ABSTRACT

CARSON, BRITTANY LEANN. Sound Around Town: Sense of Place and the Perception of the Acoustic Environment. (Under the direction of Dr. Caren Beth Cooper).

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Noise, which can be measured by decibel-based metrics (loudness or sound levels) or by a perception-based approach (through perceived annoyance), can negatively impact human health. In addition, standard decibel-based metrics don't incorporate low frequency noise which is measured as quiet by dB(A) metrics. Therefore, decisions for managing noise confront a paradox: decibel-based metrics of unhealthy sound levels are not always perceived as annoyances, especially at lower frequencies. I propose a conceptual model based on sense of place theory to explain how the noise paradox arises and interpret its relationship to the perceptual component of urban soundscapes. To do this, I outline three main objectives; (1) describe sound types in urban neighborhoods, (2) describe perceptions of sound types (anthropogenic mechanical, anthropogenic non-mechanical, and natural (biotic/abiotic)), and (3) examine the influence of place meaning and perceptions of sounds on place attachment. I used a citizen science-based research strategy to discern whether place meaning and soundscapes interact to determine place attachment for individuals living in diverse types of urban residential neighborhoods. The citizen science project that I used was called *Sound Around Town*. Following the protocols for *Sound Around Town*, volunteers responded to a survey to measure sense of place and documented their perception of sounds by conducting at least three- ten-minute listening sessions. In each listening session, volunteers seated themselves outdoors, carefully listened to sounds, and filled in paper data sheets to log the types of sounds they heard which were rated on scales of loudness and pleasantness. With complete data from 55 volunteers in the region of Raleigh, North Carolina, I found that, on average, natural sounds were perceived as more pleasant and anthropogenic mechanical sounds perceived as least pleasant, with

anthropogenic non-mechanical (human) sounds in the middle. Our research found that the type of sound source was not as important as the perception of this sound. Volunteers perceived commonly heard anthropogenic mechanical sounds, such as airplanes and cars, as more pleasant when quieter which supports previous research for the Shultz curve. However, following the Shultz curve, the noise paradox was supported in that the best predictors of place attachment were socio-cultural place meaning and the percent of sounds detected that were perceived as quiet, irrespective of their origin (anthropogenic mechanical, human, or natural). People formed attachments to places that are perceived as quiet even though these sounds might be having negative health effects like lower frequency sounds from anthropogenic mechanical sources. As cities grow and people form place attachments based on socio-cultural place meanings and quietness, future research on the acoustic environment should encompass an interdisciplinary lens that uses sense of place theory for a more holistic understanding of this important natural resource that is shaping unique urban environments.

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Sound Around Town: Sense of Place and the Perception of the Acoustic Environment

by
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DEDICATION

I dedicate this to my dad who has always encouraged my curiosity and love for learning. My mother, who taught me why people and all of their ‘dimensions’ are worth learning about, because, at the end of the day, we all need each other. My older brother, for showing me how to live fearlessly by swallowing gum. Lastly, to my granny, Dora Roberson, without her and all that she worked for throughout her life, none of us would be here today. Thank you for planting the seeds, family. I love you all so much!

BIOGRAPHY

Brittany Carson (Carson) is a graduate student studying for her master's degree in Fisheries, Wildlife, and Conservation Biology. As a graduate of North Carolina Central University, she first became interested in doing environmental research pertaining to disparities in traditionally underserved communities through her lab experience there. Multiple opportunities from that time inspired her passion for social and environmental equity. Currently, she is working on a citizen science project titled *Sound Around Town* with National Park Service Natural Sounds and Night Skies Division, NC Museum of Natural Sciences, and NC State. This project aims to assess the acoustic environment in urban and suburban areas relating to noise pollution and perceptions of sound and noise. She will explore these perceptions using theories about biophilia, sense of place, and the soundscape approach. She hopes to learn how sense of place plays into the sensory perceptions of sound as an ecosystem service that is often overlooked but has been noted for its restorative qualities for human and more than human species. She hopes to continue following her many interests and find creative ways to incorporate art, language, plants, sense of place, bio-cultural conservation, environmental/social equity, and decolonizing efforts into her future work and career.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

The environment where people live is critical to human health. Urban environments contain many resources such as air, water, and soil that, depending on their quality and distribution, can have salutary or toxic impacts on human populations (Frumkin 2001). Another key environmental resource that influences health is the acoustic environment, or all the sounds that exist in a place (Farina, 2014). Soundscapes are defined as a perceptual construct: the acoustic environment as perceived by a listener (Francis et al. 2017). As new research begins to reveal the impacts of soundscapes on human health and well-being (van Kamp et al. 2016; Ojala et al. 2019), there is a growing need to understand how humans experience different types of sounds and how these sounds – and their positive and negative impacts – are distributed across the landscape (van Kamp et al. 2016). Many programs and research initiatives are currently being developed to focus on sound as a natural resource. For example, the U.S. National Park Service created the Natural Sounds and Night Skies Division to safeguard natural sounds in National Parks for the benefit of both wildlife and human visitors (Francis et al 2017).

Sound is a quickly varying pressure wave that travels through different mediums (Faa.gov. 2018). When the energy is transferred through the air, our ears detect sound as small changes in air pressure (Faa.gov. 2018). In fact, the human ear can detect a subset of sounds that are approximately within a frequency of 20–20,000 Hz (Berglund, 1996) and range in volume from 0 dB (A) –140 dB (A) (Bennert, 2005). Since the Early Eocene (over 50 million years ago), terrestrial environments have always contained soundscapes that include animals (e.g., birds, frogs, insects) as well as other biotic and abiotic sources of sound (e.g., wind, moving water) that are familiar to humans (Gill, 2007; Senter, P. 2008). The biophilia hypothesis posits that, as a consequence of evolution, humans have an "innate tendency to focus on life and lifelike processes" (Kellert, and Wilson, 1993); this affinity may help to explain the health benefits of natural sounds. One area of support for our innate affiliation with nature comes from research demonstrating increased psychological well-being upon exposure to natural features and environments, including natural sounds (Hartig et al. 2014). For instance, research has shown that people prefer sounds of water, nature, and humans above mechanical sounds (van Kamp et al. 2012). The restorative potential of natural soundscapes is also demonstrated in Attention Restoration Theory, which examines how nature can restore and rejuvenate humans (Kaplan and Kaplan 1989). High quality natural soundscapes can therefore enhance physical and emotional well-being (van Kamp et al. 2016). But not all sounds are restorative.

2. Literature Review

2.1 The Noise Pollution Problem

Noise, can be defined as decibel-based metrics, focusing on loudness or sound pressure levels, and perception based, as unwanted sound which leads to a mental state of annoyance (Stansfeld et al. 2003) and can have profound health effects. Casey (2017) documented how noise, usually generated from mechanized sources, functions as a biological stressor because it activates the central nervous system to release stress hormones that increase the heart rate, blood pressure, and cardiac output, even while asleep. When moments of respite are absent, the presence of noise hinders the ability of stress recovery, which is important for mental and long-term health (Lundberg, 2005). In recent centuries, industrialization, development, and urbanization have altered soundscapes in ways that exacerbate noise and negatively impact human health.

The threshold of hearing for tones and frequency bands depends on the loudness (sound pressure levels) as well as the frequency (Hz) and duration (Berglund et al. 1996). The units for pressure and pressure variations are expressed in Pascal, abbreviated as Pa, which is defined as N/m^2 (Newton per square metre) (Faa.gov. 2018). The number of pressure variations per second is called the frequency of sound and is measured in Hertz (Hz) that are defined as cycles per second (Faa.gov. 2018). The higher the frequency, the more high-pitched a sound is perceived by the human ear. Since in the softest sound a normal human ear can detect has a pressure variation of 20 micro Pascals (μPa), measuring sound with Pascal would involve numbers from as small as 20 μPa to as big as 2,000,000,000 μPa (Faa.gov. 2018). In order to have smaller units for measuring sound, the decibel scale was created. The decibel is measured on a logarithmic scale, using 10 as its base, and combines the magnitude of the Pascal sound pressure measures with the perception of how humans hear sounds (Bennert, 2005) through A-weighting. A-weighting "corrects" sound pressure by weighting all sound pressure levels by their frequency in order to more closely reflect human perceptions of sound (Bennert, 2005). Therefore, researchers have focused on defining noise as loudness at particular wavelengths measured by A-weighted decibels. For the purpose of this research we will use the dB (A) based metrics as one way to discuss measurements of sound in order to provide a representative understanding of various health guidelines that have been previously identified as guiding recommendations about public health. On that basis, the dB (A) scale bounds the range of human hearing on spectrum from 0 dB (A) to 140 dB (A). The World Health Organization (WHO) guidelines for community noise recommend less than 35 dB (A) in bedrooms during the night for good quality sleep (WHO 2018) and between 48-65 dB (A) in classrooms for good teaching and learning conditions (WHO 2018). In addition, EPA standards warn that acoustic environments over 55 dB(A) interfere with conversation (U.S. Environmental Protection Agency, 1974) and over 70 dB(A) results in hearing impairment (U.S. Environmental Protection Agency, 1974).

Sound exposure levels can also be measured in ‘B’, or ‘C’ weightings (SCENIHR 2008). A-weighting differs only from ‘B’ and ‘C’ as underweighting frequencies below about 500 Hz (SCENIHR 2008). Historically, studies have shown that the human ear has peak response around 2,500 to 3,000 Hz (Faa.gov. 2018) making the ear much more resistant to noise-induced hearing loss (NIHL) at and by low frequencies. Therefore, A-weighting is more in correspondence with NIHL risks (SCENIHR 2008). The previously mentioned thresholds of dB (A) illustrate how an individual's exposure to noise can negatively affect health, but because of being A-weighted, they fail to capture impacts at the lowest intrusive noise levels (Nelson, J.P. 2008).

Low Frequency Noise is sound energy dominated between 10–200 and 20–250 Hz (Pawlaczyk-Luszczynska et al. 2003), typically below the range of sounds that humans consider to be audible (Bennert, 2005). Even though low frequency noise does not induce noise- induced hearing loss (NIHL), the transmission of low-frequency noise is noteworthy because it has long wavelengths that travel extended distances with little energy loss (Berglund 1996). Because of its extended duration, this type of frequency has been found to have many other adverse health effects from mental health to respiratory issues (Berglund 1996). Other notable effects of low frequency noise, like other types of noise, include annoyance, loss of concentration, and sleep disturbances, all of which are heightened by chronic exposure (Alimohammadi et al.2013).

In the U.S., exposures to mechanical anthropogenic sounds that produce dB(A) noise and low frequency noise have increased over recent decades with the rise of aircrafts and highway travel (Pawlaczyk-Luszczynska et al. 2003; Leventhall et al. 2003). In addition, it is important to consider that sound waves are observed through various mechanisms such as the ear, tactile senses, or resonance in body organs (Berglund et al.1996). The multifaceted traits of all the various forms of sound detection can raise perception-based reactions such as annoyance, and that annoyance may contribute in complex ways to other biological and psychological effects of the sound signal (Job, 1993; Stansfeld, 1992). Consequently, sounds can affect humans both within and beyond frequencies detectable by the human ear (Baliatsas et al. 2016) and change at various spatiotemporal scales (Brown et al. 2011) resulting in the chronic and acute exposure to both decibel-based metrics and perception-based noise and the risk of non-communicable diseases (Basner, et al. 2014). To further understand noise, more research is needed to synthesize different ways of assessing noise, including A-weighted measures of decibels, low frequency noise and human perceptions and attitudes towards different types of sounds. Understanding the interrelationships among the three ways to assess noise has the potential to aid in a more holistic design of high-quality soundscapes *and* in setting standard management practices for the outdoor acoustic environment.

2.2 Noise as an Environmental Justice Issue

Environmental justice (EJ) aims to decrease pollution by spotlighting disproportionate access to healthy living environments in which members of marginalized communities suffer excessive burdens of environmental harm and diminished quality of life (Pellow, 2016). From this perspective, sound and noise pollution is an increasing EJ concern, particularly in urban areas. Studies have found environmental hazards increase with racial segregation. For example, Casey et al. (2017) found that daytime and nighttime exposure to noise across the United States was higher in neighborhoods of lower socioeconomic status and followed patterns of racial segregation. Segregation is grounded in power differences that concentrate or displace residents in areas with low environmental quality. In many cases, segregation means excessive exposure to mobile sources of air pollution that also generate mechanical sounds, low frequency noise, and associated health impacts (Casey et al. 2017). In other cases, segregation means access to fewer green spaces and the acoustic benefits linked to heightened biodiversity and associated natural sounds (Wolch et al. 2014).

The effects of low frequency noise and noise pollution may differentially impact other vulnerable groups as well. Children are particularly susceptible to the non-auditory effects of noise because they have less cognitive capacity to understand and anticipate stressors and have limited ability to form coping strategies (Stansfeld et al. 2003). The risk of exposure could therefore have irreversible negative consequences during certain stages of youth development, with the strongest impacts on children from the age of 13-14 years old (Hygge et al. 2003). In addition, noise pollution may especially affect elderly patients with poor mental and physiological health (Bharathan et al. 2007). Hume et al. (2012) found that night-time noise was associated with cardiovascular disease and stroke in the elderly (65 yrs and older). Therefore, vulnerable populations such as children and elderly are at a higher risk for noise defined as perceived unwanted sound, decibel level, and low frequency noise. However, a key limitation to accessing noise pollution is that remediation and management of environmental noise at larger scales depends not only on understanding impacts of dB (A) based noise levels across various frequencies, but it also depends on surveying the individual's subjective preferences and perceptions of different for natural and anthropogenic, or human, sound sources.

2.3 Variation in Soundscape Perceptions: The Noise Paradox

In 1971, given growing concerns about the impact of noise pollution, the U.S. Department of Housing and Urban Development (HUD) developed a national policy about noise abatement and control. The U.S. Noise Control Act of 1972 identified time-weighted average measures of sound levels as a useful way to express total community noise exposure. In an effort to assess the impacts of this exposure, Schultz (1978) synthesized eleven social surveys of annoyance conducted in different cities and languages and interpreted them in relation to independently gathered dB (A) measures of day and night sound levels. He then developed a polynomial model in which the percentage of the community highly annoyed was predicted by measured decibels of transportation noise. Although the dose-response model was an informal approximation, it gives the appearance of tight relationship referred to as “the Schultz curve” (Schultz, 1978) which has since been used to predict community reaction to noise and guide urban planning and noise abatement regulation (Fidell, 2003).

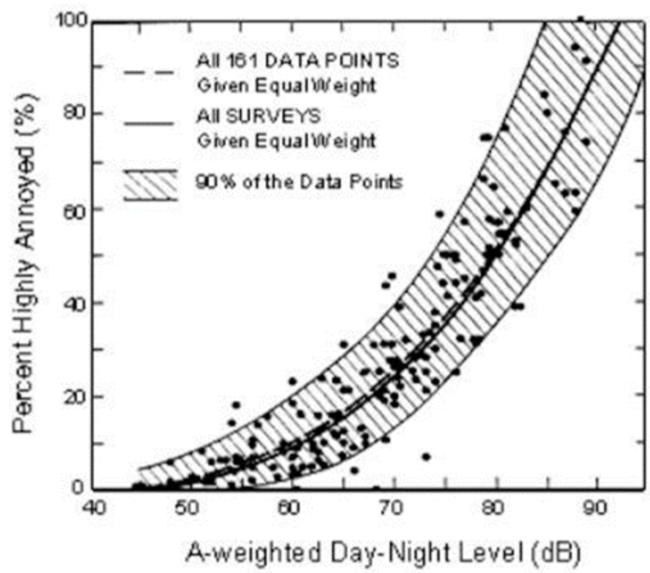

Figure 1: The Shultz Curve (Fidell, S. 2003). Schultz used "highly annoyed" (HA) as his measure of community response and day-night average sound level (DNL) as his measure of the noise in the environment. Note there is considerable variation around the dose-response curve. The paradox is that the dB(A) weren’t always predictive of the percent highly annoyed.

However, the Schultz Curve is also characterized by considerable variation around this descriptive dose-response curve (Figure 1). For example, whether individuals perceive loud sounds as annoying may depend on whether they arise from anthropogenic sources (e.g., airplanes) or natural sources (e.g., thunder). This is the result of potentially unexpected interactions between the presence and nature of sound sources and human values associated with sounds in particular places (Brown et al. 2011). In fact, counterintuitively, some low level, low frequency sounds that have a negative impact on human health, such as the distant hum of highway traffic, may not be perceived as annoying (and may even be perceived as comforting) to some people. Such variation around the Schultz curve reveals what we refer to as the noise paradox: sometimes sound levels that are known to be unhealthy (often originating from mechanical, anthropogenic sources) will not be perceived as noise based on annoyance, and vice versa. Although variation in the Schultz curve has been documented for decades, sparking a great deal of research to better understand how different people perceive the same sounds in different ways (Brown et al. 2011), we are not aware of a conceptual model to account for this paradox. Sense of place theory offers one possibility.

2.4 Sense of Place as a Conceptual Model for Exploring the Noise Paradox

Definitions of "place" vary, and conceptualizations of place emerge in a variety of ways. Agnew and Duncan (1989) defined place as a location, a locale, or a phenomenological event. Place has also been linked to life histories, social process, and individual experiences that shape one's "topophilia" or love of place (from Greek *topos* "place" and *-philia*, "love of") (Tuan, 1975). Pallasmaa (2005) noted that experiences of place involve complex sensual interactions; he maintained that our sense of a place based on our senses (its smell, touch, color, or sound) allows us to remember the place. This study refers to sense of place as sentiments that people hold regarding a specific geographic locale or place. These sentiments include meanings one attributes to the place and the subsequent attachment to the place that is derived from those meanings (Farnum et al. 2005, Jorgensen et al. 2001, Larson et al. 2018a). Where place attachment is the emotional intensity in the attraction to a place, place meanings are the reasons for that attraction.

Place meanings typically emerge from place-based experiences. They are cognitive, descriptive, or symbolic representations of a physical place that are shaped by interactions with the environment and sociocultural processes (Low et al. 1992, Kudryavtsev et al. 2012, Scannell et al. 2010, Stedman 2008). Environmental place meanings typically reflect the biophysical characteristics of place (Ardoin et al. 2012, Stedman 2003). For example, a person who enjoys natural aesthetics or watching and listening to wildlife in their neighborhood may assign a strong environmental place meaning to that place. Sociocultural place meanings typically reflect social connections, concepts of community, and culture (Ardoin et al. 2012, Manzo et al. 2006). A person who feels closely connected to their community and enjoys watching and listening to their family and friends interact in their neighborhood may assign a strongly socio-cultural place meanings to that place. Sound can play an important role in the development of place meanings. For example, natural sounds could reinforce environmental place meanings, whereas anthropogenic sounds could detract from those environmental place meanings while enhancing sociocultural meanings. Sense of place and the unique aspects of the people-place relationship is therefore an important part of human existence (Lewicka, 2011) that may be threatened with increasing globalization.

Homogenization, the uniformity created by valuing only one form of social practice, cultural belief, or built environment, of a place is an environmental justice issue because it strips people and communities of their unique identity and character (Casey, 1997). Development processes and urbanization, which often lead to uniformity, expedites the homogeneity of a place with corporations that eliminate smaller locally owned businesses. Massey (2004) discussed how ‘local place’ is a victim of globalization and articulated an argument that a ‘local place’ creates agency for residents by celebrating diversity and heterogeneity. ‘Local place’ has potential to do this because it is one of the grounds in which identity is rooted and developed (Massey et al. 2004). In fact, a growing body of literature suggests that internal perceptions about a place may impact what a person does to protect that place (Halpenny, 2010; Alam, 2011; Larson et al., 2018b; Relph, 1976). Sounds – and noise - may play an important role in heterogeneity of place by inspiring formations of identity related to people responding differently to natural and anthropogenic, or human sounds in their local soundscape. It is therefore critical that urban and suburban residents have a say in their soundscape preferences and perceptions.

Subjectivity of soundscape based on diverse conceptualization of place can help to explain the noise paradox. Subjectivity also poses challenges for noise pollution management and mitigation. In general, given that soundscapes that boost human well-being are ones dominated by natural sounds, we might surmise that such an environment would lead to higher levels of place attachment. On the other hand, soundscapes that negatively impact human well-being, that is, ones dominated by mechanical anthropogenic sounds, might lead to lower place attachment. However, low frequency noise that is "quiet" (as captured by dB (A) metrics) may not be perceived as annoying to many people because the sounds are barely audible or because they are perceived as comforting or familiar. Furthermore, even when such sounds are detected, interpretations of these sounds might differ drastically based on how people connect with place. To some, sounds considered as low frequency (trains, distant traffic, ventilation) may be viewed as pleasing because they have positive connotations based on individual attachments, shared meanings, and collective memories (Manzo, 2005).

I propose that, place attachment based on place meaning may result in residents embracing their soundscape irrespective its negative (or positive) impacts on human health. This could explain why someone who is raised in the city may be comforted and attached to sounds of traffic and voices late at night, while someone raised in the country would prefer birds, frogs, or crickets. It could also explain why soundscapes that are unhealthy (based on dB(A) metrics), and even exceed threshold levels for annoyance, are embraced by individuals seeking feelings of familiarity and belongingness that are linked to socio-cultural place meanings. Focusing on the evolution of sense of place could provide researchers with a better understanding of the noise paradox and if/when it is revealed in urban neighborhoods.

3. Current Study

Inherent to the term soundscape is emphasis on the way the acoustic environment is perceived and understood by the individual, by a group, or by a society (Brown et al. 2011). Thus, a soundscape exists through human perception of the acoustic environment of a place (Brown et al. 2011). Sound source identification is an important aspect of standardization in soundscape reporting and assessment (Brown et al 2011). As a way of examining the relationship between humans and the acoustic environment research has noted that values related to a soundscape create preferences that differ in different contexts (Brown et al. 2011). The primary problem with soundscape reporting and assessments is that the occurrence and characteristics of an individual sound sources are intertwined with the human values associated with particular places in much soundscape reporting (Brown et al 2011). In order to maintain the standardization of soundscape studies as put forth by Brown et al. (2011) we updated the sound typology to be used in an urban residential setting (Figure 9 and 10). The Brown et al. (2011) typology was originally designed to be applicable to both a soundscape study and an environmental noise study with the primary distinction between the two being the human outcomes of interest (i.e. adverse effects of noise and enhancement of soundscape quality).

In addition to reporting observations of individual sound sources, I examined the human values associated with the place where the sound observations were recorded by creating ‘listening session’ data sheets. These data sheets were based on the Brown et al. 2011 sound source typology and include a section for rating the perceptions of different sound sources by loudness and pleasantness to assess human sound source preference, and the sense of place espoused by the listener. Since low frequency noise is not sufficiently captured by dB (A) metrics, the ‘loudness’ observation attempts to begin to address this concern from a perceptual construct. The relationship between ‘place’ and sound are a critical piece in understanding the values intertwined with the identification of the sound sources within the typology. Using this new sound typology and additional information about the way listeners perceive sound and place, this research aims to full three main objectives:

1. Describe and investigate the prevalence of sound types (anthropogenic mechanical, anthropogenic non-mechanical, and natural) in urban neighborhoods.

2. Describe perceptions (loudness and pleasantness) of sound types (anthropogenic mechanical, anthropogenic non-mechanical, and natural (biotic/abiotic))

3. Examine the influence of place meaning and perceptions of sounds on place attachment.

I examine these objectives using a citizen science research framework. Citizen science is a form of public participation in scientific research (PPSR) (Shirk et al. 2012) which fall under five models as put forth by Shirk (2012). The projects are contractual, contributory, collaborative, co-created, or collegial (Shirk et al. 2012). Contributory style citizen science is generally designed by scientists and members of the public primarily contribute data (Bonney et al. 2009). The *Sound Around Town* research effort is a contributory style citizen science project which utilizes people's observations of sound events during 'listening sessions' to explore the perceptions of sound.

4. Methods

Citizen science frameworks have been implemented by other researchers to collect data on the acoustic environment at various spatial-temporal scales. Hush City is an open source app accessible worldwide that can be used to identify, access and evaluate quiet areas in neighborhoods across the globe. Hush city filters the quiet areas according to their sound levels, descriptors used to tag them, perceived quietness, visual quality and accessibility (Radicchi A. 2017). The app can be downloaded for iOS via the AppStore and for android via GooglePlay. This smartphone technology crowdsources perceptions of quiet areas with the option to include a recorded sound clip and picture of the site (Radicchi A. 2017). Another example of a citizen science-based sound study is Noise Tube. Noise Tube is also open sourced but uses crowdsourced dB(A) recordings through smartphone technology for android and apple. Volunteers use the app to record the dB(A) metrics while walking around and then upload their data to the Noise Tube website using a computer with the option to make contributions public or private (Ananthaswamy, A. 2009). These measurements are then visualised on Google Maps to construct noise pollution maps (Ananthaswamy, A. 2009). *Sound Around Town* aims to capture the perceived loudness and quietness of a site through a crowdsourced effort and dB(A) metrics, however, this project addresses outcomes from both Hush City and Noise Tube by utilizing perceptions of pleasant and quiet sounds with their dB(A) metrics. While, this project is not yet available as an app, it uses crowdsourced volunteers, or citizen scientists, online. Most importantly, what makes this citizen science framework unique, is in *Sound Around Town* methods which prioritizes sense of place theory for the analysis of observations to assess various place meanings and how they relate to sound and noise.

As a member of a team, I designed a citizen science project, *Sound Around Town*, to collect all data for this study. Partners that helped with *Sound Around Town* included the North Carolina Museum of Natural Sciences, National Park Service Natural Sounds and Night Skies Division, and North Carolina State University. We focused on the Triangle area in North Carolina, USA. The Triangle includes data points from Durham, Raleigh, and Chapel Hill with most participants located predominantly in Raleigh (Figure 2). Ultimately, *Sound Around Town* involves in situ decibel-based metrics and perception-based measurements of residential soundscapes, place meaning, and place attachment. Decibel- based metrics were captured using digital audio recording devices, designed by National Park Service Natural Sounds and Night Skies Division which were deployed at each site following an online sign-up procedure. Perceptions were captured after a brief training for logging sound observations when the digital audio equipment was deployed. The logging sound observations was called ‘listening sessions. We recruited participants via a web platform for citizen science projects called SciStarter, a press release that lead to a local radio news story, flyers, and various outreach at community events.

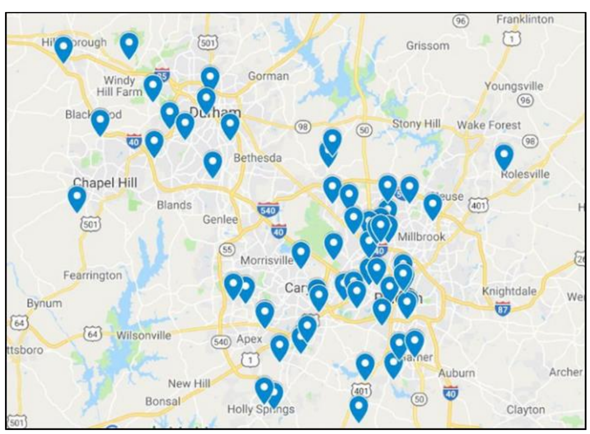

Figure 2: *Sound Around Town* Participant Distribution Map:
Screenshot of participant distribution throughout the Triangle area.

4.1 Recruitment of Participants

Volunteers were required to create an account with SciStarter.org to consent to have their name and address acknowledged publicly (Appendix A), to have neighbors' consent (Appendix A), and to respond to a questionnaire about sense of place before they could be scheduled for a deployment and begin listening sessions. The deployments were scheduled first come first served with a priority to marginalized populations (non-white populations) due to previous research on environmental justice and noise pollution. To examine other environmental injustices in this study we included questions about vulnerable populations based on the presence of elderly persons (65 and older) and children in the sense of place enrollment questionnaire. Until the cutoff in May of 2019, volunteers self-selected into this citizen science project on SciStarter.org. The deployment period lasted approximately 5-14 days, only some of these participants were scheduled for a deployment. During lulls in sign-ups researchers used different messaging strategies, such as scarcity messaging, to encourage enrollment (Appendix B).

4.2 Equipment

NPS created Digital Audio Recording devices (DAR) (Mennit 2019; Appendix C); before deployments, recording devices were calibrated following a protocol created by NPS (Appendix D). I visited each participant home and deployed a single device in their backyard. I used Energizer D Alkaline Industrial batteries 1.5v and Duracell Procell Alkaline D batteries, both types lasted approximately 5-14 days depending on the outdoor temperature. Colder days decreased battery life significantly. At each site researchers filled in a metadata sheet (Appendix E) that would then be used to approximate different sound metrics (LA dn, LA eq 24, LA eq. Night, LANS dn, LAN Seg 24, LANS eq. Night) which correlate to health guidelines for dB (A) set by various health organizations mentioned earlier, These measurements were gathered as part of the collaboration with NPS but will not be included in results for this current study.

4.3 Survey Design

The survey instrument hosted on sci-starter.org included various items that aimed to address theoretical ideas for place meaning and place attachment both of which come together to create an overall sense of place. Sense of place is roughly defined by place meanings that lead to place attachment (Larson et al. 2018a). I focused primarily on two different types of place meaning: *sociocultural place meaning* (with additional measurements for *community bonding* items), and *environmental place meaning* (with additional measurements for *nature relatedness* items). I adapted these items from previous scales (Larson et al. 2018; Schultz 2002; Leiflander et al. 2013; Raymond et al. 2010) and displayed them as sentiments related to the ideas listed above with the option rate them on a 5-point Likert scale with the responses: strongly disagree, disagree, neutral, agree, and strongly agree. Sociocultural place meaning was listed as three items that reduced into a one-dimensional scale (Table 1). Environmental place meaning was listed as three items that reduced to a one-dimensional scale (Table 1).

Table 1: Sociocultural and Environmental place meaning factor loadings

Statistical symbols: α=Cronbach's Alpha Items rated on a scale from 1= strongly disagree to 5= strongly agree

Factor/Item	*M (SD)*	Factor 1	Factor 2
Sociocultural Place Meaning (3 items, Chronbach's α= 0.85)			
SCPM6: My local area includes many people whose company I enjoy	3.9 (1.0)	94*	
SCPM5: My local area has people who share my values	3.9 (0.88)	82*	
SCPM7: My local area feels like a close knit/neighborly community	3.6 (1.1)	88*	
Environmental Place Meaning (3 items, Chronbach's α= 0.70)			
EPM3: My local area provides opportunities for enjoyment of nature	4.4 (0.60)		83*
EPM4: My local area is peaceful	3.8 (0.70)		81*
EPM1: My local area has natural beauty	4.4 (0.52)		75*

I mainly used the items for sociocultural and environmental place meaning, but I also explored, to a smaller degree, what I considered to be different aspects of sociocultural place meaning and environmental place meaning with items that evaluated community bonding and nature relatedness. There were six community bonding items were adapted from previous research (Raymond et al. 2010) that reduced to two dimensions: family bonding and 'other' bonding which included friends and activities.

Table 2: Community Bonding factor loading. Statistical symbols: α=Cronbach's Alpha; Items rated on a scale from 1= strongly disagree to 5= strongly agree

Factor/Item	*M (SD)*	Factor 1	Factor 2
Community Bonding Family (3 items, Chronbach's α=0.82)			
CB22: I live here because my family is here	2.9 (1.36)	90*	
CB23: My relationship with my family in this place is very special to me	3.5 (1.29)	86*	
CB24: Without my relationships with my family I would probably move	2.5 (1.20)	77*	
Community Bonding Other (3 items, Chronbach's α=0.81)			
CB20: Belonging to volunteer groups in this place is very important to me	3.8 (1.0)		86*
CB21: The friendships developed by doing various community activities strongly connect me to this place	3.5 (1.0)		84*
CRB	2.9 (0.86)		80*

Five items represented two dimensions of nature relatedness that were adapted and reduced from a previous scale (Raymond et al. 2010) and including experiences in nature and connectedness or oneness with nature.

Table 3: Nature Experience factor loading. Statistical symbols: α=Cronbach's Alpha; Items rated on a scale from 1= strongly disagree to 5= strongly agree

Factor/Item	*M (SD)*	Factor 1	Factor 2
Nature Experience (2 items, Chronbach's α= 0.74)			
NR15: I spend time outdoors whenever I can	4.2 (0.80)	89*	
NR14: My favorite places are outside in nature	4.4 (0.78)	86*	
Nature Connectedness (2 items, Chronbach's α= 0.61)			
NR19: I think about how what I do affects the Earth	4.7 (0.46)		89*
NR17: I feel very connected to all living things and the Earth	4.4 (0.76)		78*

Finally, these different understandings of place meanings (environmental, sociocultural, community, nature relatedness) were designed to eventually measure how predictive they could be of place attachment. The items for the place attachment construct was adapted from previous scales (Larson et al. 2018) and rated on a 5-point Likert scale with the responses: strongly disagree, disagree, neutral, agree, and strongly agree.

Table 4: Place Attachment factor loadings. Statistical symbols: α=Cronbach's Alpha; Items rated on a scale from 1= strongly disagree to 5= strongly agree

Factor/Item	***M (SD)***	**Factor 1**
Place Attachment (4 items, Chronbach's α= 0.86)		
PA9: My local area is the best place for doing activities I enjoy	3.2 (0.94)	89*
PA10: I feel happiest when in my local area	3.6 (0.92)	86*
PA11: I am very attached to my local area	3.8 (0.83)	86*
PA8: My local area says a lot about who I am	`3.4 (0.96)	75*

The online instrument included questions regarding length of residency, gender, income and racial identity in hopes to aid research for noise pollution and environmental justice efforts and to have a diverse, representative sample population. In addition, the survey asked participants to state whether or not elderly people and children were living in their current place of residence. These survey items were incorporated as a response to the various studies that have maintained that both children and elderly are part of what is considered to be vulnerable populations and therefore at higher risk for adverse health effects from environmental pollutants like noise pollution (Hygge et al. 2003; Bharathan et al. 2007; Hume et al. 2012; Casey et al. 2017). Lastly, our collaborators at NPS proposed a survey question that inquired how many different bird species they expected to hear during their listening sessions. This data will potentially be used for future research on people's values for biodiversity in different environments (urban, suburban, rural, national parks, etc.).

4.4 *Listening sessions*

Listening sessions were conducted and completed at different homes in the Triangle area (Durham, Raleigh, Chapel Hill). During visits at volunteer homes, I instructed volunteers in outdoor the listening activity using listening guidelines and how to logs sounds observations on the data sheets (Figure 3). This type of citizen science project is called a 'mentored' citizen science project because the researchers have face-to-face interaction with participants (Evans et al. 2005). Mentored means that participants underwent a brief training on how to gather data through outdoor listening observations and were then left to fill out the listening session data sheets on their own. I encouraged participants to conduct observations at various times of the day to see how perceptions might change from morning, afternoon and night and from weekdays to weekends, however, it was up to each participant to fit their listening sessions into their schedules to be the most convenient for them. During this training, members of the research team and I explained that sounds were to be rated from unpleasant to pleasant, quiet to loud on a '1 – 5' scale; '1' being quiet and '5' being loud, '1' being unpleasant and '5' being pleasant. Volunteers were then expected to complete at least three 10-minute listening sessions but could fill out more if they desired to do so. Researchers entered all data from listening sessions into google sheets, followed by two-person proofing for data entry errors.

Volunteers used the data sheets to report their sound observations. The data sheets were created from an adjusted Brown et al. 2011 typology (Figure 4) which researchers used to classify the sound observations into three main categories. The sound categories are (1) mechanical anthropogenic (2) non-mechanical anthropogenic (human) and (3) natural. These sound types branched out into more specific sounds creating the aforementioned sound typology. Sounds that were written in as either 'anthropogenic unlisted' or 'natural unlisted' were

Listening Session

Throughout your participation in Sound Around Town you will complete at least three mandatory listening sessions. However, you have the option to do as many as you like. We recommend that you complete one listening session before the mandatory sessions to get accustomed to how they work.

Here are some guidelines for a successful listening session:

1. Find a comfortable place to sit in silence. By sitting still, you're allowing nearby animals (and people) to get used to your presence and scent—and eventually ignore you. Birds will return to making *songs* or *companion calls*, which means "business as usual."
2. Try listening in a 360-degree circle—in front, behind, and all around you.
3. Listen for the *farthest* sound. Now tune that sound out and let the subtler, softer sounds surface.
4. Listen for sudden changes in the soundscape. Bird alarms might signal the presence of a predator.
5. Notice your feelings as you hear a sound. Alarm calls can be as intense as a person yelling for help.
6. Pay attention to the sounds you hear at different times of the day. Ask yourself if they change from the morning to the evening? What changes do I hear?

Now, find a comfortable spot close to your listening device for your mandatory listening session. Sitting next to the device is important for the researchers to compare what you are hearing to the recording. Next, read the list below to help prepare yourself for what sounds you might hear in your soundscape. Then, you will spend 10 minutes listening carefully.

Note sounds you hear, as detailed as possible from the list. You will be rating the pleasantness of the sound (how it makes you feel from 1=unpleasant to 5=pleasant) and the volume of the sound (from 1=quiet to 5=loud).). If you hear the sound more than once, only note the sound again if the pleasantness or volume changes and write it underneath the repeated sounds section.

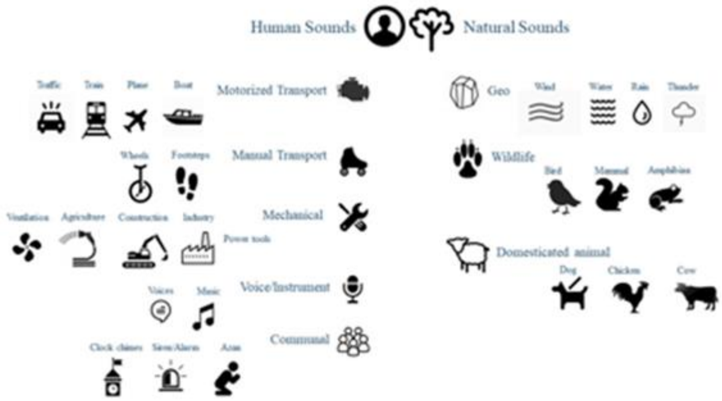

Figure 3: Listening session guidelines: Three 10-minute listening sessions were carried out during the deployment period for a total of 30 minutes of concentrated outdoor listening. Researchers provided these guidelines on how to listen in addition to a short demonstration of the listening sessions done on-site to eliminate any confusion.

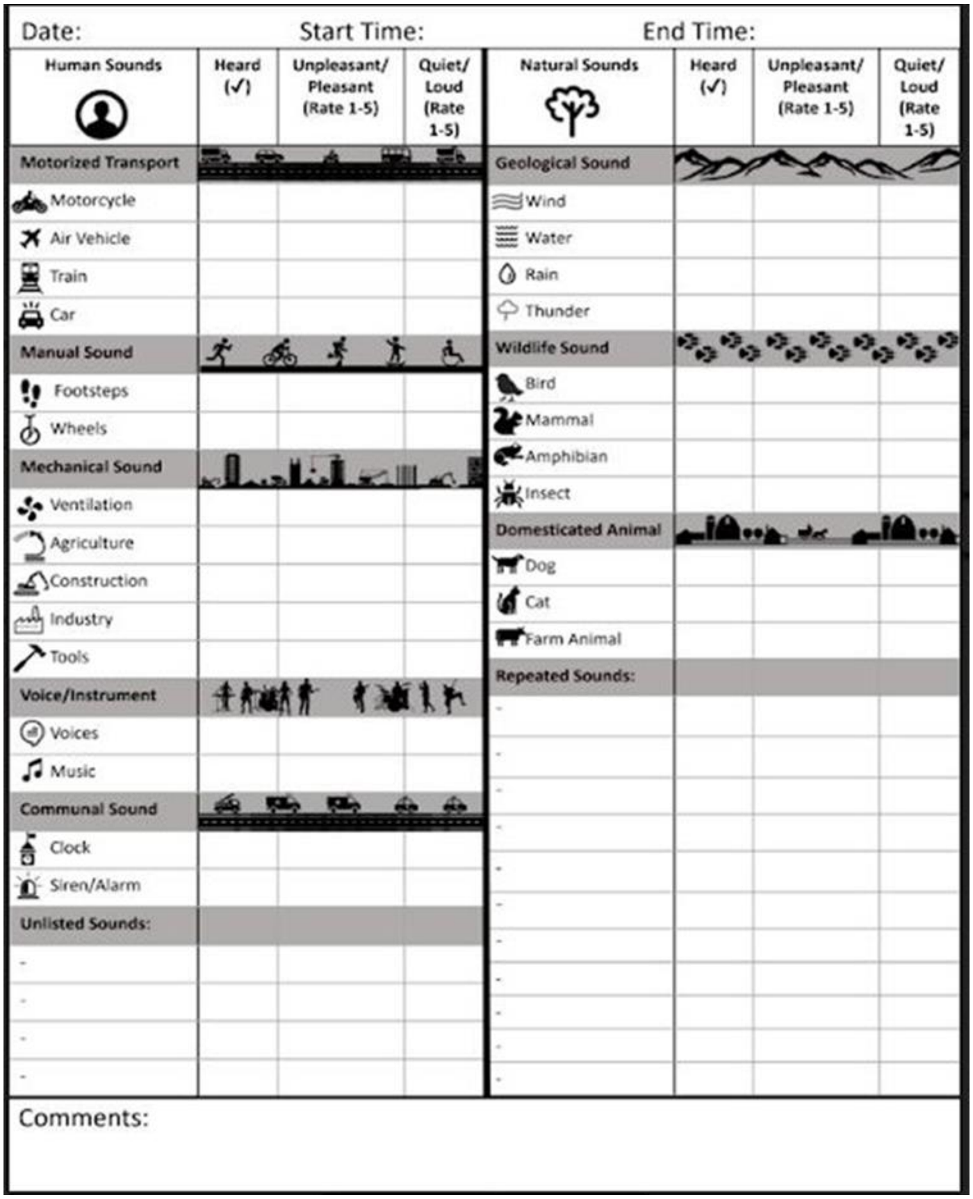

Figure 4: Listening session data sheet

The sound categories were created from the Brown et al. 2011 typology (Appendix F).

Were re-coded to fit into, and improve, the typology. For example, human movement includes sounds such as: yardwork, humans banging, neighbor moving things, children playing, basketball court, knuckles cracking (sounds were previously written in as A-unlisted). Domestic sounds include: kitchen, hot tub, door slam, knocking on door, trash can rolling, car door chime, plastic bottle dropping, coat zipper, Raleigh loose leaf collection, packing truck, pencil scratching, vacuum, sweeping, screen door closing (sounds were previously written in as A-unlisted). In addition, earth movement includes sounds such as: acorns dropping, branches breaking, acorns in grass, acorns on roof, deck leaves, maple leaf landing on paper, tress shedding, sweet gum pod falling (sounds were previously written in as N-unlisted). The updated sheet also includes more room for repeated sounds and 'motorcycle' as a sound type since it was written in under unlisted sounds very frequently.

5. Analysis

As previously mentioned, I adapted Brown et al. 2011 typology of sound classification to analyze the data. The original typology separated the sounds into two categories, (1) sounds generated by human activity and (2) sounds not generated by human activity (Appendix F). I split the human activity typology into another category resulting in sound source observations were classified into three main sources: (1) mechanical anthropogenic; sound sources from the built environments including technology, cars, aircraft, trains, industry and other sounds generated by machines or mechanics built by humans, (2) non-mechanical anthropogenic; sound sources from non-mechanical/motorized human activity such as voices, footsteps, heartbeat, sneezing, clapping etc., and (3) natural; sound sources from biotic and abiotic sources other than that of humans and human activity (Figure 5). I updated the typology to (a) further define what is meant by a natural sound vs. anthropogenic, or human sound, (b) to eliminate the human vs. nature dichotomy (i.e. the idea that human sounds are always bad), (c) to continue work done by the Brown et al. (2011)'s call for standardization in soundscape terminology and implementation, and (d) to separate and classify sound types that have been researched to create negative health effects from dB(A) and low frequency noise.

Using SAS 9.4, I analyzed the listening sessions based on their overall observation frequency, frequency per person, and the percentage of observations for each of the three main categories. I took the averages of pleasantness and loudness ratings for the perceptions of the three main categories as well as the different individual sound source type and correlated the average pleasantness and loudness for each of the individual sound types. I then analyzed the sense of place survey results using factor analysis to identify constructs related to environmental place meaning, socio-cultural place meaning, community bonding, and place attachment. Once the factors were identified, I then put each of these as variables into a step- wise regression to evaluate the main model for predicting place attachment. Variables included in the step- wise regression for predicting place attachment were: sociocultural place meaning, environmental place meaning, nature relatedness outdoors, nature relatedness connectedness, percentage of quiet, percentage of pleasant, average mechanical anthropogenic sound heard per 10-minute listening session, average natural sound heard per 10-minute listening session, total number of sounds heard per 10-minute listening session, and property values.

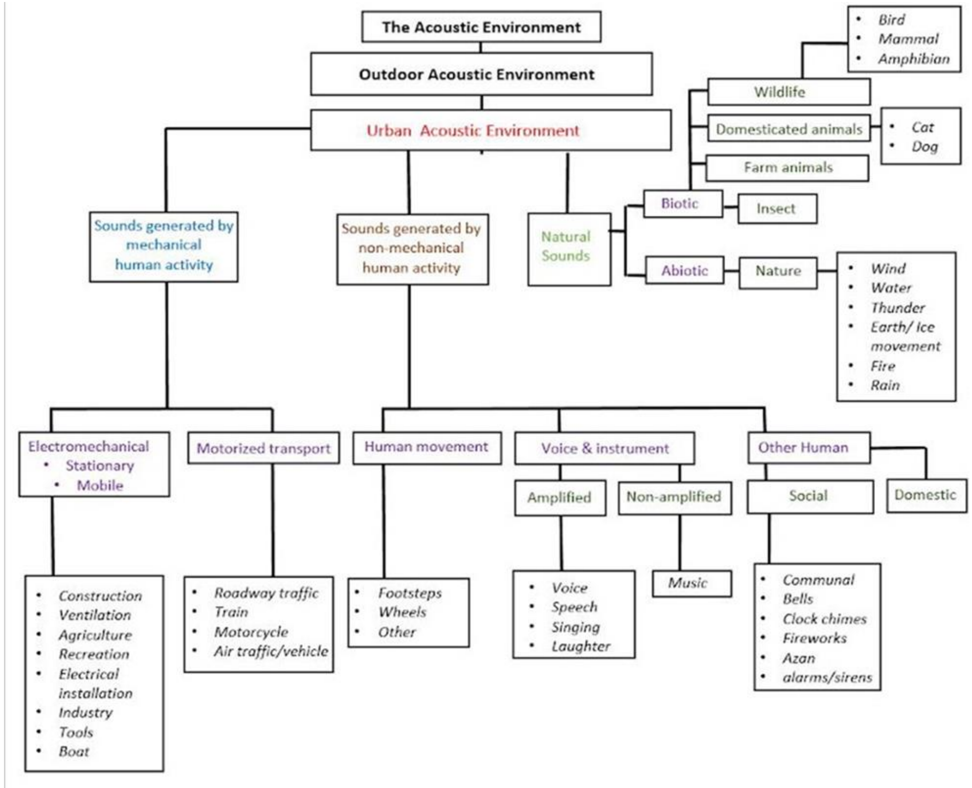

Figure 5: Revised Brown et al. 2011 sound typology

In this adapted typology, we listed mechanical anthropogenic sound sources as sounds generated by human activity, non-mechanical anthropogenic sound sources as sound not generated by motorized activity and natural sounds as sounds sources that include sounds that are not derived from humans in any way

5.0.1 Participant Background

As of May 1st 2019, roughly 218 volunteers registered for the project and completed the sense of place survey on SciStarter.org. From that sample population, 60 participants successfully deployed devices and did at least 3 listening sessions. Within that group, we were able to compile a data set of 55 people who completed the sense of place survey and received recording devices for a sampling period that varied from 5-14 days without errors and/or missing data.

The online survey was used to gather data about each participant’s sci-starter id, race, gender, average household income, length of residence, elderly people and children in residence, and birth year. Thirty-six participants identified as female, twenty-two identified as male, and one person preferred not to say. Most participants were between the ages of 40 - 49 years of age with an income in between 100,000-124,999 and a length of residency of more than 10 years. Fifty-three participants identified as White, eleven identified as Native, one identified as Hispanic and two identified as African American. Some participants selected more than one of these identities which resulted in the number shown to be is greater than the sample size of n=55. Eighteen households had people with elderly populations (65 and older) and fourteen households had children.

5.1 Results

The following section reports the results for each of the research objectives.

The results for each of these objectives were as follows:

5.1.1 Objective 1: Describe sound types in urban neighborhoods

The total sound observations heard for sample size n= 55 was 1,834 sounds. This means that 55 participants heard a total number of 1,834 sounds combined. From these sounds, I categorized the identified sounds into the three main categories (anthropogenic mechanical, anthropogenic non-mechanical, and nature). I found that 781 sounds as being generated from anthropogenic mechanical sound sources, 293 sounds that were generated from non-mechanical anthropogenic sound sources, and 760 generated from natural sounds.

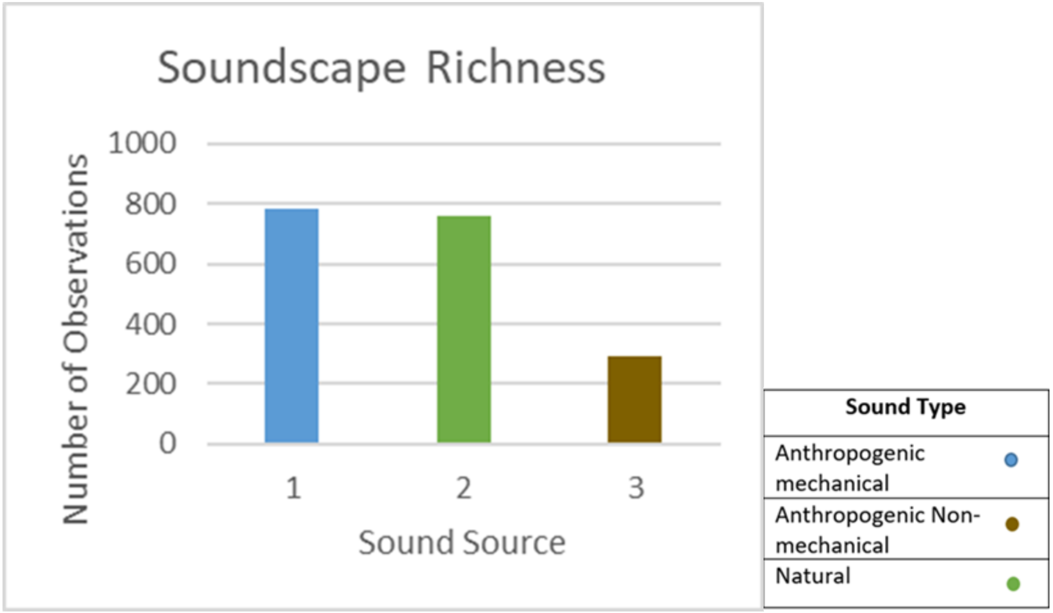

Figure 6: Soundscape tally for the three main sound types. 781 sounds were observed from anthropogenic mechanical, 293 from human, and 760 from natural sounds.

Each *Sound Around Town* participant heard an average of 9.5 ± 3.8 classifiable sounds for a 10-minute listening session. This means that each of the 55 participants observed and identified a little over 9 sounds in a 10-minute time period. On average each participant heard and identified 4.3 ± 2.0 mechanical anthropogenic sounds (Figure 7), 4.0 ± 1.5 natural (Figure 8), and 1.9 ± 1.0 non-mechanical anthropogenic sounds (Figure 9) in a 10-minute listening session. As stated previously, within the main sound categories, the typology branches out into more specific sound observations which are the sounds that appeared on the listening sessions for each individual *Sound Around Town* participant. The results for the main sound types of the soundscape tally per individual ('i') (Figure 11) and soundscape percentage per individual (Figure 12) revealed that every participant heard birds and cars (roadway traffic). Other sounds that were heard frequently for each participant was dog (47, 85%), wind (48, 87%), and tools (42, 76%).

4.3 ± 2.0 sounds heard per 10-minute session

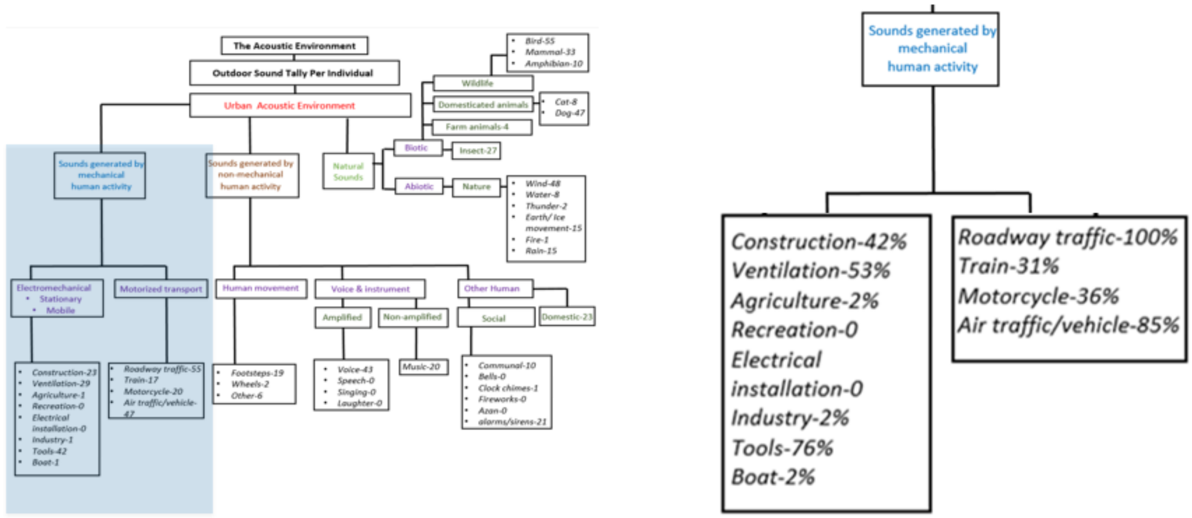

Figure 7: Descriptions of anthropogenic mechanical sound type:

Most heard sounds were Traffic/car-55 or 100% Airplane-47 or 85% and Tools- 42 or 76% with 4.3 sounds heard on average per 10-minute listening session

4.0 ± 1.5 sounds heard per 10-minute session

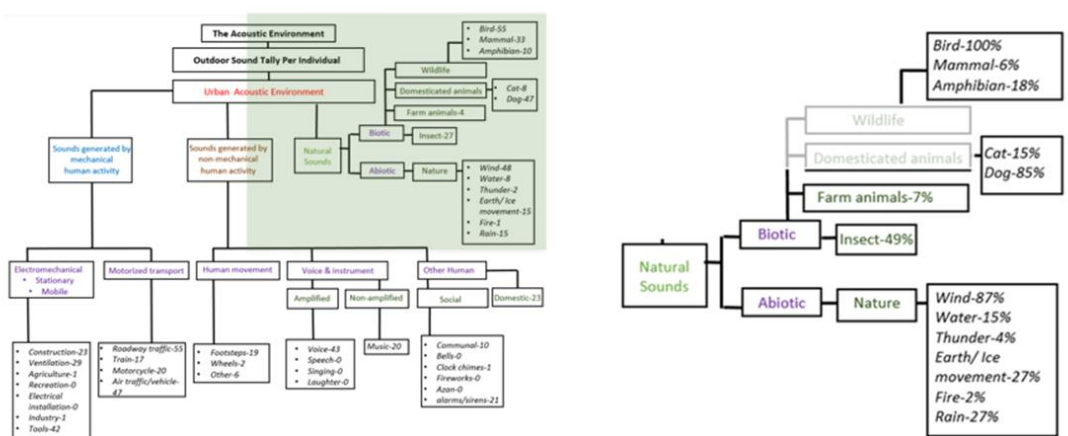

Figure 8: Descriptions of Natural sound type: Most heard sounds were Bird- 55 or 100%

Dog- 47 or 85% and Wind- 48 or 87% with an average of 4 natural sounds per listening session.

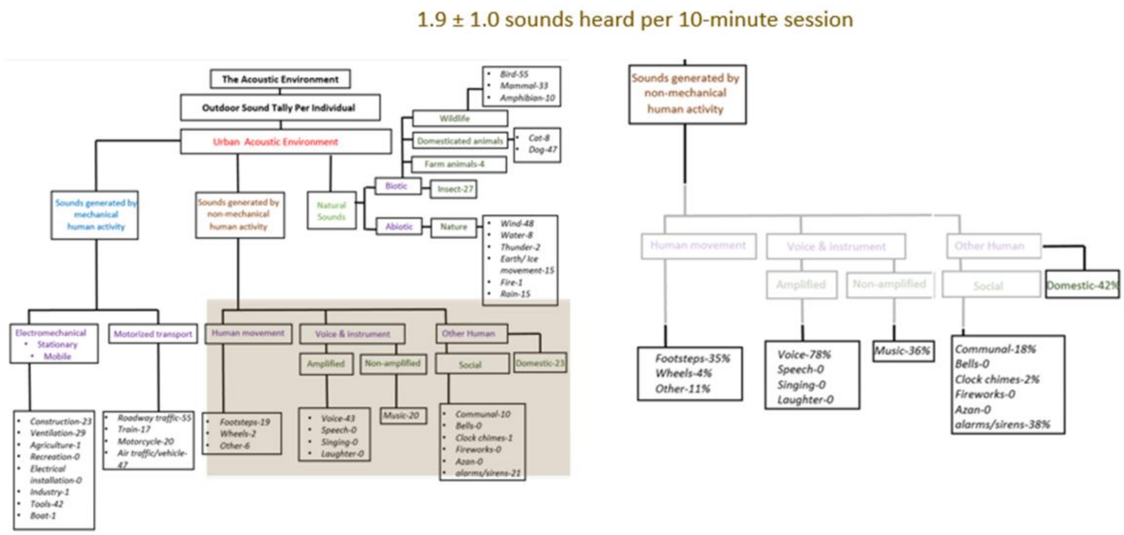

Figure 9: Description of Anthropogenic Non-mechanical sound type:

Most heard sounds were Voice- 43 or 78%, Domestic-23 or 42% and Siren/Alarm-21 or 38% with 1.9 sounds heard on average per 10-minute listening session

Soundscape percentage is reported as the overall percentage of non-mechanical anthropogenic, mechanical anthropogenic, and natural (biotic/abiotic) sound observations (Figure 16). Mechanical anthropogenic activity was observed as 43% of sounds, non-mechanical anthropogenic activity was observed as 16 % of sounds, and natural sounds were observed as 41% of sound observations (Figure 10).

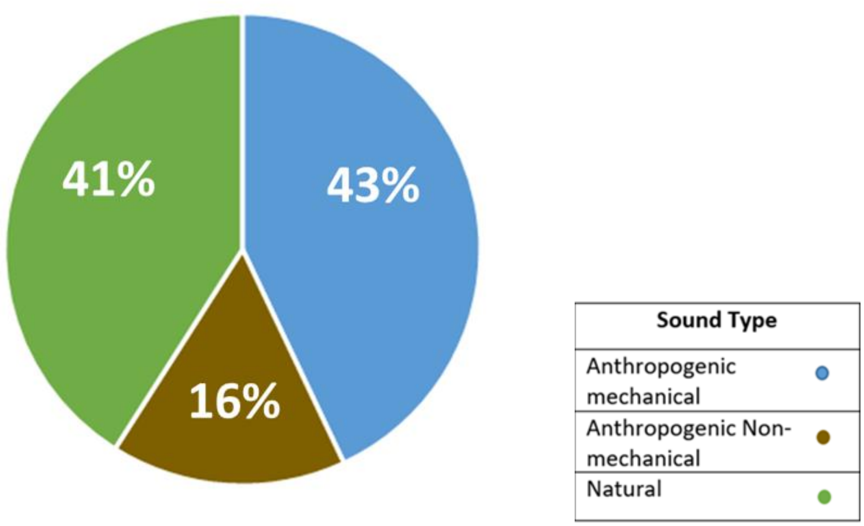

Figure 10: Soundscape percentage

As mentioned previously, I included an option on the listening session data sheet for people to write in sounds that we did not have listed (most of which were re-classified) and there was also an option to check if you heard a type of sound but could not identify exactly what you were hearing. There were 39 unknown sounds from the mechanical anthropogenic category, and 24 unlisted. There were 20 unknown non-mechanical anthropogenic sounds with 15 unlisted.

5.1.2 Objective 2: Describe perceptions of sound types (anthropogenic mechanical, anthropogenic non-mechanical, and natural (biotic/abiotic))

Perceptions of sound were analyzed on a quadrant graph with pleasantness (x-axis) and loudness (y-axis). The first quadrant includes loud and unpleasant sounds, the second quadrant includes loud and pleasant sounds, the third quadrant includes more quiet but unpleasant sounds, and the fourth quadrant is where one would find sounds that are typically quieter and also pleasant. While examining the perceptual component of each sound type, this study found that on average, anthropogenic mechanical sounds were rated as the most unpleasant of the three sound types, but were perceived as more pleasant when they were quieter (Table 5). Natural sounds were rated as being the most pleasant with the 'dog' observation being the only sound that crossed into the quadrant for unpleasant sounds. Non-mechanical anthropogenic or human sounds scored ratings in-between natural and mechanical anthropogenic sounds with the most spread in pleasant and unpleasant ratings within a sound category (Figure 12).

Table 5: Average pleasantness and loudness ratings for each main sound type

Sound Type	Mean Pleasantness	Mean Loudness
Anthropogenic mechanical ●	2.34 (±) 1.04	2.65 (±) 1.20
Anthropogenic Non-mechanical ●	3.09 (±) 1.09	2.06(±) 1.11
Natural ●	4.01 (±) 1.16	2.37 (±) 1.17

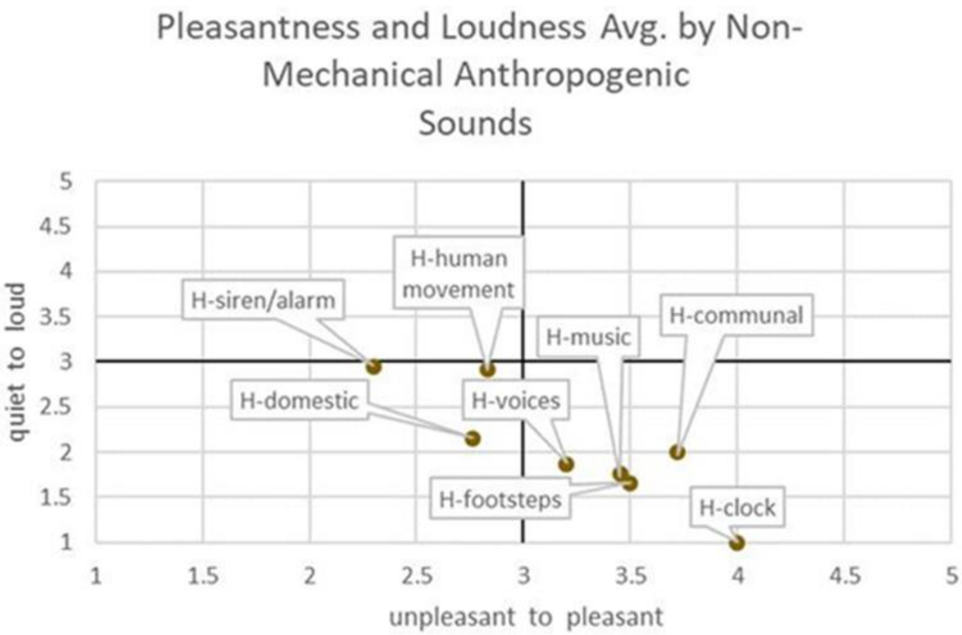

Figure 11: Average pleasantness and loudness ratings for human sound sources. These sounds spread across the axis more than any other sound type.

While the pleasantness ratings varied for the sound types, all the sounds were found to be relatively quiet (Table 5). Table 6 (continued) displays each of the expanded (from the three main categories) sound types by total number of observations (n), the total number of observations per individual (i) (Figure 12), and the average pleasantness and loudness ratings for each.

Table 6: Pleasantness and loudness ratings for each sound type where n= total observations and i= individual or participant observations

Sound Type	**i**	**n**	**mean pleasantness**	**mean loudness**
A-agriculture	1	1	2 (±) 0	1 (±) 0
A-air	47	141	2.46 (±) 1.0	2.72 (±) 1.3
A-boat	1	1	2 (±) 0	4 (±) 0
A-car	55	345	2.28 (±) 1.0	2.72 (±) 1.1

Table 6 continued

A-construction	23	67	1.99 (±) 0.9	2.69 (±) 1.3
A-industry	1	1	2 (±)0	2 (±) 0
A-motorcycle	20	33	1.42 (±) 0.7	3.27 (±) 1.2
A-tools	42	100	2.32 (±)1.0	2.48 (±) 1.3
A-train	17	29	3.28 (±) 1.0	2.52 (±) 1.3
A-unknown	21	39	2.69 (±) 1.0	2.26 (±) 1.1
A-unlisted	12	24	2.83 (±) 1.4	2.71 (±) 1.2
A-ventilation	29	63	2.40 (±) 1.0	2.29 (±) 1.2
A-wheels	2	2	3 (±) 0	2.5 (±) 0.7
H-clock	1	1	4 (±) 0	1 (±) 0
H-communal	10	18	3.72 (±) 1.0	2 (±) 0.9
H-voices	43	103	3.20 (±) 1.0	1.87 (±) 1.0
H-domestic	23	55	2.76 (±) 1.0	2.15 (±) 1.0
H-footsteps	19	32	3.5 (±) 0.8	1.66 (±) 0.7
H-human movement	6	12	2.83 (±) 1.3	2.92 (±) 1.1
H-music	20	29	3.45 (±) 1.3	1.76 (±) 1.2
H-siren/alarm	21	41	2.3 (±) 1.0	2.95 (±) 1.5
N-Rain	15	22	4.73 (±) 0.6	2.05 (±) 1.1
N-amphibian	10	16	4.69 (±) 0.5	2.25 (±) 1.3
N-bird	55	254	4.60 (±) 0.8	2.63 (±) 1.2
N-cat	8	10	3 (±) 1.2	2.4 (±) 1.1

Table 6 continued

N-dog	47	143	2.76 (±) 1.0	2.86 (±) 1.2
N-earth movement	15	39	3.15 (±) 0.9	2.38 (±) 1.2
N-farm animal	4	6	3.17 (±) 1.0	2.5 (±) 1.5
N-fire	1	1	4 (±) 0	1 (±) 0
N-insect	27	64	4.05(±) 1.1	2.20 (±) 1.1
N-mammal	33	70	3.89 (±) 1.1	1.93 (±) 0.9
N-thunder	2	4	3.75 (±) 1.9	2.5 (±) 1.7
N-unknown	13	20	3.3 (±) 1.2	1.5 (±) 1
N-unlisted	8	15	4.33 (±) 0.7	1.87 (±) 0.8
N-water	8	19	4.53 (±) 1.0	1.68 (±) 0.7
N-wind	48	112	4.5 (±) 0.8	1.96 (±) 1.1

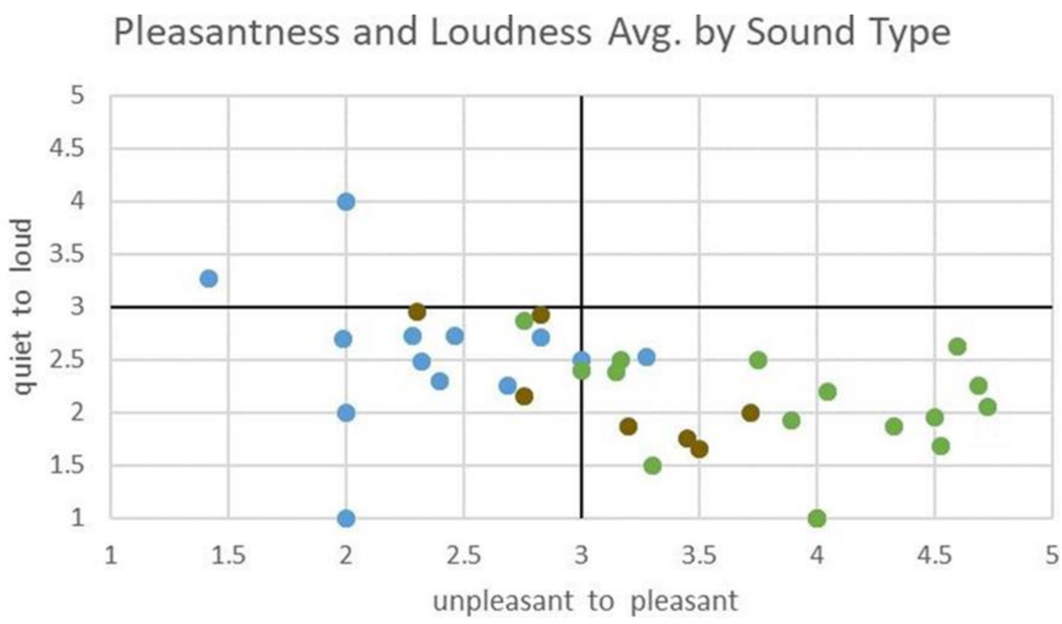

Figure 12: Average pleasantness and loudness of each of the main sound types displayed on a quadrant.

We assessed, for each sound type, the correlations between its perceived pleasantness and loudness rating. Several of the correlations were highly significant but all of them had low correlation coefficients. Despite low correlation coefficients, trends where loudness was inversely related to pleasantness emerged for some sound types. For some variables, pleasantness scores changed with loudness and for others, there was no relationship between pleasantness and loudness. Mechanical anthropogenic sounds types (Appendix G) with p values < 0.05 included: airplane, car, construction, ventilation, tools, unknown anthropogenic, and unlisted anthropogenic. Non-mechanical anthropogenic sounds (Appendix H) with p values < 0.05 included: domestic, voice, and siren sound observations. Natural sound types (Appendix I) with p values < 0.05 included: dog, mammal, earth movement, and unknown natural.

5.1.3 Objective 3: Examine the influence of place meanings and perceptions of sounds on place attachment

The factor loadings for the items in each construct were all .75 or greater. In addition, these factors were validated by Cronbach α values that ranged from 0.61 – 0.86 confirming that our scales have good internal consistency with closely related items for each construct. We reduced some of the variables from the sense of place constructs and the variables from the perception of sound types to be put into a stepwise regression analysis predicting place attachment (Table 7). The variables for sociocultural place meaning and percent quietness were found to be significant. Sociocultural place meaning and the percentage of quiet sounds are significantly correlated to place attachment. The stepwise model had a p -value = 0.005 and an R^2adj = 0.20. Therefore, sociocultural place meaning and quietness explain 20% of the variation in place attachment.

Table 7: Place attachment Prediction Stepwise Model. The variables that went into the step wise regression include: sense of place constructs for sociocultural place meaning, environmental place meaning, nature relatedness: outdoors/connectedness, average natural sounds and average mechanical anthropogenic sounds per session (dropping non-mechanical anthropogenic due to sample size), and the percentage of perceived quietness and loudness ratings.

Variable	Estimate	p
Intercept	1.6 (0.6)	0.007
SCPM	0.3 (0.1)	0.01
EPM		NS
NR-outdoors		NS
NR-connectedness		NS
% quiet	0.02 (0.01)	0.02
% pleasant		NS
Avg. A/session		NS
Avg. N/session		NS
Total per session (richness)		NS
Property value		NS

6. Discussion

Overall, I found that sociocultural place meaning and quietness were predictive of place attachment. This means that when a site was perceived as being quiet the amount of place attachment increased with significance. In addition, the proportion of sounds included 43% anthropogenic mechanical sounds, 41% natural, and 16% human or non-mechanical anthropogenic (Figure 10). While this was not a qualitative study, participants were given space to leave comments for what they liked and didn't like, suggestions, things that they learned, or were surprised by during their listening sessions. Some of the comments are included below to provide more depth into sound perception in an urban environment.

"The quiet/loud scale seemed to have shifted from the day. Sounds are scarier at night lol"

My research findings confirm that the perception of sound is more important than the source from which the sound is derived. All of the sounds types were rated as relatively quiet even when originating from a mechanical sound source. The variation in perception of the quiet/loud scale is highlighted in this participant comment, finding that other aspects of the environment, outside of dB(A) metrics, like the time of day, also can play a role in how loud a sound is perceived. This perception maintains the variation of the annoyance versus dB (A) dose response documented in the Shultz curve (Fidell, S. 2003).

"It's hard to rate the sounds of traffic from 15-501- the fact that I can hear it at this distance means it's very loud in actuality, even though it is not loud where I'm sitting now. But the fact that I can't find a place where I hear no traffic at all makes me sad."

This research also informs the presence of low frequency noise (arising from anthropogenic mechanical sources) and its relation to the noise paradox. Even though most quiet sounds were perceived as pleasant, mechanical anthropogenic sounds were rated as the most unpleasant of the sound categories. These unpleasant scores may highlight values associated with this type of sound regardless of its dB(A) measure and help explore perceptions of low frequency noise which are measured as quiet by dB(A) metrics. Even if two sounds have the same dB(A) measures, low frequency sounds travel farther and last longer. This participant describes the experience of low frequency noise realizing that even though they were sitting far away from the traffic, they could still hear it, making them feel sad. This comment directly captures how low frequency noise travels long distances with extended duration and how it can impact mood, an important component of health which can create stress-induced diseases. Generally, pleasantness ratings had considerable amounts of variation whereas all of the sound types were perceived as relatively quiet with only two observations for 'boat' and 'motorcycle' in quadrant one where loud and unpleasant sounds are designated (Figure 13).

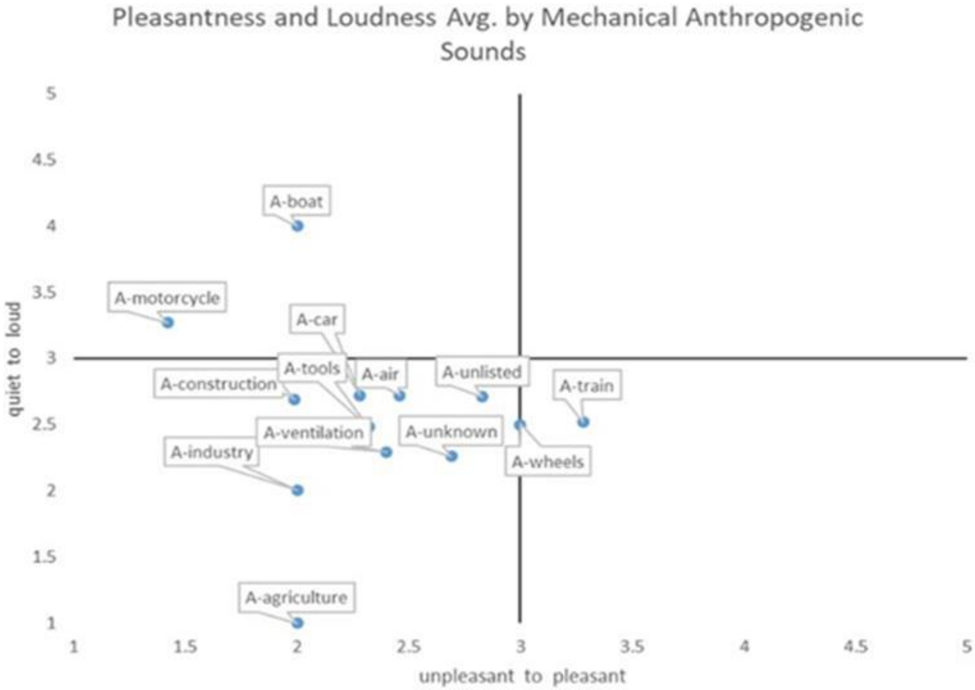

Figure 13: Average pleasantness and loudness ratings for anthropogenic mechanical sound sources. Most sounds were observed as being quiet but unpleasant.

Since low frequency sound is underweighted in traditional dB (A) metrics (Nelson, J.P. 2008), using this citizen science effort as a model for a larger sample population could expedite the identification of areas that are perceived as quiet and unpleasant with a particular emphasis on mechanical anthropogenic sounds that are primarily known to contribute to adverse health effects (Goines et al. 2007).

"I guess the urban noises we are accustomed to. The construction has been pretty irritatingly but understandably constant recently; the cars expected."

My research findings are consistent with previous research by Fiebig (2015) where he found that the perceptions of sounds include systems in which additional information is merged with what humans hear. I found trends revealing that the additional information Fiebig (2015) wrote about, that could influence perceptions, may arise from sociocultural place meanings which leads to place attachment. The participant quoted above seems to be understanding of the sounds of the urban environment especially that of cars which are said to be, 'expected'. Even though they are irritated by the sounds of construction, they are accustomed to it, and may even form place meanings associated with its prevalence because of their habituation. Even though the variable for property values was not found to be significant, interestingly, I did find that places with higher property values were likely to be louder. This could be due to the proximity to the city where housing is more expensive and there are more sound and noise generating activities occurring. This speaks to another paradox where even though loud dB(A) metrics exist in a location, and can cause many adverse health effects, the place is considered to be worth more than a quieter place located farther away from urban centers.

"It was wonderfully peaceful the first 7-8 minutes, before I heard a hammer, and buzzsaw in the distance-and then my neighbors A/C unit came on, making it impossible to hear all but the closest birds."

Future noise mitigation efforts can use the *Sound Around Town* framework to understand the perceived composition of particular soundscapes in urban areas. During a ten-minute listening session this participant commented on their soundscape being heavily dominated by anthropogenic mechanical sounds which disrupted their effect of peace and perception of faraway bird calls. Past studies have found that natural sounds can mitigate the presence of noise (Alvarsson et al., 2010; Bolin K e al. 2010). Creative noise mitigation efforts should incorporate biophilic design by integrating nature and natural elements, materials and forms into architecture and interiors. While the outdoor acoustic environment may be hazardous due to noise pollution, creating quiet indoor environments with natural features might alleviate its impact. Citizen science works in favor of involving the public in different aspects of research and should work towards more collaboration with designers and architects, especially within the field of Public Interest Design. These types of projects are defined as a participatory design practice that places emphasis on sustainable designs that include ecological, economic, and social issues. Providing spaces for participants to express their perception of sound gives researchers more opportunities to engage with the public's ideas and create noise mitigation designs that not only highlight natural features of an environment but also showcase unique socio-cultural meanings that residents value and wish to protect or display as part of these designs.

"The quality of man-made sounds (esp. that of tools and machines) is so harsh, so intrusive, and so homogenous compared to the sounds one encounters in nature. Nature provides much greater variety of stimulation, but it is not grating, and- if I but knew the language-seems to provide infinite information about the environment. Buzz saws and leaf blowers just make me want to run away"

Although the categories of sound types were not predictive of place attachment, it is noteworthy that on average all-natural sounds received higher pleasantness ratings (Table 5). On average, people heard roughly the same amount of natural sounds and anthropogenic mechanical sounds during a 10-minute listening session (Figure 14) further confirming the preference for natural sounds since they were always rated as more pleasant. This pattern supports research by Van Kamp et al. 2012 which found that people prefer nature sounds more than mechanical sounds. The perception of natural sounds as more pleasant has the potential to reinforce theories about humans and their inherent connection to the natural world asserted by the biophilia hypothesis (Kellert, and Wilson, 1993).

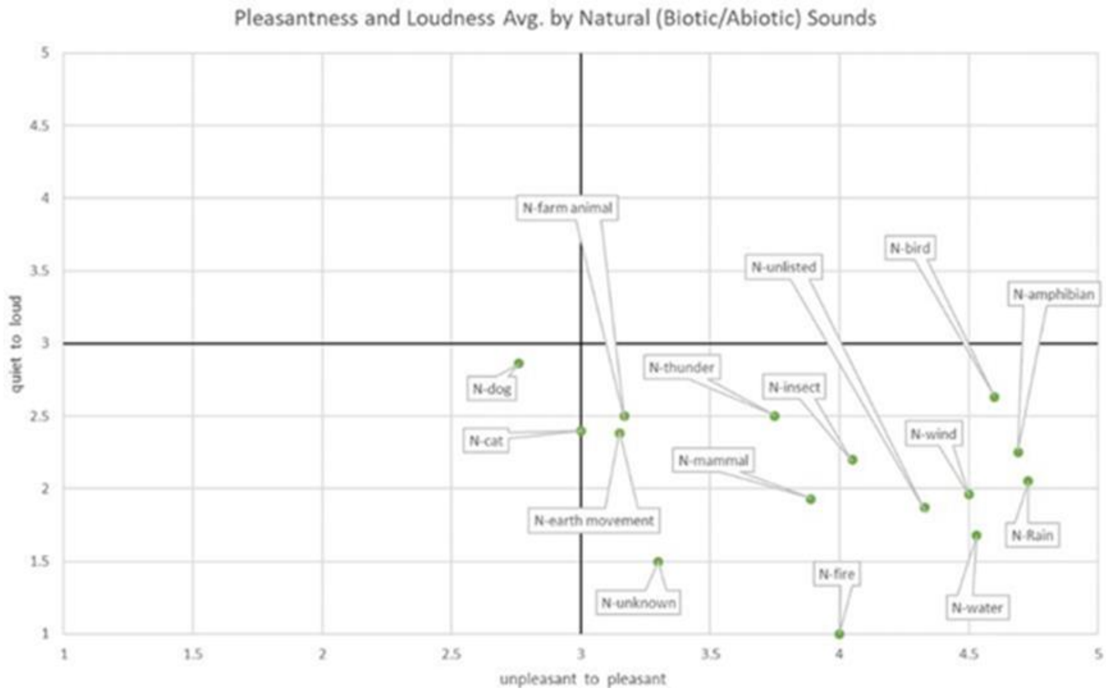

Figure 14: Average pleasantness and loudness ratings for natural sound sources. These sounds rated as being the most pleasant and quiet

6.1 Limitations

While there is a wealth of information that this research has provided, it is important to mention the challenges that were faced. For example, I have a small sample size due to recruiting difficulties and a limited timescale. Part of the small sample size was due to equipment management. Before I delivered the digital audio recorders at a site, the calibration process took 30 or more minutes per device with a limit of 9 devices. This hindered the amount of people who would receive a device as it was first come first served. In the beginning of the project, most of the participants self-selected into the study through scistarter.org and were already familiar with citizen science. I didn't start receiving large quantities of enrollments from a variety of people until the project was featured on National Public Radio special. When it came to recruiting minority groups, there were concerns about the third-party consent from neighbors, landlord disputes, and a generally apprehension for the recording device and the research itself all of which contribute to a non-representative sample population. Since the equipment was newly designed by NPS, the research team and I had to navigate battery life, weather, and the government shut down which slowed down the acoustic data analysis meant to ground-truth participants perceptions of their soundscape. Updating the typology was an on-going effort as the sound types became more convoluted. For example, ‘dog’ was perceived as being the most unpleasant of the natural sounds, in urban areas, it is questionable that dogs are a natural sound since they are owned by humans. In addition, ‘music’ might be considered a mechanical sound because it often comes from a radio or car but is listed under human, or anthropogenic non-mechanical sounds. I am still working to create a sound typology that represents multiple dimensions of the acoustic environment. Lastly, if this method of soundscape assessment is undertaken, rating sounds for pleasantness and loudness, a 10-point Likert scale is highly recommended to be used in place of my 5-point scale. The 5-point scale was not wide enough to capture all of the nuances that can be realized with a 10-point scale.

7. Future Research

Future research efforts hope to ultimately increase the sample size and promote *Sound Around Town* as a nationwide citizen science endeavor to reduce noise pollution and enhance soundscapes in the United States where, currently, there is limited regulation and reinforcement for noise pollution. This study can inform noise pollution policies by addressing low frequency noise, dB(A) metrics, and perceived annoyance. Policies may be created that incorporate perception-based reduction standards at local levels. Regulations for building and designing projects can be strengthened by requiring the use biophilic design principles especially for noise reduction. This can be done by utilizing natural barriers such as different tree species or creating habitat for animals for more natural and biodiverse sounds. In addition, the decibel dB (A) based metrics, acoustic data gathered on each site by the Digital Audio Recorders (DAR) will be analyzed in tandem with the individual perception of sound. This will provide a ground-truthing metric coupled with the perceptual measurement of sound that was analyzed in this study. More in-depth conclusions can then be drawn about the relationship between dB (A) noise, perceived noise, and preferred sounds that could mediate the stress response related to these. In the future, *Sound Around Town* will use smartphone technology to make a listening session web app designed with data automation, interactive data art, and ease of usability for the participant and researcher. The data about sound and noise gathered by citizen scientists at various spatial-temporal scales will be incorporated into sound maps created by NPS which have already begun to assess areas where there are higher levels of dB (A) measured noise pollution. These maps will inform city planners and designers to build more and better noise mitigation systems especially in underserved and vulnerable populations where there is a higher risk of disease related to noise pollution.

The *Sound Around Town* enrollment survey sought to capture a sample of people from vulnerable populations, however, our sample size was limited. Though this sample population was small, it was still important to look at participants who reported elderly people or children in the household particularly for the purpose of focusing on mechanical anthropogenic sounds sources that put these populations at a higher risk for disease. To that point, future research endeavors should work to prioritize marginalized populations and continue the research and environmental justice efforts begun by Casey et al. (2017) by pairing the disparities found in the noise pollution and socioeconomic gradient in his study, with the perceptual component of soundscape studies. Combining the two methods could allow for a wider range of perspectives for various soundscapes and aid in more holistic approaches for noise pollution remediation.

The online survey included items that asked about length of residence, although this wasn’t incorporated into our current analysis for predicting place attachment, with most of our participants having lived in their ‘place’ for 10 or more years, this is an important metric for future research. To see what affect, if any, length of residency has on place attachment.

The preliminary findings of this study support this citizen science effort in aspirations of forging many interdisciplinary perspectives on how to connect to, and manage, the outdoor acoustic environment. While these findings support the composite dimensions of soundscape research, they also have the potential to be of service to future noise studies especially regarding the occurrence of low frequency noise. Valuing outdoor acoustics asserts sound as a natural resource with ecosystem services that require more research in order to raise awareness about the complex interactions that sound, and noise can bring to the many facets of our lives.

8. Conclusion

This study utilizes people’s observations to explore the spatial and temporal perceptions of sound and noise. *Sound Around Town* engages volunteers with the acoustic environment facilitating real-time auditory identification of the types of sounds present, as well as their judgements about the pleasantness and loudness of each type of sound they hear. In this way, the project combines the decibel-based approach and perception-based approach with sense of place theory to understand the noise paradox, explaining how a diversity of people are perceiving their soundscape and the extent to which it is an asset or an annoyance.

The *Sound Around Town* research effort is a mentored contributory style citizen science project where the participants were able to meet people from the researcher team providing another unique aspect of people-to-place interaction to enhance the experience of the participant. Outcomes created involved various levels of impact for both the research team and participants of the project. For the researchers, the project questions how sense of place theory fills in the gap for how different levels of annoyance vary with decibel levels which has been researched and documented as the Schultz curve. For participants, the intended outcomes included motivation to participate in future citizen science projects, raising awareness about noise pollution, and increased appreciation for the natural soundscape through an outdoor listening activity that mirrors the observation of ecological phenomena common in other citizen science projects.

Ultimately, my results supported our assumption of the noise paradox because the perception of quietness, rather than the origin of the sound, in addition to sociocultural place meaning, led to stronger place attachment. Emphasizing the value of people-place interactions in sound studies intends to facilitate stronger connections to the outdoor environment that are specific to place. If people become more attached to a place, they may be more inclined to protect that place (Halpenny, 2010). Haywood (2013) argues that sense of place influences outcomes and outcomes influence sense of place in a continuous feedback loop that can potentially promote the benefits of citizen science such as enhanced science knowledge and literacy (Krasny and Bonney 2005), empowerment (Lawrence 2006), and the facilitation in changes of values, attitudes, norms, and beliefs (Danielson et al. 2005) - all of which are potential motivators for mobilization resulting in noise mitigation efforts in urban areas.

Other potential applications for this type of soundscape work could be in outdoor recreational areas such as city parks, urban squares, and wilderness and in residential areas like outdoor places, gardens where high quality sound is desired. This may involve strategic planning and design that improves ecological health and biodiversity, ultimately yielding psychological benefits for both human and non-human species. (Fuller, Irvine et al. 2007). Citizen science efforts such as *Sound Around Town* could help managers achieve those goals such as these.

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APPENDICES

APPENDIX A

Sound Around Town is a citizen science project aimed at documenting sound
primary volunteer research activities involve borrowing specialized equipmer
soundscapes around one's home, and answering a questionnaire about natur
The National Park Service will use the recordings to measure noise levels and
(https://www.nps.gov/subjects/sound/index.htm).

NCSU researchers will use the average noise levels for each site to map dispa
neighborhoods in Raleigh.

By participating in Sound Around Town, you are consenting to:

(1) Be publicly acknowledged for your participation, such as we can list y
website and in the acknowledgements section of scientific publicatio
are hosting a recording device. Note that if a neighbor objects to the
neighborhood, then you can only participate in the online survey and
(2) Have local scientists deliver the audio and (optional) air quality devic
for 2 weeks. We will provide you with information about how to turn
(3) Answer questions about sounds you hear on your property using pap
listening sessions, taking about 10 minutes each. Listening sessions ir
completing the questionnaire by noting the sounds you hear and hov
(4) Have a local scientist pick up the recording devices.

Based on volume of participant interest, you will be included in the study in t

For two weeks, this study will record sounds on your property which can incl
properties and potentially further away. No human ear will listen to the recor
computer software to estimate the volume of sound in the area. The comput
recordings. All recordings will be deleted once analysis is complete. We will p
analyses. You can also turn off the recording device at any time. All data are s
available. Project data are encrypted and stored on secure hard drives access

There is no compensation for participating. The benefits of participating are l
soundscape compares to others in your city, as well as how your city compare
scientists understand how soundscapes impact people and wildlife.

If you have questions about the research, please email Dr. Caren Cooper at s

If you feel your rights as a citizen scientist in Sound Around Town have been
contact Jennifer Ofstein, Regulatory Compliance Administrator, Box 7514, NC
irb-director@ncsu.edu.

Click yes to participate in this study

Click no if you do not want to participate in this study

Hello! We are a research team from NC State, the Museum of Natural Science, and the National Park Service. With the help of neighborhood volunteers, we are documenting soundscapes and their effect on people. Your neighbor

Caren Cooper

418 Frank St

has signed up to volunteer their yard to host an audio device for two weeks:

Aug 15 - Aug 29.

Learn more at https://soundaroundtown.org.

We are letting you know because the device could record sounds from your property and surrounding areas. The audio recordings are processed through computer software to estimate the volume of sound in the area. The computer cannot extract words or speech from recordings. Nevertheless, if you feel uncomfortable, have questions, or want to volunteer please contact the head researchers Dr. Caren Cooper at soundaroundtown@ncsu.edu.

Museum of Natural Sciences

Consent and Third-Party Notice: The Volunteers consented online while registering for the project on SciStarter.org. To obtain third party consent we placed door hanger shown on the right three or more days prior to each deployment of the Digital Audio Recorder (DAR) on site

APPENDIX B

Two examples messages for *Sound Around Town* on SciStarter.org

1. ***Scheduling your deployment: Only 3 Devices left for the month of December!***

Thank you for your interest in *Sound Around Town.* If you are still interested in participating. Please send me an email at soundaroundtown@ncsu.edu and let us know your name, Sci-starter ID, address and how to best schedule a time to visit you to deploy a recording device.

We can schedule via emails (soundaroundtown@ncsu.edu) or by text (770-500-4515).

2. ***Scheduling your deployment: 6 Devices left for the month of January!***

Thank you for signing up *Sound Around Town*! Please send us an email at soundaroundtown@ncsu.edu and let us know your name, Sci-starter ID, address and how to best schedule a time to visit you to deploy a recording device. We can schedule via emails (soundaroundtown@ncsu.edu). I look forward to working with you

APPENDIX C

Digital Audio Recording (DAR) devices designed by NPS

Digital audio recorders (DAR) devices were designed and tested by National Park Service Natural Sounds and Night Skies Division. Devise telescoped out so that windscreens (PCB PIezotronics 079A06) were approximately 1.52 meters (60 inches) away from the ground for optimal acoustic recording. Researchers set out devices to be more than (a) more than 9 FT from building walls, fences, or similar objects; more than 3 FT from smaller objects such as trees, shrubs, and posts; more than 50 FT from the center of the nearest road lane; not near constant noise sources such as air conditioners; and not where free-roaming dogs, deer, and other wildlife will knock it over. When these standards could not be met in residential areas the team noted measured the distance and recorded them on the metadata sheet.

APPENDIX D

DAR and microphone calibration

This document describes a procedure for performing a calibration of microphone and digital audio recorder. This is a secondary calibration method in which the performance of the test microphone is compared to that of a reference microphone that has been calibrated by a primary method.

Environmental conditions

Ensure that calibration takes place in a quiet place. Avoid any ambient noise, HVAC, voices, etc. In the event of unexpected interference, recordings can be deleted and redone as necessary.

- Record the temperature and relative humidity.

Playback recorder

The playback recorder is a second R05, not the one being tested.

- Insert batteries and SD card with calibration signal ('golayCode_2x16_1s_s05.wav')
- MENU > 2 Player Setup > Play Mode: SINGLE
- MENU > 2 Player Setup > Repeat: OFF
- Press VOL+ to set playback volume to 60.
- Ensure that REVERB and SPEED are off.
- Plug the TRS cable from the calibration device into PHONES jack.

Test recorder

Microphones will be calibrated with the associated recorder (labeled by number). Most settings will remain equivalent to those used during typical deployment, but "Rec Mode" and "Plug-in Power" must be adjusted for calibration. Also check mic bias. The mic bias setting should stick even if the R05 loses power, but good to check during calibration (better to not have participants access this given the chance someone inadvertently changes something else).

- MENU > Recorder Setup > Rec Mode: WAV-16bit
- MENU > Input Setup > Plug-in Power: OFF
- Press and hold "A<>B SPLIT", then press "MENU". Scroll down to "8 Special Setup". Scroll down about halfway to "Mic Bias", set to "*1.20". Everything else remains unchanged.

LD824 setup

- Turn on the LD824. Use the "check" button to accept any messages.
- Connect the 7 pin LEMO cable to the LD824. Connect the LD824 microphone to the 7 pin LEMO cable. Plug the TRS cable from the LD824 to the MIC input of the test recorder.

Record calibration signals

Record calibration tone

- Insert the LD824 microphone into the B&K calibrator.
- Press record on the R05. Check that the record level is set to 40.
- Turn on the calibrator. Check that a constant signal at about -15dB is present on the left channel of the R05.
- Press record again. After 3 seconds, press record to stop the recording.
- Turn off the calibrator.

Record reference signal

- Insert the LD824 microphone into the cal tube. The microphone needs to be inserted exactly 1 inch only, the tape is there to help guide this. Support the microphone so that it is perpendicular to the cal tube, check to ensure that the microphone is square to both dimensions.
- Press the << button on the playback recorder to reset the file to 00:00:00.
- Press record on the test R05 twice to arm the recorder and begin recording. Immediately press play on the playback recorder.
- One second after the signal has ended, press stop on the test R05.

Record test signals

- On the test recorder, navigate to MENU > Input Setup > Plug-in Power: ON
- Plug the left mic TRS cable into the left (white) stereo jack. Remove the cable plugged into the right (red) jack.
- Insert the left microphone into the cal tube. The microphone needs to be inserted exactly 1 inch only. This is roughly up to the 'collar' of the microphone housing. Support the microphone so that it is perpendicular to the cal tube, check to ensure that the microphone is square to both dimensions.
- Press the << button on the playback recorder to reset the file to 00:00:00.
- Press record on the test R05 twice to arm the recorder and begin recording. Immediately press play on the playback recorder.
- One second after the signal has ended recorded, press stop on the test R05.
- Repeat for the right mic. This mic will also use the left (white) stereo jack.

Record second reference signal

- Turn off plug-in power on the test recorder. MENU > Input Setup > Plug-in Power: OFF
- Plug the TRS cable from the LD824 to the MIC input of the test recorder.
- Insert the LD824 microphone into the cal tube. The microphone needs to be inserted exactly 1 inch only, the tape is there to help guide this. Support the microphone so that it is perpendicular to the cal tube, check both dimensions and ensure that the microphone is square.
- Press the << button on the playback recorder to reset the file to 00:00:00.
- Press record on the test R05 twice to arm the recorder and begin recording. Immediately press play on the playback recorder.
- One second after the signal has ended, press stop on the test recorder.

Closing

- Record the temperature and relative humidity.
- Press and hold the power button to turn off the LD824.
- Change the settings on the test R05 back for deployment.
  - MENU > Input Setup > Plug-in Power: ON
  - MENU > Recorder Setup > Rec Mode: MP3-192kbps.
  - Check other settings as necessary.
- Rename the 5 files on the test recorder according to the following format, where 'rx' refers to the recorder unit number (e.g. 'r1') and YYYYMMDD is the date of the calibration.
  - rX_calTone_YYYYMMDD
  - rx_ref_YYYYMMDD
  - rx_left_YYYYMMDD
  - rx_right_YYYYMMDD
  - rx_ref2_YYYYMMDD

Calibration protocol
Calibration protocol created by NPS. This calibration was always done in a quiet room to avoid recording tones from ambient sound sources such as AC units, people talking, computers, cell phones etc.

Materials used for calibration were (pictured from left to right) LD824 mic, Digital Audio Recorder (DAR) pictured outside of its protective casing, an SD card with a standard pitch (inside of DAR), and B&K calibrator also used to create another standard pitch. The LD824 mic and the mic for the DAR were both inserted exactly 1” into the calibration tube and ultimately created five references tones that the park service would use in their algorithm to establish the dB(A) recorded at each site. This procedure was done before each deployment to capture any changes in the microphones on the DAR from wear and tear due to exposure to the elements and standard use.

Calibration procedure and materials

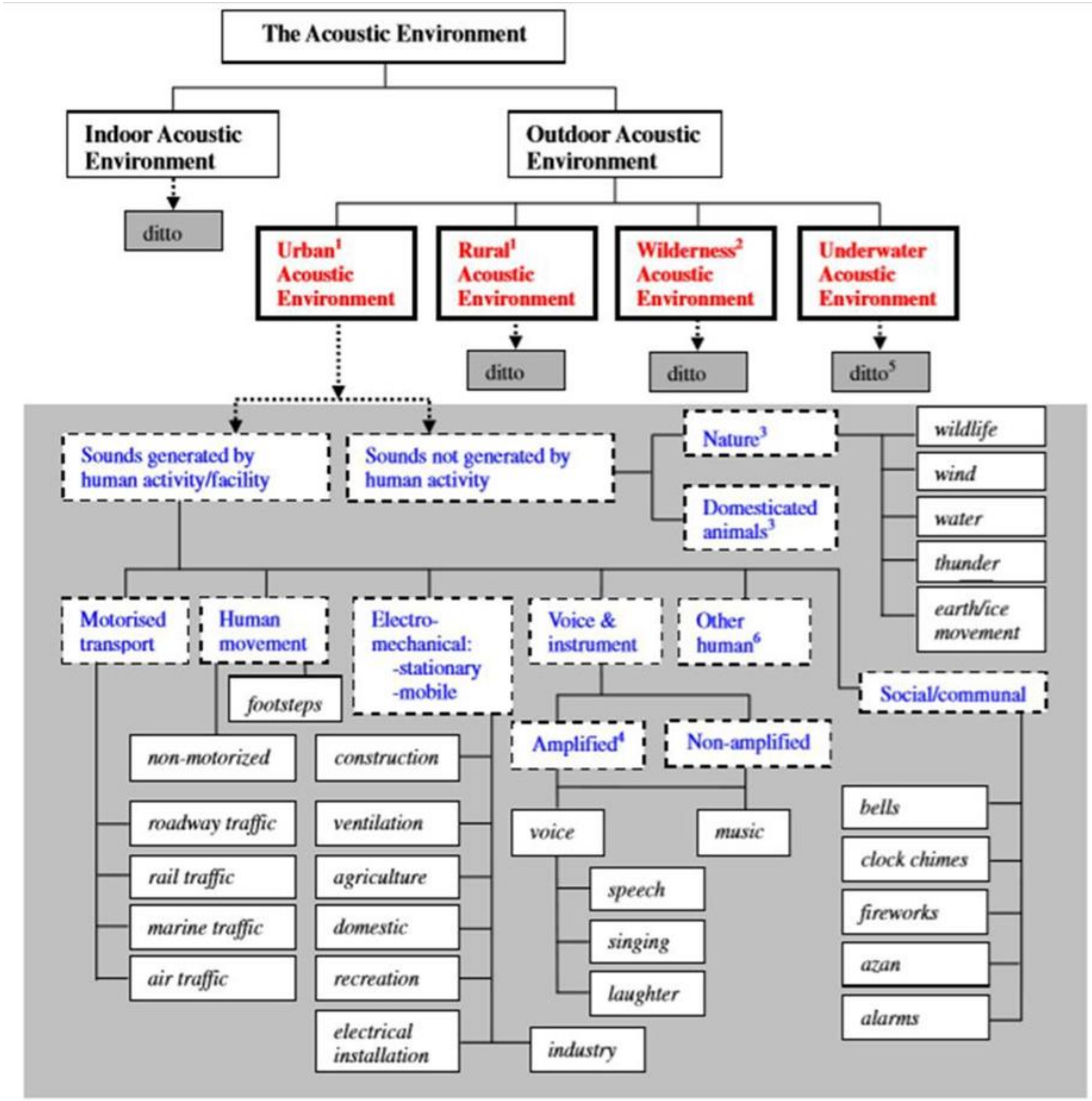
APPENDIX E

Sound Around Town Data Sheet

Name: Alan Hoyle	Sci-Starter ID: 57450
Street: 115 Autumn Ln	
City: Chapel Hill	State: NC
Zip: 27516	
Equipment Number: 2	Site ID: SA57450
Start Date: YYYY-MM-DD 2019-01-31	Start Time: 24-Hour Time 9:21
Ground Cover: ☑ Soft e.g. Dirt/Grass	☐ Hard e.g. Concrete/Wood
Distance To Nearest Wall: Feet/Inches 42ft. 6in (front pic)	
Description Of Site: Describe Where The Equipment Is In Your Yard NW 318° road adjacent to backyard Surrounded by trees ground covered in leaves	
End Date: YYYY-MM-DD 2019-02-06	End Time: 24-Hour Time 15:33
Other: Optional (e.g. Equipment Problems, Construction, Near AC Unit, etc.) Back pic 26 ft	
GPS Coordinates: Museum Use Only 35.964690, -79.064670	

Example Metadata Sheet: Metadata sheets were used at each deployment site. The NPS use the distances recorded, GPS location, and time/date (to approximate weather and wind) on this sheet in their algorithm in order calculate the acoustic levels recorded on the Digital Audio Recorder (DAR).

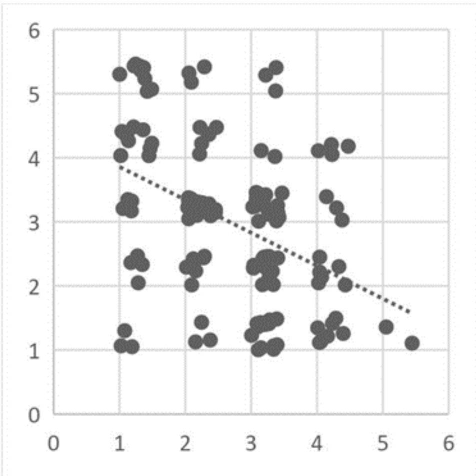
APPENDIX F



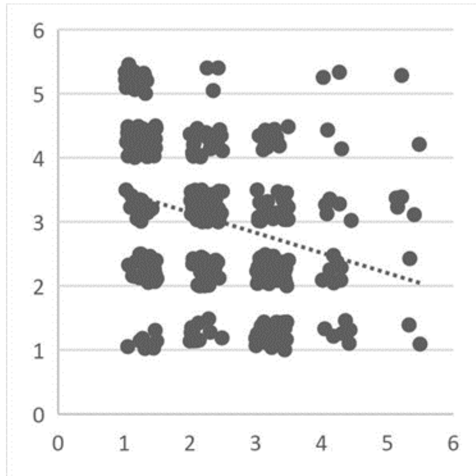
Original Brown et al. 2011 Typology for reference

APPENDIX G

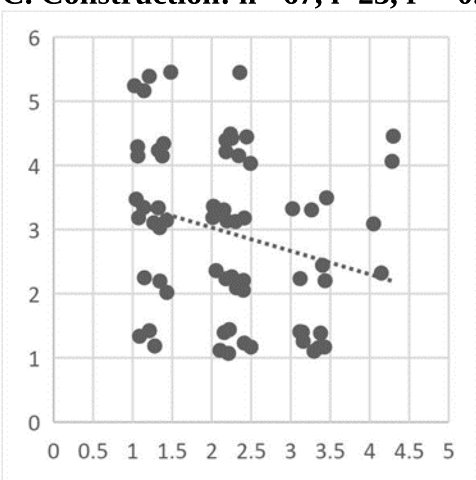
A. Airplane: n =141, i=47,
r= -0.4; p < .0001



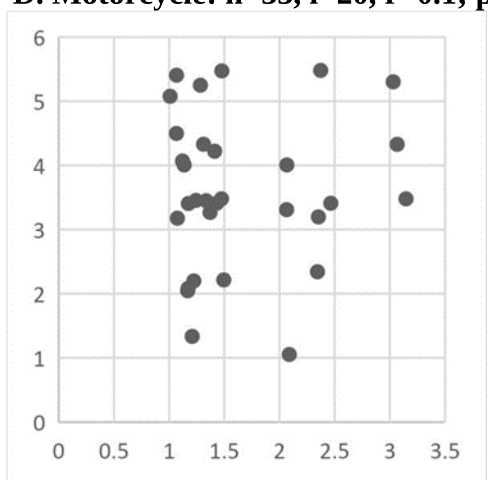
B. Car: n= 345, i=55, r= -0.3; p <.0001



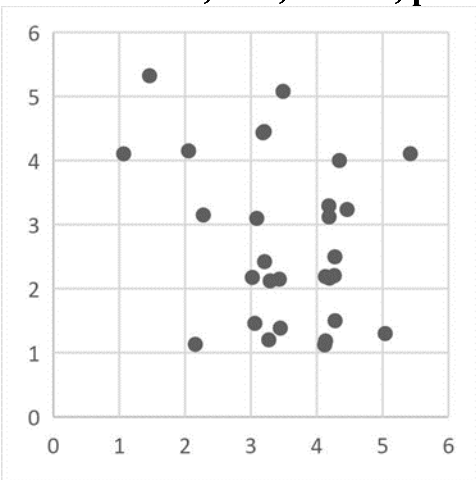
C. Construction: n= 67, i=23, r= -0.3; p= 0.03



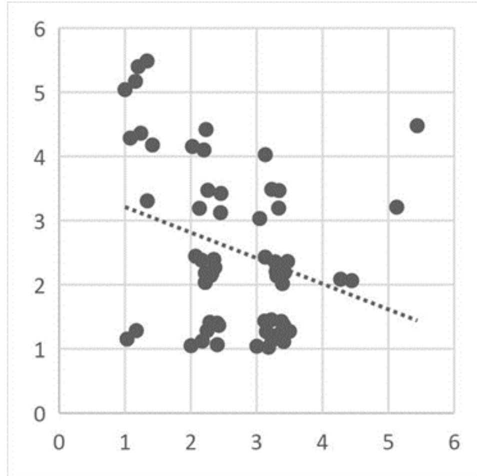
D. Motorcycle: n=33, i=20, r=0.1; p=0.68



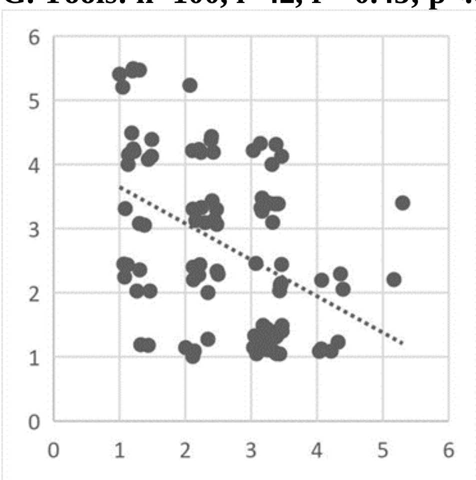
E. Train: n=29, i=17, r=-0.45; p=0.08



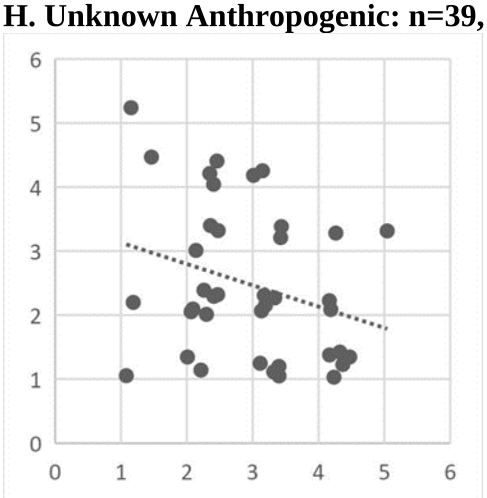
F. Ventilation: n=63, i=29, r=0.27; p=0.04



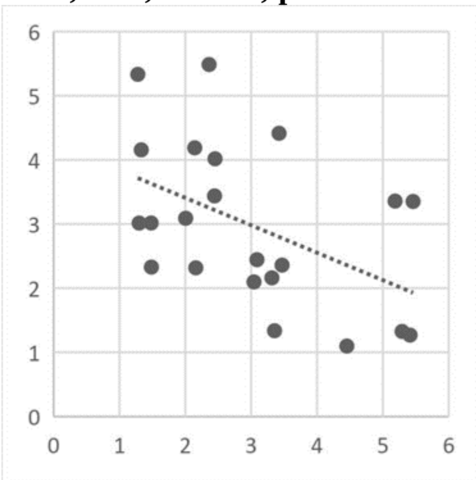
G. Tools: n=100, i=42, r=-0.45; p<.0001



H. Unknown Anthropogenic: n=39, i=21, r=0.34; p=0.04

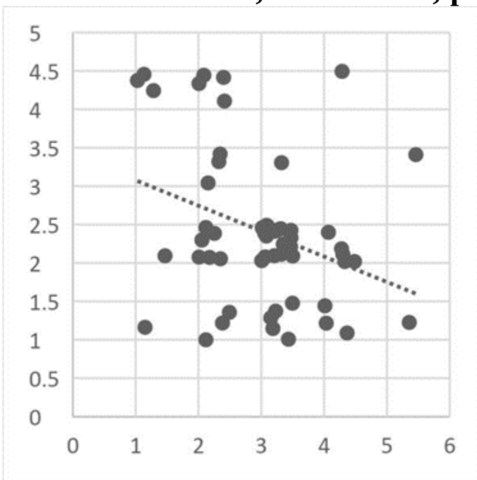


I. Unlisted Anthropogenic:
n=24, i=12, r=-0.52; p=0.013

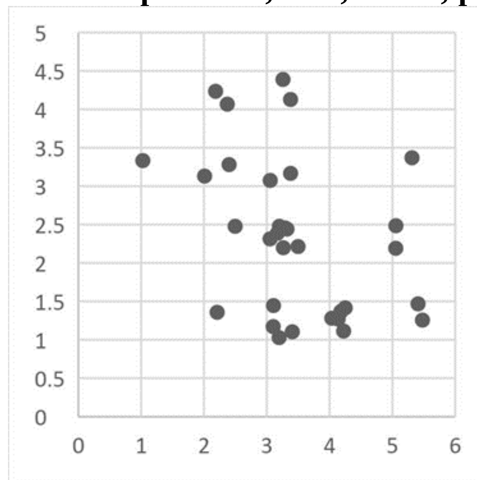


APPENDIX H

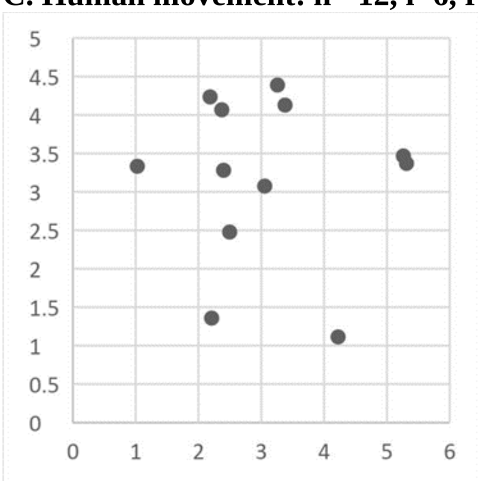
A. Domestic: n=55; i=23 r= -0.4; p= 0.003



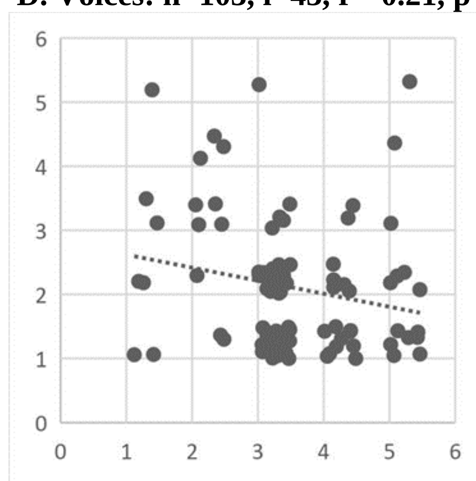
B. Footsteps: n= 32, i=19, r=-0.3; p=0.145



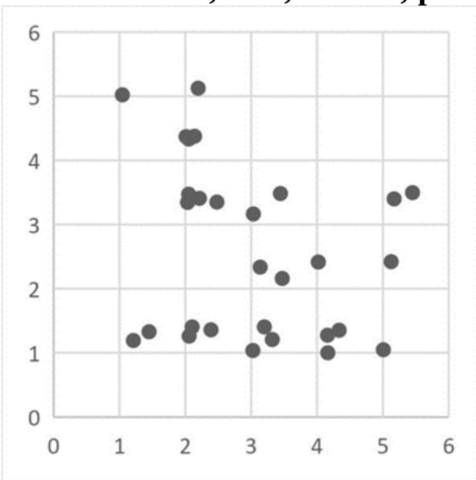
C. Human movement: n= 12, i=6, r=-0.08; p=0.81



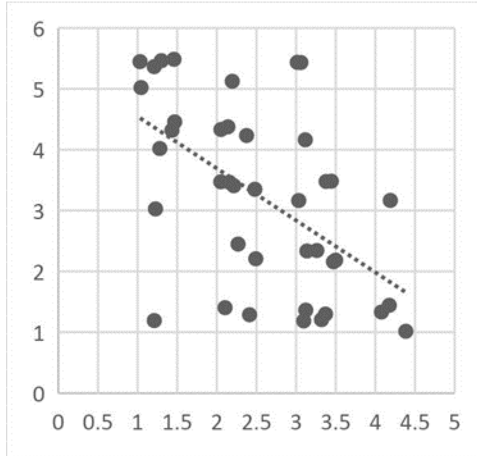
D. Voices: n=103, i=43, r=-0.21, p=0.04



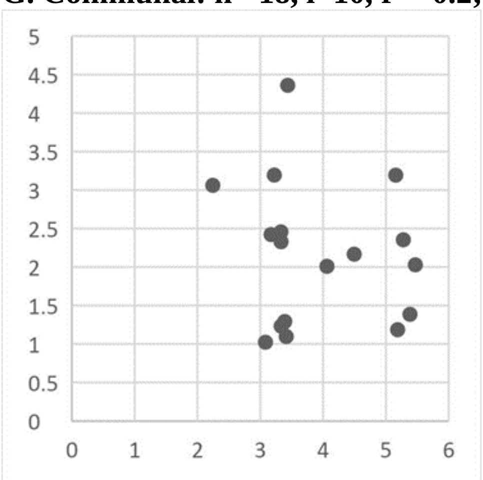
E. Music: n=29, i=20, r=-0.15; p=0.44



F. Siren/Alarm n=41, i= 21, r=-0.50; p =0.002

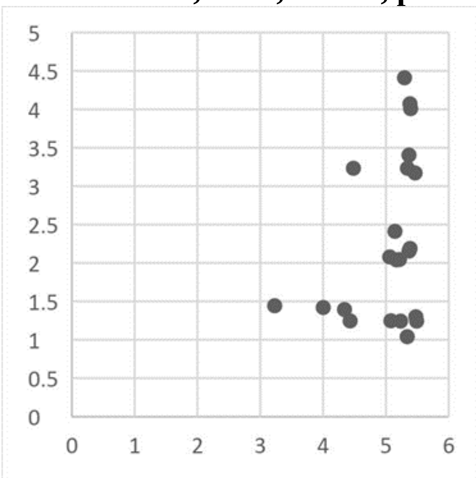


G. Communal: n= 18, i=10, r= -0.2; p=0.53

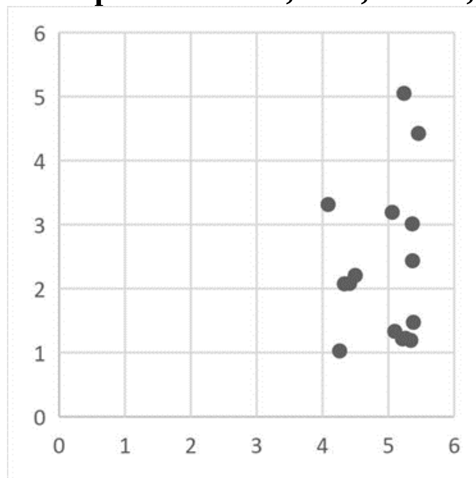


APPENDIX I

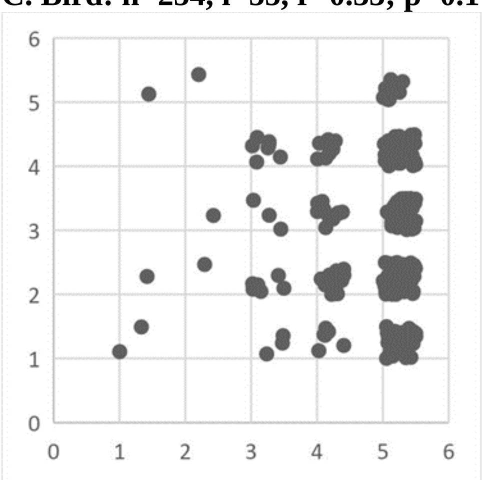
A. Rain: n=22, i= 15, r=0.33, p=0.17



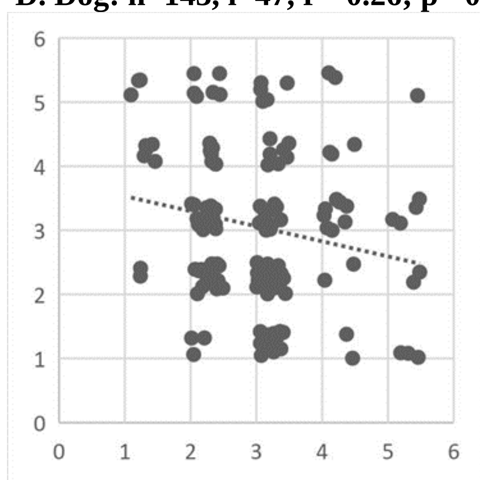
B. Amphibian: n=16, i=10, r=0.04; p=0.88



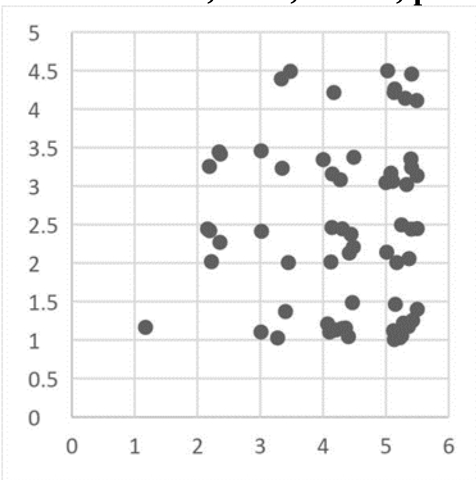
C. Bird: n=254, i=55, r=0.33; p=0.17



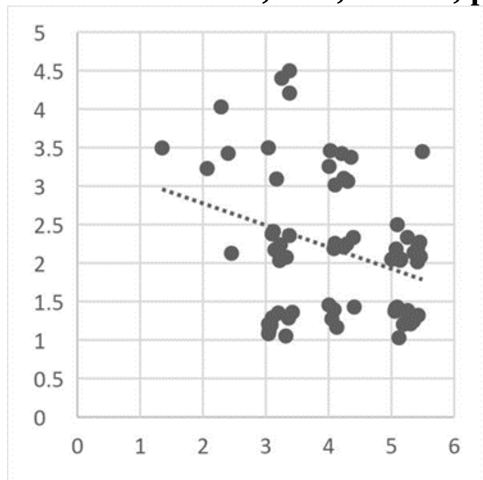
D. Dog: n=143, i=47, r=-0.26; p= 0.002



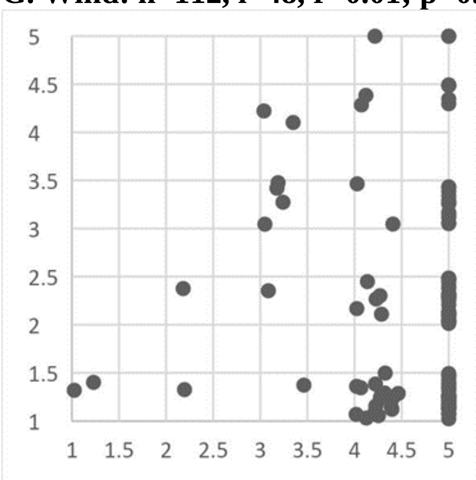
E. Insect: n=64, i= 27, r=0.01; p=0.94



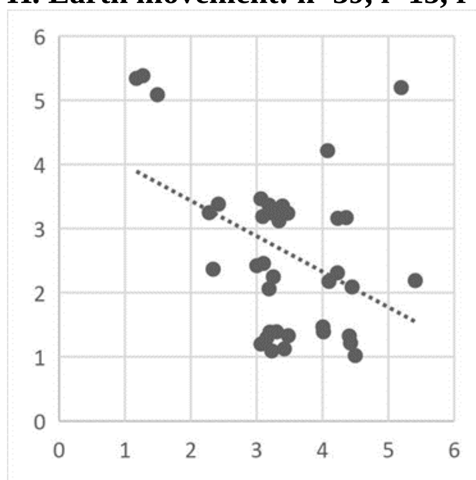
F. Mammal: n=70, i=33, r=-0.35; p=0.004



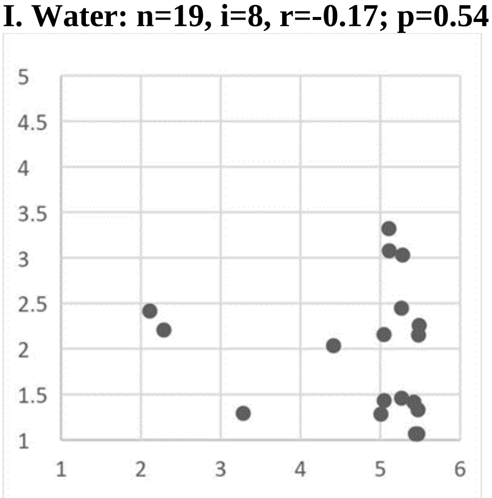
G. Wind: n=112, i=48, r=0.01; p=0.88



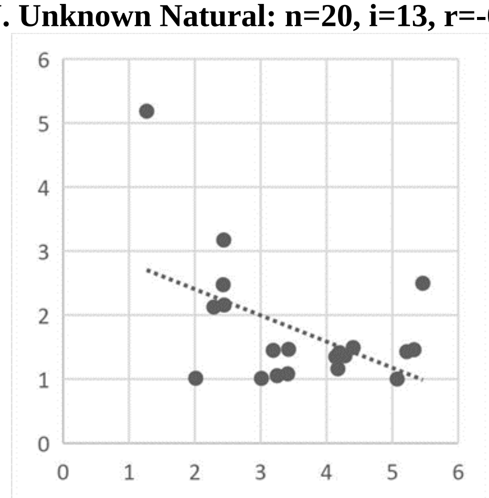
H. Earth movement: n=39, i=15, r=-0.39; p=0.01



I. Water: n=19, i=8, r=-0.17; p=0.54



J. Unknown Natural: n=20, i=13, r=-0.60; p=0.005



K. Unlisted Natural: n=15, i=8, r=0.01; p=0.76