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THE INFLUENCE OF NATURAL SOUNDS ON ATTENTION RESTORATION

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by

Lauren C. Abbott

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The thesis of Lauren C. Abbott was reviewed and approved* by the following:

Peter Newman
Professor of Recreation, Park and Tourism Management
Thesis Advisor
Head of the Recreation, Park and Tourism Management Department

Derrick Taff
Assistant Professor of Recreation, Park and Tourism Management
Thesis Advisor

Jake Benfield
Assistant Professor of Psychology

Andrew Mowen
Associate Professor of Recreation, Park and Tourism Management

Deborah Kerstetter
Professor of Recreation, Park and Tourism Management
Chair of Graduate Program

*Signatures are on file in the Graduate School.

Abstract

The evolution of internet, smartphones and tablets allow us to constantly be connected with work, friends, family, etc. The distractions of these technologies, along with a longer work week and little time for rest and relaxation, can cause mental fatigue. Mental fatigue is related to difficulty focusing and even feelings of irritability. Parks and protected areas offer a place of refuge. An existing body of literature shows being in nature can relieve stress and improve overall health and wellbeing. Research indicates that experiencing the restorative sounds of nature is an important reason for visiting national parks, and despite the growing body of protected areas soundscape-focused research, very little attention has been placed on the relationship between natural sounds and human health. This lab study aims to increase understanding regarding the positive effects of natural sound on restoration based on Attention Restoration Theory (Kaplan, 1995). Built on previous research, the researcher predicted that natural sounds will promote restoration and improve cognitive processes, while anthropogenic sounds impede restoration. These results will provide a better understanding of how parks can serve holistically as places for human, environmental and ecological health, as specifically measured through the role of natural sounds on recovery from mental fatigue. In addition, gaining a better understanding of the benefits natural sounds can have on human restoration will further validate soundscape protection. Finally, this research will help park and protected area managers develop plans and policies that aim to provide visitors with a beneficial, restorative soundscape experience.

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Chapter 1
Introduction

Problem Statement

On a daily basis we are faced with as seemingly endless number of tasks: wake up, exercise, drive to work, write emails, attend meetings, schedule appointments, find time for friends and family etc. These tasks, along with the distraction of easy access to checking email and social media via smartphones and tablets, can leave us feeling both physically and mentally exhausted at the end of the day. According to Stephen Kaplan (1987), the mental fatigue that occurs from our busy lives can cause us to lose the ability to focus, control our emotions, and make clear decisions. This thesis will focus on the restorative potential of natural sounds and their ability to facilitate recovery from mental fatigue.

Societal Context

Americans are working longer hours (Hamermesh, & Stancanelli, 2014) and potentially missing out on taking the time to rest and recover from the mental fatigue that occurs in a long work day. Additionally, increased technology use is of concern; a study found that merely having a smartphone on participants' desks negatively influenced mental performance (Thorton, Faires, Robbins & Rollins, 2014). Another study found that increased mobile phone and internet use contributed to symptoms of prolonged stress in young adults (Tomée et al., 2007). With increasing distractions from technology and busy workdays, it's no surprise that people are having difficulty recovering from mental fatigue. However, restoring mental fatigue may be as easy as taking a walk outdoors, sitting in a garden, or opening the window to hear the sounds of nature (Berman, Jonides, & Kaplan, 2008; Hartig, Mang, & Evans, 1991; S. Kaplan & R. Kaplan, 1989; Kaplan, 1995; Payne 2007, 2013).

E.O. Wilson's (1984) biophilia hypothesis proposes that humans have an innate biological association to the natural world. Famous nature writers such as John Muir and Henry David Thoreau have expressed the value of nature in relation to healing the mind and body. In the last 30 years researchers have been studying the relationship between human health and nature. Researchers from the fields of environmental psychology, recreation, leisure studies, and social ecology have been exploring the influence of natural environments on restoration, defined as recovery from stress or mental fatigue. There is a rich collection of literature that finds natural environments to be a counter-balancing force to aid in restoration (Berman et al., 2008; Hartig, Mang, & Evans, 1991; S. Kaplan & R. Kaplan, 1989; Kaplan, 1995; Payne 2007, 2013; Ulrich, 1984; Ulrich, Simmons, Losito, Fiorito, Miles, & Zelson, 1991).

Theoretical Background

This paper will focus on Attention Restoration Theory (ART). ART was developed by the research team of Rachel Kaplan and Steven Kaplan (1989), who proposed that nature can provide a restorative environment. Here, restoration refers to a positive change in psychological processes and relief from mental fatigue (S. Kaplan & Talbot, 1983; Kaplan & Kaplan, 1989). This theory asserts that functioning in our daily lives requires directed attention, meaning that substantial effort is required to ignore distractions and focus on the task at hand. Sustained directed attention leads to cognitive depletion and mental fatigue (Kaplan & Kaplan, 1989).

ART is not the only theory that has been developed to explain the relationship between the natural environment and restoration. Stress Restoration Theory (SRT; Ulrich, 1984; Ulrich *et al.,* 1991) posits that natural environments can improve emotional and physiological measures that are negatively influenced by stress. Both theories agree on nature's restorative potential, but the differences lie in the measurement of restoration. While ART proposes a cognitive response,

SRT is more concerned with recovery from physical and emotional stress. For example, Ulrich (1984) studied patients recovering from surgery in a hospital's intensive care unit and found that patients with a natural view recovered at a faster rate than patients with a built view. He used SRT to justify his findings. Conversely, Berman, Jonides, and Kaplan (2008) used cognitive tasks to measure attention restoration (based on ART) in participants who had been mentally fatigued. They found that walking in a natural setting promoted restoration while walking in an urban setting did not. ART measures restoration from mental fatigue through cognition while SRT measures restoration from stress through reported emotions and physiological events.

Parks and Protected Areas as Restorative Environments

Protected areas, such as national parks, are examples of natural environments that can provide a restorative experience. Frederick Law Olmsted (1865), an advocate for the protection of land for public use, wrote on the value of nature and its ability to relieve us from the stresses of urban life. National parks can serve as places that protect ecosystems for the enjoyment of future generations, as well as, places that support mindful reflection and restoration. National parks provide a wide range of opportunities, such as active recreation or quiet contemplation. Enjoying sounds of nature and experiencing natural quiet are common motivations for visitors to these places (Driver, Nash, & Hass, 1978; McDonald, Baumgartner, & Iachan, 1995). As visitation to national parks increases, so does anthropogenic or man-made noise (National Park Service, 2006). As a result, the National Park Service (NPS) protects sound as a resource, similar to air, water, earth, etc. The NPS has an entire department devoted to this protection called The Natural Sounds and Night Skies Division. The goal of managers is to preserve soundscapes, defined as "the human perception of physical sound sources (natural and cultural)", and manage noise within parks (NPS, 2000). Noise can be difficult to define, but in this thesis it refers to

unpleasant sounds. Acceptable levels of anthropogenic sounds are being identified and mitigated so that natural sounds are not compromised for both park visitors and wildlife (Brown, Hardy, Barber, Fristrup, Crooks, & Angeloni, 2012; Parris, Velik-lord, & North, 2009).

There is substantial evidence that viewing natural environments promotes restoration, but less is known about the effects of natural sound on restoration (Berto, 2005; Felsten, 2009; Hartig et al., 1991; Hartig et al., 2003; S. Kaplan & Talbot, 1983; Kaplan & Kaplan, 1989; Tennessen & Cimprich, 1995). Researchers are beginning to explore the relationship between natural sound and restoration (Benfield, Taff, Newman, and Smyth, 2014; Payne 2007, 2011; Ratcliffe, Gatersleben, & Sowden, 2013). Additionally, researchers in parks and protected area management field are interested in understanding the benefits of natural sounds to humans, so they can better understand the importance of protecting the acoustic environment. The goal of this thesis is to understand the influence of natural sounds on restoration, loosely based on ART. The following thesis is organized by first reviewing the existing literature related to restoration and sound. Research questions are then presented, as well as, a case study used to answer those research questions.

Chapter 2
Literature Review

The aim of this literature review is to provide evidence that supports the need to examine the relationship between natural sounds and restoration. Past studies are used to explain how natural settings and sounds facilitate a restorative experience.

Human Health and Nature

Journalist Richard Louv (2005), who coined the term, "nature-deficit disorder", argues that as a society, Americans are becoming gradually removed from the natural world. Today's children spend less time playing outside in natural settings and more time playing video games, watching television, and participating in structured after school activities. It's not just children; adults are overworked and overstressed which makes spending time outdoors a less pressing priority.

There is a diverse body of literature illustrating positive effects natural environments can have on human health and wellbeing. Japanese researchers Park, Tsunetsugu, Kasetani, Kagawa, and Miyazaki (2008) studied the physiological effects of *Shinrin-yoku,* defined as taking in the forest atmosphere or forest bathing. Cortisol, blood pressure, pulse rate, and heart rate variability were measured during and after participants walked in either a natural or city area. Results determined that participants who walked in more natural settings had improved physiological indicators of stress (lower concentrations of cortisol, lower pulse rate, and lower blood pressure) than those that walked in the city. Park et al. (2009) concluded that these results could be a justification for using forest bathing as preventative medicine.

Kuo and Taylor (2004) found that spending time in natural environments can greatly reduce symptoms of attention-deficit/hyperactivity disorder (ADHD) in children. Parents of

these children perceived improvements in ADHD after the child spent time doing an activity in a natural environment rather than activities done in other settings, such as an indoor gym. Ulrich (1984) compared the recovery rate of surgical patients and found that those who recovered in a room with a natural view had shorter hospital stays than those without a natural view. Moreover, patients with a natural view reported having better attitudes and needed less pain medication than patients who didn't have a window with a natural view. Nature has positive benefits on human health, whether it's a view of a natural setting or physically being in nature.

Attention Restoration Theory

As mentioned earlier, two separate theories have been used to measure restoration: ART and SRT. Both theories agree on nature's restorative potential, but the differences lie in the human response to the environment. ART is measured by one's ability to recover from mental fatigue. Conversely, SRT measures recovery from stress through reported emotion and physiological measures of stress reduction, such as heart rate or skin conductance. The focus of this thesis is to understand the influence of natural sounds on restoration based on ART. The researcher chose to measure restoration using ART as a theoretical base rather than SRT because of the existing literature that successfully measures restoration with the application of ART. For example, Hartig et al. (1991) studied restoration based on measures from both ART and SRT. The study was able to successfully measure components of ART, while the physiological measures related to SRT were not significant.

Background. The exploration of the relationship between nature and restoration stems from early literature on the motivations of outdoor recreationists. The majority of visitors to protected areas report they are seeking restorative experiences, such as "getting away" or a

"change and a rest" (Driver & Knopf, 1976; Driver, Nash and Hass, 1972). Stephen Kaplan's extensive research on extended wilderness trips as restorative experiences led to the development of ART and its relationship to nature. Over a period spanning 10 years, Rachel and Stephen Kaplan (1989), assessed the experiences of high school students in an outdoor challenge program, a one and half to two week long physically challenging backpacking trip through a Michigan wilderness area. The study utilized both qualitative and quantitative data collection techniques, along with measuring cognitive and affective changes in participants. Program participants reported having improved attitudes and self-esteem during the trip and six months after the trip. These results were strengthened by journal entries written by participants (S. Kaplan & Talbot, 1983).

According to ART restoration refers to a positive change in psychological processes and relief from mental fatigue (S. Kaplan & Talbot, 1983; Kaplan & Kaplan, 1989). This theory is built on the idea that functioning in our daily lives requires directed attention and substantial effort is required to ignore distractions and focus on the task at hand. ART proposes that in order to an environment to facilitate recovery from mental fatigue, it needs to be comprised of these 4 components: fascination, being away, extent and compatibility. Below each component is defined and examples are provided.

Components of ART. ***(1)*** *Fascination* is the opposite of directed attention, the catalyst for mental fatigue. Thus, fascination is critical to attention restoration. The early stages of theory development were based on past research providing evidence for splitting attention into two mechanisms: voluntary and involuntary attention (James, 1892). Voluntary attention or directed attention is described as requiring effort to eliminate outside stimuli. Conversely, involuntary attention is triggered by fundamentally captivating stimuli. Stephen Kaplan refers to this as

fascination (1989). For example, an individual who loves animals might find that reading a book on their favorite animal requires involuntary attention or no effort because this is an interesting topic, but reading a textbook on a less stimulating subject, requires directed attention. When fascination or involuntary attention occurs, there is potential for recovery from mental fatigue. Therefore, a component of a restorative environment is its ability to elicit fascination.

(2) *Being away* refers to more than just physically escaping from an environment to one that is more restorative. The sense of being away is also a state of mind. For example, if an individual were to drive from the city to a wilderness area, but still be entrenched in thoughts about daily life in the city, they are less likely to experience restoration. Being away involves a theoretical escape rather than a concrete transformation from one setting to another.

(3) *Extent* is another component required for a restorative environment. It should elicit "the sense that the immediate setting is part of some larger place or whole" (Hartig et al., 1991, p. 6). The environment must be engaging and enriching enough to capture one's complete attention. Large national parks or wilderness areas are places where it is easy to feel a sense of connectedness with a larger world. Stephen Kaplan (1995) uses Japanese gardens and historic artifacts as example for how one can conceptually experience a feeling of being connected to a larger world, without being in a large wilderness space.

(4) *Compatibility*, the final component, refers to the relationship between the individual and the environment. For a setting to be restorative, one should be able to accomplish their purpose in the given setting. For example, people who enjoy gardening, hunting, cycling or bird watching would all find compatibility with the natural environment. On the contrary, an individual who doesn't want anything to do with being outdoors, would not find a natural setting to be compatible.

Application of ART. Researchers have utilized a variety of methods for measuring the influence of natural environments on restoration including the perceived restoration scale and cognitive tasks. The following sections further describe these measures and use previous studies as examples. The purpose of this section is to demonstrate how earlier studies have measured restoration.

Perceived Restoration Scale. The perceived restoration scale or PRS was first developed by Hartig et al. (1991). The aim of PRS, is to measure an individuals' perception of the restorative qualities of an environment based on ART's four components: fascination, being away, extent, and compatibility. For example, fascination is measured by asking the participant to rate on a 5 point Likert scale how much they agree or disagree with the following statement: "My attention was drawn to many interesting things during my time in the setting" (Hartig et al., 1991, p.17).

The 20-item PRS was developed as part of Hartig et al.'s, (1991) study that used two different procedures and various measures to explore the restorative potential of the natural environment based on both ART and SRT. PRS was used to test the difference in restoration between participants who went on a walk in a natural setting vs. those who walked in an urban setting. Analysis of PRS found that participants who walked in the natural setting reported higher agreement with the four components of ART than those who walked in the urban setting. The findings from his study revealed a high internal consistency within PRS and that it was effective in measuring self-reported restoration based on ART.

The four components of ART have been analyzed beyond Hartig et al.'s (1991) initial development of the PRS. Laumann et al. (2001), tested the effectiveness of PRS in measuring study participants' evaluation of natural and urban landscapes. The research found a positive

correlation between ART and rating scales used to measure all four components of restoration. Consistent with other research (Hartig et al., 1991; Herzog, Maguire, & Nebel, 2003), natural environments were perceived as being more restorative than urban environments.

Cognition. As mentioned above, the PRS was used to measure participants' self-reported perception of restoration. Studies have also used cognitive tasks to measure the restorative qualities of natural settings. Rather than measuring the four individual components of ART, directed attention based on recovery from mental fatigue is measured. According to Berman et al. (2008), "ART identifies directed attention as the cognitive mechanism that is restored by interactions with nature" (p.1207). If participants are mentally depleted, restoration can be understood by their capacity to direct attention, measured by their ability to complete a cognitive task.

As mentioned earlier, Hartig et al., (1991) utilized different methods to measure restoration. Before this study, the existing research on ART had used self-reported measures in the form of qualitative data to demonstrate ART. While the researchers used PRS to measure self-reported restoration, they also used cognitive tasks to measure attention restoration. The study used different types of vacationers (wilderness backpackers, non-wilderness vacationers, and a control group of participants who stayed at home) to examine whether or not long term exposure to natural environments can promote restoration. Using pre-vacation and post-vacation proof reading scores to test cognitive performance, the researchers found that the wilderness backpackers improved proof reading scores while the other two groups did not. Implying that the extended wilderness vacation facilitated restoration from mental fatigue.

Berto (2005) conducted a laboratory study where participants were first given a computer generated cognitive task. They then viewed photos of natural and built environments, and finally

were asked to complete the same cognitive task. This study found that participants who viewed nature scenes improved on their cognitive task, supporting ART. Berman et al. (2008) used two separate tests to assess how different environments, urban and natural, influence cognitive tasks performed by participants. This study was different in that participants walked in different environments rather than just viewing them on a simulated screen. This research concluded that participants who walked through a natural area performed better on cognitive tasks than those who walked through an urban area. This was attributed to the restorative qualities of natural settings and their ability to restore, rather than fatigue, attention.

Berman et al. (2012) completed another study with very similar methods, but chose to collect data from participants who were diagnosed with major depressive disorder. The previous study (Berman et al., 2008) had found that healthy adults to improve cognitive function after walking in nature versus walking in an urban environment. Researchers hypothesized that depressed participants might find the nature walk to negatively impact mood and memory because it would encourage rumination. Rather than having participants complete a cognitive task to encourage mental fatigue, they were asked to reflect on a negative life experience. This study found that contrary to the original hypothesis, participants who walked in nature had both improved cognitive test scores and mood. These findings suggest that walking in nature can be beneficial for people with major depressive mood disorder.

In another study, researchers explored the effect of the natural environment on memory, cognitive process, and mood on university students (Holden and Mercer, 2014). In this study, a group of students listened to a lecture in a typical lecture hall without any windows or natural scenery. The second group listened to the same lecture in a different room with large windows producing natural light and plants with plentiful green foliage. Interesting to note, these

researchers also placed an air-freshener in the natural room with a "natural" scent. They found that students who listened to the lecture in the more natural room scored significantly higher on a memory retention test based on the lecture than the students in lecture hall without nature stimuli. However, lecture hall environments did not significantly influence mood. These findings support ART in that students in the natural lecture hall were able to recover from attention fatigue and remain more focused therefore performing better on the memory retention test.

ART was further strengthened by Tennessen and Cimprich's (1995) study that examined college students who lived in dorm rooms with and without windows that had a natural view. Students that lived in rooms with natural views scored higher on tests of directed attention. The findings of this study suggest that visual exposure to a natural setting can enhance one's psychological state. In another study, the view from one's home in the inner city was used to examine mental fatigue and aggression. Kuo and Sullivan (2001) found that woman living in the inner city who had a barren view from their home to report higher levels of aggression and mental fatigue than women who had a greener view from their home. Additionally, research has found that running in an outdoor environment provides greater restorative benefits than running in built environments (Bodin and Hartig, 2003).

Sound

Effects of noise on human health. According to the NPS Natural Sound and Night Skies Division, sound is "perceived by humans as an auditory sensation created by pressure variations that move in waves through a medium such as air or water" (NPS, 2012). The topic of noise and its effect on human health is a growing field of interest (UIrich, 1991; Goines & Hagler, 2007). It's well known that loud noise can cause hearing loss and other damage to the ear, but non-auditory factors can be affected as well: noise can induce and aggravate stress, negatively impact sleep, and decrease overall feelings of wellbeing (Babisch, 2003).

Public health researchers Hammer, Swinburn, & Neitzel, (2014) highlight the adverse effects of environmental noise to humans. They review the relationship between noise exposure and negative health outcomes such as stress, inadequate sleep, heart disease and hearing loss (Figure 1). Based on previous data that estimates 33% of U.S. residents live in an area where their exposure to noise exceeds the EPA's (Environmental Protection Agency) recommended limit of noise exposure and the 2013 census; 104 million people are exposed to noise that is putting their health at risk. The authors of this paper suggests that "tens of millions more may be at risk of heart disease and other noise-related health effects" (p. 115) and recommend that both local and national level policy should begin intervening to reduce noise levels.

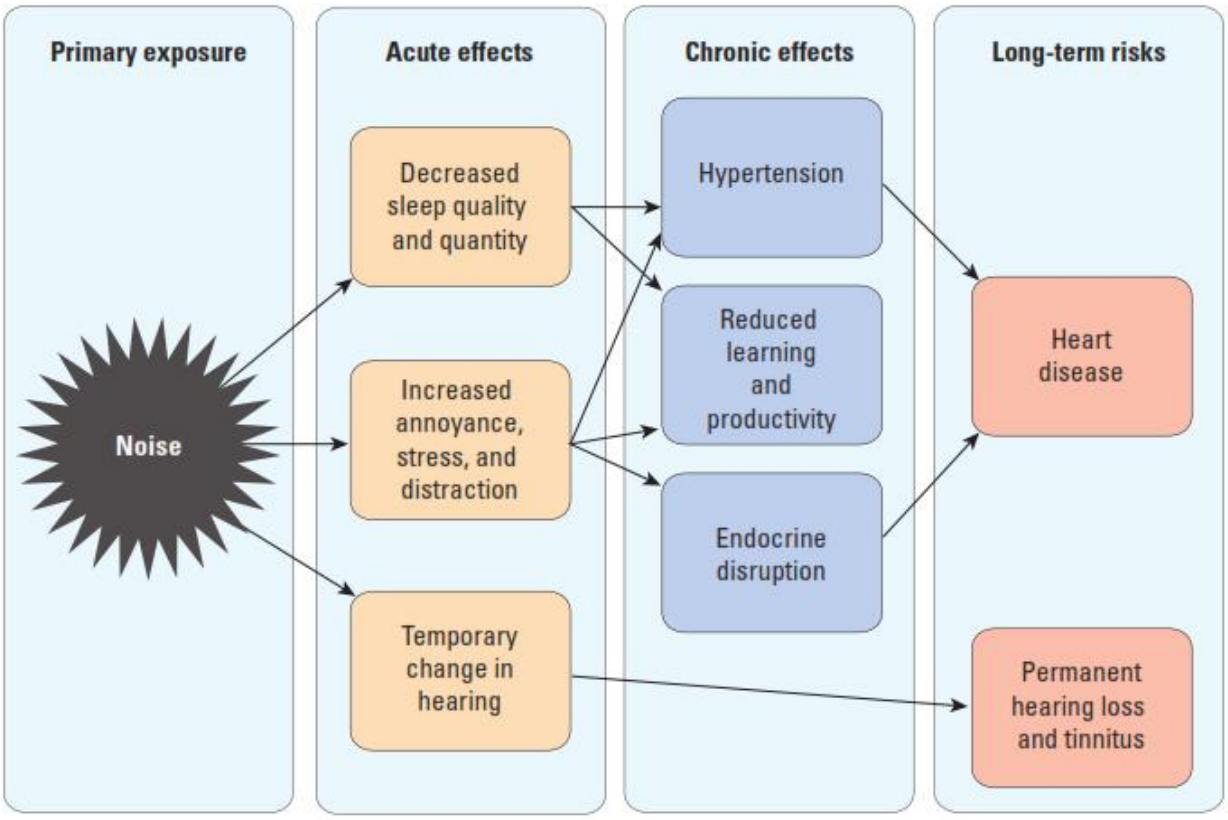

Figure 1. The side effects of noise (Hammer et al., 2014)

Cohen et al., (1980) studied the influence of noise on elementary school children. Both physiological (i.e. blood pressure) and psychological (i.e. results from a cognitive task exam) reactions to sound exposure over an extended period of time were measured to compare children from noisy schools to children from quiet schools. Participants attending noisy schools were located in the air corridor of Los Angeles National Airport. The purpose of this study was to examine the effects that occur outside of noise exposure, rather than during the event, so testing was controlled using a sound proof trailer outside the schools. Results from this study found that children in noisy schools had higher blood pressure and were more likely than children from quiet schools to give up on a task, inferring that extended exposure to noise influences cognitive processes. Authors concluded that exposure to transportation noise, such as overflights, had negative effects on task performance.

Reaction to sound is not consistent amongst all human beings. Similar to how sight can differ from person to person based in their level of vision, we react to sound based on sensitivity. Erin M. Hill (2012) examined the relationship between noise sensitivity and well-being. Given that sound is perceived differently by each individual, Hill hypothesized that participants with higher sensitivity to sound will have higher physiological stress reactions to sound and therefore diminished overall well-being. This examination determined a correlation between self-reported stress, sleep issues, and health complaints and noise sensitivity. However, results also indicated that those who leaned toward the more neurotic (more sensitive) end of the sensitivity spectrum were more likely to have mental health complaints.

Noise in natural settings. Noise in National Parks is increasing. In a place where human caused environmental impacts are kept to an absolute minimum, natural sound is becoming overshadowed by human induced noise. According to the U.S. National Park Service

(NPS), “noise levels in park transportation corridors today are at 1,000 times the natural level” (p.11). National parks and wilderness areas are places where one could expect to find silence or at least an escape from noisy urban environments. Enjoying the sounds of nature, silence and escaping noise are often the most common motivations for parks and protected area visitors (Driver et al, 1987; McDonald et al., 1995). With increased visitation to these areas, the amount of unwanted sounds from traffic, airplanes, helicopters, people, etc. has become a topic of concern. The NPS Soundscape Management Policy 4.9 states “the service will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values…” (NPS, 2006). National Park managers are taking the steps to understand acceptable levels of noise and to mitigate noise so that natural sounds are not compromised.

The National Parks Overflight Act passed in 1987, required the NPS to identify “acceptable levels” of noise produced by overflights in parks (NPS). Aircraft noise in the Grand Canyon National Park was examined, as it is a popular site for helicopter tours, and it was discovered that all locations within the park were affected by noise (Mace, Bell, & Loomis, 1999). Mace, Bell, and Loomis (1999) studied the effects of helicopter noise on the visual quality of landscapes in regard to feelings of tranquility and solitude. In this lab study, participants viewed landscape photos of the Grand Canyon while being exposed to different sounds: helicopter at two sound levels (40 dB(A) and 80 dB(A)) and natural sounds (wind, bird song, babbling brooks, natural quiet). This study found that unwanted noise affected visual landscape quality. Feelings of annoyance, solitude, and tranquility were also negatively swayed by helicopter noise. Interestingly, the specific sound level (40 and 80 dB(A)) was unimportant, all

variables that addressed landscape perception were negatively influence by unwanted sound regardless of level.

Designated wilderness is one of the highest levels of protection for public lands. Federal wilderness areas are expected to provide "outstanding opportunities for solitude or a primitive and unconfined type of recreation" (National Wilderness Preservation Act 1964, Section 2c). Tarrant, Hass, and Manfredo (1995) evaluated the effects of overflights on visitors to wilderness areas in Wyoming. This study used a dose exposure survey technique to gain an understanding of how visitor characteristics influence evaluations of overflights. In this study, dose refers to the number, proximity, and types of overflights encountered. Researchers concluded that respondents had strong negative attitudes towards hearing overflights and were slightly more affected by hearing overflights than seeing them. Levels of solitude and tranquility were also decreased by sounds of overflights. Furthermore, respondents who had previously visited the wilderness area, had lower tolerance and a higher negative attitude towards overflights. Because this particular analysis did not include actual recordings of sound levels that visitors experienced, it is important to note that their response to overflights was dependent on participants' tolerance for noise.

Beyond air traffic, other non-natural noise heard in National Parks interferes with visitor motivations and can detract from the visitors' experiences (Pilcher, Newman, and Manning, 2008). Visitors to Muir Woods National Monument were asked to complete a listening exercise and survey. Participants were asked to close their eyes and simply listen to the sounds around them. Respondents then reported the sounds they heard along with a rating of each sound. In a second phase of the study, participants rated their acceptability of sounds that were recorded in the park. The majority of respondents reported hearing human-caused sounds, which were rated

as “annoying” and natural sounds, which were rated as “pleasing”. Human-caused noise was found to be unacceptable and therefore could detract from positive visitor experiences in Muir Woods.

Perceptions of sound in natural settings. A few studies have examined the influence natural and non-natural sounds can have on landscape perceptions. Anderson, Mulligan, Goodman, and Regen (1983), examined how different sounds: birdsong, construction equipment, children, automobiles, aircraft and wind, effected participants evaluation of both natural and residential field setting and photographs. They concluded that sound significantly affected the perceived quality of a setting and that natural sounds enhance both natural and residential settings. Conversely, Viollon, Lavandier, and Drake (2002), studied the correlation between visual settings influence on sound ratings. They concluded that more urban visual settings negatively impacted sound ratings. Urban settings influenced how participants rated the pleasantness and unpleasantness of natural (birdsong) and non-natural (traffic noise) sounds.

In a similar study, noise was compared to natural sound in regards to perceptions of natural landscapes (Weinzimmer, Newman, Taff, Benfield, Lynch, and Bell, 2014). Results determined that noise from sources such as helicopters, snowmobiles, motorcycles, etc. had negative effects on participants’ perceptions of photos taken at scenic overlooks in national parks. Furthermore, natural sounds had improved perceptions on landscape acceptability. The previous studies were performed in laboratory settings, where variables are controlled.

The impact of sounds on cognition and mood. As a result of increased noise in parks, places where one could expect to find natural quite, researchers have been exploring the impacts of both natural and anthropogenic sounds to psychological measures like cognition and mood. Laboratory settings are being used to simulate a national park setting. For example, Benfield,

Bell, Troup, and Soderstrom (2010) tested participants' ability to retain and recall information based on exposure to different sounds. Participants who listened to natural sounds, uninterrupted by anthropogenic sounds scored higher on a memory test than participants exposed to natural sounds interrupted.

In a recent study, the effects natural sounds on mood were explored (Benfield, Taff, Newman, & Smyth, 2014). Previous studies addressing sound and restoration have used a visual component. This study was different in that participants did not have a visual stimuli and sounds were tested separately from visual. In this experiment participants viewed a disturbing video, with the intention of eliciting a negative mood and were then given different sounds to listen to (either natural or natural overlaid with anthropogenic sounds). Mood was measured before and after the listening treatment. This study found that participants who listening to natural sounds experienced an improvement in mood, suggesting that natural sounds can restore our emotions. Like other studies that found viewing scenery to improve mood, these findings provide evidence that natural sounds separate from visual nature can be restorative.

Restoration and Natural Sounds

There is a breadth of literature highlighting the benefits of viewing nature. More recently, research has gone beyond holistically looking at the restorative qualities of natural environments, to focus on the impacts of sound to restoration. Alvarsson, Wiens, and Nilsson (2010) tested the influence of sounds on the rate of recovery from a stressful situation. In this study, recovery from stress is tested, similar to measures used to examine SRT. After being asked to complete a stressful arithmetic task, participants were exposed to either natural sound, such as a fountain and tweeting birds, road traffic noise, or ambient noise recorded from a quiet backyard. Skin conductance levels (SCL) and high frequency heart rate variability (HF HRV) were used to

measure physical aspects of stress recovery, while a questionnaire assessed participant's perceptions of the noise or sound heard during the recovery period. Based on the results, those who were exposed to natural sound tended to recover faster than those who were exposed to traffic or ambient noise.

Payne (2008) explored the restorative nature of sounds heard at urban parks based on ART. This study examined participants' self-report of sounds they heard and their perceived restoration during their park visit. While this study found participants to perceive themselves as only slightly restored when leaving the park, participants who visited urban parks more frequently were more aware of soundscapes and had higher levels of perceived restoration. Payne (2013) continued to examine the correlation between sound and restoration by testing Perceived Restorative Soundscape Scale (PRSS). This scale is unique in that it tests restorative qualities of sound based on ART. The PRSS was found to be valid in measuring a sound's potential to provide restoration based on participants' self-report.

Self-reported measures of restoration were also used in a study that used qualitative methodology to explore the impacts of bird sounds to restoration (Ratcliffe et al., 2013). Twenty participants were interviewed and asked to imagine being stressed and then to imagine a place that would facilitate restoration. Of the natural sounds mentioned by participants 35% were bird sounds or calls, which were the most commonly mentioned natural sound. This study suggested that bird sounds may assist in restoration, but the researchers concluded that further study is needed to better understand this relationship. Specifically, quantitative data and a more detailed experiment could lead to stronger results.

In a recent study, Emfield and Neider (2014) tested the influence of both visual and auditory environments on ART. Participants were brought into a laboratory, asked to complete a

series of cognitive tasks to emulate mental fatigue. Participants were randomly assigned to a restoration period where they were exposed to one of six conditions: urban scenery, natural scenery, urban sounds, natural sounds and a combination of both sights and sounds. This study was different from others that measure restoration because the natural images and sounds used were related to water (ocean scenery, sounds of wave lapping on the beach and seagulls). To measure restoration, they were given the same series of cognitive tasks. Participants were also asked to rate their mood before and after the restoration exercise. This study found that there was no restoration effect on cognitive measures, but that the natural sights and sounds did improve mood, suggesting a more relaxing environment.

Summary

National Parks and protected areas are places where one could expect to seek refuge from the noise associated with modern society. This literature review provides evidence that both real and simulated natural environments can help improve restoration. Additionally, exposure to natural sounds can have similar benefits to viewing natural scenery. Previous research has focused heavily on the self-reported measures of the impacts that noise and natural sounds can have on restoration. However, there is a lack of research regarding the benefits of natural sounds to attention restoration as measured by cognition. **The research question posed in this thesis is: can natural sounds influence attention restoration?** Further measurement of the effects natural sound has on cognition will add to current research and further validate the positive relationship between the natural environment and human health. Examining the relationship between natural sound and restoration will not only strengthen the argument that the being in nature can improve health, but it will validate the importance of protected areas.

Study Justification

There is a rich body of literature demonstrating the restorative qualities of natural environments. Earlier studies on ART and the restorative powers of nature have focused on the visual component of being in a natural environment. Little is known about the benefits of natural sounds to attention restoration. The limited existing research suggests natural sound can provide relief from mental fatigue similar to viewing natural scenery (Berman et al., 2008; Berto, 2005; Emfield & Neider, 2014; Holden & Mercer, 2014; Tennessen & Cimprich, 1995). Earlier research has used qualitative (Ratcliffe et al., 2013) and a self-reported scale (Payne, 2007; 2011) to understand the casual linkages between natural sound and restoration. Further measurement of the effects natural sound has on attention, measured by cognitive performance, will add to current research and further validate the positive relationship between the natural environment and human health.

National parks, our country's most iconic natural places, serve as venues for people to have a restorative experience. However, as visitation increases so do anthropogenic sounds. Earlier studies on sound in national parks have indicated the negative impact of noise on visitors' enjoyment (Pilcher et al., 2008) and landscape assessment (Weinzimmer et al., 2014). The field of soundscapes research in parks lacks information about how anthropogenic and natural sounds impact restoration. Perhaps sounds such as birdsong, water, wind, etc. can provide more than a pleasant listening experience; they might improve cognitive performance and replenish the mind. Information that links natural sounds to restoration will add a missing link to the existing body of literature on ART and could potentially aid natural resource managers in further justifying the protection of natural sounds. Perhaps suggesting that natural sounds are not only important to visitors' experience, but also important for their health, can help managers promote the

protection of natural sounds by developing plans and policies that aim to provide visitors with a beneficial, restorative soundscape experience.

Study Purpose and Hypotheses

The purpose of this thesis is to understand the influence of natural sounds to restoration in a simulated park setting. Past studies in a similar context have been successful in understanding the negative effects of noise on park scenic perception and enjoyment (Benfield et al., 2010; Weinzimmer et al., 2014) and different types of parks (Rainbolt, Benfield, & Bell, 2012). Based on previous research that suggests natural settings can provide relief from mental fatigue and promote cognitive performance (Berman et al., 2008; Berto, 2005; Emfield & Neider, 2014; Holden & Mercer, 2014; Tennessen & Cimprich, 1995) the researcher hypothesizes:

H_1 Natural sounds will promote restoration while anthropogenic noise will impede restoration as measured by cognition.

H_2 Participants who listen to natural sounds will have a more restorative experience than the control group as measured by cognition.

In order to answer the hypothesis, the researcher used the ART framework. Previous studies have been successful in demonstrating the restorative potential of natural sound using self-reported measures based on ART (Payne, 2007; 2011; Ratcliffe et al., 2013), yet little is known about the influence of sounds on the cognitive performance measure of ART. Benfield et al., (2010) measured the influence of sounds on memory, a function of cognition, but was not examining restoration specifically. Similar to other studies that have demonstrated the positive impacts viewing natural environments can have on attention restoration, the current case study

aims to examine the influence of natural sounds on attention restoration as measured by cognitive performance.

Chapter 3
Methods

Overview

The present study is based on methods used by, Berman et al. (2008) and Emfield and Neider (2014) that utilized cognitive tasks, specifically the backwards digit-span task, to measure human restoration in a natural environment. Berman et al. (2008) used time spent in a natural setting as a treatment, while Emfield and Neider (2014) simulated a natural environment using a visual stimuli and sound recordings. This project will also utilize time in a simulated natural environment to measure restoration. Benfield et al. (2014) identified the effects of natural sound in improving human affect. This study aims to take these research findings further by examining the attention aspect of cognition and identifying whether or not the sound environment can influence one's ability to recover from mental fatigue.

Study location

This project was conducted in a research lab on the Pennsylvania State University's University Park campus, a large-size university in the northeast United States. The researcher also employed two undergraduate research assistants to aid in data collection. Both the researcher and the research assistants followed a specific script and protocol to ensure consistency during lab procedures (Appendix B).

Participants

194 graduate and undergraduate students over the age of 18 were recruited on campus. The researcher required participants to identify self-reported normal or corrected vision and hearing in order to view information presented in cognitive tasks and to hear sound clips played through headphones. Extra credit was offered as an incentive to increase study participation.

However, an optional written assignment was offered as an alternative for extra credit if the student did not wish to participate in the study. All participants read through an implied consent and agreed to voluntarily participating in the study.

Experimental design

The experimental design was comprised of three separate sections (Figure 2). First participants completed a mentally fatiguing task, then were given time to recover while listening to one of four different sound conditions or a control (no sound), and finally completed a cognitive task to measure how well they recovered from the first task.

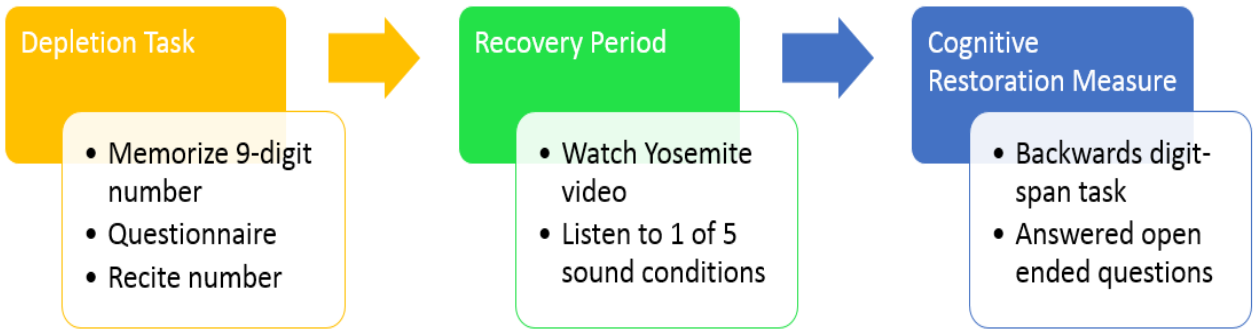

Figure 2 .Experimental design

Depletion task. After reading through an informed consent form, participants were instructed to participate in a cognitively demanding task and then answer a series of questionnaires. Similar to the methods used by Berman et al. (2008) and Emfield and Neider (2014) study participants were first asked to complete a cognitively demanding task. Here the intention is to induce mental fatigue in participants so that recovery can be measured. The researcher sought advice from an expert in the field of psychology, who provided guidance on

how to properly choose a task that would mentally fatigue participants. A delayed free recall task was used chosen. For this procedure participants were asked to memorize a nine-digit number. After the number was read out loud to the participant, they were asked to fill out a questionnaire that took 10 to 15 minutes to complete. Upon completion of the questionnaire, the participant was asked to recite, out loud, the nine-digit number, which the researcher recorded. The procedure was then repeated with a different nine-digit number and a shorter questionnaire, only lasting about 5-7 minutes. It was expected that this task mentally fatigued participants, in order to later measure attention with a separate cognitive task (Emfield & Neider, 2014).

Figure 3 Video scene of Yosemite National Park (visual stimuli for the recovery period)

Recovery period. Participants were given a recovery period lasting seven minutes. The time for recovery was determined by the researcher's pilot data and other research using similar methods (Benfield et al., 2014; Emfield & Neider, 2014). In 5 minutes, participants did not report feeling recovered from the cognitive task, whereas in 7 minutes they reported feeling more

recovered. It was thought that a longer recovery period would allow for all participants to recover, regardless of listening condition. During this time participants were prompted to imagine that they are relaxing in a national park. A video taken from a meadow in Yosemite National Park was viewed on a large projection screen (Figure 3). Utilizing a randomized sampling schedule, participants listened to one of five listening conditions of various sound environments through noise cancelling headphones (Bose Quiet Comfort 15 brand noise canceling headphones). There were four different listening conditions and a control. During each of the four listening periods, subjects were exposed to either a natural sound or natural sound interrupted by anthropogenic motorized noise. A fifth group or control group was exposed to no sound, but noise canceling headphones were used to eliminate any outside sounds. All subjects were exposed to the same visual stimuli. The natural sounds chosen for this experiment are wind and birdsong, which have been rated as highly pleasing in past studies (Pilcher et al., 2009). The four experimental sounds are described below:

(1) *Natural sound*

(2) *Low natural sound*

(3) *Anthropogenic sound*

(4) *Low anthropogenic sound*

Performance measure/cognitive task. The backwards digit-span task was used to measure cognitive ability after the recovery period. The purpose of this task was to measure attention restoration from mental fatigue. The backward digit-span task has been successful in measuring attention restoration and has been used in similar studies (Berman et al, 2008; Emfield & Neider, 2014) because “the backwards digit-span task relies heavily on directed-attention

mechanisms because such working memory measures have a large attention component" (Berman et al, 2008, p. 16).

Participants were asked to listen to a digit sequence and were then asked to replicate the same sequence in backwards order. Digit sequences began with 2 digits and increased up to 8 digits. For example, the research assistant would read out loud to the participant a series of numbers such as, "1, 3, 5". The participant would then recite the same series back to the researcher, but in backwards order (e.g., "5, 3, 1"). The number sequences were read to the participant in ascending order. So the first digit span was two digits, increasing from there up to a maximum of eight digits. The backwards digit-span score was based on the maximum number of digits the participant could recite backwards to the researcher, eliciting a score between two and eight.

Experimental Sounds

During each of the four listening periods, subjects were randomly exposed to either a natural sound, natural sound interrupted by anthropogenic motorized noise, or silence (Table 1). Bose Quiet Comfort 15 brand noise canceling headphones were used for all for conditions. Motorcycle sound was chosen as a source of anthropogenic noise because this sound is rated as more annoying than other sounds in a natural setting (Kariel, 1990; Weinzimmer et al., 2014). Factors such as loudness and frequency of anthropogenic noise events were determined based on previous research (Benfield et al., 2010; 2014). Loudness has been found to be an important predictor of human annoyance to transportation noise (Mace et al., 1999; Galloway and Jones, 1974; Kryter, 1985). Motorcycle sounds are laid over natural sounds at a higher dB(A) to mimic actual events (Alvarsson et al., 2010; Mace et al., 1999). Moreover, anthropogenic sounds faded in and out of the sound clip to better imitate how these sounds are heard in a park setting.

Four sound clips were prepared with assistance from the NPS's Natural Sounds and Night Skies Division and The Pennsylvania State University Acoustical Engineering Department. All clips were extracted from acoustic recordings in national parks. Editing and mixing were performed using Audacity®. The sounds levels for all four sound conditions were measured with a binaural head and torso simulator Brüel & Kjær type 4100. Table 1 describes the sounds used and the sound level for each individual sound.

Table 1. Sound conditions and sound levels.

Sound Condition	Sound Level dB(A)
Control	No sound (noise canceling headphones)
Low Natural	
Bird song and wind	52.8
Low Anthropogenic	
Bird song and wind, propeller plane, and motorcycle	53
Natural	
Bird song and wind	60
Anthropogenic	
Bird song and wind	52.8
Propeller plane	66.6
Motorcycle	61.4

The researcher chose to test different sound levels in order to gain a better understanding of how sounds could play a role in restoration. Developing different levels of loudness for the same sound clip (natural and anthropogenic) allowed for the researcher to analyze whether sound level or sound source where having an influence on restoration.

Questionnaire

The primary purpose of the questionnaire was to cognitively tax participants while they were attempting to memorize a nine-digit number during the depletion task. The secondary purpose of the questionnaire was to gather basic demographic data.

Demographics. Variables such as sex, age, college major, and zip code were also obtained. Additionally, information about the population of their hometown or city and political ideology were gathered. Finally, participants were asked if they have visited Yosemite National Park, the park depicted in the video used for the visual stimuli.

Open ended questions. Halfway through data collection, the researcher added a two open ended writing prompts to the end of the procedure. Similar to the qualitative research conducted by Racliffe et al. (2013), the researcher wanted to explore the feelings that emerge from hearing natural sounds. After the participant completed the final task, they were asked to answer these two prompts:

(1) "After the first task in which I had to remember the number while doing the survey, I felt…"

(2) "While watching the national park video I felt…"

Participants were told that they could write as little or as much as they felt necessary. These questions were added to 1) understand whether or not participants were being depleted by the first task and 2) gain additional insight into how people felt during the recovery period.

Data Analysis

These data were analyzed using Statistical Packages for the Social Science (SPSS) version 20, commonly used analytical software in the social sciences field. A significance level

of 0.05 was used to test research questions. This is also the commonly used significance level in the parks, recreation, and human dimensions research field (Vaske, 2008).

Demographics. Information about participants' demographic information was analyzed using results from frequency analyses.

Restoration. For this study the researcher analyzed restoration between subjects rather than within subjects. The between subjects design allowed the researcher to measure restorative effects between participants in the different sound conditions. To answer the research question: can natural sounds influence restoration as measured by cognition; several analyses were conducted. A series of independent sample t-tests were used to identify significant differences in mean scores between sound conditions. Means and t-values were reported.

Open ended question. One of the open ended questions, "While watching the national park video I felt…" was analyzed to explore the influence of the recovery period on attention restoration. The qualitative questions were added halfway through data collection, to better understand the emotional aspect of the recovery period. Therefore, these finding are not central to the research findings, but may reveal trends and implications for future research. Given the exploratory nature of this research, qualitative data was coded inductively (Creswell, 2008). Themes were developed based on reoccurring concepts that emerged throughout participants' writing reflections. This inductive analysis was chosen due to the empirical nature of these question prompts. The researcher developed coding themes by reading through the question responses methodically and repeatedly. All reading was done blind of the participant's sound condition. This was done so that the researcher could develop themes, unbiased of participants' sound condition. After initial themes were determined, the researcher coded all 136 writing

responses. After all writings had been coded for themes, they were then coded based sound condition.

Chapter 4
Results

The purpose of the following chapter is to report the results from this experimentally designed study. To understand the influences of natural sounds on restoration, this research examined the participants' ability to restore based on their cognitive performance.

The researcher successfully recruited 194 (*n*=194) undergraduate and graduate participants from classrooms at the Pennsylvania State University with extra credit being offered as an incentive for participation. Study subjects who were not cognitively depleted by the initial number memorization task were cleared from the data set. The researcher wanted to analyze data from participants who were believed to be cognitively depleted and therefore could be influenced by the recovery period. The goal of the study was to measure restoration, therefore participants who were not depleted and requiring recovery would not have been useful in this study. The researcher determined depletion based on the maximum number of digits the participant could recite following the questionnaire (the first task in the lab procedure). If the participant could memorize 5 or more digits on either test or could recited 4 or more digits on both tests, they were coded as "depleted". Those who could not meet this requirement were coded "not depleted" and were not used in the analysis of these data. A total of 143 (n=143) participants were coded as "depleted". Fifty-one participants were not included in the data analysis (26.3%).

Demographics

Table 2 demonstrates the socio-demographic data for study participants (*n*=143). The sample included more male participants than female (59.4% male and 40.6% female). The majority of participants were between the ages of 21 and 25 (63%). A small number of participants have lived the majority of their life in a rural town (7%) or large city (10.5%). The

majority of participants reported living in small towns to medium size cities. While the socio-demographic data was not pertinent to answering research questions, it gives researchers an overview of the sample population.

Table 2. Participant's demographic data

Socio-Demographic Variables		Frequency	Valid Percentage
Gender			
	Male	85	59.4
	Female	58	40.6
Age			
	18-20	43	30.1
	21-25	90	63.0
	26 and older	10	6.9
Population of city where you have spent the majority of your life			
	Large city (500,001 or more people)	15	10.5
	Medium city (50,001-500,000 people)	35	24.5
	Small city or town (10,001-50,000 people)	51	35.7
	Small town (2,501-10,000 people)	31	21.7
	Rural area or town of less than 2,500 people	10	7.0

H_1 Natural sounds will promote restoration while anthropogenic noise will impede restoration as measured by cognition.

The primary purpose of the data analysis was to understand the influence of sounds on attention restoration as measured by cognitive performance. A one-way analysis of variance (ANOVA) test was used to investigate significant differences between sound conditions based on the mean score for the backwards digit-span task (score between 2 and 8). With sound condition as the independent variable and mean backward digit span score as the dependent variable, we did not find any significant differences. This test did not support Hypothesis 1 and the null hypothesis was accepted. Participants who listened to the natural sound condition did not have significantly higher cognitive scores when compared to those who listened to anthropogenic sounds.

H_2 Participants who listen to natural sounds will have a more restorative experience than the control group as measured by cognition.

In order to further analyze restoration effects between different sound conditions, we conducted several independent samples t-tests. The mean scores for the backwards digit-span task (maximum number of digits participant can recite backward, 2-8) for the control group were compared to the other four sound conditions. This analysis compared the performance of participants who experienced no sound during the recovery period with participants who listened to natural sounds or natural sounds overlaid with anthropogenic at different sound levels.

Table 3. Results from independent samples t-test for mean backward-digit span score comparing sound conditions to the control condition

Sound Condition	n	Mean[1]	SD	df	t-score	Cohen's d
Control (no sound)	33	5.45	1.23			
Low Natural	24	5.67	1.13	51.93	-0.67	0.19
Low Anthropogenic	25	5.48	1.30	50.30	-0.08	0.02
Natural	28	6.14	1.14	58.44	-2.25*	0.60
Anthropogenic	32	6.03	1.28	62.65	-1.85	0.48

[1]Score average based on maximum digits participant can recite backwards (ranging from 2 to 8)

*p<.05 (two-tailed)

The first independent samples t-test compared the mean backward digit-span scores for the control condition with the *low natural* sound condition (Table 3). There was no significant difference in the mean cognitive performance score (backward digit-span) between these two sound conditions (t= -0.67, p>.05). The same analysis was used for both the high and low combined anthropogenic and natural sound conditions. There was no significant differences between performance in these sound conditions compared with the control condition (t = -0.08 and t =-1.85, p>.05). When the mean backward digit-span scores for the *natural* sound condition (mean= 6.14) was compared with the control (mean= 5.45), the *natural* sound condition significantly outperformed the control (t= -2.25, p<.05). This series of tests partially supports Hypothesis 2.Participants who listened to natural sounds had a more restorative experience than the control group as measured by cognition.

Because there was a significant relationship between the natural sound condition and the control condition, effect size was calculated to further understand the significance of the

relationship. According to Vaske (2008), the use of effect size can emphasize the strength of a relationship. The value of Cohen's d for the independent samples t-test comparing performance in the control condition to the natural sounds condition was .60 which is classified as a medium to large correlation (Cohen, 1988). According to Cohen (1988) a" .5 correlation is about as high as they come in predictive effectiveness in applied psychology" (as cited in Vaske, 2008, p. 108). Therefore, the value of Cohen's d found here represents a strong relationship.

Sound Level

Analysis was also conducted on the differences in mean backward digit-span scores for sound conditions at varying sound levels (measured in dB(A)). Two independent samples t-tests were conducted to understand if sound level influenced performance. We did not find significant differences in mean performance scores for the natural sound and *low natural* sound conditions ($t= 1.50$, $p>.05$). Additionally, there was no significant difference in performance scores between the *anthropogenic* and the *low anthropogenic* sound conditions ($t= -1.60$, $p>.05$).

Open Ended Question

The open ended question, "After the national park video I felt…" was coded to further understand the influence of the recovery period on attention restoration. Also, this question was asked halfway through data collection, so the responses do not reflect the entire sample. A total of 136 participant responses were analyzed. Though, this analysis was not central to the purpose of this thesis, Table 4 demonstrates the number of times each theme was mentioned in response to the open ended question sorted by the sound condition the participant was exposed to. Overall, the themes that emerged most frequently were comments about feeling relaxed, calm, or peaceful. There are not major differences between sound conditions and these themes.

Table 4. Content Analysis

Coding Themes	Control (n=25)	Low Natural (n=23)	Anthropogenic (n=25)	Low Anthropogenic (n=24)	Natural (n=39)	Totals (n=136)
Tired	3	1	1	1	5	11
Sleepy	0	3	1	2	2	7
Bored	5	3	1	4	5	18
Anxious	2	3	1	1	0	7
Annoyed	0	0	5	1	0	6
Focused	3	1	1	2	3	10
Calm	9	7	3	4	7	30
Relaxed	12	13	13	13	22	73
Peaceful	7	4	5	2	8	26

Chapter 5
Discussion

The purpose of this thesis study was to investigate the influence of natural sounds on restoration as measured through cognitive performance. A between subjects study design was used to investigate cognitive performance on participants who listened one of five different sound conditions (*natural, anthropogenic, low anthropogenic*, or no sound). This chapter will discuss the research findings and highlight managerial implications

H_1 Natural sounds will promote restoration while anthropogenic noise will impede restoration as measured by cognition.

These data did not support H_1. When the cognitive scores from the anthropogenic sound conditions were compared to the control condition, there was not a significant difference in mean cognitive test scores. The anthropogenic sound conditions did not have an effect on the overall mean score for the backwards digit-span task. Similar to the findings of Emfield and Neider's (2014) study, analysis of these data found no significant differences between sound conditions and cognitive performance. Furthermore an analysis of differences in mean cognitive performance scores between the *natural* and *anthropogenic* sound conditions did not result in significant differences. As a result, the null hypothesis was accepted. Although not statistically significant, the mean cognitive test score for the participants who listened to the *natural* sound condition was higher than both the *low* and *high anthropogenic* sound conditions.

It's possible that because the anthropogenic sound conditions were a mix of natural sounds overlaid with anthropogenic noise, the natural sounds were restorative, regardless of the anthropogenic interruptions. This is supported by the significant difference between performance in participants in the natural sound condition and the control condition. Because this study was a

between subjects design and not a within subjects design, it is unclear if the anthropogenic interruptions influenced an individual's cognitive performance. It's possible that all the sound conditions, not including the control, facilitated restoration. While the researcher, attempted to control for this in the pretesting, perhaps the transportation-influenced sound conditions were not loud enough or frequent enough to impede restoration.

In previous studies that explored the influence of natural sounds on humans, it was found that natural sounds can improve mood (Benfield et al, 2014) and memory (Benfield et al, 2010). Both of these studied used similar methods and sound conditions, as the research presented in this thesis. It's probable that the specific methods used in this study were unable to measure whether or not anthropogenic sounds impede restoration. Similar to Emfield and Neider's (2014) the 7 minute recovery period might not have been adequate for measuring cognitive restoration. The researcher was concerned that a long period of time might result in all participants recovering from the first depletion task. Conversely, a shorter time period might not have allowed for restoration to occur.

H_2 Participants who listen to natural sounds will have a more restorative experience than the control group as measured by cognition.

These data supported Hypothesis 2. Based on separate comparisons of mean cognitive performance scores from each of the four sound conditions and the control condition, participants who listened to natural sounds significantly outperformed those who listened to no sound. Because the participants listening to natural sounds had higher cognitive test scores than those in the control condition, we can estimate that participants in the natural sound condition mentally recovered from the initial depletion task. With mental recovery being the indicator of

restoration, the natural sound group had a more restorative experience than those in the control condition.

This study found that exposure to natural sounds, specifically bird song and wind, provide recovery from mental fatigue. As mentioned earlier, the majority of previous research on ART has focused on study participants' response to viewing natural scenery. While this study did use a visual stimulus (video from Yosemite National Park), all participants viewed the same scene, including the control group. This means, that given the same visual stimulus, the participants exposed to natural sounds were able to restore when compared to those who were exposed to silence. Based on these data, natural sounds can aid in recovery from mental fatigue.

Attention Restoration Theory

The aim of this study was to measure how natural sounds influence cognition based on findings from previous studies supporting ART. Preceding research has used qualitative (Ratcliffe, 2013) and the PRS (Payne, 2007; 2011) to measure the effects of natural sound on attention restoration, while this study used cognitive tasks (Emfield & Neider, 2014). Findings from this study partially support ART in that natural sounds facilitated restoration and anthropogenic sound had no effect on restoration. These findings posit that spending time in nature, in a place rich in natural sounds can provide relief from mental fatigue.

Because this study focused on attention restoration, it's possible that other forms of restoration could have been occurring. Similar to findings by Benfield et al. (2014), natural sounds could have had a positive effect on mood, however the researcher did not test for this. Additionally, because participants in the control condition and the low level sound conditions had the lowest cognitive test scores, although not statistically significant, they were possibly too relaxed to perform well on cognitive tests. These participants might have been experiencing

physiological restoration or emotional restoration, like the measures used to test SRT (Ulrich, 1984; Ulrich et al., 1991). Anecdotally, the researcher and the research assistants reported finding participants asleep during the recovery period. This is perhaps why sleep machines that play soothing natural sounds are so popular. When played at low levels, these sounds can lull one to sleep.

Sound Level

Our initial study question did not aim to understand the influence of varying sound levels on restoration. The purpose of using different sound levels was to inform whether or not restoration occurred as a result of the sound source (natural vs. anthropogenic) independent from the sound's source. When the relationship between the low natural sound condition and control condition was analyzed, there was not statistical significance. Based on the researcher's findings the louder natural sounds had an effect on cognitive performance while the low natural sounds did not. In this laboratory experiment natural sounds played at a higher sound level (60 dB(A)) were more likely to restore participants from mental fatigue and improve focus therefore allowing for improved cognitive performance.

The overall means for the backwards digit-span task, although not statistically significant, suggest that louder sound conditions outperformed quieter sound conditions (Table 3). As previously mentioned, the low level and control sound conditions might have facilitated other types of restoration, but not attention restoration. Participants who were found sleeping might have been relaxed, but in a way that was not conducive to performing well on a cognitive task.

Open Ended Question

Analysis of the qualitative question, "After watching the national park video I felt…" revealed that most participants felt relaxed, calm or peaceful during the recovery period. For

example, a participant who listened to the *low natural* sound condition wrote, "while watching the national park video I felt relaxed and felt as if I was there with the streams in the background and the birds chirping nearby. I felt I could relax if only for a few moments." This quote exemplifies the feelings that the lower natural sound condition elicits. While these sounds may be relaxing and calming, they don't necessarily offer an auditory environment that facilitates cognitive performance. Other themes that emerged were feelings of boredom, tiredness and sleepiness. A participant in the control condition wrote,

> *While watching the video, I felt like I was wasting time. The video seemed like it was just a picture and I got bored very quickly. Although I was bored, I tried to pay attention as much as possible but I was distracted by my thoughts.*

In this quote, the participant mentions twice that they feel bored. It's possible that the lack of auditory stimulation caused participants to lose focus and feel sleepy or bored, which probably didn't improve cognitive ability.

This proposition could be supported by research testing arousal and cognitive performance (Flynn et al., 1996; Loewen, & Suedfeld, 1992; Yerkes & Dodson, 1908). The Yerkes-Dodson law submits that when arousal is too high or too low, performance deteriorates. Mid-level arousal facilitates the optimal performance (Yerkes & Dodson, 1908). In a study that addressed pharmacist performance in relation to ambient and unpredictable noise, louder sound interruptions increased performance (Flynn et al., 1996). Noise did not impede performance, but improved performance scores. In the current study, it's possible that the low level and no sound conditions did not provide enough stimulation to promote cognitive performance. Also, the *natural* sound condition that was played at 60 dB(A), aroused participants in a way that was optimal for attention restoration. This also could explain why the cognitive performance scores for participants in the anthropogenic sound conditions were not different from the natural. The

transportation noise interruptions used in the anthropogenic sound conditions might have been arousing and therefore a driving force in attention restoration.

Management Implications

The main goal of this study was to understand the influence of natural sounds on restoration. The methods used in this study, were developed in a way that simulated a national park experience. During the recovery period, participants were shown a video from Yosemite National Park and prompted to imagine that they were actually in that scene. Additionally, the sound conditions were developed in a way that mimicked actual park experiences. The purpose of this methodology was to not only add information to existing academic literature, but provide real world applications. Park and protected area managers can suggest places that are rich in natural sound for visitors seeking a restorative experience. Moreover, parks can designate quiet areas or zones of the park so that natural sounds can be heard by visitors. For example, as a result of soundscapes research in Muir Woods National Monument, the Cathedral Grove area is designated as a "quiet zone" and is permanent part of the park's management (Manning & Anderson, 2012; Stack et al., 2011).

Findings from this study also further justify the importance of natural sounds and their protection in national parks and other protected areas. As discussed earlier, noise in national parks is increasing. As visitation to our country's most scenic places increases, so does unwanted sounds from transportation. If visitors are coming to parks with the intention of having a restorative soundscape experience, anthropogenic noise should be kept to a minimum.

Chapter 6
Conclusion

The intention of this thesis study was to understand the influence of natural sounds on restoration. Earlier studies have used self-report measures to understand the connection between sounds of nature and restoration (Payne, 2007; 2011; Ratcliffe et al. 2013). More recently, natural sounds have been shown to improve mood, implying the restorative potential of natural sounds (Benfield et al., 2014). Based on previous literature that used natural scenery, both real and simulated, to suggest natural environments can restore participants from mental fatigue by measuring cognitive performance, the researcher hypothesized that natural sounds could have the same effect. Therefore indicating the restorative qualities of natural sound. Moreover, the study methods were designed in way to simulate a national park experience, to add information to the existing literature on the impacts of anthropogenic and natural sounds to park visitors.

Akin to other studies that have used a laboratory setting to understand the influence of sounds in a park setting, the researcher conducted the study in a laboratory using experimental methods (Benfield et al. 2010; 2014; Rainbolt et al., 2012; Weinzimmer et al., 2014). After a mentally depleting task, participants were exposed to a natural, anthropogenic, or control sound condition. Recovery from the depletion task was measured by cognitive performance in the backwards digit-span task. The maximum number of digits the participant could recite backwards (between 2 and 8) indicated whether or not restoration was taking place. Results were measured between subjects in the different sound conditions.

The researcher hypothesized that participants exposed to natural sound conditions would score higher on the cognitive task than those exposed to the anthropogenic sound conditions. There was no significant relationship in mean cognitive performance scores between participants

in the natural and anthropogenic sound conditions. The researcher also hypothesized that natural sounds would provide a more restorative experience than the control condition. This hypothesis was supported. Results from the study indicate that natural sounds facilitate restoration while anthropogenic sounds have no effect.

Unique to this study, sound conditions were developed using different sound levels to understand if the effects on cognitive performance were based on sound level or source of the sound. Findings suggest louder sound conditions might promote recovery from mental fatigue while quieter sounds demonstrated no effect on performance. Participants in the louder natural sound condition outperformed the control (no sound) condition while participants who heard the same sounds at a lower level did not. Additionally, analysis of the open ended question, revealed a large number of participants reported feeling peaceful, calm or relaxed during the recovery period. It's possible that the lower sound conditions were emotionally restorative, but not optimal for cognitive performance.

Findings from this experiment provide evidence that simulated natural environments can be restorative, adding to the existing literature on ART. Different from Emfield and Neider's (2014) research, this study suggests that exposure to natural sounds can promote recovery from mental fatigue. To the best of the researcher's knowledge, this is the first study to examine the influence of sound on attention restoration in a national park context. Earlier studies examined the contrast between natural and urban sounds (Emfield & Neider, 2014). This study tested conditions developed to imitate sounds that could be heard in parks. These findings can also expand the existing literature on sound in national parks.

Ultimately, parks and protected serve as a place to conserve ecosystems for future enjoyment. Based on this study and other research defining the restorative qualities of nature, they can also serve as places to promote human health and restoration. The grandfathers of parks in the United States, Muir and Olmsted for example, saw the value of protecting these places for their inherent beauty, but also as places to restore the soul. As we know, experiencing natural sounds is an important motivation for visitors to these places. Whether we are conscious of it or not, hearing bird song or wind rustling in an aspen grove are sounds that are not just enjoyable, but perhaps vital to restoration. Spending time in natural settings and listening to natural sounds with limited anthropogenic interruptions could potentially reverse mental fatigue, improving the ability to focus.

Limitations and Future Study

This study was limited by a few different factors. First, the demographic sampled was fairly homogenous. Like most laboratory studies in the social sciences field, we conveniently sampled undergraduate students. Additionally, the nature of undergraduate life might have resulted in testing participants who were cognitively depleted even before entering the lab. University students are spending their days attending lectures, studying and balancing a social life, which probably leaves them mentally exhausted. In the future, it would be beneficial to test the same methods on a different demographic, i.e. children or older adults, to understand if natural sounds have the same effect on a wider range of individuals.

The sound conditions developed for the recovery period might have also been a limiting factor. The anthropogenic sound conditions were a mix of natural sounds (bird and wind) overlaid with transportation noise interruptions to imitate what one might hear in a national park. As discussed earlier, it's conceivable that participants recovered regardless of condition because

all sound conditions contained natural sounds. In future studies, it would be beneficial to test sound conditions that only contain anthropogenic sounds or sound conditions that have natural sounds overlaid with more consistent anthropogenic sounds; like the sound of a highway or busy road.

Arousal may have influenced cognitive recovery. Future research on attention restoration and natural sounds would be advanced by understanding how arousal effects cognitive performance. This study did not test for arousal or record when participants had fallen asleep. The discussion about participants falling asleep during the recovery period was only anecdotal. It would be interesting to have noted how many participants fell asleep and what sound treatment they had been given. This could lead to information about the influence of sound on physiological and emotional recovery.

Because the purpose of this study was to understand how sounds in national parks could affect visitors, the researcher used a visual stimuli --- a video of Yosemite National Park. Essentially the study did not determine if the sounds would be as restorative without the visible nature scene. Although, all participants (including the control) received the same visual treatment, this study was limited in that sounds were not tested independent of a visual component. In the future, it would be beneficial to test the same methods, but without a nature scene. Instead asking participants to sit in front of a blank wall, similar to the methods used by Benfield et al. (2014).

This study was limited by a few factors, but ultimately, there is still little known about the role sounds play in restoration. The current study used an experimental design in a laboratory setting to explore this relationship. Findings from this study could be used to develop field studies testing the same phenomena. Rather than simulating an experience, researchers could test

attention restoration in parks and protected areas. Furthermore, the field of environmental psychology and recreation management would benefit from understanding the physiological and affective responses to sound in natural areas. When it comes down to it, the potential for new research in how nature benefits health is limitless.

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Appendix A
Questionnaire

In the space by each item, put the number from the scale below that best reflects your answers.

1	2	3	4	5	6
Disagree Strongly	**Disagree**	**Disagree Slightly**	**Agree Slightly**	**Agree**	**Agree Strongly**

_____1. I get annoyed when my neighbors are noisy.

_____2. I get used to most noises without much difficulty.

_____3. I find it hard to relax in a place that's noisy.

_____4. I get mad at people who make noise that keeps me from falling asleep or getting work done.

_____5. I am sensitive to noise.

_____6. Motorcycles ought to be required to have bigger mufflers.

Listed below are statements about the relationship between humans and the environment. For each one, please indicate whether you agree or disagree.

1	2	3	4	5
Strongly Disagree	**Mildly Disagree**	**Unsure**	**Mildly Agree**	**Strongly Agree**

_____1. We are approaching the limit of the number of people the earth can support.

_____2. Humans have the right to modify the natural environment to suit their needs.

_____3. When humans interfere with nature it often produces disastrous consequences.

_____4. Human ingenuity will ensure that we do NOT make the earth unlivable.

_____5. Humans are severely abusing the environment.

_____6. The earth has plenty of natural resources if we just learn how to develop them.

_____7. Plants and animals have as much right as humans to exist.

_____8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.

_____9. Despite our special abilities humans are still subject to the laws of nature.

_____10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.

_____11. The earth is like a spaceship with very limited resources.

_____12. Humans were meant to rule the rest of nature.

_____13. The balance of nature is very delicate and easily upset.

_____14. Humans will eventually learn enough about how nature works to be able to control it.

_____15. If things continue on their present course, we will soon experience a major ecological catastrophe.

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way <u>right now</u>. Use the following scale to record your answers:

1	2	3	4	5
very slightly or not at all	**a little**	**moderately**	**quite a bit**	**extremely**

_____ interested	_____ irritable
_____ distressed	_____ alert
_____ excited	_____ ashamed
_____ upset	_____ inspired
_____ strong	_____ nervous
_____ guilty	_____ determined
_____ scared	_____ attentive
_____ hostile	_____ jittery
_____ enthusiastic	_____ active
_____ proud	_____ afraid

Please answer the following questions using the scale provided. These are personal preferences and have no right or wrong answer. Thank you for you participation!

1	2	3	4	5	6	7
Strongly Disagree			**Neither**			**Strongly Agree**

_____1. Beautiful scenery has always been a significant part of my life.
_____2. The smells of outdoors give me no pleasure.
_____3. Experiencing nature is central to my life.
_____4. I have found the sound of rustling leaves to be pleasant.
_____5. I enjoy long walks.

Please respond to each item by circling <u>one response per row:</u>

	Rarely/Not at All	Sometimes	Often	Almost Always
It is easy for me to concentrate on what I am doing.	1	2	3	4
I can tolerate emotional pain.	1	2	3	4
I can accept things I cannot change.	1	2	3	4
I can usually describe how I feel at the moment in considerable detail.	1	2	3	4
I am easily distracted.	1	2	3	4
It's easy for me to keep track of my thoughts and feelings.	1	2	3	4
I try to notice my thoughts without judging them.	1	2	3	4
I am able to accept the thoughts and feelings I have.	1	2	3	4
I am able to focus on the present moment.	1	2	3	4
I am able to pay close attention to one thing for a long period of time.	1	2	3	4

1. Your sex: Male _____ Female _____
2. Your age: _____
3. Your college major: _____
4. Zip code where you lived the majority of your life: _____
5. Which of the following types of areas best describes the place where you have lived the majority of your life?

   □ large city (500,001 or more people)

   □ medium city (50,001 – 500,000 people)

   □ small city or town (10,001 – 50,000 people)

   □ small town (2,501 – 10,000 people)

   □ rural area or town of less than 2,500 people

6. Which best describes your political orientation? (Circle only one number)

Liberal Left		Left Leaning	Independent	Right Leaning		Conservative Right
-3	-2	-1	0	1	2	3

7. About how long ago was your last visit to a National Park, National Forest, or Wilderness Area? _____
8. Approximately how many hikes (day and overnight) have you taken in National Parks, National Forests, or Wilderness Areas **in the past 12 months**?

   _____

9. Approximately how many hikes (day and overnight) have you taken in National Parks, National Forests, or Wilderness Areas **in your lifetime**? _____
10. Have you visited Yosemite National Park in your lifetime?

    □ Yes

    □ No

Final Questions:

After the first task in which I had to remember the number while doing the survey, I felt..._____
_____
_____
_____
_____
_____
_____
_____

While watching the national park video I felt...._____
_____
_____
_____
_____
_____
_____
_____

Appendix B
Lab Procedure Book

[TYPE THE COMPANY NAME]

The influence of natural sounds on restoration

Thesis Study

11/21/2014

Project Book

Investigators:

Lauren Abbott, RPTM

Jake Benfield, Psych (PSU Abington)

Derrick Taff, RPTM

Peter Newman, RPTM

Contents

Project Summary:

The purpose of this project is to investigate the influence of different acoustical environments on laboratory subjects' performance on cognitive tasks. The laboratory environment will aim to simulate a national park setting in order to gain information about how humans are effected by environmental noise in national parks

The present project is loosely based on Berman et al. (2008) and Jehncke et al. (2011) methods in using cognitive tasks to measure human restoration in a natural environment. Berman et al. (2008) used time spent in a natural setting as a treatment, while Jehncke et al. (2011) simulated a natural environment using a visual stimuli and sound recordings. Benfield et al. (2010) identified the effects of non-natural sounds heard in national parks on memory. Memory is a component of cognitive performance. We plan to take this research further by examining the attention aspect of cognition and identifying whether or not the sound environment can influence one's ability to direct attention or process different types of stimuli.

Telephone Calls:

Confirmation Call Script:

Natural Sounds 24 Hour Reminder: Phone Call

The following script should be used to remind participants of their upcoming involvement in a study. This phone call should occur within 24 hours prior to the beginning of the study. For example, if the participant is scheduled for 2:00 PM on Wednesday, February 12, a research assistant should run through this script on Tuesday, February 11th.

"Hello, may I please speak to _____. My name is _____ and I am calling from the Social Science Acoustics lab at Penn State University. I'm calling to confirm your scheduled appointment with the Perceptions of Conditions in National Parks study at our office at *[Day/Date/Time]*. Please come to room 4 in the Keller building, which is in the basement.

[If Participant is coming to their appointment]:

Do you remember/know how to get here, or would you like me to give you directions?

(If so, read the directions from the Direction sheet. Make sure this sheet is available at the time of the call.)

Do you have any additional questions?

(Only answer questions that you are sure you have the correct information about. If you don't know or are not absolutely sure about what to say, write down the question and the person's name and phone number and inform them that project staff will call them back. Then inform project director of the call immediately.)

Thank you for your participation! We look forward to seeing you at *[Time]* on *[Day/Date]*. This appointment will last approximately an hour and a half. Please don't hesitate to call us if there is an emergency or if you have any further questions. Our number is 847-606-0275. *(Record date/time of visit in Scheduling Book)*

[If participant is NOT Coming to their appointment]:

- Always wait until the participant cancels before you ask them if they want to reschedule. WE will reschedule participants in some instances. Inform the person that they may be rescheduled and project

Inform them that staff will email them another doodle poll in the next 24 hours. Remember to record their name and phone # and contact the project director immediately.

- If a participant has any problems or questions, tell them that the project staff will contact hem as soon as possible. Record their name and telephone number and notify project director.

Leaving Messages Script:

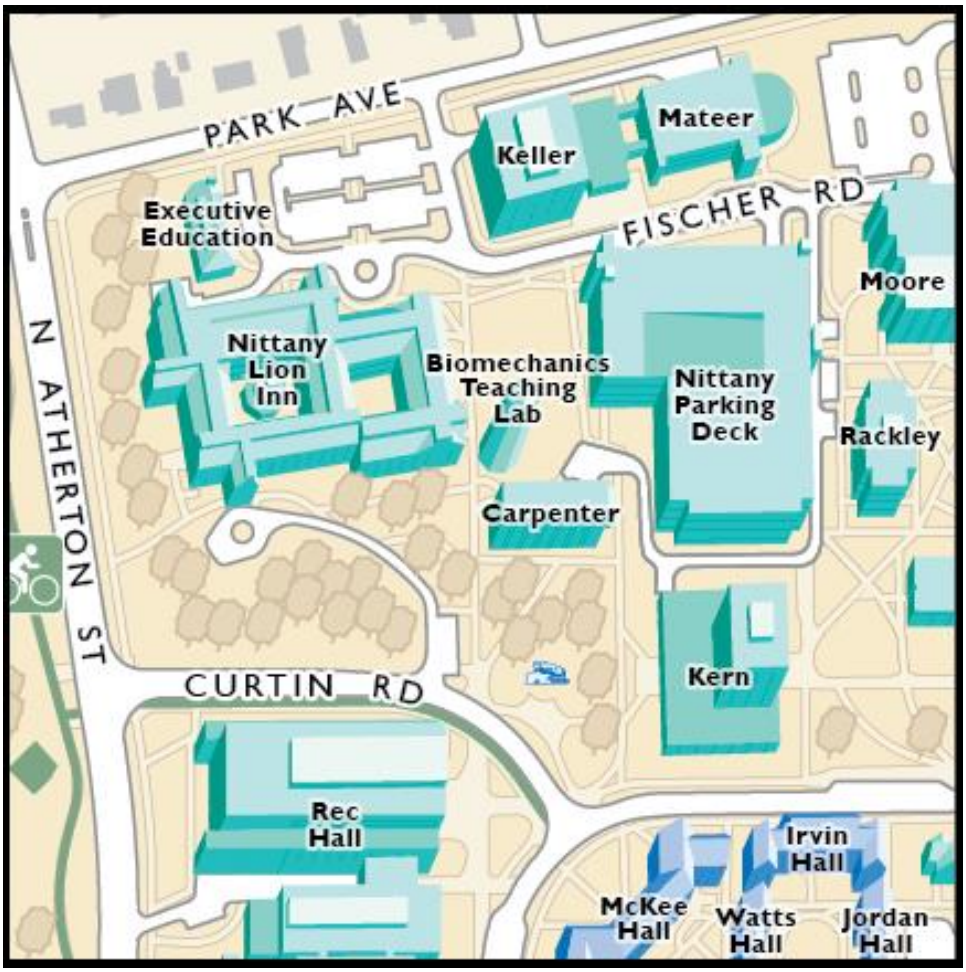
LEAVING MESSAGES FOR SOUNDSCAPE

If a scheduled participant doesn't answer their phone when calling to remind them of their appointment, use the following script to leave them a message.

Hi [Participant name], this is _____ calling from the social science acoustics laboratory at Penn State reminding you about your appointment on [Day of the week], [Month] [Date] at [Time of day]. We have you scheduled to participate in the Perceptions of Conditions in National Parks. The lab is in room 4 of the Keller which is in the basement. Please be sure to call us back at the lab to inform us of any problems, concerns, or ask us any questions. Once again our phone number is 847-606-0275. Thank you and have a nice day.

Directions to Lab:

The lab is located in the basement of the Keller Building, located on Fischer Road, across from the Nittany Parking Deck on the Northwest side of campus. The most efficient way to access the basement is to enter through the front doors and immediately turn left, prior to walking through the second set of doors. This is entry to the basement, walk down the stairs and room 3 will be on your right hand side.



Study Involvement Questions

How long are these visits? How many visits?

-Your visit will run for approximately 1 hour

What if I miss an appointment? Am I out of the study?

-No, we are very flexible and can reschedule your appointment if you can't make it. But we do ask that if you know in advance you will not be able to come to an appointment that you call us so we can reschedule your visit.

What sorts of things will I be doing for the assessment visits?

- You will be asked to fill out several questionnaires and complete a listening exercise.

Other Questions

Is this study dangerous to my health? What are the risks?

-No.

Is this a student-run study? You said Penn State University. Is it college students or professionals?

-This study is being run through the Recreation, Park and Tourism Management Department at PSU. The principal investigator is Dr. Peter Newman, who is a professor of Recreation, Park and Tourism Management at Penn State. Although there are some undergraduates that are assisting on the project, it is run by Dr. Newman here at Penn State. It has been approved by the Penn State University IRB office as appropriate research.

Will I find out what the study shows when it is over?

-Yes, at the end of the study if you would like we can get your address and then once all of the results have been compiled, we can send you a copy.

Study Procedure

The study will utilize a 4 sound type (between) X 2 Time point (within) design in which participant cognitive ability will be measured both before and after a cognitive restoration period in which some will experience nature sounds while others will experience different forms of manmade sounds.

Step-by-Step Procedure:

1. Participants will receive informed consent
2. The participant will participate in a cognitive depletion task (They will be asked to memorize a nine digit number.)
3. The lab assistant will administer part 1 of the questionnaire to the participant.
4. Participant will be asked to read back the 9 digit number, while the lab assistant records the number.
5. The lab assistant will ask the participant to memorize another 9 digit number.
6. The lab assistant will administer part 1 of the questionnaire to the participant.
7. Participants will be given a restorative/relaxation period. They will be asked to imagine that they are relaxing in a national park. A video taken from a meadow in Yosemite National Park will be viewed on a large projection screen. Participants will listen to various sound environments through noise cancelling headphones.
8. Participants will complete another cognitive task (Backwards digit span) that is administered and scored by the lab assistant.
9. Participants will be debriefed and compensated for extra credit or course research credit (as applicable).

Procedure Materials:

1. Informed consent form
2. Questionnaire part 1
3. Questionnaire part 2
4. Depletion task and score form
5. Backwards digit span packet and score form
6. Laptop
7. Noise canceling headphones

Soundscape and Health Mastersheet

Procedure Checklist:

Time participant arrived: _____

Room 4:

____ Implied Consent form explained and copy given to participant

____ Explain cognitive depletion task and administer part 1

____ Questionnaire part 1 completed

____ Ask participant to recite 9 digit number

____ Cognitive depletion task part 2

____ Questionnaire part 2 completed

____ Ask participant to recite 9 digit number

Move to projection room:

____ Explain relaxation period and hand participant headphones (10 minutes

____ Explain and administer the backwards digit span task

Move back to Room 4:

____ Debrief participant

____ Extra credit

CONSENT FOR RESEARCH

The Pennsylvania State University

Title of Project: Perceptions of Conditions in National Parks

Principal Investigator: Lauren Abbott

Address: *801 Ford Building, University Park, PA 16802; lca132@psu.edu*

Telephone Number: (814) 867-1756

Advisor: Derrick Taff, Ph.D.

Advisor Telephone Number: (814) 867-1756

We are asking you to be in a research study. This form gives you information about the research.

Whether or not you take part is up to you. You can choose not to take part. You can agree to take part and later change your mind. Your decision will not be held against you.

Please ask questions about anything that is unclear to you and take your time to make your choice.

1. **Why is this research study being done?**

The purpose of this study is to investigate the influence of different acoustical environments on laboratory subjects' restoration.

We are asking you to be in this research because your course instructor has agreed to give you course credit in exchange for volunteering your time. We are seeking undergraduate students from Pennsylvania State University.

This research is being done to find out how natural sounds influence human restoration.

Approximately 600 people will take part in this research study.

2. **What will happen in this research study?**

Upon arriving at the lab, you will be asked to review the consent form if you agree to participate. All of your information will remain anonymous and you will not be asked to use any identification information. You will complete a few questionnaires so we can get some background information about you (note that you are allowed to skip any questions you prefer not to answer). We will then give you a questionnaire that aims to understand your mood and personality. You will then be asked to complete a series of tasks that aim to challenge your mental ability. Next, you will be given time to restore from these tasks and you will view a nature scene and listen to a sound recording. You will be asked to do another series of tasks and fill out another questionnaire. Once complete, we will debrief and you will be able to leave the lab.

3. **What are the risks and possible discomforts from being in this research study?**

There are no known risks associated with the study procedures.

It is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

4. What are the possible benefits from being in this research study?

There are no direct benefits to participants.

4a. What are the possible benefits to you?

There is no direct benefit to you for participating in this study. However, by participating we hope that you will gain insight into current research in the field of human dimensions of natural resources.

4b. What are the possible benefits to others?

Society and others may benefit from the results of this study. Gaining information on the links between human health and the environment. Further justifying the need for parks and protected areas.

5. What other options are available instead of being in this research study?

You may decline participation in this study at any time. If participating for class extra credit, an alternative to participating in this study is to read a journal article on a similar subject (chosen by instructor) and write a 1 page review of the article.

6. How long will you take part in this research study?

If you agree to take part, it will take you about 40-55 minutes to complete this research study. You will not be asked to return to the research site.

7. How will your privacy and confidentiality be protected if you decide to take part in this research study?

Efforts will be made to limit the use and sharing of your personal research information to people who have a need to review this information.

- Your research records will be labeled with your code number and will be kept in a locked room.

In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

We will do our best to keep your participation in this research study confidential to the extent permitted by law. However, it is possible that other people may find out about your participation in this research study. For example, the following people/groups may check and copy records about this research.

- The Office for Human Research Protections in the U. S. Department of Health and Human Services
- The Institutional Review Board (a committee that reviews and approves research studies) and
- The Office for Research Protections.

Some of these records could contain information that personally identifies you. Reasonable efforts will be made to keep the personal information in your research record private. However, absolute confidentiality cannot be guaranteed.

8. What are the costs of taking part in this research study?

Not applicable

8a. What will you have to pay for if you take part in this research study?

Not applicable

11. What are your rights if you take part in this research study?

Taking part in this research study is voluntary.

- You do not have to be in this research.
- If you choose to be in this research, you have the right to stop at any time.
- If you decide not to be in this research or if you decide to stop at a later date, there will be no penalty or loss of benefits to which you are entitled.

12. If you have questions or concerns about this research study, whom should you call?

Please call the head of the research study (principal investigator), Lauren Abbott at (814) 867-1756 if you:

- Have questions, complaints or concerns about the research.
- Believe you may have been harmed by being in the research study.

You may also contact the Office for Research Protections at (814) 865-1775, ORProtections@psu.edu if you:

- Have questions regarding your rights as a person in a research study.
- Have concerns or general questions about the research.
- You may also call this number if you cannot reach the research team or wish to talk to someone else about any concerns related to the research.

INFORMED CONSENT AND AUTHORIZATION TO TAKE PART IN RESEARCH

Your participation implies your voluntary consent to participate in the research.

Visit Script & Procedures

Verify the participant:

-A potential participant should arrive and be waiting outside of the lab. Greet the person and verify that they are here for the National Parks and Sound study.

Research Assistant
-*Hello, are you here for the Perceptions of Conditions in National Parks study?*
-If the person indicates that they are NOT waiting for the study, just say thank you and continue to wait for the actual participant. If the person indicates that they ARE waiting for the Perceptions of Conditions in National Parks study, introduce yourself and invite the person into the lab.

Research Assistant
-Hello, please come in and have a seat. My name is _____ and I am a research assistant for the Social Science Acoustics Laboratory.

Implied Consent:
-Obtain consent from the participant to participate in the study. Say the following:
Research Assistant
-Now I'm going to go through the implied consent with you. I will hand you a copy to read at this time. This form explains the procedures you will follow during today's study. Remember that your information will be kept confidential and your participation is completely voluntary. Please stop me at any point if you have any questions and I will explain more thoroughly. **(Go through implied consent)**
*Okay, well if you don't have any questions we can continue.(***Answer any questions the participant has without giving away specific details about the research question or hypothesis of the study)**
If you have to use the restroom, we ask that you do so now because once the study begins you will not be able to. **(Allow participant to go to the bathroom, or if they say no, continue)**

One additional thing we ask of you is that you turn your cell phone off for the duration of the study. So please turn off your cell phone and we can get started with the study. **(wait for participant to turn off phone and then move on to the next section)**

Cognitive Depletion Task and Questionnaires:

Research Assistant

Now I am going to give you a questionnaire to complete. Before you begin, I will read you a nine-digit number. It's VERY important that you memorize this number. I will ask you to repeat the number back to me in a little while. I will only read the number once, so listen very carefully. Let me know when you are ready to begin.

(Read the number in a slowly at a consistent pace. Try not to develop a rhythm or change your voice tone while reading the number. Read only once)

Here is the number:

7 – 1 – 3 – 5 – 8 – 7 – 3 – 2 - 0

Research Assistant:
-You will now complete a small series of questionnaires. This should take 5-10 minutes. Please answer each question to the best of your ability, take your time and let me know when you are done. **(Hand participant questionnaire part 1 packet)(Should take ~15-20 minutes to complete)**

Thank you for completing the questionnaires. Now can you please recall, out loud, the number I read to you before completing the questionnaire.

Number the participant repeats back to you after the questionnaire is complete:

_____

Now I am going to give you a second number to memorize. It's VERY important that you memorize this number. I will ask you to repeat the number back to me in a little while. I will only read it once, so listen very carefully. Let me know when you are ready to begin.

(Read the number in a slowly at a consistent pace. Try not to develop a rhythm or change your voice tone while reading the number. Read only once)

6 - 9 - 1 - 6 - 3 - 2 - 5 – 8-0

You will now complete a small series of questionnaires. This should take 5-10 minutes. Please answer each question to the best of your ability, take your time and let me know when you are done. **(Hand participant questionnaire part 1 packet)(Should take ~15-20 minutes to complete)**

Thank you for completing the questionnaires. Now can you please recall, out loud, the number I read to you before completing the questionnaire.

Number the participant repeats back to you after the questionnaire is complete:

_____

Relaxation Task (for both experimental groups):

Research Assistant:

- Now it is time to begin the next task. Please follow me into the next room. Please sit down in this chair **(point to chair).** *You will watch a video of a nature scene from a national park. You will also be given headphones to hear sounds that accompany the scenes. It's important that you imagine that you are actually in this setting* **(Make sure headphones are switched on)**. *I will leave you here to do this. It should take 7 minutes so I will return when you are done. You can put the headphones on now and I will play the video of nature scenes* **(Hand participant noise-cancelling headphones)** *I will leave now and I will be back in 7 minutes when your video is complete.* **(Turn lights off as you leave room; Return 7 minutes later.)**

Backwards digit span task

Research Assistant:

We will now begin our final task. Listen carefully to my instructions. (skip to **READ TO PARTICIPANT**)

Instructions for digits backward task.

administer questions:

(1) read each digit span **only once** at an even rate of 1 digit per second.

(2) read part a of question; pause for response, then score.

(3) read part b of question; pause for response, then score.

(4) if participant does not respond, do **not** encourage further.

(5) stop when participant misses part a **and** part b of any **one** question.

score questions:

(1) to be scored correct, no digits may be omitted or be in forward order.

READ TO PARTICIPANT:

Research assistant says:

I am going to say some numbers. Listen carefully, and when I am through, say them right after me, but in backwards order. SAY: "Ready" BEFORE EACH QUESTION. For example, if I say 9-2-7, what would you say?

PAUSE FOR PARTICIPANT TO RESPOND. DID THEY RESPOND CORRECTLY (7-2-9)?

YES ☐.(7-2-9) SAY: That's right. Let's go on with the rest of the numbers. **PROCEED TO 1ST ITEM**

NO☐. SAY: No, you would say 7-2-9. I said 9-2-7, so to say it backward you would say 7-2-9. Now try these numbers. Remember, you are to say them backward: 3-6-5.

WHETHER THE PARTICIPANT IS CORRECT OR WRONG ON THE SECOND EXAMPLE, THE TEST WILL PROCEED.

		CORRECT	WRONG
2.	**A. 2 - 5 (ANS = 5-2)**	**1**	**2**
	B. 6 - 3 (ANS = 3-6)	**1**	**2**

CAPI CHECK: IF BOTH A & B ARE CODED WRONG, SKIP TO INTERVIEWER REMARKS.

3.	**A. 5 - 7 - 4 (ANS = 4-7-5)**	**1**	**2**
	B. 2 - 5 - 9 (ANS = 9-5-2)	**1**	**2**

CAPI CHECK: IF BOTH A & B ARE CODED WRONG, SKIP TO INTERVIEWER REMARKS.

4.	**A. 7 - 2 - 9 - 6 (ANS = 6-9-2-7)**	**1**	**2**
	B. 8 - 4 - 9 - 3 (ANS = 3-9-4-8)	**1**	**2**

CAPI CHECK: IF BOTH A & B ARE CODED WRONG, SKIP TO INTERVIEWER REMARKS.

5.	**A. 4 - 1 - 3 - 5 - 7 (ANS = 7-5-3-1-4)**	**1**	**2**
	B. 9 - 7 - 8 - 5 - 2 (ANS = 2-5-8-7-9)	**1**	**2**

CAPI CHECK: IF BOTH A & B ARE CODED WRONG, SKIP TO INTERVIEWER REMARKS.

6.	**A. 1 - 6 - 5 - 2 - 9 - 8 (ANS = 8-9-2-5-6-1)**	**1**	**2**
	B. 3 - 6 - 7 - 1 - 9 - 4 (ANS = 4-9-1-7-6-3)	**1**	**2**

CAPI CHECK: IF BOTH A & B ARE CODED WRONG, SKIP TO INTERVIEWER REMARKS.

		CORRECT	WRONG
7.	**A. 8 - 5 - 9 - 2 - 3 - 4 - 2 (ANS = 2-4-3-2-9-5-8)**	**1**	**2**
	B. 4 - 5 - 7 - 9 - 2 - 8 - 1 (ANS = 1-8-2-9-7-5-4)	**1**	**2**

CAPI CHECK: IF BOTH A & B ARE CODED WRONG, SKIP TO INTERVIEWER REMARKS.

8.	**A. 6 - 9 - 1 - 6 - 3 - 2 - 5 - 8 (ANS = 8-5-2-3-6-1-9-6)**	**1**	**2**
	B. 3 - 1 - 7 - 9 - 5 - 4 - 8 - 2 (ANS = 2-8-4-5-9-7-1-3)	**1**	**2**

Debriefing:

Research Assistant:
The purpose of this study was to see how you responded to one of several presentations of information related to national parks. There are several elements to this study that I will now explain to you and debrief you on. First, we had you fill out several questionnaires to gather information about your personality and mood before the tasks we asked you to complete. We then had you memorize a 9 digit number which was mentally tiring. We then allowed you time to relax by having you watch a video of a national park. Finally, you completed a cognitive task to measure how well you recovered from the first task. Do you have any questions for me?

If participant is participating for class credit or assignment: (Verify we have the correct class and professor information, including section #) *We will notify your class/professor of your completion of this study and you will receive proper credit.*
If you have any further questions, please contact Lauren Abbott with questions, complaints or concerns about the research. The research team can answer questions about the research procedure.

Also, please do not share any information about the lab procedure with others. It's very important that participants come into the lab, unaware of the purpose of this study.

Thank you so much for your participation. Have a good day.

(Study is over; Participant can leave.)