

Soundscapes of Bryce Canyon National Park:

A Multi-Method Analysis of Aircraft Overflights

Final Report

Submitted to:

Laura Schrage, Sarah Haas, & Sean Eagan
Bryce Canyon National Park

Prepared by:

Britton Mace
Southern Utah University, Department of Psychology



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1 EXECUTIVE SUMMARY

This project examined the soundscape of Bryce Canyon National Park using a multiple methodological approach to better understand acoustic zones throughout the park and the influence of aircraft overflights on visitor experience. The project was divided into two phases.

- Phase I involved the creation of a visitor survey to measure the importance of the soundscape of the park.
- Phase II involved attended audibility logging in multiple locations throughout the park to quantify differences between acoustic zones.
- The second component of phase II utilized percent time audibility data from the attended logging results and sound recordings collected in the park to create a controlled laboratory study focusing on aircraft overflights.

Visitor Surveys

Phase I entailed participating in numerous workshops with park managers at Bryce and personnel from the NPS Natural Sounds Program Office. These workshops helped identify the important variables and methodology for a visitor survey on the importance of soundscapes. Surveys were created for frontcountry and backcountry visitors, with many variables included to move beyond the standard response of annoyance when examining visitor expectations of the Bryce soundscape and reactions to aircraft overflights. Frontcountry and backcountry surveys for Bryce visitors were planned to be distributed in the fall of 2007, however with a full review required by the Office of Management and Budget, surveying was delayed until 2008. It was during this 9-month review process, in consultation with the Bryce management team, the research plan in Bryce was determined to continue with different methods other than visitor surveying while a multi-agency advisory group was convened to work on the survey methodology. It was agreed by all parties it would be beneficial to create a standardized visitor surveying protocol that could be used in many national parks. Phase I of the Bryce Soundscape Project consequently moved on to Phase II and focused on attended audibility logging and laboratory simulations.

Attended Audibility Logging

A key analysis issue for park managers has been determining what levels and types of sound are appropriate or acceptable for different management areas within a park. One of the first steps in a program of soundscape research is to identify the frequency, loudness, and duration of sounds commonly experienced and produced by visitors to a National Park. There a number of accepted methodological techniques for capturing the soundscape of a national park, each with inherent advantages and disadvantages. One technique that has proven to be cost effective while

producing useable data is audibility logging. Attended sound logging captures audibility using software developed by the Natural Sounds Program Office of the National Park Service and is run on a palm pilot, allowing portability in the field. Audibility logging is completed by a single observer who records what is audible to them using touch screen technology and a stylus. Ideally, attended sound logging should be combined with on-site sound recording in order to have a complete record of the actual sound present in a given location. Sixteen sites were identified in Bryce Canyon National Park to reflect a spectrum of locations within the hypothesized acoustic zones of the park. Many of these sites were selected for sound logging and recording over a two year period, in four different acoustic zones:

- Very Busy Acoustic Zone (3 main sites)
 - The Lodge area
 - Sunrise Point
 - Sunset Point
- Frontcountry Viewpoints (Moderately Busy Acoustic Zone) (3 main sites)
 - Fairyland Point
 - Farview Point
 - Rainbow Point
- Short Hikes (Below the Rim Acoustic Zone--about 1 mile from the rim) (2 sites)
 - Amphitheatre Trails
 - Fairyland Trail
- Backcountry (Least Visited Acoustic Zone)
 - Two sites along the Riggs Spring Loop

Data collected from these sites show variations in the type, frequency, and duration of anthropogenic and natural sounds. Main findings include:

- In the busiest acoustic zone with the highest density, human-caused sounds (voices, vehicles) were found to be audible over 90% of the time, with a short average noise-free-interval of 36 seconds.
- Moderately busy frontcountry viewpoints had a high percentage of audible vehicles and visitors nearly analogous to the busiest areas of the park, with an average noise-free-interval of 39 seconds.
- Short hiking trails had a much lower audibility percentage of vehicles and the sounds created by visitors, differing from the moderately-busy acoustic zone by nearly 20%, and the busiest acoustic zone by nearly 30%. However other anthropogenic sounds such as high altitude passenger jets were readily apparent 25-30% of the time.

- Natural sounds were audible in the backcountry 95% of the time, nearly a 20% increase over the other acoustic zones. Although the backcountry seems to afford the greatest opportunity to experience natural ambient sounds, anthropogenic sounds are evident even in the remote areas of the park greater than half of the time. This is due primarily to the presence of aircraft overflights and encounters with hikers and backpackers.
- The one ubiquitous sound encountered in all acoustic zones was that produced by aircraft, with high altitude jets audible on average around 25-30% of time in all locations where attended audibility logging was completed. Backcountry locations had the highest audibility percentage for aircraft, over 40%, as there were fewer opportunities for masking from other sound sources.
- The most frequently audible natural sounds, in all acoustic zones of the park, were the wind and birds.
- Measures of loudness using the A-weighted decibel scale primarily ranged between 20 and 40 dB(A) for natural sounds, and 30-60 dB(A) for anthropogenic sounds.

When analyzing all the results from the attended audibility logging phase of this project, it becomes clear there are many detectable auditory differences based on the number of visitors and vehicle activity level found with the different areas of the park. The establishment of acoustic zones is, therefore, beneficial in order to begin developing indicators of quality and management standards for the distinct soundscape spectrum present in each location.

Laboratory Experiment

Soundscape laboratory studies employ methodological techniques common to environmental psychology adapted from the landscape assessment literature. More specifically, real world conditions from natural areas are depicted with digital photographs and sound recordings while participants assess aesthetic, cognitive, and affective dimensions using Likert-type rating scales.

The present research compares noise created by helicopters, propeller planes, and high altitude jets in a laboratory setting with Likert scale ratings of scenic park landscapes and soundscapes. A between-subjects design with 215 participants was employed with ratings completed on 40 landscapes of Bryce Canyon on six dependent measures (scenic beauty, naturalness, solitude, tranquility, annoyance, and overall preference). Scenes were paired with either natural sounds (30 trials) or aircraft noise (10 trials) to simulate the 25% time audibility level average found in the park with audibility logging. Each scene and sound was viewable and audible for 30 seconds, so the total exposure to aircraft noise was 5 minutes out of a 20 minute rating session. Decibel levels for aircraft and natural sounds did not exceed 50 dB(A). Participants served in only one of three aircraft noise conditions, hearing only one type of aircraft during the evaluation session.

- Results found all types of aircraft noise to cause important reactions. When compared with natural sounds, annoyance increased, while solitude, tranquility, naturalness, scenic beauty and overall preference all decreased when aircraft noise was audible. This was true for all types of aircraft: helicopters, propeller planes, and high altitude jets.
- Differences were found between the three types of aircraft noise examined in this study, showing they are not perceived identically. Based on the mean ratings, helicopters were the most annoying of the three types of aircraft noise, and had lower ratings of solitude, tranquility, naturalness, and overall preference than propeller planes and jets.
- The major differences between the types of aircraft noise were the comparisons of jets with propeller planes and helicopters. When compared with the other two noise sources, high altitude jet noise was less annoying and had higher ratings of solitude, tranquility, naturalness, and overall preference. Propeller plane and helicopter noise was found to statistically differ only on ratings of naturalness and overall preference. In other words, the psychological reaction to helicopters and props is quite similar.
- Annoyance increased as the number of doses of aircraft noise increased. This pattern is evident with all types of aircraft noise, with annoyance ratings during the first dose of noise lower than ratings in the second and third doses. Differences in annoyance ratings were also evident between the natural sound segments, with higher ratings of annoyance found on the final nature sound segment, which followed three doses of aircraft noise.
- Several of the dependent variables clearly show a restorative effect when encountering natural sounds following exposure to aircraft noise. Ratings spike for solitude, tranquility, and naturalness on the first trial following the first and second doses of aircraft noise. After the third noise dose, ratings of solitude, tranquility and overall preference did increase, but not to the levels found in the second and third sets of nature sounds.
- These results show that aircraft noise, whatever the source, has disruptive effects on psychometric attributes important in a natural setting such as Bryce Canyon National Park. After three doses of aircraft noise, positive responses are dissipating and the noise exposure is perceived as excessive.
- Aircraft noise, especially helicopters, at the level of 25% time audible may be the upper limit of exposure deemed acceptable by visitors, as deleterious effects to solitude, tranquility, preference, naturalness, and heightened annoyance become apparent.

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3 Introduction

Bryce Canyon National Park was created in 1928 and is located in south-central Utah. Bryce was protected as a national park because of its unique geologic formations, including amphitheatres a thousand feet deep filled with rock spires called “hoodoos”. By western national park standards, Bryce is a small park, spanning 56.2 square miles (nearly 36,000 acres), encompassing more length than width in a north to south orientation. The park boundaries follow the length of the Paunsaugunt Plateau, offering numerous overlooks along the main road. Visibility on the rim of this plateau can stretch as far as 200 miles on clear days, providing visitors distant vistas of the surrounding terrain. Despite the small size of the park, opportunities abound for exploration away from the main road, with numerous hiking trails dropping into the amphitheaters among the hoodoos. Much of Bryce is classified as wilderness (60% of the park) providing the nearly 1.5 million annual visitors the chance to experience the peace and quiet found in the backcountry. Because of its location and abundance of wilderness, many unique resources are present in the park. These resources include not only the geology, flora, and fauna found in Bryce, but also clear distant views, unparalleled night sky visibility, and one of the quietest soundscapes in the United States. The mission of park managers at Bryce is to preserve and protect these unique resources for the benefit of visitors and non-human inhabitants today and into the future.

Most are familiar with the term “landscape” to describe what can be perceived visually in a given area, however the equivalent term of “soundscape” for what is audible in a setting is much less known. A soundscape refers to the complete acoustic environment of any given area, built or natural. It is the combination of many individual species, the sound of the planet, the weather, and, more recently, the increasingly common sounds of humans. In terms of a National

Park, both natural and human generated sounds may be expected and considered desirable and appropriate, depending on the purpose and meaning of the park. Perhaps due to the recency of which soundscapes in national parks have received legislative attention, researchers have been slow in providing an understanding of the natural world with regard to sound.

3.1 Legislation and Planning

Legislation such as The National Parks Overflight Act of 1987 and the National Park Scenic Overflight Concession Act of 1994 illustrate the importance placed on natural quiet in the past 25 years. The ambient silence often found in natural areas was, at one time, available and accessible (and, for that matter, taken for granted), but as human-produced noise has spread, natural quiet has since been recognized as a resource to be protected. In fact, the National Parks Air Tour Management Act of 2000 directs the National Park Service and the Federal Aviation Administration to articulate operational policies in the national parks designed to protect, maintain, and restore the soundscape where natural and cultural resources, and/or visitor enjoyment is being negatively affected by aircraft noise. This legislation specifically recognizes natural soundscapes as valuable and important resources in need of protection--something national park visitors and the general public recognized long ago. Additional legislation and directives have also played a vital role in defining soundscape related issues and ways in which sound resources should be managed.

For example, National Park Service Management Policy 4.9 (2006) states the park service will preserve the natural soundscapes of the park to the greatest extent possible, and restore degraded soundscapes to their natural condition. This policy also directs park superintendents to identify levels and types of human-caused sound that are acceptable within

the purpose of the park. Furthermore, action should be taken to prevent or minimize noise that is deemed unacceptable or inappropriate for visitors at specific sites within a park. National Park Service Directors Order 47 describes the creation of soundscape management plans to address the elimination, mitigation, or minimization of inappropriate noise sources in a park. As part of the planning process, superintendents are to describe the baseline ambient sound conditions, identify sound sources and sound levels, and describe desired future soundscape conditions and the means by which to achieve these desired conditions. In addition, Directors Order-47 established the Natural Sounds Program Office, founded in 2000 and located in Ft. Collins, Colorado.

The necessity for soundscape management planning is based on the requirements set forth in these described directives and legislation, as well as the recognition that natural sounds are intrinsic to natural resources in the parks and the enjoyment of park visitors. Anthropogenic noise, in terms of the type, loudness, frequency, duration, and context, can disrupt both natural ecological processes in parks and visitor experiences. One of the first steps, therefore, in developing a soundscape management plan for a national park is to obtain physical measurements of the soundscape at locations representing a variety of acoustic zones, or areas having similar sound qualities. Protocols have been developed for the collection, measurement, and analysis of sound data in national parks to provide a standardized procedure to produce a baseline of ambient sound conditions. Using techniques such as attended audibility logging and on-site sound recording, current metrics being collected and considered with management proposals are the source of the sound, the maximum decibels of a sound or noise event, the number of events, the length of noise free intervals, audibility, time of audibility, and the

dispersion of the sounds. These metrics can then be compared with management objectives for the given acoustic zone or for the park as a whole.

3.2 Aircraft Overflights

Audibility logging and sound recordings in many national parks have consistently included the clearly audible sounds of aircraft. Noise emanating from jets carrying commercial passengers and cargo, helicopters and planes used for scenic overflights, park service maintenance, fire and emergency operations, as well as military aircraft are among the most common in the airspace above national parks. Research on aircraft overflights over national parks has primarily focused on scenic air tours, only recently expanding to other soundscape and noise issues. Overflight management of any type of aircraft requires cooperation with the Federal Aviation Administration, and, in some cases the military, as these agencies have jurisdiction over airspace. The national park service has jurisdiction over land-based resources. The NPS and FAA have focused most of their attention on national park units which have scenic air tours, such as Grand Canyon, with an emphasis on designing scenic flight corridors, establishing noise free zones, and agreeing to regulations regarding time of day and dose exposure.

In recent years, other aircraft overflight issues have emerged with little or no research available to establish basic management standards in affected areas. For example, commercial airports handled more than 8.5 million flights in 1999, nearly double the number of flights handled in the mid-1970s. FAA statistics show the number of commercial flights emanating from the U.S. in 2006 averaging between 900,000 and one million a month. This breaks down to approximately 31,000 flights a day, or 1300 every hour. It is important to realize these numbers

represent averages, so during busy hours of the day the number of commercial flights in the air can be much greater. Miller (2008), for example, shows how 3,345 jet departures in one hour in October of 2000 nearly blanket the entire United States with their flight paths. Furthermore, these numbers are all expected to increase in the future. While little research exists on how commercial jet overflights affect national park visitors, anecdotal reports suggest visitors do notice them. For example, on September 11, 2001, backcountry hikers in National Parks knew that something had gone very wrong because there were no sounds from jet overflights present while they were backpacking (Bell, Mace, & Benfield, 2009). Commercial jets are usually high enough when going over most national parks so they yield less noise than tourist aircraft, but visitors do notice them and they can interfere with some activities (Williams, 2007). Furthermore, decades of research in urban environments by environmental psychologists and other researchers has clearly demonstrated many adverse affects associated with jet aircraft noise.

Aircraft noise and noise pollution from a number of different sources has been the focus of extensive research study in built environments with findings showing both short- and long-term consequences for psychological well-being, social relationships, and human performance (Glass & Singer, 1972). These negative effects occur even at levels below the threshold of awareness. Chronic noise exposure impacts many people in urban settings, amplifying social conflicts and interfering with daily tasks. Chronic stressors also undermine normal development and play havoc with general health in all age groups (Baum, Singer, & Baum, 1981; Bell, Green, Fisher, & Baum, 2001; Campbell, 1983).

Prolonged exposure to excessive noise in the home, school, hospital, and workplace is associated with a multitude of health problems, including hearing loss (Kryter, 1994) and high

blood pressure (Talbot et al., 1990). Researchers have found a relationship between frequent exposure to transportation noise and sleep problems, perceived health, and frequency of illness (Bronzaft, et al., 1998). A series of studies in Munich, Germany with elementary school children as participants found clear evidence of stress related effects and cognitive deficits as a result of aircraft noise exposure (Evans, Bullinger, & Hygge, 1998; Evans, Hygge, & Bullinger, 1995). Children living near Munich International Airport were found to have higher levels of stress hormones, higher diastolic blood pressure, lower reading scores, and memory detriments compared to those students in quieter neighborhood schools. Students near the airport also displayed less tolerance for frustration, higher levels of annoyance, and less motivation compared to students in quieter surroundings (Evans et al., 1995). In a similar study, Evans et al. (1998) examined 217 third- and fourth-grade children living either near a new airport in Munich over a two-year period or in urban areas outside of the noise affected zone. Results showed that chronic exposure to aircraft noise was associated with greater levels of stress symptoms, higher resting blood pressure, and higher levels of urinary catecholamines. Furthermore, perceived quality of life (a combined index of physical, psychological, social, and functional daily life scores with $\alpha = .92$) was found to be significantly lower in those students exposed to aircraft noise following the opening of the new airport.

Noise is inherently a psychological phenomenon, defined as any unwanted sound, which introduces a subjective component. For example, sounds such as loud music may be perceived as enjoyable to some, but can be annoying to others. When sound is deemed unwanted and becomes noise, the negative effects are most pronounced when it is loud, unpredictable (e.g., intermittent as opposed to a constant hum), and uncontrollable (Glass & Singer, 1972). If the perceiver considers the noise as unnecessary, or if the perceiver believes the producer is

unconcerned about the welfare of others, annoyance levels further increase. Level of annoyance is augmented if the noise is believed to be hazardous to health, if it is associated with fear, and if the perceiver is dissatisfied with other aspects of the environment (Green & Fidell, 1991; Miedema & Vos, 1999). Furthermore, noise impedes concentration, enhances recall of negative memories, and increases fatigue (Persinger, Tiller, & Koren, 1999; Willner & Neiva, 1986). For these reasons, psychological reactions are inherent to experiencing sound and should always be included in soundscape policy development and management decisions.

3.3 Escape from Stress and Restorative Experiences

Social scientists have also focused on the therapeutic effects of escape from urban stress such as noise pollution (Driver, Tinsley, & Manfredi, 1991; Driver, Nash, & Haas, 1987; Kaplan, 1995; Ulrich, 1993). Recreation researchers have found that a primary reason for visiting a national park, wilderness area, forest, or other outdoor recreational environment is to escape the stressors found in urban areas (Driver, 1996; Driver & Brown, 1983). Yet, as national parks and other natural areas become increasingly popular for recreational escape, noise pollution accompanying visitors can degrade the experience. Ulrich et al. (1991) have demonstrated that following a stressful experience, the viewing of natural scenes increases positive feelings and reduces physiological indicators of stress (blood pressure, skin conductance, muscle tension), whereas viewing urban scenes does not. Attention Restoration Theory proposes that the restorative value of a nature experience is, in part, due to the soft fascination of natural scenes, which allow stress-depleted attentional capacities to be renewed (R. Kaplan & S. Kaplan, 1989; S. Kaplan, 1995). In an experiment completed by Hartig, Mang, & Evans (1991), participants engaged in activities causing mental fatigue and then either read magazines and listened to music, or went for a walk in either an urban area or along a stream in a

regional park. Those who went for a walk in the park exhibited greater restoration of their mental fatigue than did the other groups.

Appreciating the expanse of a scenic vista and listening to the wind softly whistling through the trees, hearing the birds and the melody of a brook are all a part of the restorative power of the natural world. These revitalizing experiences can be compromised by the din of cars, trucks, buses, aircraft, snowmobiles, motorized watercraft, and off-road recreational vehicles. Indeed, as the following sections will show, people place a high value on natural sounds and quiet, while anthropogenic noise is often considered intrusive and bothersome in national parks and other natural areas.

Visitors to national parks have continually indicated that an important reason for their visit is to enjoy the quiet surroundings and the natural soundscape parks can offer. McDonald, Baumgartner, & Iachan, (1995) conducted surveys with more than 15,000 visitors to 39 NPS units and found 91% considered enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks, second only to viewing the scenery (93%). Another survey completed in 1998 in parks across the country found 95% of Americans regarded opportunities to experience natural peace and the sounds of nature as an important reason for preserving national parks, with 72% stating it to be a very important reason (Haas and Wakefield, 1998). In a study conducted in Zion National Park by Grau (2005), natural and human-caused sounds were integrated with a visual crowding model, with visitors evaluating varying levels of density. Results suggest sounds are just as important, if not more, than other setting attributes related to visitor satisfaction.

Experiencing the soundscape and natural quiet are valued experiences of all park visitors, not just specific groups or recreational users, although there do appear to be some differences in the level of response to noise based on recreational motivation (Berglund, Lindvall, & Nordin, 1990; Tarrant, Hass, & Manfredo, 1995). Freimund, Vaske, Donnelly, and Miller (2002) investigated visitor tolerance for hearing aircraft overflights and motorized boats by employing video surveys to assess visitor norms. Visitors to the frontcountry were found to have a higher tolerance for the sounds of aircraft and motor boats compared with backcountry visitors. Marin et al. (2011) found that a visitor's motivation for experiencing quiet (low, moderate, or high) can affect acceptability of anthropocentric noise encountered in a national monument. These authors suggest using acoustic zoning as a management tool to provide for differences in visitor motivation for quiet, something which is emphasized in the present study in Bryce Canyon National Park.

Field research in other natural environments has also found natural quiet and the sounds of nature to be important inherent qualities of a positive visitor experience. Tarrant, Haas, and Manfredo (1995) examined visitor characteristics and dose exposure (number, proximity, and type) on evaluations of aircraft overflights in wilderness areas. Findings from this study indicate that respondents have strong negative attitudes toward hearing and witnessing aircraft in wilderness areas. Participants found sightseeing and single-engine aircraft to be the most annoying. Visitors also reported their levels of tranquility and solitude to be negatively affected by the presence of aircraft noise. Kariel (1990) obtained data from 713 visitors to three Canadian national parks (Banff, Yoho, and Kootenay) with a survey in campgrounds adjacent to highways. Participants were asked to rate a variety of mechanical and natural sounds common to the area using a five-point bipolar scale measuring pleasantness and annoyance. Rank-order

results indicated the top eight annoying noises to be mechanical in origin, with chainsaws, motorized trail bikes, automobiles, and aircraft sounds being the most annoying. Respondents were pleased with nature-related sounds (water, wind, and birdsong), a finding consistent with the research of Anderson, Mulligan, Goodman, & Regen (1983). Kariel (1990) concluded that the level of human- and technology-related sounds should be kept generally low (below the background level of about 15 dB(A) in outdoor recreation-type environments.

Pilcher, Newman, and Manning (2009) asked 280 visitors to Muir Woods National Monument to identify specific sounds they experienced during their visit. A majority of respondents noticed the sound of water (81%) and wind, along with the noise created by people and groups. Human caused noise varied in the amount of time it was audible based on location, ranging between 40 and 80 percent. The longest noise free interval at any sampled site was found to average 93 seconds, with other sites having noise free intervals averaging as short as 31 seconds. Visitors reported being most annoyed with the sounds of other people, aircraft, cell phones, vehicles, and machinery used for park operations. Furthermore, as the noise generated by the number of visitors increased (i.e. people noise), ratings of acceptability significantly declined (Pilcher, et al., 2009).

3.4 Dose-Response

While there have been an increasing number of noise related studies completed by social scientists in the parks in past twenty years, Staples (1996) has argued, rightfully so, that the majority of soundscape research in parks has been dominated by acousticians and engineers. While progress from a psychological and social scientific point of view has been made recently, research has often remained reliant on the dose-response approach, employing a single response

metric, annoyance (Staples, 1998). Methodology using the dose-response framework estimates the amount of noise an individual was exposed to (the dose), while having the respondent evaluate how annoyed they are with the dose they have encountered (Fidell, et al., 1996). Reliance on annoyance as a sole response variable is inadequate in a setting like a national park, where many other psychological factors are apparent and important to the study of soundscapes. As previously discussed, visitors to parks come with expectations of a quiet park where the sounds of nature are clearly audible. Visitors come seeking the opportunity to experience solitude and tranquility where nature surrounds, dominates, and restores. These variables need to be operationalized into research designs to provide a more complete understanding of the visitor experience with regard to sound. Social scientific methods and the standard dose-response methodology need to be expanded to include additional responses so land managers are provided comprehensive data that provide an understanding of how visitors conceptualize the soundscape, ascribe meaning to the sound environment, and how people respond when natural sounds are impacted by anthropocentric noise (Pilcher, et al., 2009; Staples, 1998). This will also enable researchers and park managers the ability to develop numerous indicators of quality and management standards that can be used in planning, evaluation, and, if necessary, enforcement.

3.5 Environmental Psychological Perspective

Several studies have sought to examine additional soundscape related variables by expanding the number and type of response to include aesthetic, cognitive, affective, and behavioral responses. Unique methods have also been explored in the field and in controlled laboratory experiments to further our understanding of natural soundscapes and the effects of human-caused noise. In one such study, a paired comparison method common to economics was modified to examine the value of public and private goods commonly found in national parks

(Mace, Clarke, et al., 1999). Natural quiet was found to be the public good with the second highest value, just behind clean, clear views. This same result was found with groups of participants from Rocky Mountain National Park, a group of university students, and a group of undergraduates who were also exposed to helicopter noise in a laboratory simulation of conditions in the Grand Canyon.

Laboratory soundscape experiments employ methodological techniques common to environmental psychology adapted from the landscape assessment literature. More specifically, real world conditions from natural areas are depicted with digital photographs and surround sound or noise reducing headphones while subjects assess aesthetic, cognitive, and affective dimensions using Likert-type rating scales. Mace, Bell, and Loomis (1999) simulated real world conditions in the Grand Canyon in order to study the effects of helicopter noise on psychological reactions in the laboratory. A repeated measures, within-subjects design was employed in this study with 80 university undergraduates serving as participants. A set of slides depicting scenic vistas from viewpoints along the south rim of Grand Canyon were rated on 10-point likert-type scales while natural sounds and helicopter noise was randomly presented in the background through a surround sound system. Participants completed positive and negative affect measures prior to and immediately following exposure to the experimental conditions. Results indicated that helicopter noise at both a 40 dB(A) and an 80 dB(A) level had a significant effect on landscape ratings of preference, scenic beauty, annoyance, solitude, tranquility, freedom, and naturalness. Furthermore, affect was significantly more negative following exposure to helicopter noise. Results suggest that helicopter noise, even at a relatively quiet 40 dB(A), interferes with many attributes considered to be important to a park visitor experience, and has a subtle affect on the perceived scenic beauty of park landscapes.

Other lab experiments have focused on the source of helicopter noise and the perceived meaning attributed to the presence of the noise (Mace, Bell, and Loomis, 2003). Previous research has found that people will tolerate or even be pleased with a disturbing sound, at least for a short time period, if they believe that it provides aid or is beneficial in some way. Attributing responsibility to the source party of the noise, therefore, serves as a mediating variable. In this experiment, 200 undergraduates rated national park scenic vistas while being exposed to either natural sounds (birds, brooks, wind), or helicopter noise attributed to either tour overflights, backcountry maintenance operations, or the rescue of a backcountry hiker. Regardless of the source, 60 dB(A) helicopter noise resulted in lower ratings of scenic beauty, solitude, tranquility, freedom, naturalness, and preference, and higher ratings of annoyance. These effects occurred across all types of national park vistas (canyons, mountains, water, forests, and deserts). Scale ratings became significantly more negative as a result of exposure to 6 minutes of helicopter noise, a percent time audibility rate of 40% in this study. In follow-up investigations, helicopter noise attributed to fire fighting or rescuing endangered species had similar negative effects. Results suggest that park management-related overflight noise is just as disturbing as tourist aircraft noise, and that the impact of this noise is substantial across demographic variables (Mace, et al., 2003).

Other laboratory research using methodology nearly identical to the last two studies just described examined the effects of different types of anthropogenic noise (aircraft, motor vehicles, and human voices) on similar psychometric measures (Benfield, Bell, Troup, & Soderstrom, 2010a). This study tested 250 undergraduates in a between subjects design, exposing participants to natural sounds and anthropogenic sounds in the range of 40-65 dB(A). Participants rated scenes from five national parks (Yellowstone, Olympic, Saguaro, Grand

Canyon, and Everglades) on nine Likert-type scales (solitude, tranquility, naturalness, solitude, preference, freedom, annoyance, serenity, and appropriateness). Results found all three types of human-caused noise to have a significant negative effect on all nine psychometric variables in all rated park environments. Air traffic was most influential, however the results show both vehicle noise and the presence of voices causing negative reactions. These effects were mostly exacerbated with an increase in decibel level, with the exception of vehicle traffic, whose ratings remained similarly negative despite increased volume.

As is evident from the research described so far, visitors to national parks come seeking the sounds of nature. Birdsong, flowing water, wind blowing through the trees, leaves rustling, and the sounds of wildlife are all important components of a positive park soundscape experience. If the park visit does not meet expectations, certain psychological needs remain unfulfilled, especially when considering the reasons people seek out natural areas (Driver, et al., 1987, 1991; Ulrich, 1993). Psychological research suggests that aftereffects of noise may be as important as the reactions during the in actual experience. Consequently, certain cognitive dimensions associated with a variety of recreational activities and experiences may be negatively affected both at the time of the visit, and when recalled in the future. For example, McDonald et al. (1995), using a mail-back survey, asked more than 15,000 visitors both at the time of their park visit and a month later about their level of annoyance associated with the aircraft they encountered while at the park. A month following their visit, respondents reported seeing and hearing more aircraft, being more annoyed, and having their enjoyment and attainment of natural quiet significantly more impaired than when they were actually visiting the park. These findings suggest that exposure to aircraft noise in national parks has negative long-term consequences.

Perhaps interference with the restorative functions of the nature experience helps to explain some consequences of the impingement of urban stressors on natural areas.

Parks operate under the visitor experience and resource protection (VERP) framework. As part of the meeting both requirements, parks have educational programs, including exhibits, ranger led talks, and other interpretive materials and opportunities. Researchers have also contributed to our understanding of cognitive processes being disrupted by anthropogenic noise in the context of a national park while a person is engaged with interpretive materials. Benfield, Bell, Troup, & Soderstrom (2010b) exposed undergraduates to nature sounds, voices, or ground traffic noise while they viewed slides of three national parks (Yellowstone, Saguaro, and Great Smokey) with relevant interpretive materials pulled from park websites. Participants memory was then assessed using a 38-item recognition and recall test of the interpretive material they just experienced. Results showed that memory deficits were apparent when participants were exposed to the human-caused noise of voices and ground traffic compared to a control condition. Natural sounds did not show a reduction in memory performance. These results are particularly compelling when considering the sound stimuli was presented at relatively low intensity (in the 40-45 dB(A) range). Interestingly, the effects of ground traffic on memory retention were nearly twice that found with human voices. The results of this study have ramifications for park management, and argue the soundscape also needs to be taken into consideration with regard to interpretation activities in a national park.

Taking all of the research into consideration, it is apparent that noise in parks can be annoying or intrusive to visitors and can detract from their enjoyment of the experience (Miller, 1999). With the spread of multiple sources of anthropogenic noise into national parks, escape from this environmental stressor becomes more difficult. Humans can detect and are sensitive to

small quantities of unnatural sound levels in natural settings. Physical measures of excessive sound levels indicate they are ever more commonplace in natural settings, yet the emphasis of policymakers on physical measures of intensity may understate the problem. In fact, in some parks natural soundscapes are changing or disappearing at such a fast rate that some may be completely gone before their existence can even be documented, all a result of the spread of anthropogenic noise (Krause, 2002). Psychological research suggests that the impact of these stressors is magnified by other factors such as unpredictability and lack of perceived control, as well as expectations regarding appropriateness and recreational motives.

The perception of sound and the subjective interpretation of noise is inherently psychological. Consequently, attempts to regulate and control "unwanted sounds" in national parks requires more than reliance on just physical measures of sound, especially when considering the park service must take a variety of visitor related variables into consideration as part of the VERP framework. This multiple use mandate has created an often heated conflict with the issues surrounding aircraft overflights (Bell, et al., 2009). For example, the beauty and expanse of many national parks is particularly spectacular when viewed from a helicopter or fixed-wing tourist aircraft, and for some with disabilities air tours are the only realistic means of accessing some of the splendid scenery of the backcountry. Yet, the noise from these aircraft is annoying to those on the ground who are there to experience solitude and tranquility (Bell, et al., 2009). While the noise created by helicopters flying over national parks has been found by past research to be aversive, other types of aircraft are also frequently encountered in national parks and they, too, need to be assessed. Air tours are flown in propeller planes and small jets, while the flight paths of high altitude commercial jets routinely cross national parks. Those on the ground do notice these overflights, as visitor surveys in Bryce Canyon attest: 72% of visitors

noticed overflights, including helicopters, commercial jets, and small propeller planes, with 55% of respondents being bothered or annoyed by overflight noise. When given a list of potential alternatives and solutions, visitors were most in favor of placing restrictions on flight paths over Bryce Canyon (Mace & Blackham, 2003; Riddle, Mace & Cox, 2006).

3.6 Problem Under Study

One of the key issues for park managers is determining the levels and types of sound that are appropriate or acceptable for different acoustic zones and management areas within a park. Consequently, research endeavors should focus on several methodologies examining multiple variables, from both a physical and a social scientific perspective. Using a variety of methods in a program of research is the best approach when trying to gain a complete understanding of the soundscape of a park. Manning, et al. (2009) provide an excellent example of how a program of research using multiple methods at Muir Woods National Monument contributed to a greater understanding of visitor-caused noise and its consequences while also benefitting park soundscape management efforts.

The present study employs a multi-methodological approach with attended audibility logging, sound recording, and a laboratory experiment to examine the soundscape of Bryce Canyon National Park. Variables such as percent time audible and noise free intervals will be obtained from many individual locations within four acoustic zones, representing the busiest areas of the park all the way to the backcountry. Sound recordings and decibel measurements from many of the sites where attending logging data will be collected will then be used in a laboratory experiment to simulate natural sounds and three different types of aircraft noise (helicopters, propeller planes, and high altitude jets). Scenic digital photographs of Bryce

Canyon will be presented to undergraduates in the lab along with natural sound and aircraft noise, with participants completing Likert-type scale ratings of the scenic park landscapes and soundscapes using the psychometric variables of annoyance, solitude, tranquility, naturalness, scenic beauty, and overall preference. It is hypothesized different types of aircraft noise will produce different psychological reactions. Based on previous psychological and acoustic research in the lab and field, helicopter noise is expected to be judged most negatively, with propeller plane noise less, and jet aircraft noise the least disruptive, due to the physical differences between the three types of aircraft sound stimuli. This project will result in Bryce Canyon National Park gaining knowledge of the relationship between the soundscape environment (natural and human produced sound) and the social scientific variables that influence visitor enjoyment of the park. Using these multiple methods, this project will provide a more complete understanding of what factors are important in managing soundscapes within the acoustic zones of BRCA.

3.6.1 Phase I

Phase I entailed participating in numerous workshops with park staff at Bryce Canyon and the NPS Natural Sounds Program Office in Ft. Collins, Colorado. As a result of these workshops, surveys measuring frontcountry and backcountry visitors' expectations and experiences of the soundscape of Bryce Canyon were created. Additional meetings with park managers in Bryce led to refinement of the research protocol, a survey distribution plan, and methodology to be used when collecting survey data from visitors to the frontcountry and backcountry of the park. Frontcountry and backcountry surveys for Bryce visitors were planned to be distributed in the fall of 2007, however with a full review required by OMB, surveying was delayed until 2008, at the earliest. The completed survey for frontcountry visitors can be found

at the end of this report in Appendix A. The completed survey for backcountry visitors to Bryce is located in Appendix B at the end of the full report.

Research permits and a submission packet were produced and sent to the NPS and the Office of Management and Budget (OMB) for approval. Following approval by the NPS social science office, the surveys and methodological protocol was sent to OMB and following an initial review process of 3 months, OMB requested a full review be conducted on the surveys and the protocol to be used in Bryce. It was during this 9-month review process, in consultation with the Bryce management team and personnel from the Natural Sounds Program Office, that the research plan in Bryce was determined to continue with different methods other than visitor surveying while a multi-agency advisory group was convened to work on survey design and methodology. This advisory group included social scientists, park managers from Bryce and other national parks, personnel from the Natural Sounds Program Office and the Volpe Center. It was agreed by all parties it would be beneficial to create a standardized visitor surveying protocol that could be used in many national parks. Phase I of the Bryce Soundscape Project consequently moved on to Phase II and focused on attended audibility logging and laboratory simulations.

4 Audibility Logging Method

4.1 Phase II – Audibility Logging

During a site visit in May of 2007, personnel from the Natural Sounds Program Center of the National Park Service based in Ft. Collins, Colorado, members of the Bryce Canyon National Park resource management team, and social science researchers identified 16 acoustic monitoring sites in Bryce Canyon National Park. These sites were selected for attended audibility logging and sound recording based on their representation of different acoustic zones within the park. Selected sites included areas with high, moderate, infrequent and no visitation. Sites included popular lookouts, frontcountry hiking trails, and areas in the backcountry. For the purposes of the current project, eight of these identified sites were then selected for the completion of attended audibility logging and sound recording to identify the percentage of time specific sounds were audible at each location as well as noise free intervals. Sound recordings completed during the attended sound logging sessions were also used in the second phase of this research project to assess the human response to different types of sound. Several variables were rated by participants viewing and listening to depicted landscapes and soundscapes representative of the different acoustic zones in which they were recorded and photographed in BRCA.

4.2 Audibility Logging Materials

A personal data assistant (PDA) was used to collect audibility data using software developed by the Natural Sounds Program Center of the National Park Service. The software Soundscape V5 is a custom made application for handheld PDA units designed to collect attended audibility logging data. The software allows the user to click color coded buttons on the screen of the PDA to identify specific sounds that are audible to the

researcher. Multiple buttons can be clicked simultaneously, allowing many audible sound sources to be logged at the same time. A second click of the same button stops the logging process. Therefore, when a button is clicked, the software records the source of the sound and the duration of audibility, producing the percentage of time each sound source is audible in a given location. Noise free intervals (NFI) are also generated by the Soundscape V5 program when there are no anthropogenic sounds audible.

Digital sound recorders were also used in many of the locations where attended audibility logging was completed to capture a record of the on-site physical soundscape. Several sound clips were produced from these recordings for use in the laboratory in Phase II of this research. The sound recorders used were the Marantz Model PMD660 and the Edirol Model R-09HR. Built-in stereo microphones were used for most recording sessions, however a few recordings were made with an external microphone (Edirol CS-15) attached to a tripod and fitted with a wind screen to reduce the amount of wind induced noise.

Decibel meters were used to capture the loudness of different sound events in the same locations where attended audibility logging and sound recording took place. Decibel readings were obtained with a Sper Scientific Datalogging Sound Meter Model 840013. A decibel range for aircraft overflights was obtained so loudness levels in the phase II laboratory research would represent on-site exposure.

Additional materials used in Phase II included a backpack with a clipboard holding blank paper and a map of BRCA with sound logging sites marked, a headlamp, walkie-talkie, and an emergency first aid kit.

4.3 Audibility Logging Procedure

As a part of the May, 2007 site visit to Bryce by personnel from the Natural Sounds Program Center of the NPS, a training session was held on the operation of the PDA's and Soundscape V5 program and procedure to follow when completing attended audibility logging. The principal investigator subsequently trained several research assistants on the campus of Southern Utah University to provide enough personnel to complete the logging necessary in Phase II of this research. Once training was complete, several specific sites in BRCA were selected where attended audibility logging data and sound recordings were gathered. These sites included:

- Very Busy Acoustic Zone (3 main sites)
 - The Lodge area
 - Sunrise point
 - Sunset point
- Frontcountry Viewpoints (Moderately Busy Acoustic Zone) (3 main sites)
 - Fairyland point
 - Farview point
 - Rainbow point
- Short Hikes (Below the Rim Acoustic Zone--about 1 mile from the rim) (2 sites)
 - Amphitheatre Trails
 - Fairyland Trail



Figure 1. Locations of several of the attended audibility logging sites in the northern section of Bryce Canyon National Park.

- Backcountry (Least Visited Acoustic Zone)
 - Two sites along the Riggs Spring Loop

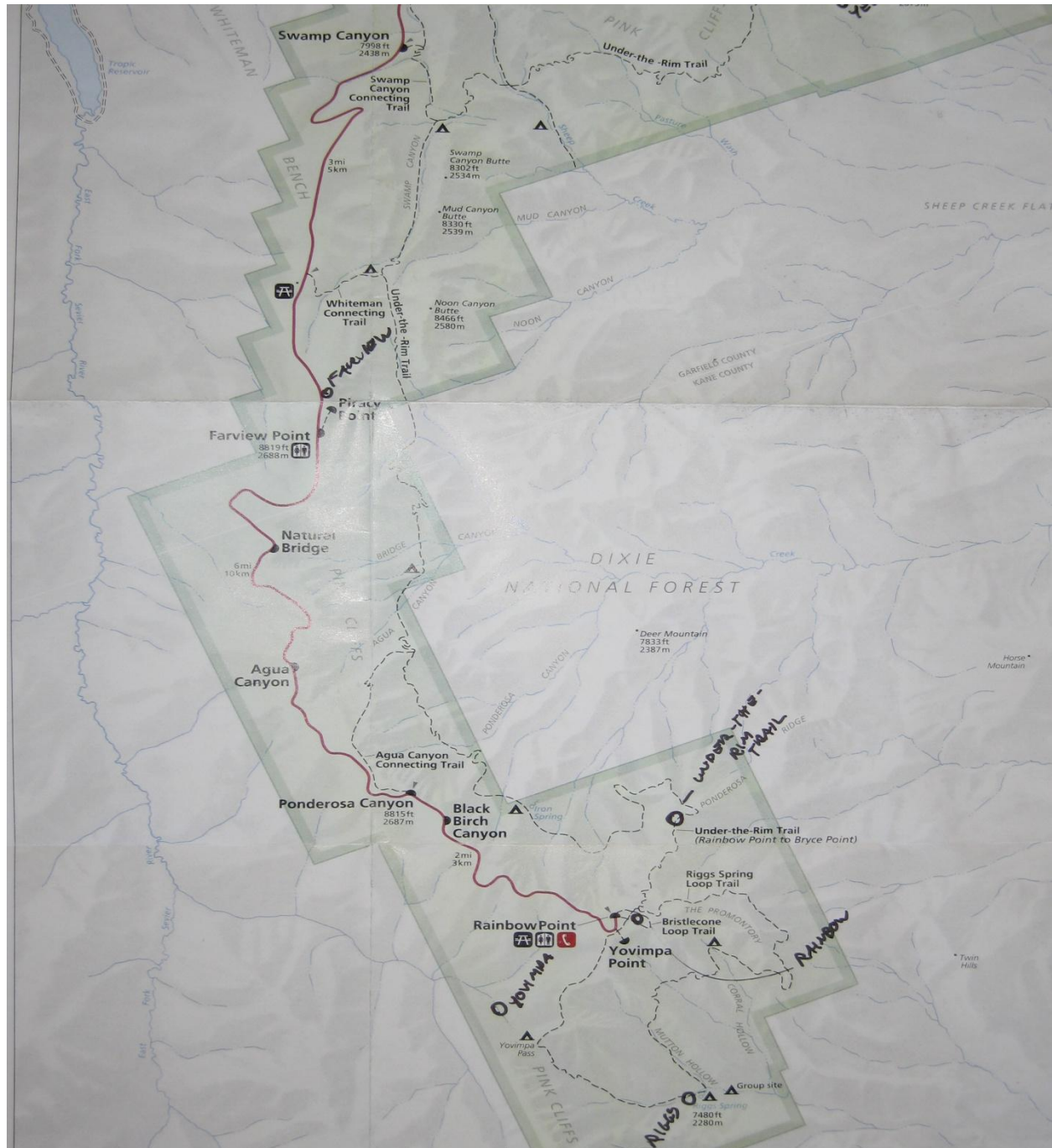


Figure 2. Attended audibility logging sites in the southern section of Bryce Canyon National Park.

Researchers began completing attended audibility logging and sound recording from these locations in the fall of 2008, and finished data collection in the summer of 2010. The researcher would arrive at the audibility logging site, set up the digital sound recording equipment, obscure themselves from other visitors by moving into a copse of trees or just off the trail, make themselves comfortable in a seated position, and begin the audibility logging session by running the Soundscape V5 program on the PDA. Logging sessions typically lasted between 15 minutes and 1 hour, depending on weather conditions. While the NPS manual accompanying Soundscape V5 suggests each session to be one hour in length for ease of data analysis, from a psychological point of view there are concerns with attention span and vigilance in such lengthy sessions. Therefore, if audibility loggers caught themselves becoming distracted or less vigilant, they would shorten the session and move to another location, hence the range in logging session length. Researchers also took numerous digital photographs from each attended logging and recording site to be used in Phase II of this research project.

5 Phase II Results: Audibility Logging

5.1 Busiest Acoustic Zone

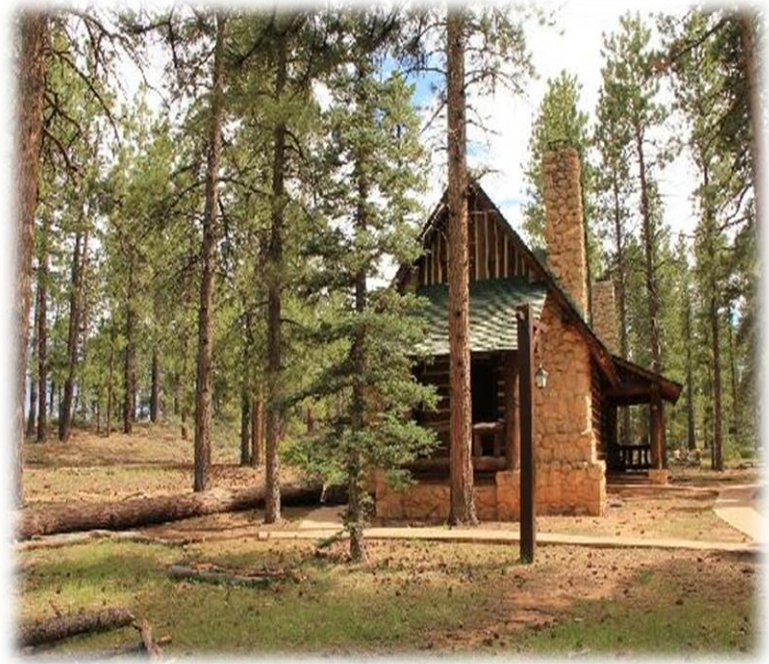
Three locations were chosen for attended audibility logging encompassing the busiest areas of the park. These sites were the area surrounding the Lodge, Sunrise Point, and Sunset Point. Attended audibility logging was conducted for 766 minutes in these three heavily visited areas of the busy acoustic zone. Detailed audibility logging results in aggregate for the busiest acoustic zone can be found in Table 1.

Table 1. Overall attended audibility results for the busiest acoustic zone.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
People, Voices	57.5	1,786	158	167
Bird	52.0	1,794	138	173
Wind	51.4	1,794	169	140
Vehicle	51.1	1,796	65	360
People, Walking	46.2	1,784	119	178
Jet	26.2	474	95	127
People	20.3	1,795	199	47
Motor	10.8	1,561	141	35
Insect	6.6	540	19	160
Building Utilities	3.6	984	555	3
Heavy Equipment	2.7	343	73	17
Non-natural, unknown	2.7	695	15	80
Motorcycle	2.1	102	40	24

As can be seen in Table 1, voices were the most frequently encountered element of the soundscape in the busiest acoustic zone. Dominant nature sounds included birds and the wind. People walking around the area and high altitude jets were other anthropogenic sounds that were often present. Additional audible sound sources that were evident in the busiest areas acoustic zone included buses (1.5 percent time audible, 7 events), propeller aircraft (1.4%, 18 events), thunder (1.3%, 26 events), mammals (1.3%, 10 events), and aircraft of an unknown origin (1.3%, 19 events). All other logged sound sources were audible less than one percent of the time. In sum, in the busiest acoustic zone, all combined non-natural sounds were audible 86.7% of the time. All road vehicles were audible a total of 44.7% of the time, and all aircraft were audible 29% of the time. The longest noise free interval (NFI) was found to be 642 seconds, with an average NFI of 36 seconds in the busiest areas of the park.

Attended audibility logging was carried out in three specific areas within the busiest acoustic zone of Bryce Canyon National Park. One of these areas was the environment surrounding the lodge. The site chosen for audibility logging was approximately half of the way between the lodge and sunrise



point, off one of the side trails that takes visitors to and from the lodge and sunrise point. A total of 226 minutes of attended sound logging was completed at the lodge location. Detailed attended audibility logging results for the lodge site are presented in Table 2.

Table 2. Attended audibility results for the area around the Lodge.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
People, Voices	65.9	847	131	68
Vehicle	58.6	891	87	91
Bird	48.6	1,407	183	36
People, Walking	48.2	1,327	107	61
Wind	40.7	511	120	46
Motor	34.1	1,561	385	12
Jet	31.3	474	141	30
Insect	15.2	540	40	52
Building Utilities	12.3	984	555	3
Water (Rain)	6.6	899	899	1
Non-natural, unknown	5.8	695	111	7
Bus	5.1	214	98	7
Motorcycle	4.2	102	36	16
Mammals	4.2	466	94	6
Grounds Care	2.3	81	17	19

The majority of sounds were human-caused in the area around the lodge, with the voices of visitors, vehicles, and the sound of people walking being audible a large percentage of the time. As far as natural sounds are concerned, birdsong and wind were the most frequently heard. Other sound sources audible in the area around the lodge not included in the table were vehicle doors (1.8%, 10 events), building doors (1.7%, 15 events), RV's (1.2%, 2 events), aircraft-unknown (1.2%, 3 events), thunder (1.1%, 6 events), propeller aircraft tour (1.1%, 1 event),



heavy trucks (1%, 3 events), ravens (1%, 2 events), and heavy equipment (1%, 3 events). All other logged sound sources were audible less than one percent of the time, and included dogs, helicopters, car alarms, personal audio devices, chipmunks, and slamming

dumpsters. In summation, the area surrounding the lodge was found to have all non-natural sounds audible 98% of the time. All road vehicles were audible a total of 62.2% of the time, and all aircraft were audible 35.2% of the time. The longest noise free interval (NFI) was found to be 43 seconds, with an average NFI of 14 seconds at the attended audibility site near the lodge.

Sunrise point is a heavily visited lookout in the park and was chosen as an audibility logging site within the busiest acoustic zone. A total of 155 minutes of sound were logged by an attendant at the sunrise point location, a spot just to the northwest of the overlook and off the rim

trail out of the direct line of sight with visitors. Table 3 depicts the detailed audibility logging results for sunrise point.

Table 3. Attended audibility results for Sunrise Point.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
People, Voices	77.1	1,786	199	36
Bird	75.7	1,550	213	33
Wind	56.7	776	139	38
People, Walking	52.1	1,034	156	31
Vehicle	42.8	356	83	48
People	39.6	1,795	613	6
Jet	26.5	210	88	28
Insect	7.6	141	11	66
Thunder	3.6	116	34	10
Motorcycle	3.4	76	52	6
Natural, unknown	2.2	79	20	10

Sunrise point was found to have the voices of visitors audible 77% of the time, with the sounds of people walking and motor vehicles the next most frequently encountered human-caused sounds. The sounds of birds singing and swooping were evident 75% of the time, with the wind being another often heard natural sound. Additional sound sources not displayed in table 3 that were audible at Sunrise Point included non-natural sounds of an unknown origin (1.4 percent of the



time, 40 events), rain (1.2%, 3 events), a horse (1%, 1 event), and a personal audio device (1%, 1 event). All other logged sound sources were audible less than one percent of the time and included a helicopter, dog, reptile, motor, and a chipmunk. At sunrise point, all combined non-natural sounds were audible 86.9% of the time. Road vehicles were audible a total of 46.6% and all aircraft were audible 25.4% of the time. The longest noise free interval (NFI) was found to be 642 seconds, with an average NFI of 50 seconds at sunrise point.

Sunset point is another heavily visited lookout in the park, and was chosen as an audibility logging site within the busiest acoustic zone because of its proximity to the lodge and two major parking areas. A total of 386 minutes of attended audibility logging was completed at sunset point. The site chosen at sunset point was on the rim of the amphitheatre, just south of the main viewpoint and a short distance from the trail, assuring some anonymity for the audibility logger. Table 4 illustrates the detailed audibility logging results from sunset point.

Table 4. Attended audibility logging results for Sunset Point.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	55.5	1,794	229	56
Vehicle	50.0	1,796	52	221
People, Voices	44.7	1,786	164	63
Bird	44.5	1,794	99	104
People, Walking	42.6	1,784	115	86
People	23.8	1,117	157	35
Jet	23.2	317	78	69
Heavy Equipment	4.8	343	79	14
Aircraft, Propeller	2.3	161	34	16
Wind, Light	2.1	493	493	1
Natural, unknown	2.2	79	20	10

As found at the other audibility logging locations in the busiest acoustic zone, the sound of the wind and birds were the most common natural sounds at Sunset Point. Motor vehicles, people talking and walking were encountered more frequently than any other human caused-sounds. Other sound sources not depicted in the table that were audible around sunset point included aircraft of an unknown origin (1.8%, 16 events), building doors (1.7%, 15 events), RV's (1.2%, 2 events), motors (1.4%, 20 events), non-natural sounds of an unknown origin (1.3%, 33



events), insects (1.1%, 42 events), and helicopters (1%, 5 events). All other logged sound sources were audible less than one percent of the time, and included vehicle doors, thunder, construction, motorcycles, grounds care, natural sound of an unknown origin, car alarms, chipmunks, personal audio devices,

slamming dumpsters, mammals, a magpie, and dogs. In aggregate, sunset point was exposed to non-natural sounds that were audible 74.4% of the time. All road vehicles were audible a total of 41.6%, and all aircraft were audible 26.8% of the time. The longest noise free interval (NFI) was found to be 539 seconds, with an average NFI of 36 seconds at the attended audibility site near sunset point.

As is evident from these results, the busiest areas of the park contain primarily sounds

produced by visitors and their motor vehicles. The sounds of people talking and walking are the most frequent non-natural sounds encountered in the busiest areas where audibility logging data was collected. Motor vehicles, primarily automobiles, were also audible a large percentage of the time. High altitude passenger jets could be heard 23-30% of the time, depending on the location. Other audible terrestrial vehicles include motorcycles, buses, RV's, and trucks in the busiest areas of the park. Wind and birds were the most frequently audible natural sounds in this acoustic zone, with insects and thunder occurring only rarely. As would be expected in the busy areas of the park, the opportunity to experience natural quiet is infrequent, with the average noise free interval being less than one minute in the sampled locations in the busiest acoustic zone of the park.

When interpreting the results, it is important to point out that more time was spent logging at sunset point, which skewed the overall data for this acoustic zone. Specifically, the percent time audibility of visitors talking and walking was somewhat lower at sunset point than the other two sites in the busiest acoustic zone, which brought the overall percentage of time that people were audible down when all logging site results were combined in the busy acoustic zone. It is, therefore, most beneficial to examine the site specific results, thus allowing small-scale comparisons.

5.2 Frontcountry Viewpoints (Moderately Busy Acoustic Zone)

Bryce Canyon National Park has several scenic viewpoints affording the visitor easily accessible scenic vistas of the hoodoos the park is famous for. Visitors will often frequent several of the overlooks on a day trip to get a sense of the geologic marvel that is Bryce. Overlooks around the lodge and main area of the park receive heavy visitation, with other more

distant viewpoints receiving less. It was therefore hypothesized the auditory experience at some of the more distant viewpoints would be different than that at the busiest area of the park. To examine this hypothesis, three more distant overlooks were selected for attended audibility logging. The chosen overlooks were Fairyland Point, Farview Point, and Rainbow Point. These points are also distant from one another, representing the far southern tip of the park all the way to the furthest developed overlook on the north side of the park. As loggers were travelling the distance between Fairyland and Rainbow Point, they would often stop at the many other overlooks away from the busiest area of the park. Several audibility logging sessions were also conducted at these other frontcountry viewpoints to ascertain if the auditory experience was similar at all frontcountry viewpoints that were away from the busiest areas of the park. The additional sites included in this acoustic zone analysis include a small amount of audibility logging data from Bryce Point, Paria Point, Swamp Point, and Yovimpa Point. Audibility logging results are presented in sum for all of these seven locations, the three main sites initially chosen for analysis, as well as each individual site. Attended audibility logging was conducted for a total of 1,572 minutes (26.2 hours) at these seven overlooks, representing sites within the moderately busy frontcountry acoustic zone. Detailed results for all seven of the viewpoints representing this acoustic zone are presented in Table 5.

Table 5. Overall attended audibility results for the frontcountry viewpoints acoustic zone.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	63.6	2,691	230	260
Vehicle	48.7	1,800	76	604
Bird	42.2	2,903	100	398
People, Walking	38.1	1,783	144	250
People, Voices	36.5	1,784	123	281
Jet	26.3	693	102	243
People	14.7	1,495	98	142
Insect	10.0	2,585	24	387
Motor	5.5	754	72	72
Natural, Unknown	4.7	3,414	69	64
Motorcycle	2.4	154	46	50
Personal Audio Device	2.2	320	25	84
Rain	2.1	658	166	12
Aircraft, Propeller	2.1	430	76	26

Natural sounds most often encountered at the frontcountry viewpoints were wind and birds. Motor vehicles were audible nearly half of the time, with people walking and talking, and high altitude jets being the next most audible anthropogenic sounds. Additional sound sources in the moderately busy frontcountry viewpoint acoustic zone that are not viewable in table 5 also included ravens (1.7 percent time audible, 29 events), thunder (1.1%, 34 events), propeller aircraft tour (1.0%, 6 events), and vehicle doors (1.0%, 73 events). All other logged sound sources were audible less than one percent of the time. In sum, all seven lookouts were found to have non-natural sounds audible a total of 82.7% of the time. All road vehicles were audible a total of 38.1% of the time, and all aircraft were audible 34.1% of the time. The longest noise free interval was found to be 928 seconds, with an average NFI of 36 seconds at these seven scenic points in the park.

Three specific viewpoints were identified as representative sites of the frontcountry acoustic zone receiving a moderate level of visitation. These sites were Fairyland, Farview, and Rainbow Points. A total of 1,148 minutes of attended audibility logging was completed at these three sites, with the combined results for all three locations presented in Table 6.

Table 6. Overall attended audibility results for three main viewpoints within the moderately busy frontcountry acoustic zone.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	61.4	2,691	211	201
Vehicle	54.9	1,800	92	410
Bird	41.9	2,903	99	290
People, Voices	39.6	1,784	142	192
People, Walking	38.1	1,783	173	152
Jet	23.3	460	94	170
People	12.7	1,495	93	94
Insect	12.2	2,585	23	361
Motor	6.8	754	71	66
Natural, Unknown	6.3	3,414	74	59
Motorcycle	2.7	154	52	36
Rain	2.9	658	166	12
Personal Audio Device	2.7	320	25	73
Aircraft, Propeller	2.4	430	70	24

At the three main sites chosen for audibility logging in the moderately busy acoustic zone, road vehicles, the sounds of visitors (talking, walking, and other people related sounds), and high altitude jets were the most frequently attended to sounds from a human source. Wind, birds, and insects were the most often heard sounds that were natural in origin. Audible sounds also present but not included in the table included ravens (1.8%, 19 events), thunder (1.5%, 34 events), propeller aircraft scenic flights (1.4%, 6 events), vehicle doors (1.1%, 67 events), and buses (1%, 10 events). All additional sounds were audible less than one percent of the time, and

included aircraft of an unknown origin, RV's, dogs, natural sounds of an unknown origin, mammals, trucks, garbage cans, grounds care, car alarms, and brakes. The combined data from Fairyland, Farview, and Rainbow Points found non-natural sounds to be audible 77.4% of the time. Road vehicles were audible a total of 51.4% of the time, and all aircraft were audible 28.2% of the time. The longest noise free interval (NFI) was found to be 928 seconds, with an average NFI of 38 seconds at the three main sites comprising the moderately busy frontcountry acoustic zone.

Fairyland Point is a frontcountry overlook that has a moderate amount of visitation and is located outside of the main area of the park, the furthest easily



accessible viewpoint on the northern end of the park. A total of 302 minutes of sound logging was completed at the fairyland point location, a spot just to the northwest of the overlook along the rim yet out of the direct line of sight of visitors. Table 7 depicts the detailed audibility logging results for fairyland point.

Table 7. Attended audibility logging results for Fairyland Point.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	67.8	1,531	157	78
Vehicle	38.4	1,172	64	108
Jet	22.4	291	71	57
Natural, unknown origin	21.6	3,414	145	27
Bird	17.6	270	28	113
People	14.5	664	50	53
People, Voices	8.2	331	30	49
People, Walking	7.2	138	37	35
Motor	6.9	754	114	11
Aircraft, Propeller	2.7	92	34	14

Fairyland Point was found to have a lower percentage of some of the most frequently encountered anthropogenic sounds than other areas within this acoustic zone and the busiest areas in Bryce. For example, while vehicles and the sounds created by people were still present, they were, on average, encountered 20% less often at Fairyland. As far as natural sounds, the wind was present quite often, with unidentifiable nature sounds and birds the next most attended



to. Additional sounds encountered at Fairyland Point that are not listed in the table included aircraft of an unknown origin (1.2%, 19 events), and vehicle doors (1.1%, 32 events). All other sounds were audible less than one percent of the time, and

included ravens, non-natural sound of an unknown origin, motorcycles, mammals, dogs, car alarms, and a single personal audio device. Non-natural sounds were audible at Fairyland Point a total of 61% of the time. Road vehicles were audible a total of 31.4% of the time, and all aircraft were audible 25.8% of the time. The longest noise free interval (NFI) was found to be 500 seconds, with an average NFI of 44 seconds at the attended audibility site near Fairyland Point.

Farview Point is a viewpoint located along the main road heading south towards Rainbow point. Farview has a moderate amount of visitation as it is a nice viewpoint to gaze at the distant vista to the east. There is also a short trail to Piracy Point which takes visitors away from the parking lot and allows a quieter view of the surrounding landscape. The spot chosen for audibility logging was located along the trail to Piracy Point, in a northerly direction from Farview point, along the rim of the plateau and a few paces off the main trail. A total of 405 minutes of sound logging was completed at the Farview Point location. Table 8 depicts the detailed audibility logging results for Farview Point.



Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Vehicle	71.7	1,800	118	168
Wind	70.1	2,691	236	72
Bird	58.2	2,903	139	102
People, Walking	49.4	1,144	133	90
People, Voices	46.1	1,180	143	78
Jet	28.6	459	98	71
Insects	21.9	2,585	31	169
Motor	10.2	190	73	34
People	7.4	905	66	27
Motorcycle	5.2	154	55	23
Raven	3.4	212	82	10
Portable Audio Devices	2.9	304	27	26
Aircraft, Propeller	2.8	430	112	6

Table 8. Attended audibility logging results for Farview Point.

Vehicles were audible at Farview Point more frequently than at any other site sampled. The sound of visitors walking and talking, along with the sound of high altitude jets were the other most often sounds attended to at Farview Point. Like most other places in Bryce, the most prevalent natural sounds were the wind, birds, and insects. Sounds that were also audible, but



not detailed in Table 8, included rain (1.4%, 5 events), RV's (1.4%, 5 events), propeller aircraft scenic tours (1.2%, 2 events) and vehicle doors (1.1%, 11 events). Other sounds were audible less than one percent of the time, and included trucks, thunder, natural and non-

natural sounds of unknown origins, chipmunks, buses, grounds care, and car alarms. Farview point had non-natural sounds audible a total of 92.1% of the time. Road vehicles were audible a total of 76.3% of the time, and all aircraft were audible 32.4% of the time. The longest noise free interval (NFI) was found to be 928 seconds, with an average NFI of 19 seconds at the attended audibility site near Farview Point.

At the southern end of the road in Bryce sits Rainbow Point. Distant views in all directions are prevalent at this overlook that receives a moderate amount of visitation as it represents a destination for visitors who want to see as many of the parks viewpoints as possible. Rainbow Point is higher in elevation than the other viewpoints and is densely forested in most areas. The location also offers access to a short nature trail, the Bristlecone Loop, which many visitors walk all or a portion. There is also access to the backcountry



trail system, including the Riggs Spring Trail and the Under-the-rim Trail. The site chosen for audibility logging was just south of the viewpoint in the forest close to the Bristlecone Loop Trail. A total of 406 minutes of sound logging was completed at the Rainbow Point location, with detailed results presented in Table 9.

Table 9. Rainbow Point attended audibility logging results.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
People, Voices	59.6	1,784	234	62
People, Walking	52.5	1,783	511	25
Wind	51.9	1,789	263	48
Bird	46.9	1,799	161	71
Vehicle	45.1	1,192	84	131
Jet	20.8	460	120	42
People	17.8	1,495	309	14
Insects	8.0	504	25	79
Water	7.1	1,719	1,719	1
Rain	6.7	658	234	7
Portable Audio Devices	4.8	320	26	45
Motor	4.0	362	47	21
Thunder	3.2	80	37	21
Propeller Air Tour	2.8	232	168	4
Bus	2.6	125	79	8
Motorcycle	2.4	118	66	9
Wind, Light	2.3	558	558	1
Aircraft, Propeller	2.1	226	131	4

Visitors talking and walking were the most frequently discernable sounds at Rainbow Point, both above 50%, with road vehicles audible 45% of the time. High altitude jets were heard 20% of the time. The sound of the wind and birds were, once again, found to be the most



frequent natural components of the soundscape. Rain occurred during some of the time during which audibility logging was being completed, which led to rain and running water to be audible around 7% of the time. Rainbow Point also had audible sounds emanating from

dogs (1.9%, 13 events), RV's (1.4%, 4 events), vehicle doors (1.3%, 24 events), ravens (1.1%, 5 events), mammals (1.1%, 11 events), natural sounds of an unknown origin (1%, 16 events), and aircraft of an unknown origin (1%, 4 events). Other sounds were audible less than one percent of the time and were comprised of dumpsters or trash cans, animals, non-natural sounds of an unknown origin, squirrels, brakes, and a building door. Rainbow Point had non-natural sounds audible a total of 79% of the time. Road vehicles were audible a total of 46.6% of the time, and all aircraft were audible 26.3% of the time. The longest noise free interval (NFI) was found to be 859 seconds, with an average NFI of 52 seconds at the attended audibility site near Rainbow Point.

Yovimpa Point is located close to Rainbow Point at the end of the main road in the park. Yovimpa sits off to the west of the parking area and requires a short walk away from the road to access the overlook. The viewpoint is connected with Rainbow Point via the Bristlecone Loop Trail and also provides backcountry access with a trailhead for the Riggs Springs Trail. There are distant views to the north, west, and south at Yovimpa point, and the overlook receives a moderate amount of visitor traffic. Noise from the road is less audible at Yovimpa than other viewpoints in the park. It is less forested than the area surrounding Rainbow Point, and is an exposed edge of the plateau that receives plentiful wind. Audibility logging was completed in a location just to the south of Yovimpa point, just off one of the connecting trails of the Bristlecone



Loop. Audibility logging was conducted for a total of 155 minutes at Yovimpa Point. Detailed audibility logging results can be found in Table 10.

Table 10. Yovimpa Point attended audibility logging results.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	77.8	1,486	345	21
Bird	55.0	1,432	102	50
Jet	30.3	347	134	21
People	28.1	585	202	13
People, Walking	26.3	594	111	22
People, Voices	18.8	426	70	25
Vehicle	18.6	256	38	45
Motor	3.6	338	338	1
Insects	2.3	62	22	10

Yovimpa point receives a large amount of wind due to the exposure it has to the west and south. This was reflected in the audibility logging results, with the wind being heard nearly 78% of the time. Birds were the other natural sounds that were audible over half of the time. The most frequently audible human sound source at Yovimpa was the sound of high altitude jets, followed closely by the sounds made by visitors. Vehicle audibility dropped off substantially due to the short walk that is required to reach the point from the parking area. Additional audible sounds logged at Yovimpa Point included propeller driven aircraft (1.9%, 1 event) and motorcycles (1%, 2 events). The only other sounds audible at Yovimpa Point while logging was being completed were grounds care maintenance and non-natural sounds of an unknown origin, with both of these sound sources audible less than one percent of the time. In sum, Yovimpa Point had non-natural sounds audible 67.6% of the time. Road vehicles were audible a total of 19.4% of the time, and all aircraft were audible 32.2% of the time. The longest noise free



interval (NFI) was found to be 691 seconds, with an average NFI of 60 seconds at the attended audibility logging site at Yovimpa Point.

Swamp Lookout is a pull out spot on the main road leading to Rainbow and Yovimpa Points. The lookout provides access to the backcountry via a connector trail to the

Under-the-Rim trail and is frequented by backpackers, hikers, and visitors stopping for a view. It can be considered a moderately used site based on the variety of user groups and the proximity to the main road and exposure to vehicular traffic. Swamp lookout provided a nice respite for audibility loggers travelling between the main areas of the park and the viewpoints at the end of the road, and hence some audibility data were collected in this location for comparison with other sites along the main road. Audibility logging was completed in a location just to the northeast of the parking lot for Swamp Lookout, approximately a tenth of a mile from the road. Audibility logging was conducted for a total of 158 minutes at Swamp Lookout. Detailed audibility logging results are depicted in Table 11.

Table 11. Swamp Overlook attended audibility logging results.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	74.5	1,794	645	11
Bird	50.3	1,462	192	25
People, Walking	42.9	669	227	18
Jet	42.1	693	138	29
Vehicle	42.1	333	56	72
People, Voices	27.4	603	163	16
People	8.9	332	53	16
Insects	6.4	182	56	11
Raven	3.9	106	37	10
Portable Audio Device	2.6	72	22	11

Swamp overlook had a good dose of wind while audibility logging was being conducted. Nearly three-quarters of the time the wind was present. Birds were the next most frequently audible sound. The remaining high percentages were for human-caused sounds: jets, motor vehicles, and the sounds of visitors. Other sounds audible at Swamp Overlook included vehicle doors (1.8%, 6 events), propeller driven aircraft (1.3%, 1 event), and non-natural sounds of an unknown origin (1%, 2 events). All remaining sounds were audible less than one percent of the time, and included dogs, natural sounds (unknown), aircraft of an unidentifiable type, and motorcycles. Swamp Lookout had non-natural sounds audible a total of 81.2% of the time. Vehicles on the main road and parking area were audible a total of 43.8% of the time, and all aircraft were audible 43.6% of the time. The longest noise free interval (NFI) was found to be 845 seconds, with an average NFI of 38 seconds at the attended audibility site near Swamp Overlook.

Paria Viewpoint requires a short drive from the main road to access, and is located off a

short spur trail from the parking area. There are distant views to the south and east from Paria, which sits atop the plateau above the hoodoos. There is no trail access from Paria, so visitors to this area come just for the scenic vistas. Paria Viewpoint is a moderately visited location as it is not too distant from the main area of the park near the Lodge and Sunset Point and is along the same road that takes visitors to Inspiration and Bryce Points. Audibility logging was completed at Paria Viewpoint at a site approximately half of the way between the parking lot and the viewpoint along the rim of the plateau. The attending logger was just off the trail, out of view of visitors in order to remain unobtrusive. As Paria was not one of the main locations to be sampled in the moderately visited frontcountry acoustic zone, only 65 minutes of sound logging was completed at this site. Data are presented for comparison purposes with other sites within this acoustic zone, and are displayed in Table 12.

Table 12. Paria View attended audibility logging results.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	59.8	548	97	24
People, Walking	42.8	318	62	27
Jet	37.2	221	66	22
People, Voices	27.6	549	63	17
Vehicle	24.1	121	43	22
Bird	22.3	147	32	27
People	20.2	177	44	18
Insects	3.8	67	30	5
Motorcycles	2.3	42	15	6

As with many areas of Bryce, the dominant natural sound found at Paria View was the wind. Other natural sounds included birds, at a lower percentage than found at other locations, and a few insects. Non-natural sounds included people walking, jets, visitors talking, and road

vehicles. Other sounds audible at Paria View not included in the table were natural and non-natural sounds of an unknown origin, although both of these sources were very limited, being present less than one percent of the time. In sum, non-natural sounds were audible a total of 88.6% of the time at Paria View. Road vehicles were audible a total of 25.9% of the time, and all aircraft were audible 37.1% of the time. The longest noise free interval (NFI) was found to be 64 seconds, with an average NFI of 16 seconds at the attended audibility site at Paria View.

Bryce Point receives a moderate amount of visitor traffic during the summer and shoulder seasons, as it is located in close proximity to the main areas of the park. The viewpoint requires a short drive from the main road, and is located in close proximity to Paria View and Inspiration Point. Bryce Point affords the visitor scenic views of the Bryce Amphitheatre and the distant lands of the Grand Staircase National Monument. There is trail access to the Under –the-Rim Trail and to Peekaboo Loop, so there is a mix of sightseers, hikers, and backpackers that frequent Bryce Point. Audibility logging was completed at Bryce Point a short distance from the parking area along the short spur trail to the actual overlook. As Bryce Point was not included as one of the main locations to be sampled in the moderately visited frontcountry acoustic zone, only 55 minutes of sound logging was completed at this site. Data are presented for comparison purposes with other sites within this acoustic zone, and are displayed in Table 13.



Table 13. Attended audibility logging results for Bryce Point.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
People, Voices	52.9	402	56	31
People, Walking	44.9	191	48	31
Vehicle	43.5	146	26	55
Wind	31.8	588	117	9
Jet	29.7	264	140	7
People	27.1	894	894	1
Motorcycles	6.7	92	44	5
Bird	5.1	75	28	6
Motor	3.8	55	25	5

People talking and walking were the most frequently audible sounds at Bryce Point, followed by motor vehicles. The wind was the most common natural sound, present 31.8% of the time, much less than other viewpoints. Like the wind, birds were also less frequently encountered at Bryce Point than other overlooks in the park. Motor vehicles were audible 43% of the time, and jets close to 30% of the time at Bryce Point. Other than those listed in the table, the only other sound audible at Bryce Point during the attended sound session was a single occurrence of a non-natural sound of unknown origin, which was audible less than one percent of the time. Over the 55 minutes of sound logging at Bryce Point, non-natural sounds were audible a total of 98.7% of the time. Road vehicles were audible a total of 49.5% of the time, and all aircraft were audible 29.7% of the time. The longest noise free interval (NFI) was found to be 16 seconds, with an average NFI of 5 seconds at the attended audibility site at Bryce Point. Based on these results, Bryce Point might be more indicative of the busiest acoustic zone as people and vehicles were audible nearly all of the time. It is important to point out, however, that this observation is based on very limited data. Many more hours of audibility logging need to be completed at Bryce Point to gather a more accurate representation of the soundscape in this area.

As is evident from these results, the moderately busy areas of the park contain primarily sounds produced by vehicle traffic and visitors walking and talking. The sounds of automobile traffic were the most frequent anthropogenic sounds encountered in the moderately busy frontcountry areas where audibility logging was conducted. High altitude passenger jets were audible 21-42% of the time, depending on the location. Other aircraft were also audible, primarily propeller aircraft and other planes. The sounds of motorcycles, buses, RV's, and trucks were also apparent in this acoustic zone, although not nearly as frequently as automobiles. Wind and birds were the most frequently audible natural sounds in this acoustic zone, with insects and thunder occurring only rarely. Because of the regular encounters with visitors and their vehicles, the opportunity to experience natural quiet is quite difficult at the overlooks and viewpoints in the frontcountry of Bryce Canyon National Park. The average noise free interval for all sites within the moderately busy frontcountry acoustic zone was found to be 38 seconds, only two seconds greater than the average NFI in the busiest areas of the park.

Several additional comparisons are relevant when examining the audibility logging results from the moderately busy frontcountry acoustic zone with the results from the busiest acoustic zone. The percentage of time anthropogenic sounds were audible dropped nearly ten percent within the sites comprising the moderately busy acoustic zone compared to the busiest acoustic zone. This finding can be explained when examining the specific types of human caused sound, with people walking and talking being less frequently heard in the moderately visited frontcountry sites. Interestingly, the audibility of vehicles actually increased slightly in the moderately busy frontcountry acoustic zone compared to the busiest sites. This small difference can be explained by focusing on the individual sites within the moderately busy frontcountry acoustic zone. One potential explanation is the excessive vehicle sounds audible at

Farview Point, where visitors are stopping at the viewpoint while others are continuing on their way along the main road. As the viewpoint is immediately adjacent to the road, vehicle traffic is nearly always audible. A similar result was found for the audibility logging site near Swamp Overlook, another location where some visitors stop and others are continuing along the main road. Much less vehicle sound were encountered at the other sites within the moderately busy acoustic zone as these other sites (Rainbow, Yovimpa, Fairyland, Paria, for example) are destination sites where the road ends in a parking lot and there are no passers-by continuing on in their vehicles. Finally, the percentage of time aircraft were audible in both the busiest and moderately busy acoustic zones of the park was nearly identical, with high altitude passenger jets responsible for the vast majority of aircraft sound exposure.

5.3 Short Hikes--Below the Rim Acoustic Zone

There are numerous short hike opportunities in Bryce Canyon National Park, most of which can be accomplished as a loop hike. Many of these trails are located near the main area of the park and afford visitors the opportunity to walk below the rim of the plateau amongst the hoodoos. As with many trails, the further one ventures away from the trailhead, the fewer the number of fellow adventurers encountered. To get an idea of what the acoustic conditions on the hiking trails in the Bryce amphitheatre are like, two sites were chosen for audibility logging. One site was along the Queens Garden Trail, and a second site was on the Fairyland Loop Trail. Each site was approximately one mile from the trailhead, well below the rim of the plateau. Researchers also completed a limited amount of audibility logging on other short hiking trails, including a location near the Hat Shop and along the Bristlecone Loop Trail between Rainbow

and Yovimpa Points. It was hypothesized the auditory experience on a short hike away from the hustle and bustle of the main areas of the park and the road would be much different than the soundscape of the busy and moderately busy frontcountry acoustic zones. Audibility logging results are presented in summation for all of the short hike locations, as well as each individual site. Attended audibility logging was conducted for a total of 548 minutes at these locations with detailed results for this acoustic zone presented in Table 14.

Table 14. Attended audibility logging results for all combined short hikes.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	55.8	1,968	187	98
Bird	49.0	2,288	67	239
Jet	29.9	606	83	118
People, Voices	21.2	1,202	52	134
Insect	20.2	1,761	40	168
Vehicle	17.4	1,737	63	91
People, Walking	12.6	446	47	89
Rain	10.2	991	418	8
People	6.2	574	41	50
Raven	4.8	587	174	9
Motor	3.3	258	57	19
Natural, Unknown Origin	2.7	67	16	57
Aircraft, Unknown Origin	2.3	150	54	14

As is evident in Table 14, the most prevalent sounds on the short hikes were natural in origin, specifically the wind and birdsong. High altitude jets were the most often audible human caused sound, followed by the voices of visitors hiking the trails. Additional sounds other than those presented in the table included propeller aircraft scenic tours (1.3%, 2 events) and vehicle doors (1.2%, 13 events). Sounds audible less than one percent of the time include motorcycles, grounds care (trail maintenance activities), light wind, buses, non-natural sounds of an unknown

origin, RV's, trucks, chipmunks, dogs, mammals, squirrels, construction, car alarms, a single helicopter, and thunder. Non-natural sounds were audible a total of 58.9% of the time. Road vehicles were audible a total of 18.2% of the time, and all aircraft were audible 32.4% of the time. The longest noise free interval (NFI) was found to be 929 seconds, with an average NFI of 56 seconds on the shorter frontcountry trails at Bryce Canyon National Park.

Audibility logging data was collected in a location along the Queens Garden Trail in the Bryce Amphitheatre, approximately two tenths of mile from the junction with the Navajo Loop Trail. To access this location, researchers would hike down the Navajo Loop Trail and turn north on the Queens Garden Trail, hiking a short distance from the trail junction to the audibility logging location. Many visitors looking for a short hike will take either trail and or combine the two trails into a longer loop hike. It is important to point out that the southern portion of the Navajo Loop Trail remains closed to through hikers due to a rockfall that happened on May 23, 2006, effectively burying this part of the trail with the rubble from a toppled section of the rock wall. For this reason, visitors often combine the Navajo Trail with the Queens Garden or Peekaboo Trails to experience more of the Bryce Amphitheatre. Audibility logging was completed for 227 minutes in this location, with results detailed in Table 15.



Table 15. Amphitheatre trails attended audibility logging results.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Bird	54.8	1,799	54	139
Wind	41.8	692	139	41
People, Voices	24.7	1,202	50	68
Jet	23.2	219	60	53
Vehicle	19.0	1,737	152	17
Insects	15.9	545	20	106
Rain	11.8	891	322	5
People	8.4	574	46	25
People, Walking	6.9	138	30	31
Raven	2.5	99	68	5

Birdsong and wind were the most common natural sounds encountered at this audibility logging location along the Queens Garden Trail. The sound of hikers talking was the most common anthropogenic sound, followed closely by high altitude passenger jets. Road vehicles could be heard nearly a mile from the main road and parking areas, though the sounds were faint and distant. Additional audible sounds experienced along the Amphitheatre Trails included grounds care/trail maintenance (1.7%, 3 events), natural sounds of an unknown origin (1.5%, 11 events), aircraft of an unknown type (1.3%, 2 events), buses (1.3%, 3 events), and the sound of slamming vehicle doors (1.1%, 7 events). Sounds audible less than one percent of the time include motorcycles, propeller aircraft, trucks, motors, mammals, squirrels, construction, non-natural sounds of an unknown origin, chipmunks, car alarms or horns, and thunder. Non-natural sounds were audible a total of 57.1% of the time. Road vehicles were audible a total of 19.9% of the time, and all aircraft were audible 24.8% of the time. The longest noise free interval (NFI) was found to be 929 seconds, with an average NFI of 58 seconds on the Amphitheatre trails at Bryce Canyon National Park.

Another trail in the amphitheatre region was used to assess the soundscape of the trails located in the below the rim acoustic zone. The Fairyland Loop trail receives a mix of hikers, from those seeking a short directional hike to those visitors completing the entire 8 mile loop and traversing areas considered semi-backcountry. The Fairyland Loop trail receives significantly fewer hikers than the Navajo and Queens Garden Trails because of its length and multiple elevation changes. The Fairyland Trail can be accessed from Fairyland Point or the Rim Trail, just north of Sunrise Point. The site chosen for attended audibility logging was approximately one mile from the trailhead at Fairyland Point. The audibility logger positioned themselves on the north side of the trail, just out of sight of hikers. Logging was completed at the Fairyland Trail site for a total of 161 minutes. Results can be found in Table 16.



Table 16. Attended audibility logging results for Fairyland Trail.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Bird	70.1	2,288	260	26
Wind	51.1	1,968	260	19
Insects	43.7	1,761	184	23
Jet	43.7	606	169	25
People, Voices	28.0	577	150	18
People, Walking	22.7	446	157	14
Raven	12.7	587	307	4
Vehicle	12.1	260	78	15
Propeller Aircraft Tour	4.5	219	216	2
Aircraft, Unknown Origin	3.7	150	120	3
Vehicle Door	2.5	105	48	5
Aircraft, Propeller	2.0	190	190	1

As found along the Queens Garden trail, birdsong and wind were the most common natural sounds, with insects also frequently audible at the Fairyland trail location. High altitude jets were the most often encountered human-caused sound along the Fairyland Trail, with the sounds of hikers talking and walking the next most common sounds. Similarly to the results obtained along the Queens Garden Trail, the faint sound of road vehicles in the parking area were audible, even nearly a mile away. Other sounds that were present a low percentage of the time included light wind (1.9%, 3 events), and an RV (1.2%, 1 event).

Sounds experienced less than one percent of the time included non-natural sound of an unknown origin, a truck, a motor, a helicopter, thunder, a squirrel, a mammal, and a single personal audio device.



Non-natural sounds were audible a total of 64.3% of the time. Road vehicles were audible a total of 15.7% of the time, and all aircraft were audible 47.7% of the time. The longest noise free interval (NFI) was found to be 586 seconds, with an average NFI of 108 seconds on the Fairyland Trail.

A short amount of time was spent doing some audibility logging further along the Bristlecone Trail at the end of the park road at Rainbow Point. A set of logging data close to Rainbow Point was included in the moderately visited frontcountry acoustic zone, as researchers



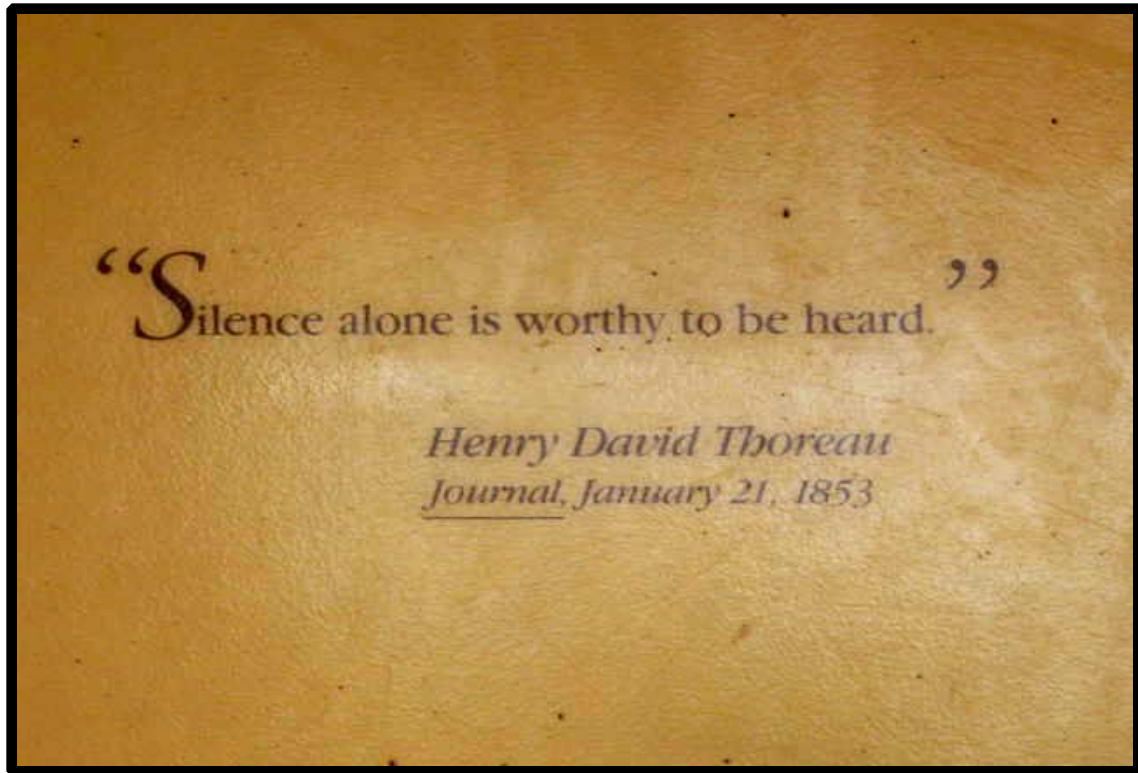
often would take the short hike to Yovimpa Point using the Bristlecone Trail. The trail is one mile and takes hikers away from the main parking area at Rainbow Point, through a forested landscape to the edge of the southern cliffs of Bryce. Extensive views to the south are present here along the edge of the plateau.

Audibility logging was completed a short distance from a small wooden shelter built to provide protection from the elements and provide interpretive materials. In fact, one of the quotes presented on the inside of this structure from Henry David Thoreau states, “Silence alone is worthy to be heard.” Why not collect some audibility logging data in this site to hear if silence is, in fact, present at this location? A total of 75 minutes of audibility logging was completed here, with results viewable in Table 17.

Table 17. Attended audibility logging results for the Bristlecone Loop Trail.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	92.8	1,798	232	18
Vehicle	31.2	259	26	55
People	19.7	288	37	24
Jet	19.5	109	59	15
Natural, Unknown	15.1	57	16	44
People, Walking	15.0	176	36	19
People, Voices	14.0	171	30	21
Motor	7.9	239	51	7
Insects	5.5	57	11	23
Bird	4.4	35	9	22
Motorcycles	3.6	57	32	5
Aircraft, Unknown Origin	3.5	47	20	8
Non-Natural, Unknown	2.6	65	13	9

With the southern and western exposure of this location, it is not surprising to find this to be a windy spot. The sound of the wind was nearly always present here. Other natural sounds included insects and birds. While the Bristlecone Trail does lead away from the parking area and main road, there remains quite a bit of audible vehicle traffic. The sounds of people and jets are also present in this location. Sounds that were heard but that did not appear in the table above included car alarms, mammals, natural sounds of an unknown origin, dogs, propeller aircraft, and vehicle doors. All of these sounds were audible less than one percent of the time. In summary, non-natural sounds were audible along the Bristlecone Trail a total of 66.9% of the time. Road vehicles were audible a total of 26.2% of the time, and all aircraft were audible 23% of the time. The longest noise free interval (NFI) was found to be 135 seconds, with an average NFI of 23 seconds on the Bristlecone Loop Trail. While silence may be worthy to experience, with all the vehicle traffic, people, and aircraft audible at this location, it appears that silence has become an infrequent experience.



From Bryce Point there is trail access that takes hikers below the rim of the plateau and into the amphitheatre via the Peekaboo Loop Trail. There is also access to the backcountry Under the Rim Trail, which can also be used as a day hiking excursion by venturing to the Hat Shop rock formations and returning to Bryce Point (4 miles round trip). Few hikers partake of the hat shop option, as there are several loop hikes available that attract the majority of visitors. This section of the under the rim trail is one of the furthest away from the main road and parking areas, affording the hiker the opportunity to have a backcountry experience even if traversing only a short distance. Audibility logging was completed along the trail to the Hat Shop, about two miles from the trailhead at Bryce Point, near the rock formations that represent the destination for most day hikers. As this was not originally one of the locations included in the sampling plan, only a short amount of time (75 minutes) was spent audibility logging at this site. Results are presented in Table 18.

Table 18. Attended audibility logging results for the Hat Shop Trail.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	65.5	678	164	18
Bird	37.2	862	32	52
Jet	34.8	211	63	25
People, Walking	3.1	85	15	9

Like other trails comprising the short hike acoustic zone, wind and birds were the most frequently audible sounds along the trail to the Hat Shop. The most dominant anthropogenic sound was that of high altitude passenger jets. Other hikers were only heard 3% of the time, showing this to be a much less used trail than other below the rim hikes. Noticeably absent are the sounds of vehicles. Two miles from a parking area appears to be a great enough distance to eliminate the audibility of the cars, buses, trucks, motorcycles, and RV's on the road. In fact, not a single road vehicle was heard at this location. Other sounds that were audible a low percentage of the time included the voices of people (1.8%, 12 events), aircraft of an unknown origin (1.6%, 1 event), and chipmunks (1.4%, 7 events). Sounds audible less than one percent of the time at the Hat Shop included insects, people, a squirrel, natural sounds of an unknown origin, and animals. All combined non-natural sounds were audible 39.4% of the time. Aircraft made up a majority of the non-natural sounds encountered at the Hat Shop, being audible a total of 36.4% of the time. The longest noise free interval (NFI) at the Hat Shop was found to be 291 seconds, with an average NFI of 72 seconds. In stark contrast to the results of many of the other audibility logging sites describe thus far, natural sounds were audible a total of 83.4% of the time.

Short hikes in the park have a much different audibility spectrum than the moderately busy and busiest areas of the park. Within the acoustic zone representing short hikes, there is far

less vehicle noise and the sound of visitors talking and walking than is experienced in the busy and moderately busy acoustic zones. In fact, sounds of an anthropogenic origin differed from the moderately-busy acoustic zone by nearly 20%, and the busiest acoustic zone by nearly 30%. The sounds of the wind and birds are the most frequently encountered natural sounds on the short hiking trails in Bryce. Interestingly, high altitude jets were the most frequent anthropogenic sound encountered on the short hikes, with jet noise audible nearly 30% of the time on average. Other aircraft were also audible, primarily propeller aircraft. The opportunity to experience natural quiet and hear the sounds of nature are more available on the short hiking trails compared to the busy and moderately busy frontcountry acoustic zones. The average noise free interval for all sites where audibility logging was conducted in the short hike acoustic zone averaged nearly a minute (56 seconds), compared to 38 and 36 second NFI's in the moderately busy and busy acoustic zones, respectively.

5.4 Backcountry Acoustic Zone

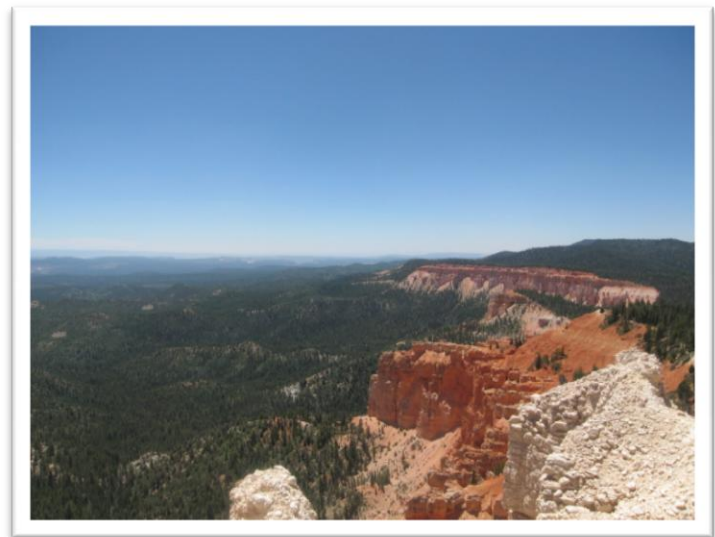
There are a few backcountry hiking opportunities in Bryce Canyon National Park. Backpackers can spend a day or two or up to a week or more hiking a portion of the Under the Rim Trail, or completing the entire 25-mile route. One of the more popular options is the Riggs Spring Loop Trail at the southern end of the park, which can be accessed from either Rainbow or Yovimpa Point. Here backpackers can spend a night or two traversing some of the most remote backcountry of the park accessible by trail. The Riggs Spring Loop is a 9-mile hike taking visitors through a forested section of the park below the rim of the plateau, offering three different backcountry camping options. Day hikers can also complete the entire loop without

spending the night in the backcountry. The number of visitors on the Riggs Spring Trail is much less than found on the short hikes of the Amphitheatre trails. For this reason, the Riggs Spring Trail was chosen for audibility logging as representative of the backcountry acoustic zone, one of the quietest areas of the park. Two locations along the trail were chosen for audibility logging. One site was the Yovimpa Pass backcountry campsite, approximately 1.6 miles from the trailhead at Yovimpa Point. The second site was near the Riggs Spring backcountry campsites, 3.3 miles from the Yovimpa Point trailhead and 5.3 miles from the Rainbow Point trailhead. The soundscape of the backcountry acoustic zone was hypothesized to be much different than the other acoustic zones of the park where audibility logging was completed. Specifically, natural sounds were expected to dominate the soundscape, with a very limited number of anthropogenic sounds experienced in the backcountry. Audibility logging was conducted for a total of 492 minutes in the backcountry acoustic zone, with detailed results presented in Table 19.

Table 19. Backcountry attended audibility logging results along the Riggs Springs Loop.

Sound Source	Percent Time Audible (%)	Max Event (In Seconds)	Mean (In Seconds)	Number of Events
Wind	62.2	1,177	291	63
Bird	61.1	3,598	132	136
Insects	33.8	3,597	129	77
Jet	32.3	476	154	62
Water	23.5	1,487	694	10
Flowing Water	12.2	3,589	3,589	1
People, Voices	11.8	1,965	435	8
Aircraft, Unknown origin	8.7	837	182	14
People, Walking	7.1	1,869	348	6
Natural, Unknown origin	3.9	414	143	8
People	3.5	480	42	25
Aircraft, Propeller Tour	2.3	274	227	3

As is evident in Table 19, the most prevalent sounds in the backcountry were natural in origin, specifically the wind, birdsong, and insects. High altitude jets were the most often audible human caused sound, audible 32.3% of the time. The sound of water was also audible at the Riggs Spring site, one of few places in the park affording the opportunity to experience this sound. The sounds generated by hikers and backpackers were rare, especially when compared with the other acoustic zones. Thunder was also audible in the backcountry (1.2%, 16 events). The sounds of vehicles could be heard on a few occasions from the site at Yovimpa Pass (0.2%, 10 events), as well as the sound of motors (0.1%, 2 events), but these occurrences were limited and the decibel level was low. There are four wheel drive trails to the west of Yovimpa Pass in the National Forest, outside the boundaries of Bryce Canyon National Park, which were the source of the motor vehicles. Mammals and chipmunks were also audible in the backcountry, although



both sound sources were audible less than one percent of the time. Along the Riggs Spring Trail, non-natural sounds were audible a total of 51.9% of the time, and consisted primarily of aircraft, which had a percent time audible of 42.3%. Road vehicles were audible a total of 0.2% of the time. The longest noise free interval (NFI) was found to be 1,287 seconds (21.45 minutes), with an average NFI of 131 seconds in the backcountry acoustic zone along the Riggs Spring Trail. Natural sounds were audible 95.6% of the time in the backcountry.

These results clearly show differences in the soundscape of the backcountry compared to

the other acoustic zones of the park. Natural sounds are dominant, with the greatest opportunity to experience the sounds of nature without many of the intrusions from anthropogenic sound sources found in other areas (and acoustic zones) of the park. Vehicle noise is nearly completely absent in the backcountry, with only rare encounters that are faint and distant due to the adjacent four wheeler trails on the national forest. Wind, birds, and insects are the most often experienced elements of the soundscape in the backcountry. The one human-caused source of sound that is easily detectable and frequent in the backcountry is not of a terrestrial source, but is, instead, airborne. High altitude jets and other aircraft are the most frequently experienced sounds of an anthropogenic origin, and are probably detected more often in the backcountry acoustic zone because of the significant decrease in other human-caused sound sources. Still, the longest noise free interval was experienced in the backcountry, exceeding 20 minutes, with the average NFI over 2 minutes.

Table 20 presents the noise free intervals for the four acoustic zones where audibility logging was completed in the park in order to compare the opportunity to experience the natural soundscape.

Table 20. Comparisons of noise free intervals by acoustic zones.

Noise Free Interval	Busiest Areas	Moderately Busy Viewpoints	Short Hikes	Backcountry
Longest NFI (In seconds)	642	928	929	1,287
Average NFI (In seconds)	36	38	58	131

The opportunity to experience natural quiet and the sounds of nature are key components of a pleasurable visit to a natural setting such as Bryce Canyon National Park. As is evident in Table 20, some acoustic zones in the park afford more opportunities than others to experience the sounds of nature without the intrusions of anthropogenic sound sources. Moving away from the busiest and moderately busy areas of the park creates a greater chance of having a longer noise free interval and increases the average length of hearing only natural sounds. On limited occasions, natural sound segments longer than 10 minutes without anthropogenic noise were found even in the busiest areas of the park. On average, however, in the busy and moderately busy acoustic zones the noise free intervals were a little over half a minute, showing extended periods of quiet are difficult to attain. Even on the short hikes and backcountry trails, where longer NFI's were found, the averages were 1 and 2 minutes, respectively. It is questionable whether this is enough time to become fully immersed in the surroundings and produce a contemplative state of mind.

Summary statistics are important to analyze in order to compare how the soundscapes of the four acoustic zones are similar and different based on the types of activities that are present at these varied areas of the park. Table 21 presents the combined sound source results in audibility percentage for all natural and non-natural sounds, as well as all road vehicles, and aircraft for each of the four proposed park acoustic zones.

Table 21. Summary statistics for percent time audible data for each overall sound source by acoustic zone.

Sound Source	Busiest Areas	Moderately Busy Viewpoints	Short Hikes	Backcountry
All non-natural sources	87.7	77.4	57.1	51.9
All road vehicles	44.7	51.4	19.9	0.2
All aircraft	29.0	28.2	24.8	42.3
All natural sources	75.8	75.9	76.4	95.6

When looking at the results presented in Table 21, it becomes evident that some of the hypothesized differences in acoustic zones are apparent. For example, the frontcountry-backcountry trail acoustic zones have a much different audibility experience than the moderately busy and busiest acoustic zones of the park. Within the short hike and backcountry acoustic zones, there is far less sound of an anthropogenic origin. Specifically, vehicle noise and the sound of visitors talking and walking are found much less frequently on the frontcountry and backcountry hiking trails than in the busy and moderately busy acoustic zones. In fact, sounds of an anthropogenic origin differed from the moderately-busy acoustic zone by nearly 20% for short hikes compared to the moderately busy viewpoints, and differed with the busiest acoustic zone by nearly 30%. In the backcountry, human-caused sources of sound dropped by another 5%, although it is important to point out the percent time audible of all non-natural sounds in the backcountry remained above 50%.

When examining specific sound sources, the percentage of time road vehicles are audible

is markedly different on the short hiking trails and the backcountry than in the busy and moderately busy acoustic zones. Road vehicle noise exposure actually increases from the busiest areas to the moderately busy viewpoints. This finding can be explained based on the specific locations where audibility logging was completed. Some of the overlooks in the moderately busy acoustic zone are immediately adjacent to the main road where vehicles are travelling at a higher rate of speed than the sites where audibility logging was completed in the busiest areas. While there are many people present around the lodge, sunrise, and sunset points, the road access to these areas requires a much slower speed limit, thereby reducing the amount of vehicle noise



present when compared to those locations that have a parking area and the main road close by. Along the short hiking trails road vehicles were audible nearly 20% of the time, but the sounds were faint and off in the distance and, on most occasions, just barely detectable. The only road

vehicle traffic that was audible in the backcountry came from four-wheel drive trails in the national forest whose boundary abuts Bryce Canyon National Park. Sound intrusions from road vehicles audible in the backcountry were extremely rare and infrequent (0.2%), detectable on only a couple of occasions at a low decibel level and far off in the distance.

Aircraft overflights, however, are apparent in all acoustic zones. The primary source of the overflights are high altitude passenger jets, as Bryce is located underneath one of the main west-to-east flight routes. Interestingly, aircraft were audible most frequently in the backcountry

acoustic zone, occurring over 42% of the time. Aircraft may be audible more frequently in the backcountry, and hence more representative of the actual number of overflights, due to the lack of other types of mechanical sounds (such as road vehicles) that can mask some overflights or reduce the amount of time they are distinguishable from the background ambient conditions.

While the percentage of time non-natural sounds are audible noticeably decreased across acoustic zones, the percentage of time natural sounds were audible slightly increased across acoustic zones, with a significant increase in the backcountry. Natural sounds were audible in the backcountry 95% of the time, nearly a 20% increase over the other acoustic zones. Even as natural sounds are evident a large percentage of the time in all acoustic zones, they are often simultaneously accompanied by anthropogenic sounds in the busiest and moderately busy areas. Although the backcountry seems to afford the greatest opportunity to experience natural ambient sounds, human-caused sounds are evident even in the remote areas of the park greater than half of the time. This is due primarily to the presence of aircraft overflights and encounters with hikers and backpackers. In all acoustic zones, the sounds of the wind and birds are the most frequently encountered natural sounds in Bryce Canyon National Park.

When analyzing all the results from the attended audibility logging phase of this project, it becomes clear there are many detectable auditory differences based on the number of visitors and vehicle activity level found with the different areas of the park. The establishment of acoustic zones is, therefore, beneficial in order to begin developing indicators of quality and specific standards for the distinct soundscape spectrum present in each location. For example, in the busiest acoustic zone of the park it would be expected to hear the sounds produced by other visitors and their vehicles simply due to the number of people present. Similarly, at viewpoints located along the main road with a moderate number of visitors, the expectation of having long

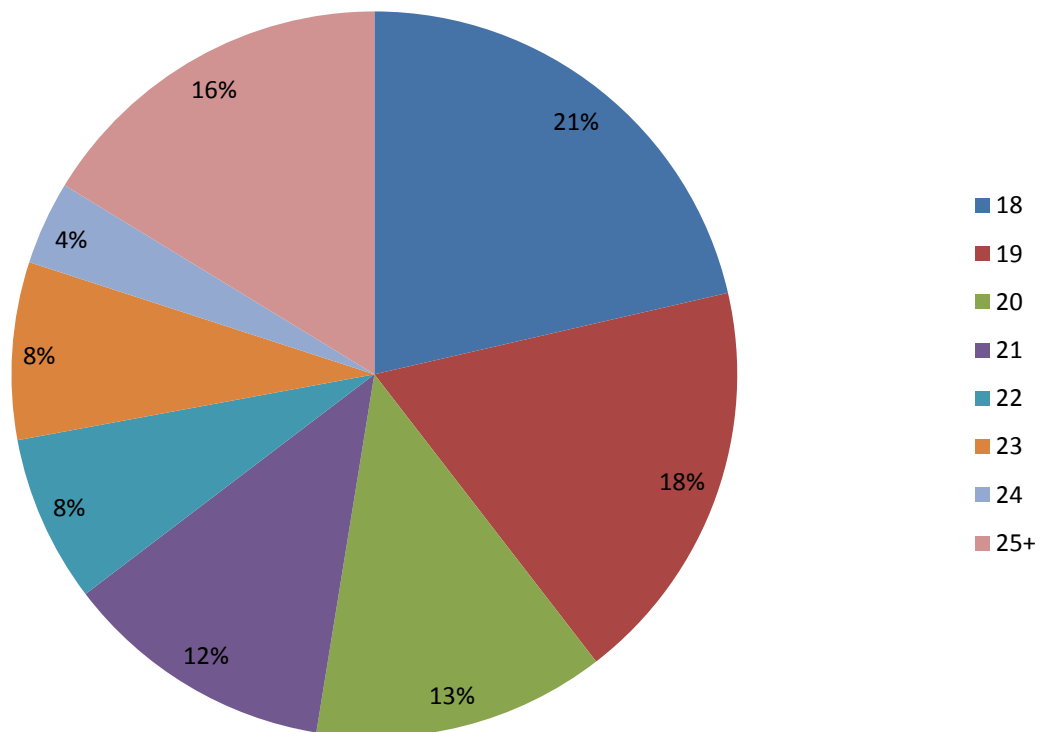
periods of natural quiet is unrealistic. However, when hiking and backpacking, the auditory expectations and what is viewed as acceptable and appropriate to the setting would be markedly different. Percent time audibility data is useful to begin the process of determining what is considered acceptable for specific anthropogenic sound sources found in different acoustic zones. Additional methodological protocols can then be implemented to more specifically address these issues. Visitor surveying and experimental laboratory studies are examples of different methodologies that address the human dimensions of soundscape perception. As aircraft were audible at every site within each acoustic zone investigated in the first portion of Phase II of this project, and in order to gain a more complete understanding of how the sound of specific types of aircraft are perceived, more rigorous scientific procedures were undertaken. Phase II of the current project also sought to address the issue of aircraft overflights in more detail based on the results obtained from the attended audibility logging by employing laboratory protocols common to environmental psychology.

6 Method—Phase II—Laboratory Experiment

6.1 Participants and Design

Two-hundred fifteen students (140 women and 75 men) at Southern Utah University completing a research requirement for general psychology or earning credit in another course served as participants in the laboratory sound experiment. Participants ranged in age from 18 to 40 and older and served in one of three experimental conditions. Age distribution for all participants is displayed in Figure 3.

Figure 3. Age Distribution of Laboratory Participants.



The three between-subjects conditions were: (1) scenes of Bryce Canyon National Park with nature sounds and helicopters audible on 25% of the trials; (2) scenes of Bryce Canyon National Park with nature sounds and propeller driven aircraft audible on 25% of the trials; and, (3) scenes of Bryce Canyon National Park with nature sounds and high altitude passenger jets audible on 25% of the trials. Natural sounds were audible 75% of the time in all three conditions.

6.2 *Laboratory Experiment Materials*

A soundproof laboratory room with three individual computer stations was used for data collection. Dell desktop personal computers with high resolution monitors were used by participants to complete the experimental procedures. Landscape scenes from Bryce Canyon National Park were taken with a Nikon PowerShot S80 digital camera at the locations where observer logging was conducted in the park. Forty different landscape scenes were used in the laboratory experiment. A sample set of digital photos used in the experiment are depicted in Figure 4 below.

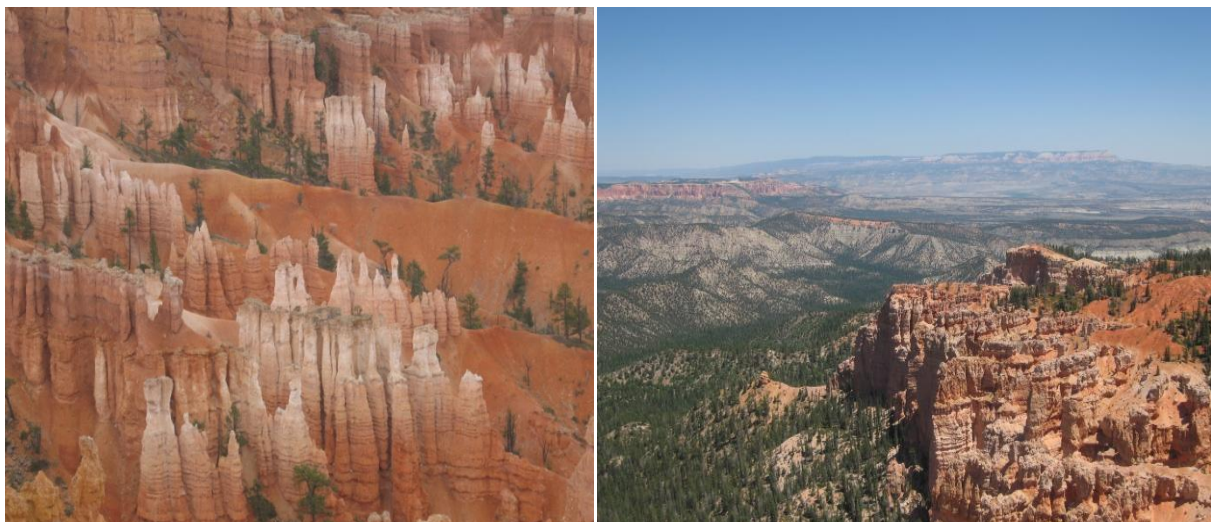






Figure 4. Examples of landscape stimuli from Bryce used in the laboratory experiment.

Sound recordings from Bryce were completed using an Edirol R-09HR digital sound recorder with built in stereo microphones and additional recording made with an Edirol CS-15 external stereo microphone. Sound recordings were edited using Adobe Audition version 3.0, so that nature sounds and different types of aircraft could be isolated and put into 30-second tracks. Audio tracks were also manipulated using the audition program to create realistic sounding fade-in and fade-out effects to simulate aircraft flyovers in Bryce Canyon National Park. Adobe

Authorware, version 7.0 software was used to program the presentation of visual and auditory stimuli and collect the responses of participants to the dependent variables on a sliding 10-point scale controlled by the computer mouse. Sound levels were recorded in Bryce using a Sper Scientific 840013 Sound Meter. Decibel measurements for natural and aircraft sounds were then set on the computer to represent conditions commonly found in Bryce Canyon National Park. Audio Technica QuietPoint ATH-ANC7 Active Noise-Cancelling Headphones were plugged into the computer and used by all participants to listen to the auditory stimuli.

Ten-point Likert-type scales were created using Adobe Authorware version 7.0 so participants could easily rate each depicted landscape and the associated soundscape on six dependent measures. Each scale would appear on the bottom of the computer screen following 20 seconds on uninterrupted presentation of each landscape slide and the audio representing the soundscape. The six dependent variables measured in this study were: naturalness, scenic beauty, solitude, tranquility, annoyance, and overall preference. Each scale ranged between one and ten, one being low and ten being high. Numeric scales were not visible to the participants; they would simply move the mouse to position their response along the black bar representing the scale between the bipolar anchor points of low and high (for annoyance, solitude, and tranquility). The anchor points for scenic beauty were not very scenic and very scenic. The anchor points for naturalness were not very natural and very natural. Anchor points for overall preference were do not prefer and greatly prefer. Each landscape/soundscape was rated on these six attributes: scenic beauty, naturalness, annoyance, solitude, tranquility, and preference. These specific scales have been used in previous research (Benfield, et al., 2010a; Mace et al., 1999; 2003) and were found to load on a single factor with an eigen value of 4.61, accounting for 66% of the variance (Mace, 1997). Data on age, gender, size of hometown, along with the frequency

and recency of visitation to a national park were collected using a personal computer following completion of all other aspects of the study.

6.3 *Laboratory Experiment Procedure*

Participants entered the laboratory and were instructed to be seated at one of the three computer stations. A brief verbal description detailing the computer software, rating scale definitions, and use of the headphones was explained to familiarize participants with the procedural aspects of the experiment. Once any questions were answered, participants began the computer program portion of the experiment. Participants completed an informed consent embedded with additional instructions at the beginning of the computer exercise. A practice trial in which participants became familiar with how to position the computer mouse to complete each rating scale was then presented. Once participants felt comfortable with the scaling procedure, actual data collection commenced.

Participants were shown 40 natural landscapes from Bryce Canyon National Park where attended logging and sound recording was completed during the field stage of this research project. Synchronized with each scene, sounds from BRCA were audible during the entire time the scene was visible. Landscapes and soundscapes were presented for 20 seconds for each of the 40 trials before the rating scales would appear on the bottom of the screen. Once the scales appeared at the bottom of the screen, the sights and sounds continued until all ratings were completed (which usually took 10-15 additional seconds). A random order was generated where three noise segments (helicopter, propeller plane, or jet aircraft, depending on condition) were presented in blocks of three or four trials to create realistic noise experiences that would be encountered in the park. Nature sounds were audible on all other trials. Specifically, nature

sounds were audible during the first eight trials, noise was audible on trials nine through eleven, natural sounds on trials 12 to 18, noise on trials 19-21, natural sounds on trials 22-30, noise on trials 31-34, and natural sounds on the remaining trials 35-40 (see Table 22). This order ensured noise was present on 25% of the trials, while natural sounds were audible on 75% of the trials. Each of the three conditions received the same order of events, however, the type of noise present was different. In one condition, participants experienced helicopter noise during the noise segments. In the second condition, noise from propeller aircraft was audible during the noise segments. In the third condition, high altitude jet aircraft noise was audible during the noise segments. In all conditions, natural sounds and noise were presented between 30 and 50 decibels. Noise would fade in and fade out, however the $L_{\max}$ was always set at 50 dB.

Table 22. Presentation order of audio trials in the laboratory assessment.

Trial Number	Type of Auditory Stimuli
1 through 8	Natural Sounds
9 through 11	Noise (Helicopter, Prop, or Jet)
12 through 18	Natural Sounds
19 through 21	Noise (Helicopter, Prop, or Jet)
22 through 30	Natural Sounds
31 through 34	Noise (Helicopter, Prop, or Jet)
35 through 40	Natural Sounds

During the completion of the ratings, sights and sounds remained visible and audible. Participants rated each depicted landscape and associated soundscape on the six dependent

variables: naturalness, scenic beauty, solitude, tranquility, annoyance, and overall preference. Each scale ranged between one and ten, one being low and ten being high. Numeric scales were not visible to the participants, they would simply move the mouse to position their response along the black bar representing the scale between the bipolar anchor points. Once all scales were completed for any given trial, the next trial would begin until all 40 trials were completed. The computer software recorder all scale entries into a database of responses. At the conclusion of the landscape and soundscape ratings experiment, participants answered a few short demographic questions, were fully debriefed and given the opportunity to ask any questions.

7 Phase II Results: Laboratory Experiment

7.1 Mean Ratings

Scaled responses for each of the 40 depicted landscapes and associated soundscapes were collected by the computer and input into an SPSS file for all statistical analyses. Means for each of the six dependent variables were calculated for the three conditions for all individual trials. Examining the results in this way shows clear differences between natural sounds and the presence of aircraft noise, whatever the source. Figure 5 displays the means for each of the 40 trials broken down by condition for the ratings of annoyance. Recall that annoyance ranged from one (very low) to ten (very high). Each data point in figure 5 represents the combined scores of all participants (~70) for each trial by condition (helicopter, propeller plane, jet aircraft).

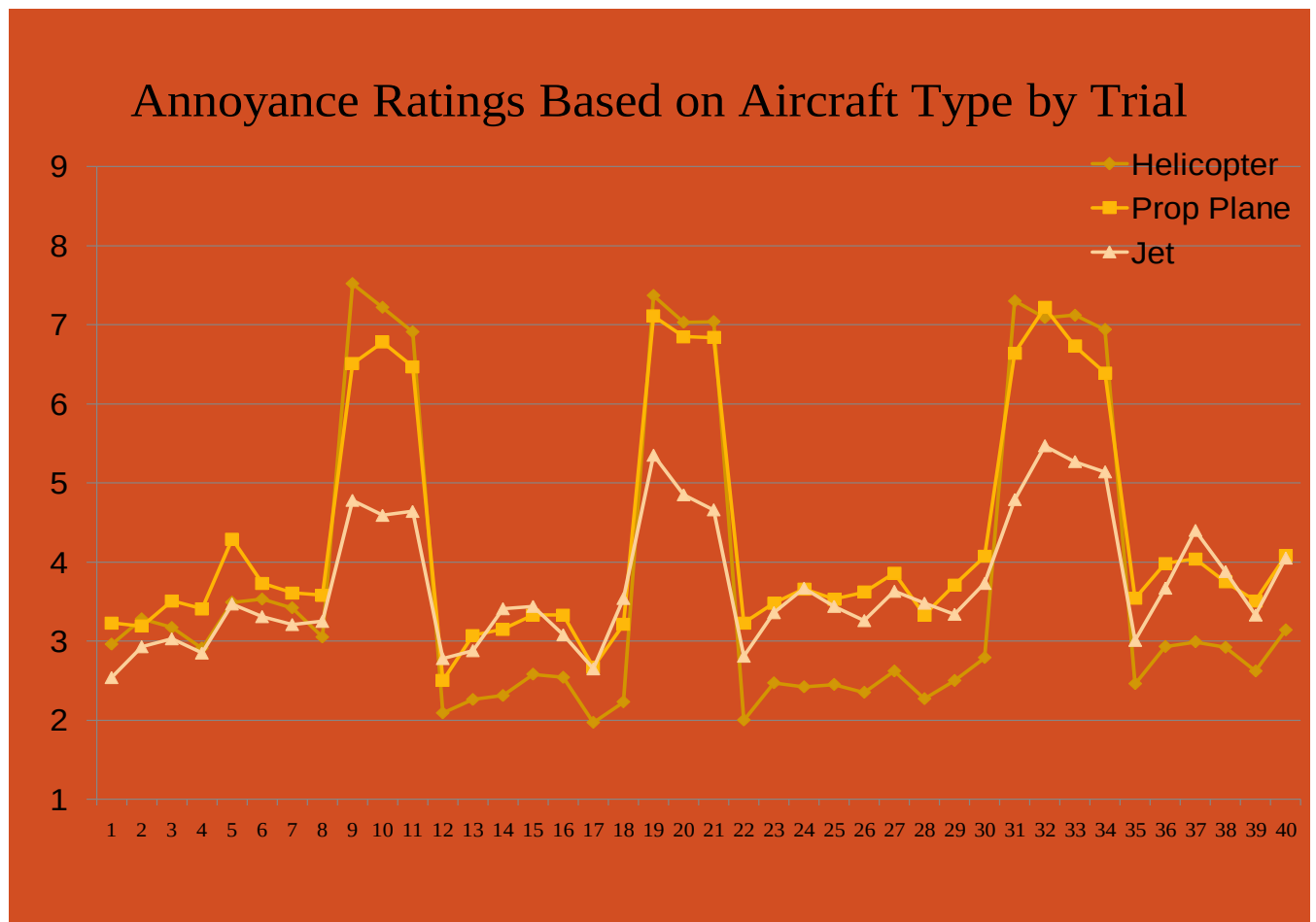


Figure 5. Means for ratings of annoyance by trial for each of the three conditions.

As is evident in Figure 5, annoyance was heightened by the presence of aircraft noise. Helicopter noise produced the highest annoyance, followed by propeller planes, and jet aircraft. Natural sounds were much less annoying than all types of aircraft noise. Note the mean ratings for annoyance on the second, third and fourth sets of nature sounds following the dose of aircraft noise. There is a recovery effect following aircraft noise exposure, with the immediately following trials rated less annoying than the aircraft noise and the first set of landscapes and natural sounds. In other words, annoyance ratings are at their lowest immediately following a dose of aircraft noise.

Participants also rated each landscape/soundscape on the opportunity to experience solitude. Ratings for solitude were also completed on the computer using a slide bar and arrow, with anchors being very low (coded as 1) to very high (coded as 10). The mean ratings for each of the three conditions by trial for the opportunity to experience feelings of solitude are displayed in Figure 6.

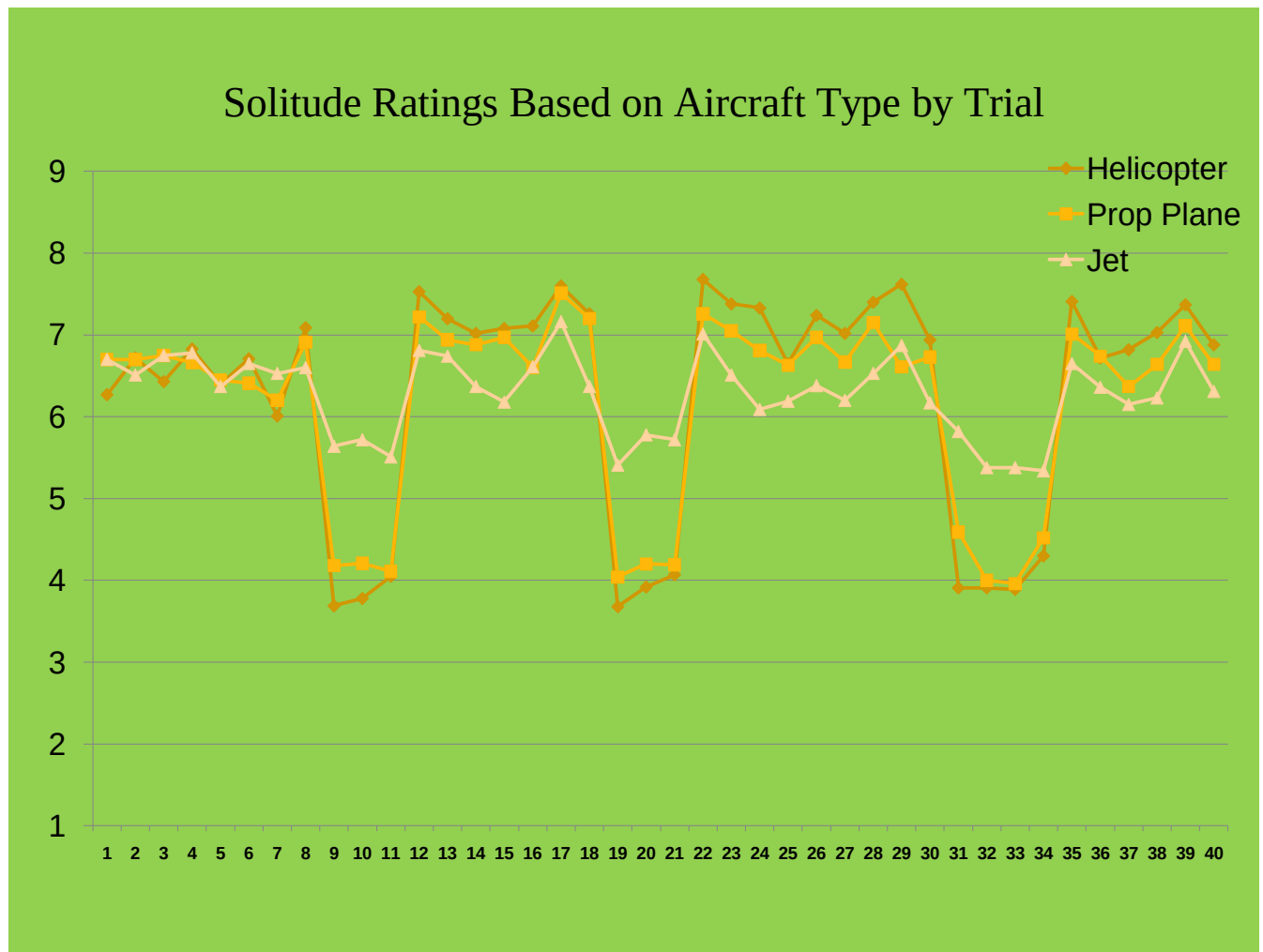


Figure 6. Mean ratings of solitude for each condition by trial.

Solitude, while initially rated high in the first few trials of natural sounds, declined when aircraft noise was audible. Helicopter noise intruded on the opportunity to experience solitude,

as did noise from propeller planes, and high altitude jets. Natural landscapes, when paired with natural soundscapes produced high ratings of solitude. As found with ratings of annoyance, a rebound effect was apparent with ratings of solitude, as the second and third sets of natural sounds had higher solitude means than the aircraft noise trials and the first set of natural sounds.

Ratings of tranquility were completed in a similar fashion as the other dependent variable ratings. Participants used a sliding scale on the computer to rate each landscape/soundscape on tranquility ranging from very low (1) to very high (10). Mean results for each trial by condition for ratings of tranquility are displayed in Figure 7.

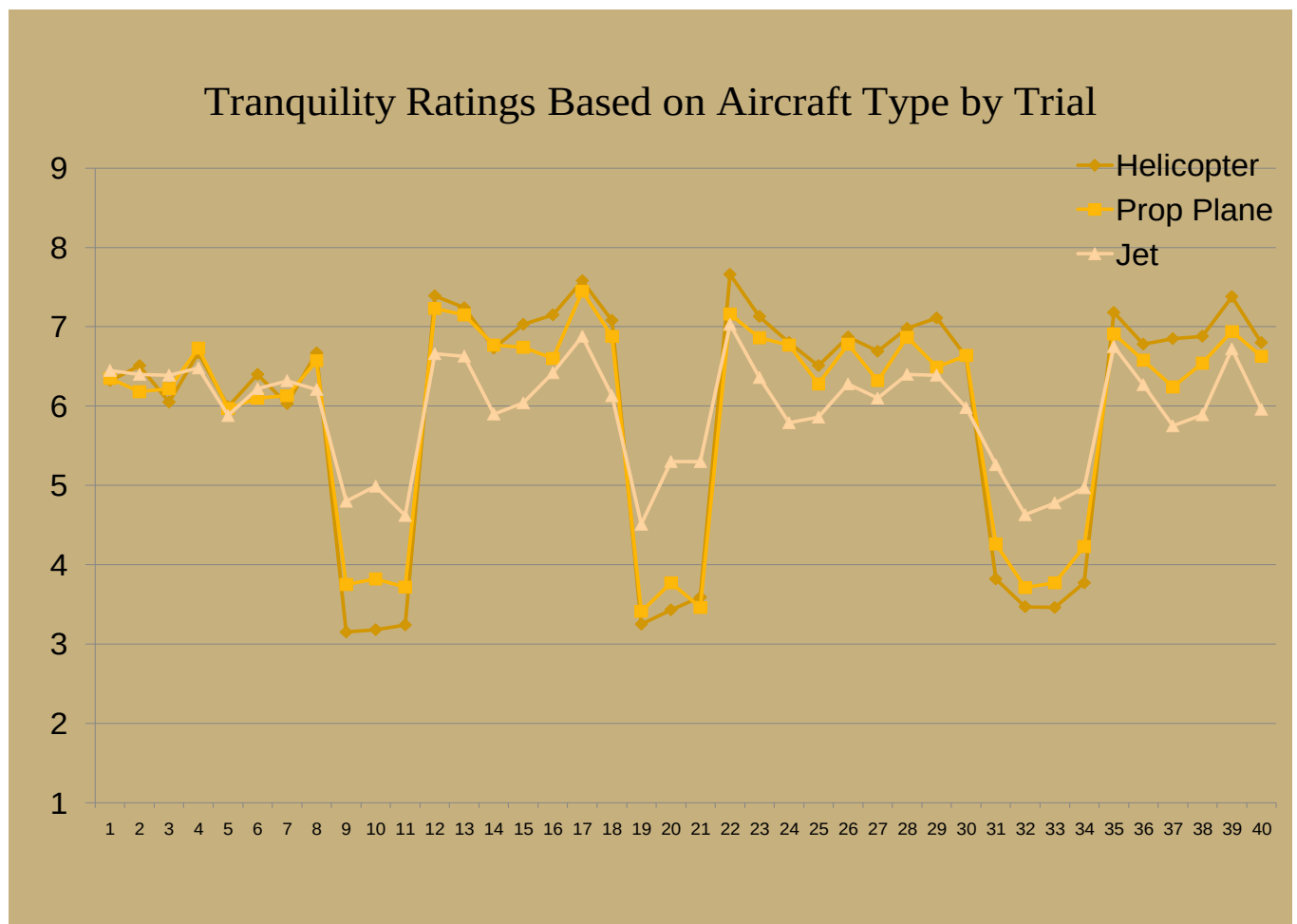


Figure 7. Mean ratings for tranquility for each trial by sound condition.

Tranquility ratings followed a similar pattern as those of solitude. Natural sounds produced high levels of tranquility, with a drop in mean ratings for each aircraft noise condition. The largest drop in tranquility ratings occurred with helicopter noise, followed by propeller planes, and finally high altitude jets. The second and third set of nature sounds were rated higher than the first set, showing a recovery effect similar to that found with the dependent measures of annoyance and solitude.

The fourth scale rated dependent variable was naturalness, with scenes and sounds evaluated using a sliding scale identical to the other rated variables. Naturalness ratings ranged from not very natural (1) to very natural (10). Mean results for naturalness ratings are presented in Table 8 for the three conditions for each trial.

Landscapes and soundscapes of Bryce were rated high on naturalness for those trials where the sounds of nature were apparent. Naturalness ratings ranged between 7 and 8 with nature soundscapes, and dropped to between 6 and 7 when aircraft were audible. The greatest decline in naturalness ratings occurred when helicopter noise was present. Ratings of naturalness were slightly higher for propeller planes than helicopters, but remain lower than when natural sounds were audible. High altitude jet aircraft noise caused a slight decline in ratings of naturalness compared to nature sounds, although jets were rated higher on naturalness than the other aircraft noise conditions. Overall, the most natural ratings occurred during the second and third sets of natural soundscape trials for all three conditions.

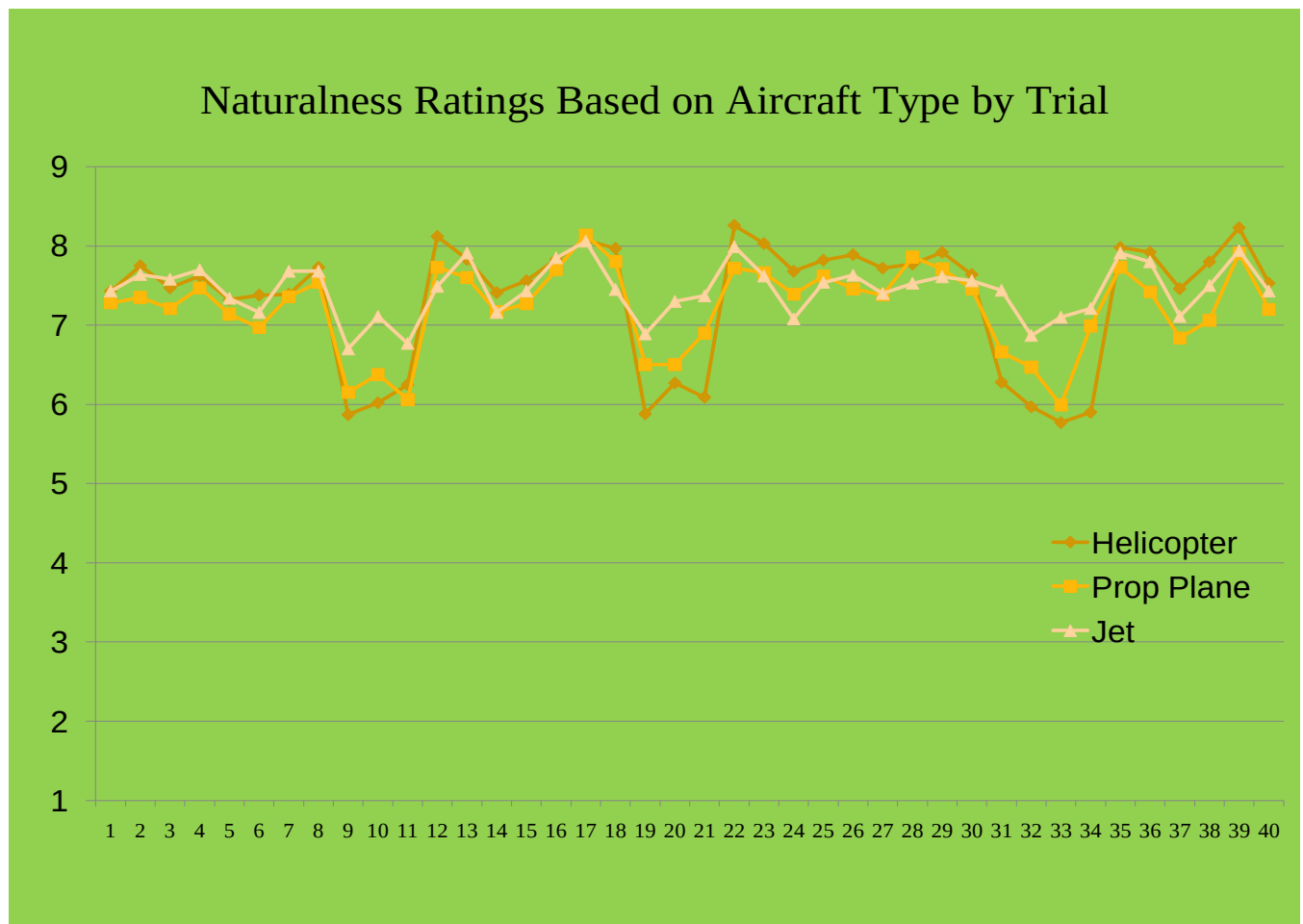


Figure 8. Mean ratings for naturalness by trial for helicopter, propeller plane, and jet aircraft conditions.

Stimuli were also rated on scenic beauty, which is a visual variable used in past landscape assessments. Auditory stimuli have been found to have an effect on ratings of scenic beauty in previous research, so ratings of scenic quality were completed by participants in the present study. Scenic beauty ratings were completed using a sliding scale on the computer program displaying the visual scenes and playing the natural and aircraft sounds. Ratings ranged from not very scenic (1) to very scenic (10). Mean ratings for all participants by trial for all three aircraft noise conditions are viewable in Figure 9.

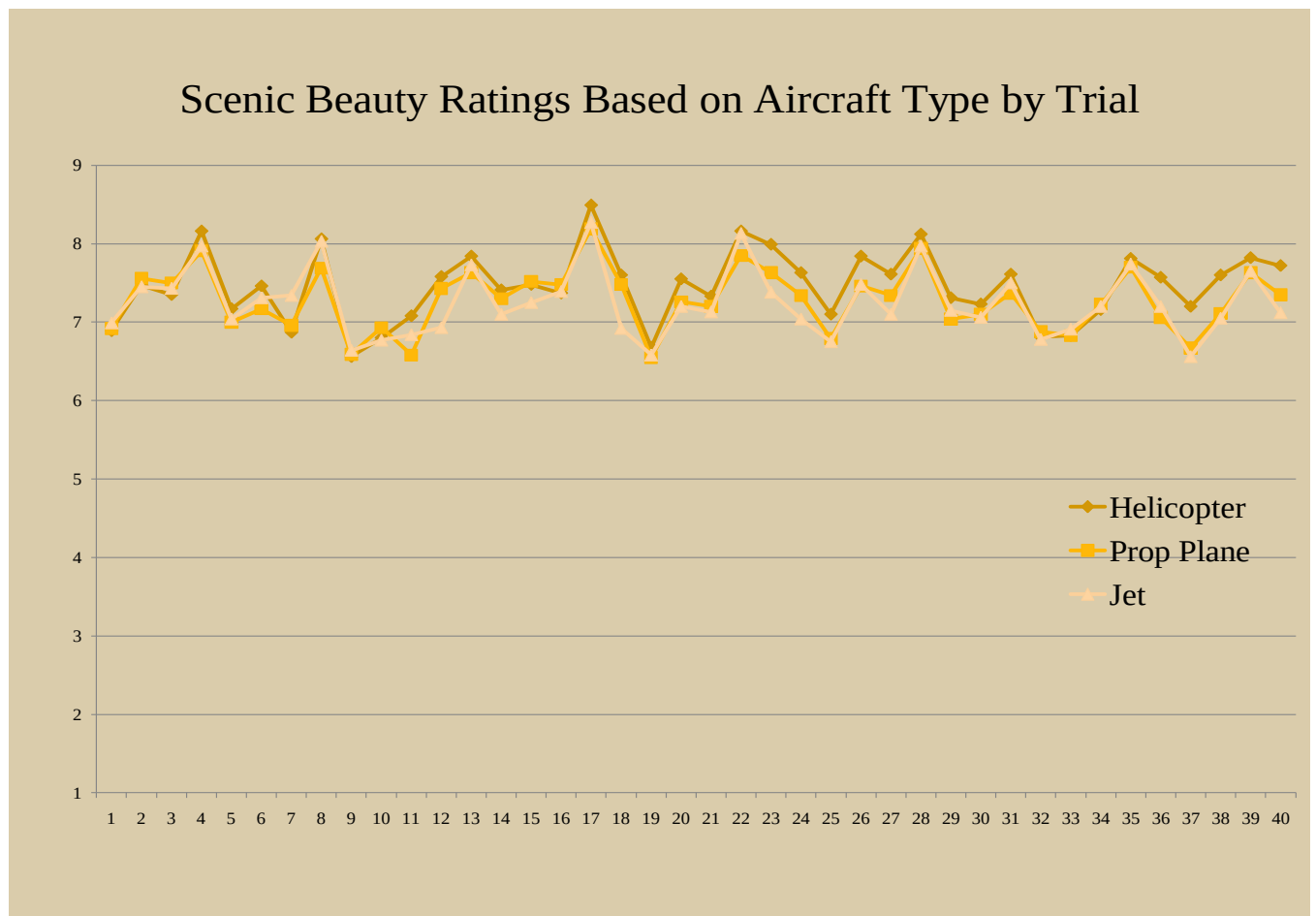


Figure 9. Scenic beauty mean ratings for the aircraft noise conditions for all 40 trials.

Most of the mean ratings for scenic beauty were high, ranging between 7 and 8 when the soundscape was composed of the sounds of nature. When aircraft noise was present, mean ratings slightly dropped to an average between 6.5 and 7 on the 10-point scale. Mean ratings for the three types of aircraft noise are similar throughout all 40 trials, showing much less variability than the other dependent variables. As previously discussed, scenic beauty is primarily a visual attribute, and with the displayed landscapes all conceivably high in natural scenic quality, it would be expected that scenic beauty ratings would be highly positive with less variability than the other less visually dominant dependent variables.

The final scale on which the landscapes and soundscapes of Bryce were evaluated was overall preference. Ratings ranged between do not prefer (1) to greatly prefer (10). Participants rated each of the 40 scenes with associated audio using the same type of sliding scale displayed on the computer screen used to rate all other dependent variables. Mean results for overall preference for every trial for all three conditions are viewable in Figure 10.

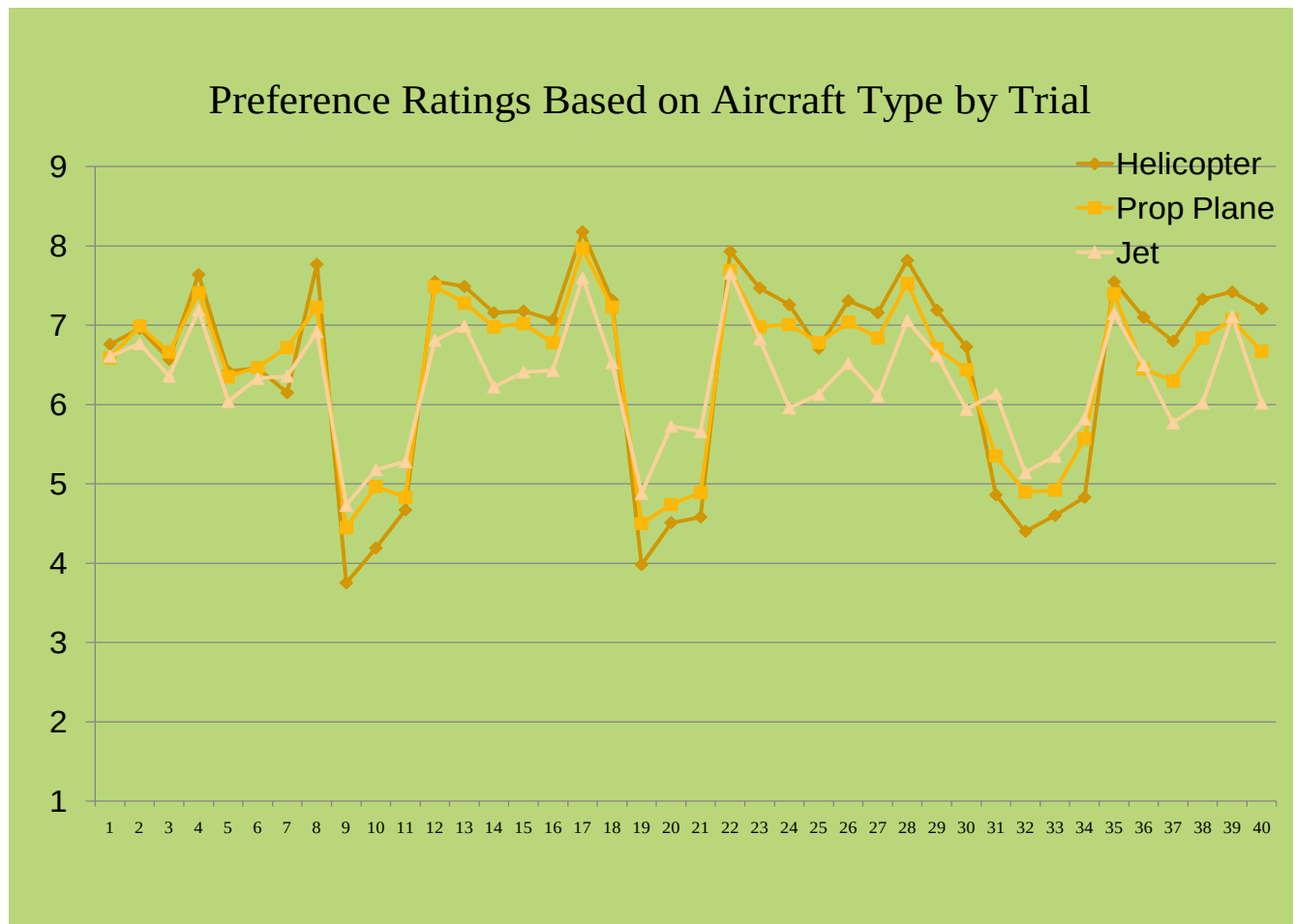


Figure 10. Overall preference mean ratings for aircraft noise conditions by trial.

Overall preference ratings followed a similar pattern as many of the other dependent measures, specifically solitude, tranquility, and annoyance. The first few trials had highly

preferred ratings when nature sounds were present, with a decline of 2-3 points, on average, when aircraft noise of any type was audible. The sounds of helicopters produced the greatest decline in ratings of overall preference, followed closely by propeller driven aircraft and high altitude jet aircraft noise. Preference ratings did show a recovery following aircraft noise exposure, more apparent in the second and third set of nature sounds than the fourth.

Mean ratings were calculated for each condition by combining responses for all trials where aircraft noise was present. For example, in the helicopter noise condition, all responses for solitude were combined on those trials where helicopter noise was present. A similar procedure was employed for those trials which included only the presence of natural sounds. Mean ratings and standard deviations for all six dependent variables in each aircraft noise condition and nature sounds are displayed in Table 23.

Condition		Annoyance	Solitude	Tranquility	Naturalness	Scenic Beauty	Preference
Natural Sounds	M	3.17	6.78	6.58	7.60	7.44	6.90
	SD	2.17	1.84	2.00	1.71	1.65	1.98
Helicopter	M	7.15	3.92	3.44	6.03	7.04	4.44
	SD	2.26	2.24	2.30	2.50	1.93	2.48
Propeller Plane	M	6.76	4.20	3.79	6.46	6.94	4.91
	SD	1.95	1.95	1.91	2.15	1.88	2.01
Jet	M	4.96	5.57	4.92	7.08	6.95	5.39
	SD	2.39	2.09	2.07	2.05	1.98	2.19

Table 23. Means and standard deviations for all dependent measures by soundscape condition.

A bar graph is displayed in Figure 11 to compare the effects of the type of auditory stimuli (natural sounds and aircraft noise) on the mean ratings of the dependent variables.

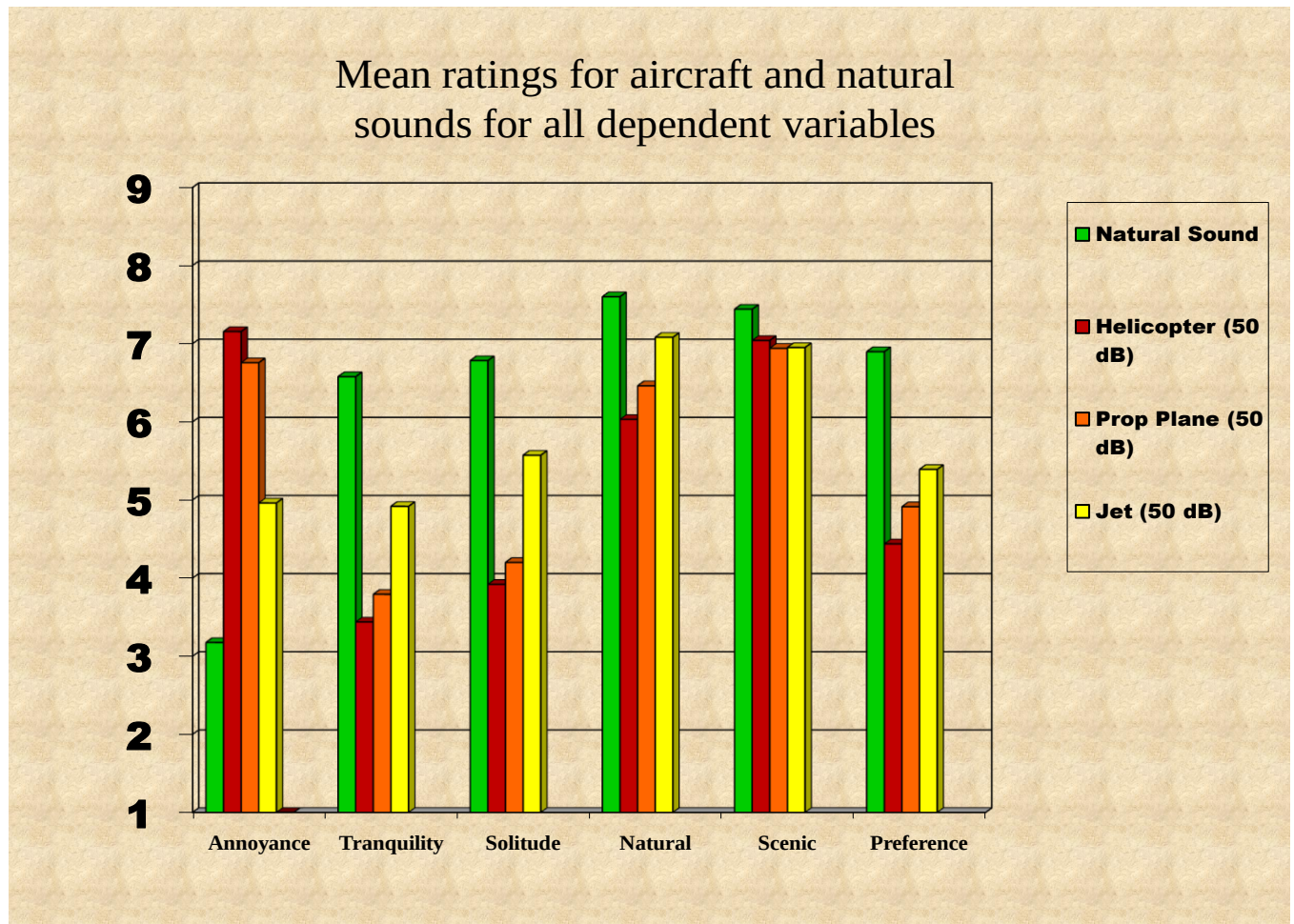


Figure 11. Natural sounds and aircraft noise mean ratings for the six dependent variables.

As can be discerned from examining Table 23 and Figure 11, scenes where natural sounds were present produced high ratings of tranquility, solitude, naturalness, scenic beauty, and overall preference. Annoyance ratings were low when nature sounds were present. Mean ratings for tranquility, solitude, and preference declined when aircraft noise from helicopters,

propeller planes, and jet aircraft at 50 dB(A) were audible. Naturalness and scenic beauty slightly declined when aircraft noise of all types was audible. Annoyance increased for all types of audible aircraft, but especially for helicopters and propeller planes.

7.2 Significance Tests

As differences are apparent between the mean ratings on some of the six dependent variables during the four natural sound exposure segments within each aircraft noise condition, for the purposes of significance testing each natural sound segment was coded independently. Using Wilks' Lambda, a between-subjects MANOVA on the six dependent variables revealed significant differences between the three aircraft noise conditions and natural sounds, $F(36, 37715) = 117.84, P < .0001$, Wilks' $\lambda = 0.626$, partial $\varepsilon^2 = .075$, observed power = 1.0. Demographic variables such as gender, age, and the number of visits to a National park were included in this analysis as covariates. In no instance did any of these demographic measures produce significant differences on the six dependent measures.

A series of univariate analyses of variance were completed in order to partial out which dependent measures were contributing to the significant effect. All six dependent measures were found to be statistically significant. Participants were more annoyed when aircraft noise was present, $F(6, 8593) = 620.29, P < .001$, partial $\varepsilon^2 = .30$, observed power = 1.0. Solitude was significantly lower when aircraft noise was audible, $F(6, 8593) = 413.43, P < .001$, partial $\varepsilon^2 = .22$, observed power = 1.0. Tranquility was adversely affected by the presence of aircraft noise, $F(6, 8593) = 459.78, P < .001$, partial $\varepsilon^2 = .24$, observed power = 1.0. Landscapes and the associated soundscapes were perceived as less natural when aircraft noise was audible, $F(6, 8593) = 111.61, P < .001$, partial $\varepsilon^2 = .07$, observed power = 1.0. Scenes of Bryce Canyon

National Park were rated as more scenic when natural sounds were present, $F(6, 8593) = 21.03$, $P < .001$, partial $\varepsilon^2 = .01$, observed power = 1.0. Finally, depicted environments were more preferred when natural sounds were audible compared to aircraft noise at 50dB(A) audible 25% of the time, $F(6, 8593) = 268.82$, $P < .001$, partial $\varepsilon^2 = .16$, observed power = 1.0.

7.3 Comparisons Between Aircraft Noise Conditions and Natural Sounds

Differences were expected to exist between the presence of aircraft noise and when the sounds of nature were audible. Large differences were found between the three types of aircraft noise (helicopter, propeller plane, high altitude jet) and natural sounds. More specifically, the noise of helicopters was found to be more annoying than natural sounds, less natural, causing fewer opportunities for tranquility and solitude, lower scenic beauty, and overall the least preferred (all at a $P < .001$). The propeller plane noise condition was found to be nearly analogous to helicopter noise, causing more annoyance, less solitude, tranquility, naturalness, scenic beauty, and lower overall preference than natural sounds (all at a $P < .001$). Similarly, compared to natural sounds, the high altitude jet noise condition (at 50 dB(A)) was significantly more annoying, and produced lower ratings of naturalness, solitude, tranquility, scenic beauty, and preference (all at a $P < .001$).

7.4 Aircraft Noise Conditions Comparisons

The degree to which the types of aircraft would be similar or differ from one another on the dependent variables was less predictable based on the lack of previous research examining this issue in the context of a national park. Noise from helicopters and propeller planes were found to be quite similar and produced no statistically significant differences on the degree of annoyance, solitude, tranquility, and scenic beauty. The helicopter and propeller plane

conditions were significantly different on naturalness and overall preference, with helicopters being perceived as less natural ($P<.01$) and least preferred ($P<.01$). The helicopter noise condition was found to be statistically different than the jet aircraft noise condition on all dependent variables except scenic beauty. Specifically when compared to high altitude jet aircraft at the same decibel level and exposure rate, helicopter noise was more annoying ($P<.001$), and was much lower on solitude ($P<.001$), tranquility ($P<.001$), naturalness ($P<.001$), and overall preference ($P<.001$). When compared with high altitude jet airplane noise, the propeller airplane condition was found to be more annoying ($P<.001$), lower on solitude ($P<.001$), tranquility ($P<.001$), naturalness ($P<.001$), and preference ($P<.001$). Propeller plane noise and jet aircraft noise did not significantly differ on scenic beauty. Overall, then, helicopter noise was perceived as the most disruptive, followed closely by propeller plane noise, with jet airplanes being the least negative of the three noise conditions. It is important to point out, however, that all three types of aircraft noise are significantly more negative than natural sounds.

7.5 Natural Sound Segment Comparisons

Nature sound trials were grouped into four segments for the purposes of analysis with differences emerging between the segments on some of the rating scales. When compared with the second set of natural sounds, the first set was found to be higher on ratings of annoyance ($P<.001$), and lower on solitude ($P<.001$), tranquility ($P<.001$), overall preference ($P<.001$), and naturalness ($P<.05$). The first set of natural sounds also was found to have significantly lower ratings of solitude ($P<.001$) and tranquility ($P<.001$) than the third set of natural sounds, with naturalness approaching significance ($P=.055$). The only significant difference between natural sound segments one and four were lower ratings of tranquility for the first natural sound segment ($P<.05$). Natural sound segment two was found to have lower mean ratings of annoyance

($P < .001$) than the third and fourth nature sound segments. Overall preference was found to be higher in natural sound segment two than segment three ($P < .05$). Lastly, when compared with nature sound segment three, the fourth natural sound segment had higher mean ratings of annoyance ($P < .001$).

8 Discussion

Results from this multi-methodological investigation provide useful findings for enhancing our understanding of the Bryce Canyon National Park soundscape and the managerial implications associated with aircraft overflights. Audibility logging results taken from numerous locations in the park provide baseline information to help create distinct acoustic zones based on the types and amount of specific sound sources that are audible at each location. Results generated from the laboratory portion of this study clearly show the negative effects that different types of aircraft noise have on a variety of important indicators of quality that are to be managed as protected resources of the park. The effects of aircraft noise on these indicators of quality can then be used to aid in the development of soundscape standards for different acoustic zones of the park.

8.1 Audibility Logging

Results generated from the attended audibility logging phase of this project support the idea of establishing acoustic zones based on the audible qualities present within a given area. Many of the busy lookouts had visitors and vehicles audible a large percentage of the time, which is to be expected given the number of people who want to visit these overlooks. Short hikes away from the main road had a much different acoustic profile than the overlooks. While

encounters with other hikers still occur, the sound generated by visitors was typically much less on short hikes than at the busy overlooks. Vehicles could only be detected when it was quiet, and they were low in terms of decibel level. Backcountry sites had few encounters with other visitors and very few, if any, audible motor vehicles. Therefore, based on these varying auditory conditions found in different areas of the park, the establishment of acoustic zones each with unique management standards would be supported. The one ubiquitous sound encountered in all acoustic zones was that produced by aircraft, with high altitude jets audible on average around 25-30% of time in all locations where attended audibility logging was completed. Baseline acoustic zone management standards for aircraft overflights could, therefore, be developed for all acoustic zones with a maximum acceptable exposure level, which could then be adjusted based on the outcome of future research and changing conditions. Scenic helicopter tours may, for example, begin to increase in frequency once again in Bryce, and given the results of the laboratory portion of this study, as well as previous research, an acceptability rate of 25% time audible for helicopter noise may exceed what many visitors find appropriate. This may be especially true for backcountry users, something which future research should help to determine. When these types of situations arise, management standards for different types of established acoustic zones should be flexible enough to respond to changing conditions and new data.

The establishment of acoustic zones is, therefore, beneficial in order to begin to identify specific indicators of quality and then to develop standards for the distinct soundscape spectrum present within each acoustic zone. Furthermore, results from the audibility logging and laboratory experiment can also contribute to the development of a soundscape management plan for the entire park, proscribing the ideal and acceptable auditory components found in each acoustic zone. What is ideal (appropriate) and what is acceptable are two different standards that

require more research to adequately address in a systematic manner. For example, the percentage of time a vehicle is audible in the busiest acoustic zone may be acceptable at 40 or 50%, however this percentage would surely be unacceptable in other acoustic zones such as along short trails or in the backcountry. While this may be viewed as an acceptable standard by many, it may not be the ideal standard for any acoustic zone if the natural soundscape is to truly be a protected resource. At any rate, if a given sound source is found to be unacceptable within a specific acoustic zone, or if the threshold percentage of what is considered acceptable or appropriate for a given area is exceeded, management alternatives should then be undertaken to reduce the frequency of the sound source. With many anthropogenic sound sources, however, this is easier said than done.

Take, for example, the issue of aircraft overflights previously discussed. In the attended audibility logging portion of this study, high altitude jet aircraft were found to be audible ranging between 20-45% of the time, depending on location. Propeller planes were detectable much less frequently, with helicopters nearly non-existent. What to do about aircraft overflights over national parks has primarily focused on scenic air tours, and only recently expanded to other soundscape and noise issues with the establishment of the Natural Sounds Program Office in 2000 as a result of NPS Director's Order #47. Overflight management of any type of aircraft requires cooperation with the Federal Aviation Administration, as they have governance over airspace, while the NPS has jurisdiction over land-based resources. The two agencies have focused most of their attention on areas overly affected by scenic tours, such as Grand Canyon, designing scenic flight corridors, establishing noise free zones, and agreeing to regulations regarding time of day and dose exposure. However, as the years have passed, other aircraft overflight issues have emerged with little or no research to establish basic management standards

in affected areas. For example, commercial airports handled more than 8.5 million flights in 1999, nearly double the number of flights handled in the mid-1970s. FAA statistics show the number of commercial flights emanating from the U.S. in 2006 averaging between 900,000 and one million a month. This breaks down to approximately 31,000 flights a day, or 1300 every hour (Mace, 2006). It is important to realize these numbers represent averages, so during busy hours of the day the number of commercial flights in the air can be much greater. Miller (2008), for example, shows how 3,345 jet departures in one hour in October of 2000 nearly blanket the entire United States with their flight paths. Furthermore, these numbers are all expected to increase in the coming decades. High altitude jet overflights are so common that on September 11, 2001, backcountry hikers in national parks knew that something terrible must have happened because there were no audible sounds from jets (Bell, et al., 2009). Commercial jet flights over national parks are usually high enough that they typically yield less noise than aircraft used for scenic tours, but visitors do notice them and they can interfere with some activities (e.g., Williams, 2007). If noise emanating from these commercial flights is deemed excessive, inappropriate, or unacceptable, changing the flight routes would require collaboration of the NPS and FAA and could also pose a safety risk given the number of aircraft attempting to utilize the same flight corridor. For these reasons, changing the flight paths of commercial planes to reduce the percentage of time these aircraft are audible in national parks is not even on the radar.

Other types of managerial changes to improve soundscape conditions may be less difficult to accomplish, especially if decisions can be made solely by park managers. For example, one pressing noise issue in the busy frontcountry areas of the park is the amount of road vehicle noise that is audible. Attended logging found vehicle noise to be present a large percentage of the time at most of the busy or moderately busy viewpoints and overlooks along

the main road. Previous research has found the presence of ground traffic noise at 45 dB(A) and 60 dB(A) to increase annoyance and hostility, while having deleterious effects on serenity, solitude, tranquility, naturalness, appropriateness, overall preference, and scenic beauty (Benfield et al., 2010a). If specific numbers for percent time audible and $L_{\max}$ are used as standards in the frontcountry acoustic zone of Bryce, and if those standards are exceeded in certain areas, it would be necessary to plan for changes in the management approaches to attempt to reduce the amount of audible vehicle noise, especially if impacts are apparent to visitors and wildlife. This might be accomplished by changing the voluntary shuttle system schedule to make it more attractive for visitors who wish to see numerous viewpoints. Alternatively, if visitation numbers continue to rise it would be beneficial to investigate the feasibility of making the shuttle mandatory instead of voluntary during the busiest times of the year to reduce the amount of traffic on the main road of the park. With the current status of the voluntary shuttle transportation system, it would also be advantageous to institute the use of additional incentives to increase ridership. With the implementation of any of these changes, the soundscape should benefit as the total amount and frequency of vehicle noise at the busiest viewpoints would be significantly reduced, thereby increasing the noise free interval and providing more opportunities to experience natural sounds while visiting the frontcountry.

Experiencing quiet surroundings, escaping noise, and being able to hear the sounds of nature are important expectations of visitors to national parks (Driver et al., 1991; Gramman, 1999; Haas & Wakefield, 1998; McDonald, et al., 1995). One of the metrics computed with attended audibility logging is the noise free interval (NFI), which summarizes the amount of time only natural sound sources are audible, excluding all anthropogenic sounds. Results were found to vary based on the specific area being logged and by acoustic zone, with the backcountry

having the longest average NFI of 131 seconds. Short hikes had an average NFI of nearly a minute. Moderately busy viewpoints and the busiest acoustic zone of the park had very similar average NFI's, differing by only two seconds, and lasting on average just over half a minute. NFI's can be used as indicators of quality, with sound logging results used to develop specific standards of quality for the different acoustic zones of the park. For example, it may be determined that the average NFI in the backcountry should be much longer than that found on short hikes, as those who are willing to traverse long distances into wilderness settings desire a higher degree of solitude and tranquility than those on a mile or two walk. Similarly, those taking a short hike are probably seeking an escape from the large crowds often found at the viewpoints, and expect to be able to hear the sounds of nature by engaging in a short hike below the rim of the amphitheatre. Data from this study show relatively short NFI's, with many intrusions from anthropogenic sound sources present in all acoustic zones. Vehicles, voices, and jets were found to be the most frequently encountered human sources, with multiple exposures resulting in shortened NFI's. Once NFI standards are determined for the different acoustic zones in Bryce, continued monitoring can be completed to ensure acceptable conditions. If an established NFI is routinely violated, management action would then be necessary to identify and reduce the source of the excessive anthropogenic noise. Future research in Bryce should survey different types of visitors as to what they find acceptable in terms of frequency of exposure to people, vehicles, and aircraft to develop more specific NFI standards for the different acoustic zones of the park.

8.2 *Natural Sounds and Aircraft Type*

A major portion of this project centered on the human dimensions of aircraft overflights, with the average percent time audibility of aircraft from the attended audibility logging results used to create the laboratory portion of the study. High altitude jet aircraft were audible between 20 and 45 percent of the time, depending on location. A conservative 25% time audible was therefore used in the landscape/soundscape assessment portion of this project for all types of aircraft (jets, propeller planes, helicopters). Participants rated 40 landscapes of Bryce Canyon on six dependent measures (scenic beauty, naturalness, solitude, tranquility, annoyance, and overall preference). Scenes were paired with either natural sounds (30 trials) or aircraft noise (10 trials) to simulate the 25% time audibility level found in the park. Each scene and sound was viewable and audible for 30 seconds, so the total exposure to aircraft noise was 5 minutes out of a 20 minute rating session. Decibel levels for aircraft and natural sounds did not exceed 50 dB(A). Participants served in only one of three aircraft noise conditions, hearing only one type of aircraft during the evaluation session.

As displayed in the results section of this report, all types of aircraft noise caused important reactions. When compared with natural sounds, annoyance increased, while solitude, tranquility, naturalness, scenic beauty and overall preference all decreased when aircraft noise was audible. This was true for all types of aircraft: helicopters, propeller planes, and high altitude jets. These results show that aircraft noise, whatever the source, has negative effects on landscape/soundscape appreciation and experience.

One of the major contributions of this project was the inclusion of different types of aircraft noise into the study design. This allowed some of the first comparisons to be made between the effects of specific types of aircraft noise on psychometric scales known to be

important in natural settings. Differences were found between the three types of aircraft noise examined in this study, showing they are not perceived identically. Based on the mean ratings, helicopters were perceived as the most annoying of the three types of aircraft noise, and had lower ratings of solitude, tranquility, naturalness, and overall preference than propeller planes and jets. Seemingly negative ratings on these psychometric variables were expected when helicopter noise was present based on findings from previous studies (Mace, Bell, and Loomis, 1999; 2003; Benfield, et al., 2010a). Although helicopter noise was the most negative of the three types of aircraft based on the average mean ratings, propeller planes and helicopters were found to statistically differ only on ratings of naturalness and overall preference. Propeller planes and helicopters, were, therefore, quite similar in the level of annoyance they produced, as well as how they both affected ratings of solitude, tranquility, and scenic beauty. The major differences between the types of aircraft noise were the comparisons of jets with both propeller planes and helicopters. When compared with the other two noise sources, high altitude jet noise was less annoying and had higher ratings of solitude, tranquility, naturalness, and overall preference. This clearly shows there are significantly more disruptive effects on psychometric attributes important in a natural setting when helicopter and propeller plane noise is audible than when high altitude jets are present, at least at a 25% audibility rate at 50 dB(A).

When specifically examining the pattern of annoyance ratings with aircraft noise exposure, it is apparent that annoyance increases as the number of doses of aircraft noise increases. This pattern is evident with all types of aircraft noise, with annoyance ratings during the first dose of noise lower than ratings in the second and third doses. Completing the pattern, participants were most annoyed during the last aircraft noise dose (the third). Differences in annoyance ratings were also evident between the nature sound segments, with higher ratings of

annoyance found on the final nature sound segment, this following three doses of aircraft noise. This pattern of responses shows participants become more annoyed, either due to the increasing presence of aircraft noise or because of the experimental design and fatigue. Future research could answer this question by increasing (or decreasing) the percentage of time aircraft noise is audible, and/or decreasing the number of scene ratings to 25-30 to reduce fatigue, as opposed to the 40 rated scenes used in this study.

Patterns are also apparent with the other psychometric scale variable ratings. Ratings during the initial exposure to natural sounds produce high ratings of solitude, naturalness, tranquility, scenic beauty, and overall preference, with low annoyance. However, following the first dose of aircraft noise and the subsequent second set of natural sounds, ratings on solitude, tranquility, naturalness, scenic beauty, and overall preference all increase compared to the first set of natural sounds, while annoyance is at the lowest level. It is almost as if respondents realize how pleasant it is to be rid of the aircraft noise immediately following the first dose. Ratings during the third set of natural sound are close to those obtained for the second set of natural sounds, although they are slightly less positive. This trend continues into the fourth natural sound set, with ratings returning close to the baseline numbers obtained in the first set of natural sounds. These results suggest that after three doses of aircraft noise, participant responses are dissipating and the exposure to the noise is being perceived as excessive. This pattern would be expected to continue if more aircraft noise doses were encountered, with appreciation of many important natural environment qualities being adversely affected.

Several of the dependent variables, therefore, clearly show a restorative effect when encountering natural sounds following exposure to aircraft noise. Ratings spike for solitude, tranquility, and naturalness on the first trial following the first and second doses of aircraft noise

(as is viewable in Figures 5-7). While restoration was apparent in all cases following noise exposure, the largest effects occurred following the first and second noise doses. After the third noise dose, ratings of solitude, tranquility and overall preference did increase, but not to the levels found in the second and third sets of nature sounds. The restorative effect appears to be most apparent for the ratings of annoyance in the helicopter noise condition. Immediately following a dose of helicopter noise, annoyance significantly dissipates more on the ensuing nature sound trials compared to the other types of aircraft. Percent time audible may be having an effect; as there is an increase in the number of noise doses, recovery becomes less apparent. In support of this statement, the fourth set of nature sound ratings began to tail off, suggesting there are cumulative effects of aircraft noise exposure on the evaluation of National park landscapes and soundscapes. If this is the case, 20-25% time audible of aircraft noise may be the upper limit of exposure before deleterious effects to solitude, tranquility, preference, naturalness, and heightened annoyance become evident. Future research should directly test this assumption to see if an increase in the percent of time aircraft noise is audible causes recovery to become less and less apparent to the point where restoration is extinguished.

8.3 Limitations

A complete representation of the soundscape of a national park requires a number of different methodological approaches. Each method has advantages and disadvantages, with no method able to completely represent all the relevant variables associated with the scientific study of soundscapes. Technological advancements have improved many soundscape related methods, including attended logging and digital recording. Attended audibility logging using software developed by the Natural Sounds Program Office is a significant step forward over sound logging using a pen, paper, and a watch. Sound recording using hand-held digital recorders has

made it possible to easily capture hundreds of hours of sound, even in remote locations. Despite the advancements in technology and methodology, limitations remain.

Attended audibility logging requires a large number of hours in each location in order to fully capture accurately the resident sound sources. Long periods of training are also necessary in order to finely discriminate between different sounds. Sometimes it is difficult to distinguish one sound from another, which can skew the results. In the context of the present study, at times it was difficult to clearly identify if there was a jet audible or if there was faint, rolling thunder off in the distance. In busy areas there can be difficulty keeping track of multiple sources. While one of the major advantages of using a pda and the NPS software for audibility logging is the ability to log multiple sources at any one time, it becomes difficult to keep track of multiple streams of sound in busy areas, especially when new sounds begin and when other sounds are no longer audible. As a result, accuracy suffers. Attentional drift is also an issue. Maintaining focus over the suggested hour long audibility session is questionable in terms of overall accuracy. Future research should address this issue to test different lengths of audibility logging to provide an answer to this potential limitation. Despite these issues, attended audibility logging using a pda is still a much better approach than using pen and paper. The program allows the opportunity to gain knowledge about relative patterns of audibility in different acoustic zones using a quick and economical method. Percentages and NFI's can then be used in more controlled settings, using experimental procedures to examine the affects of different types of sound on a variety of human dimensions while maintaining an approximation of real-world conditions.

With regard to the findings of the laboratory portion of phase II of this study, one potential limitation has to do with the issue of external validity. That is, do the results obtained

in the lab generalize to park visitors. It should be noted that the findings of the laboratory research fit well with the soundscape and noise literature, including previous research with visitors in park settings. For example, Tarrant, Haas & Manfredi (1995) found visitors to a wilderness area to be bothered and highly annoyed with human-caused sounds. Similarly, the laboratory landscape/soundscape assessment of Bryce Canyon National Park found undergraduate students to be highly annoyed with the presence of aircraft noise, especially that generated by helicopters and propeller planes. It can be argued that undergraduate students are not analogous to the diverse population of park visitors, however field studies using park visitors as subjects may also suffer from sampling bias issues, especially if there is the case of displaced visitors (Pilcher, et al., 2009). For example, if noise-sensitive visitors avoid an area (or an entire park) because they know it will be noisy, they will not be present to render their judgments, thereby producing an unrepresentative sample of all potential park visitors and positively skewed results. Furthermore, some national park visitors may come to the park with unrealistic expectations and preferences (Harrison et al., 1980; Miller, 1999), and be in an overly positive affective state since they are on vacation, another potential biasing factor. For these reasons, results from studies completed in the field with park visitors should be augmented with data from other methodological approaches, including laboratory studies, legal statutes, and policy, when managerial decisions are being considered (Pilcher, et al., 2009).

Laboratory studies offer the additional advantages of controlled experimental manipulation and systematic testing of specific variables of interest. Economically, laboratory research offers many advantages in terms of time, cost, and an easily available participant pool. Furthermore, researchers have used similar laboratory protocols to examine aspects of the visual and auditory dominance and congruence in the U.S., Canada and Spain, with results generalized

to numerous settings (Anderson et al., 1983; Carles, Bernaldez, & de Lucio, 1992; Gifford & Ng, 1982). Finally, results from well-designed laboratory experiments allow for much stronger conclusions than those obtained from correlational survey research (Aronson, Wilson, & Brewer, 1998).

One of the limitations of the present study is the inclusion of only one level of loudness and exposure rate of the three types of aircraft noise. This was designed to simulate as realistically as possible the current conditions of aircraft overflights currently existing in Bryce Canyon National Park. The results of the laboratory experiment are applicable to current conditions and project probable impacts if propeller plane and helicopter traffic were to increase to being audible 25% of the time. However, as on-site conditions change, and from a theoretical point of view, it would be advantageous to examine different audibility rates and decibel levels in future research.

Finally, participant fatigue may be another potential limitation with the laboratory study. A few participants stated the rating procedure was too lengthy following completion of the task. It could be the increase in annoyance and decline of the five other dependent measures in the final set of nature ratings was due to fatigue and participants wanting to be finished with the experiment. Future research could test this assumption by using a smaller set of evaluative stimuli to shorten the amount of time participants are completing the landscape/soundscape ratings. It should be noted, however, that complete participation with all experimental procedures took no longer than 30 minutes for all participants from time of arrival to time of departure, and previous experiments using similar methodology had rating sessions occupying between 45-60 minutes..

8.4 Suggestions for Future Research

Several suggestions have already been discussed regarding future directions in research, however with the scientific study of soundscapes being a fairly new area of investigation, there are many additional projects that are warranted. With technological advancements in sound monitoring and recording, these approaches should be paired together in the other areas of Bryce to further refine which areas fit into the specific acoustic zones. Based on the audibility logging results found in Bryce, future research specific to different acoustic zones should address how other sources of noise impact the same indicators of quality used in this study. More audibility logging should also be conducted in other backcountry and wilderness areas of the park. Audibility logging results (specifically percentages of time audible and noise free intervals) could then be used for future laboratory research to examine context effects and other sound sources to better understand the human reaction to different types of anthropogenic sound.

For example, based on the findings of this research, noise emanating from helicopters, propeller planes, and jet aircraft caused many psychological dimensions to be deemed more negative. Based on the findings from previous studies, vehicle noise and human voices have also caused important negative reactions on identical and similar human dimensions (Benfield, et al., 2010a; Pilcher, et al., 2009). More specifically, research in Muir Woods National Monument found the noise produced by the loud voices of visitors to be some of the most annoying noise sources, more annoying than aircraft, showing there are significant context effects related to the specific location and the expectations and motivations of visitors to those locations (Pilcher, Newman, and Manning, 2009). On the other hand, laboratory research using methodology nearly identical to that used in landscape/soundscape portion used in Phase II of this study found aircraft noise to be the most annoying and account for the largest percentage of variance when

compared to vehicle and vocal noise when participants were rating five different national parks (Benfield et al., 2010a). It should be noted, however, that Benfield et al. (2010a) found the presence of all types of noise (aircraft, traffic, vocal) to significantly detract from important indicators of quality such as solitude, tranquility, and serenity in a National park context when compared to natural sounds. These results have implications for a park like Bryce, when scenic vista overlooks are common and the primary destination for many visitors. For these reasons, it would be beneficial to examine the sounds produced by different types of terrestrial motor vehicles and the noise made by visitors themselves, especially when considering the high percent time audible found at many of the overlooks in Bryce for these types of sounds. In future research, motor vehicle sounds should be differentiated and examined in more detail to ascertain if, for example, there are similar or different reactions to motorcycles, cars and trucks, shuttle buses, and recreational vehicles in national parks such as Bryce that have a large amount of vehicle traffic. If these noise-producing vehicles are found to yield similar results, it could be argued that the presence of any anthropogenic sound that is deemed unnatural to the setting may be viewed as inappropriate and intrusive.

Results from the present and past research suggest that different types of human-caused noise may be simply deemed inappropriate for the setting of a national park and will always be rated as a negative encounter. For this reason, future research should systematically address the mere presence of aircraft and other types of noise in the just-noticeable range to examine this question more directly and contribute to theoretical development. Furthermore, several pieces of legislation suggest the use of quiet technology (especially with helicopters) resulting in reduced noise levels will help solve the dilemma. Well designed laboratory research should be conducted to systematically investigate if this is a viable management and legislative alternative. Finally,

visual intrusion of aircraft should also be addressed. If the mere presence of anthropogenic noise in natural settings such as national parks and wilderness areas has detrimental effects, then the visual presence of aircraft or other noise-producing vehicles may have a similar effect.

Context effects can also be further addressed in a laboratory setting. Participants in the laboratory component of this project were told to imagine themselves as visitors to Bryce Canyon National Park. This can be regarded as a general visitor context, as the participants were not told anything more specific about what their recreational motives were if they were visiting the park, just that they are going to view some of the scenery and listen to some of the sounds from Bryce. Future research should systematically manipulate the recreational motive context by providing participants with more detailed instructions describing the activities they are planning to engage in on their “visit” to the park. For example, with only subtle changes to the procedures, subjects could be told “imagine you are going to Bryce Canyon National Park to go on a short hike.” Alternatively, “you are going to Bryce to go on a three-day backpacking trip with a friend.” Or, “you are doing a day trip to Bryce to briefly visit several viewpoints and overlooks.” Results from this type of study would provide insight into the similarities and differences based on the context and motivation of participants.

Future investigations in the field should also focus on visitor context and motivation. There is some evidence of differences between mountaineers and car campers with annoyance levels caused by a variety of human-caused noise (Kariel, 1980), therefore a field study specifically targeting different recreational users would add to the literature and address the multiple-use mandates that federal land managers must balance. There are several ways in which researchers can address these issues in a field setting. The traditional approach is to survey or interview visitors in different areas of the park who are engaged in different activities. One such

project is currently underway in Bryce, with the surveying of hikers on the Fairyland Loop Trail using instruments very similar to those created in Phase I of this project. As previously discussed, due to the extended review process involved with surveying visitors on soundscape issues in national parks, a decision was made in collaboration with park managers to forego surveying at the time and instead complete the audibility logging and laboratory experiment. In the meantime, a working group of social scientists, acousticians, and personnel from the Natural Sounds Program Office of the NPS, the Volpe Center of the Department of Transportation, and the Federal Aviation Administration continued to refine the surveys to create protocols that could be used in those national parks and monuments with aircraft noise issues. The result of this five year working group has resulted in an agreed upon series of surveys being distributed along hiking trails in several national parks, including Bryce, during 2011. This effort also has the added benefit of pairing surveying with gps tracking and acoustic monitoring by having acousticians place a number of monitors along the trail that respondents are hiking, enabling a comparison of how on-site auditory conditions influence survey responses. Results are pending, however it is exciting to see the effort put forth in Phase I of this Bryce Soundscape Project come to fruition in such a meaningful way.

Another way to consider visitor motives in the park is to use a similar approach described above for the laboratory protocol on context effects and place a shortened version of the computerized landscape/soundscape evaluation program in the visitor center as part of an “exhibit” that also collects data. A more sophisticated approach would be to create a visitor information kiosk that has high definition video and binaural sound from different areas of the park (trails, overlooks, backcountry campsites, etc.) which visitors can preview as potential options to visit during their time in the park. This approach would help the park provide

information to visitors while collecting data at the same time. For example, the auditory component of the computerized kiosk could be manipulated to include any number of natural and human-caused sounds (aircraft, vehicles). Among other responses, visitors could then rate whether they would be willing to hike the depicted trail, or spend time at the overlook, or find a backcountry area acceptable for an overnight backpacking trip. This type of approach offers the advantage of reducing the burden put on the visitor (and researchers) so often encountered with other field methodologies like surveying and interviewing. Whatever method is used in future research projects in the field and the lab, it would be advantageous to include additional variables such as appropriateness and acceptability when evaluating different sources of anthropogenic noise.

8.5 Conclusions

Taking everything into consideration, the methodology and results from the two phases of this study argue for the creation of acoustic zones within Bryce Canyon National Park and clearly show the importance of natural sounds. To maintain a positive visitor experience, the percentage of time aircraft are audible in a natural setting such as Bryce Canyon National Park should not exceed 20-25% in all areas of the park. As previously discussed, lesser amounts may be warranted in settings such as the backcountry, where visitor motives for experiencing natural quiet, solitude, and tranquility are probably greater than those visitors at frontcountry lookouts, for example. The development of acoustic zones and the important indicators of quality and management standards for each zone should be based on reliable research protocols using multiple methods. Attended logging, acoustic monitoring, laboratory and field experiments, visitor surveying, and attended listening are all important methods of helping to better understand the multifaceted components associated with the human dimensions of soundscapes.

None of the methods are perfect; each has advantages and disadvantages, but taken together the resulting data from these different approaches help to clarify the issues, establish useable indicators and standards of quality, and reduce confusion and conflict.

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10 Appendix A: Frontcountry Visitor Survey

Contact Script

The following contact script will be used by interviewers:

“Hello! The National Park Service and Southern Utah University are conducting a visitor survey at Bryce Canyon to gather visitors’ opinions about the parks’ programs and natural resources. This information will help the park in planning and managing visitor services and natural resources. Participation is completely voluntary and all responses are anonymous. The questionnaire takes about 10 minutes to complete. Would you be willing to help us out?”

IF NO: “Thank you.” (Enter contact information on log sheet and go to next eligible visitor.)

IF YES: “Thank you. This anonymous survey will help the National Park Service and Southern Utah University understand the value of the area’s resources to park visitors. You may skip any question you wish or discontinue at any time. You are free to ask questions at any time. Please fill out this survey and return it to me when you are finished.”

Date & Time: _____

Location: _____

BRYCE CANYON SOUNDSCAPE SURVEY--FRONTCOUNTRY

Your responses to this survey will help the National Park Service and Southern Utah University understand the value of the park experience to visitors and will enable the Park to better serve the public. Participation is voluntary. You may discontinue the survey at any time for any reason. You may ask questions at any time. You may skip any question you do not wish to answer.

1. The following statements refer to your experience at **the viewpoint you have just finished visiting**. Please answer the questions by marking the box that best represents your experience or feelings.

	Strongly Agree			No Opinion		Strongly Disagree
The scenic beauty of the park from this point is spectacular.	☐	☐	☐	☐	☐	☐
The sounds of nature are readily apparent here.	☐	☐	☐	☐	☐	☐
This viewpoint is peaceful.	☐	☐	☐	☐	☐	☐
From this vantage point, the park appears natural.	☐	☐	☐	☐	☐	☐
I was bothered by the amount of car/bus/truck noise at this location	☐	☐	☐	☐	☐	☐
I was bothered by the noise of low flying planes while at this viewpoint.	☐	☐	☐	☐	☐	☐
This place makes me feel better emotionally.	☐	☐	☐	☐	☐	☐
My experience at this location in the park was inspirational and enlightening.	☐	☐	☐	☐	☐	☐
I was bothered by the sounds other visitors made while at this viewpoint.	☐	☐	☐	☐	☐	☐
This is a tranquil place.	☐	☐	☐	☐	☐	☐
I feel calm and relaxed.	☐	☐	☐	☐	☐	☐
It is quiet here.	☐	☐	☐	☐	☐	☐
I feel restored as a result of visiting this place.	☐	☐	☐	☐	☐	☐

	Strongly Agree		No Opinion		Strongly Disagree		
I was bothered by the noise of high altitude jet aircraft while at this viewpoint.	☐	☐	☐	☐	☐	☐	☐
This is a serene place.	☐	☐	☐	☐	☐	☐	☐
This viewpoint offers the opportunity to experience solitude.	☐	☐	☐	☐	☐	☐	☐
The number of visitors present at this viewpoint was excessive.	☐	☐	☐	☐	☐	☐	☐
I was bothered by the noise of helicopters while at this viewpoint.	☐	☐	☐	☐	☐	☐	☐
Overall, I enjoyed my time spent at this viewpoint.	☐	☐	☐	☐	☐	☐	☐

2. The National Park Service defines a soundscape as the "total acoustic environment of an area." I found the soundscape at the viewpoint I just visited to be:

Exceptional	Acceptable	Annoying
☐ ☐ ☐	☐ ☐ ☐	☐ ☐

3. When considering all sounds experienced in the entire park, I found the soundscape in Bryce Canyon National Park to be:

Exceptional	Acceptable	Annoying
☐ ☐ ☐	☐ ☐ ☐	☐ ☐

4. Please answer the questions by marking the box that best represents your experience in the entire park.

	Strongly Agree		No Opinion		Strongly Disagree	
There were too many people present in the park to have an enjoyable experience.	☐	☐	☐	☐	☐	☐
The amount of car/bus/truck noise in the park was excessive.	☐	☐	☐	☐	☐	☐
The amount of noise from park machinery and operations was excessive.	☐	☐	☐	☐	☐	☐
The amount of jet aircraft noise I noticed in the park was excessive.	☐	☐	☐	☐	☐	☐

	Strongly Agree		No Opinion		Strongly Disagree	
The amount of noise from low flying planes I noticed in the park was excessive.	☐	☐	☐	☐	☐	☐
The amount of helicopter noise I noticed in the park was excessive.	☐	☐	☐	☐	☐	☐
Tourist flights over the park should be allowed during sunrise and sunset.	☐	☐	☐	☐	☐	☐

5. What sounds would you consider **appropriate** for Bryce Canyon National Park? Please consider the following list of sounds and rate their appropriateness by marking the box that best represents your opinion.

	Appropriate					Inappropriate	
Birdsong	☐	☐	☐	☐	☐	☐	☐
Wildlife	☐	☐	☐	☐	☐	☐	☐
Wind/breeze	☐	☐	☐	☐	☐	☐	☐
Quiet	☐	☐	☐	☐	☐	☐	☐
Water	☐	☐	☐	☐	☐	☐	☐
Cars/trucks	☐	☐	☐	☐	☐	☐	☐
Tour buses	☐	☐	☐	☐	☐	☐	☐
Helicopters	☐	☐	☐	☐	☐	☐	☐
Low flying planes	☐	☐	☐	☐	☐	☐	☐
High altitude jet aircraft	☐	☐	☐	☐	☐	☐	☐
Motorized trail equipment	☐	☐	☐	☐	☐	☐	☐
People talking	☐	☐	☐	☐	☐	☐	☐
Children playing	☐	☐	☐	☐	☐	☐	☐
Thunder	☐	☐	☐	☐	☐	☐	☐
Cellphones ringing	☐	☐	☐	☐	☐	☐	☐
Music	☐	☐	☐	☐	☐	☐	☐
Camera shutters	☐	☐	☐	☐	☐	☐	☐
Car alarms or horns	☐	☐	☐	☐	☐	☐	☐

6. Please list the most pleasing sounds you have encountered during your visit to Bryce:

7. Please list the most unpleasant or annoying sounds you have experienced while visiting Bryce:

8. Please check all appropriate boxes below of the viewpoints you have visited on this trip to Bryce.

☐ This is the first view point I visited. ☐ Fairyland and/or Paria Points.
☐ Sunrise, Sunset, Inspiration, and/or Bryce Points
☐ Swamp, Farview, Natural Bridge, Rainbow and/or Yovimpa Points.

9. Which of the following activities did you engage in, or do you plan to engage in, while visiting the park? (Check all that apply.)

☐ camping in campground	☐ wildlife watching
☐ camping in backcountry	☐ time at viewpoints
☐ hiking	☐ bookstore/gift shops
☐ photography	☐ horseback riding
☐ stargazing	☐ sightseeing flight
☐ Ranger program	☐ tour the visitor center
☐ stay in lodge/hotel	☐ snowshoe/ski

10. Please rate how important each of the following reasons were for your visit to Bryce Canyon National Park using the following scale:

	Very Important						Not Important
View the natural scenery	☐	☐	☐	☐	☐	☐	☐
Enjoy the soundscape and natural quiet	☐	☐	☐	☐	☐	☐	☐
Appreciate the geology of the park	☐	☐	☐	☐	☐	☐	☐
Escape from the stress of daily life	☐	☐	☐	☐	☐	☐	☐
Spend time with friends and/or family	☐	☐	☐	☐	☐	☐	☐
Engage in outdoor physical activity	☐	☐	☐	☐	☐	☐	☐
Learn about the park	☐	☐	☐	☐	☐	☐	☐
View the night sky	☐	☐	☐	☐	☐	☐	☐
Watch the sunrise and/or sunset	☐	☐	☐	☐	☐	☐	☐
Watch wildlife	☐	☐	☐	☐	☐	☐	☐

11. How much time do you plan to spend at Bryce on this visit? (Circle one.)

a) 1-3 hour day visit b) 4-8 hour day visit c) 8-12 hour/overnight visit d) 2 or more days

12. What is your permanent Zip code? _____ OR Country: (if not U.S.) _____

13. Which best describes the place where you live? ☐ urban ☐ suburban ☐ rural

14. Please circle your age: 18-24 25-34 35-44 45-54 55-64 65-74 75+

15. Please circle your gender: M F How many people are in your party? 1 2 3 4 5 6 7 8+

16. Do you have any recommendations for park management or any further comments on your experience at Bryce Canyon?

11 Appendix B: Backcountry Visitor Survey

Contact Script

The following contact script will be used by interviewers:

“Hello! The National Park Service and Southern Utah University are conducting a visitor survey at Bryce Canyon to gather visitors’ opinions about the parks’ programs and natural resources. This information will help the park in planning and managing visitor services and natural resources. Participation is completely voluntary and all responses are anonymous. The questionnaire takes about 10 minutes to complete. Would you be willing to help us out?”

IF NO: “Thank you.” (Enter contact information on log sheet and go to next eligible visitor.)

IF YES: “Thank you. This anonymous survey will help the National Park Service and Southern Utah University understand the value of the area’s resources to park visitors. You may skip any question you wish or discontinue at any time. You are free to ask questions at any time. Please fill out this survey and return it to me when you are finished.”

COVER LETTER

Dear Backcountry Visitor,

We hope you enjoyed your trip through the backcountry of Bryce Canyon National Park! As part of the management planning process, we are interested in your feedback regarding the trip you have just completed and the experiences you had along the trail. Enclosed is a survey that will take about 10 minutes to complete. A self-addressed postage paid envelope is also included for your convenience. Your responses to this survey will help the National Park Service and Southern Utah University understand the value of the park experience to backcountry visitors, and will enable the Park to better serve the public. Participation is voluntary, and you may skip any question you do not wish to answer. We hope you will choose to participate as your feedback is most valuable. When you complete the survey, please place it in the self addressed postage paid envelope and return it to the researchers at Southern Utah University. If you complete the survey prior to exiting the park, you can give your completed survey to the ranger at the exit station on your way out. We greatly appreciate your time and participation. Thank you!

Sincerely,

Britton Mace
Associate Professor
Southern Utah University

Kristin Legg
Chief of Resource Management
Bryce Canyon National Park

BRYCE CANYON SOUNDSCAPE SURVEY--BACKCOUNTRY

Your responses to this survey will help the National Park Service and Southern Utah University understand the value of the park experience to visitors and will enable the Park to better serve the public. Participation is voluntary. You may discontinue the survey at any time for any reason. You may ask questions at any time. You may skip any question you do not wish to answer.

1. The following statements refer to your experiences during the trip through the backcountry of Bryce Canyon National Park. Please answer the questions by marking the box that best represents your experience or feelings.

	Strongly Agree			No Opinion			Strongly Disagree
The scenic beauty of the park along this route is spectacular.	☐	☐	☐	☐	☐	☐	☐
The sounds of nature are readily apparent here.	☐	☐	☐	☐	☐	☐	☐
This trail is peaceful.	☐	☐	☐	☐	☐	☐	☐
From the backcountry, the park appears natural.	☐	☐	☐	☐	☐	☐	☐
I was bothered by the amount of car/bus/truck noise while hiking this route.	☐	☐	☐	☐	☐	☐	☐
I was bothered by the noise of low flying planes while hiking this route.	☐	☐	☐	☐	☐	☐	☐
Being in the backcountry makes me feel better emotionally.	☐	☐	☐	☐	☐	☐	☐
My experience in the backcountry was inspirational and enlightening.	☐	☐	☐	☐	☐	☐	☐
I was bothered by the sounds other visitors made during my trip through the backcountry.	☐	☐	☐	☐	☐	☐	☐
The backcountry of Bryce offers tranquility.	☐	☐	☐	☐	☐	☐	☐
I felt calm and relaxed after visiting the backcountry.	☐	☐	☐	☐	☐	☐	☐
It is quiet in the backcountry.	☐	☐	☐	☐	☐	☐	☐
I feel restored as a result of visiting this place.	☐	☐	☐	☐	☐	☐	☐

	Strongly Agree		No Opinion		Strongly Disagree	
I was bothered by the noise of high altitude jet aircraft while at this viewpoint.	☐	☐	☐	☐	☐	☐
This is a serene place.	☐	☐	☐	☐	☐	☐
This trail offers the opportunity to experience solitude.	☐	☐	☐	☐	☐	☐
The number of visitors present at this viewpoint was excessive.	☐	☐	☐	☐	☐	☐
I was bothered by the noise of helicopters while hiking this route.	☐	☐	☐	☐	☐	☐
Overall, I enjoyed my time spent in the backcountry.	☐	☐	☐	☐	☐	☐

2. The National Park Service defines a soundscape as the "total acoustic environment of an area." I found the soundscape **in the backcountry** of Bryce I visited to be:

Exceptional	Acceptable	Annoying
☐ ☐ ☐	☐ ☐ ☐	☐ ☐

3. When considering all sounds experienced in **the entire park**, I found the soundscape in Bryce Canyon National Park to be:

Exceptional	Acceptable	Annoying
☐ ☐ ☐	☐ ☐ ☐	☐ ☐

4. Please answer the questions by marking the box that best represents your experience in **the entire park**.

	Strongly Agree		No Opinion		Strongly Disagree	
There were too many people present in the park to have an enjoyable experience.	☐	☐	☐	☐	☐	☐
The amount of car/bus/truck noise in the park was excessive.	☐	☐	☐	☐	☐	☐
The amount of noise from park machinery and operations was excessive.	☐	☐	☐	☐	☐	☐

	Strongly Agree		No Opinion		Strongly Disagree	
The amount of jet aircraft noise I noticed in the park was excessive.	☐	☐	☐	☐	☐	☐
The amount of noise from low flying planes I noticed in the park was excessive.	☐	☐	☐	☐	☐	☐
The amount of helicopter noise I noticed in the park was excessive.	☐	☐	☐	☐	☐	☐
Tourist flights over the park should be allowed during sunrise and sunset.	☐	☐	☐	☐	☐	☐

5. What sounds would you consider **appropriate** for Bryce Canyon National Park? Please consider the following list of sounds and rate their appropriateness by marking the box that best represents your opinion.

	Appropriate					Inappropriate	
Birdsong	☐	☐	☐	☐	☐	☐	☐
Wildlife	☐	☐	☐	☐	☐	☐	☐
Wind/breeze	☐	☐	☐	☐	☐	☐	☐
Quiet	☐	☐	☐	☐	☐	☐	☐
Water	☐	☐	☐	☐	☐	☐	☐
Cars/trucks	☐	☐	☐	☐	☐	☐	☐
Tour buses	☐	☐	☐	☐	☐	☐	☐
Helicopters	☐	☐	☐	☐	☐	☐	☐
Low flying planes	☐	☐	☐	☐	☐	☐	☐
High altitude jet aircraft	☐	☐	☐	☐	☐	☐	☐
Motorized trail equipment	☐	☐	☐	☐	☐	☐	☐
People talking	☐	☐	☐	☐	☐	☐	☐
Children playing	☐	☐	☐	☐	☐	☐	☐
Thunder	☐	☐	☐	☐	☐	☐	☐
Cellphones ringing	☐	☐	☐	☐	☐	☐	☐
Music	☐	☐	☐	☐	☐	☐	☐
Camera shutters	☐	☐	☐	☐	☐	☐	☐
Car alarms or horns	☐	☐	☐	☐	☐	☐	☐

6. Please list the most pleasing sounds you have encountered during your visit to Bryce:

7. Please list the most unpleasant or annoying sounds you have experienced while visiting Bryce:

8. Please describe your backcountry travel route, including entry and exit points.

9. Which of the following activities did you engage in while visiting the park? (Check all that apply.)

- | | |
|---|--|
| ☐ camping in campground | ☐ wildlife watching |
| ☐ camping in backcountry | ☐ time at viewpoints |
| ☐ hiking | ☐ bookstore/gift shops |
| ☐ photography | ☐ horseback riding |
| ☐ stargazing | ☐ sightseeing flight |
| ☐ Ranger program | ☐ tour the visitor center |
| ☐ stay in lodge/hotel | ☐ snowshoe/ski |

10. Please rate how important each of the following reasons were for your visit to Bryce Canyon National Park using the following scale:

	Very Important					Not Important	
View the natural scenery	☐	☐	☐	☐	☐	☐	☐
Enjoy the soundscape and natural quiet	☐	☐	☐	☐	☐	☐	☐
Appreciate the geology of the park	☐	☐	☐	☐	☐	☐	☐
Escape from the stress of daily life	☐	☐	☐	☐	☐	☐	☐
Spend time with friends and/or family	☐	☐	☐	☐	☐	☐	☐
Engage in outdoor physical activity	☐	☐	☐	☐	☐	☐	☐
Learn about the park	☐	☐	☐	☐	☐	☐	☐
View the night sky	☐	☐	☐	☐	☐	☐	☐
Watch the sunrise and/or sunset	☐	☐	☐	☐	☐	☐	☐
Watch wildlife	☐	☐	☐	☐	☐	☐	☐

11. How much time did you spend at Bryce on this visit? (Circle one.)

a) 1-3 hour day visit b) 4-8 hour day visit c) 8-12 hour/overnight visit d) 2 or more days

12. What is your permanent Zip code? _____ OR Country: (if not U.S.) _____

13. Which best describes the place where you live? ☐ urban ☐ suburban ☐ rural

14. Please circle your age: 18-24 25-34 35-44 45-54 55-64 65-74 75+

15. Please circle your gender: M F How many people are in your party? 1 2 3 4 5 6 7 8+

16. Do you have any recommendations for park management or any further comments on your experience at Bryce Canyon?