continuing this research is to explore how birds are adapting to anthropogenic sound, by further researching how birds communicate among species. We all committed to this project with a clear idea that anthropogenic noise is detrimental for bird species and that the birds are helpless to the invading noise pollution. However, a factor we never considered was how bird species are actively adapting to the intensifying anthropogenic noise. All species are designed to adapt to disturbance and ecosystem change, and while research has been conducted that proves anthropogenic noise pollution has reduced bird populations in certain locations, little research has been orchestrated on how bird species are showing resilience by adapting to incoming human sounds. Understanding bird communication will allow us to determine how anthrophony is actively affecting this communication. This could be useful for determining mitigation techniques in future conservation efforts by understanding which factors of noise pollution affect bird species more than others.

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Figures

Welcome to the UBC Botanical Garden [Map]. (n.d.). In *UBC Botanical Garden*. Retrieved February 2, 2018. http://botanicalgarden.ubc.ca/visit/visitor-info-maps/maps/

Appendix A: Map of the UBC Botanical Gardens