



Bryce Canyon National Park

Acoustic Monitoring Report 2009-2010

Natural Resource Technical Report NPS/BRCA/NRTR—2011/421



ON THE COVER

2010 Yovimpa backcountry acoustic monitoring station
NPS Photo

Bryce Canyon National Park

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Executive Summary

During the spring and summer of 2009 and 2010, Bryce Canyon National Park (BRCA) conducted a soundscape study focusing on areas within the park where American peregrine falcon (*Falco peregrinus anatum*) territories were known to occur. Seventeen acoustic monitoring systems were deployed throughout the park at front and backcountry locations.

The primary purpose of this two-year monitoring effort was to gather baseline soundscape data for use in the development of a Soundscape Management Plan and a future Air Tour Management Plan (ATMP) required by the National Parks Air Tour Management Act of 2000. In addition to soundscape planning efforts, BRCA staff conducted behavioral observations on nesting peregrine falcons to investigate if low flying aircraft (helicopters and propeller planes) caused behavioral responses from individuals within their breeding territories. Data collected included existing ambient, natural ambient, and percent time audible statistics for sound sources, as well as behavioral responses of peregrines when aircraft were within approximately 3000 meters of active nesting areas or perch sites. Data also serve as a permanent record of existing acoustical conditions in the spring and summer of 2009 and 2010. Acoustic systems were deployed for approximately 30 days at frontcountry locations and for approximately 15 days at backcountry locations and logged one-second sound pressure (decibel) levels and continuous audio recordings. Existing and natural ambient statistics in A-weighted decibels (dBA) for two time periods - day and night - were documented for each monitoring location (Table 1).

Table 1. Median natural and existing ambient* for all sites during day and night.

Site Name	Nighttime Ambient (7pm – 7am)				Daytime Ambient (7am – 7pm)			
	L _{nat}	L ₁₀	L ₅₀	L ₉₀	L _{nat}	L ₁₀	L ₅₀	L ₉₀
<u>FRONTCOUNTRY</u>								
BRCA005	40.3	46.5	40.9	35.1	34.3	45.5	37.8	30.2
BRCA006	38.8	46.4	40.4	34.0	31.8	45.8	37.8	30.0
BRCA007	24.9	33.7	27.1	22.5	32.0	45.0	37.4	31.5
BRCA008	31.0	38.3	32.4	26.8	27.1	37.7	30.6	24.7
BRCA013	20.9	29.0	22.5	18.4	23.7	37.0	28.0	22.0
BRCA015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BRCA016	39.3	44.5	40.2	35	39.0	46.9	41.0	34.4
BRCA017	40.6	46.5	41.6	37.0	37.4	48.0	42.1	35.8
BRCA018	24.4	32.1	26.0	21.9	27.0	39.7	32.4	25.6
BRCA019	36.1	44.3	38.0	32.0	29.1	40.6	33.4	27.7
<u>BACKCOUNTRY</u>								
BRCA009	25.8	31.0	26.2	21.9	27.9	36.5	28.5	22.0
BRCA012	24.1	31.9	25.0	19.7	24.5	35.1	26.1	20.5
BRCA014	15.3	23.4	16.2	14.7	18.7	31.4	21.7	17.7
BRCA020	22.3	29.2	23.2	18.2	31.2	38.9	32.4	26.9
BRCA021	18.5	26.0	19.0	16.6	28.9	38.7	31.2	24.8
BRCA022	15.8	23.0	16.0	14.6	21.5	33.5	23.7	18.4
BRCA023	36.0	37.9	36.0	35.3	36.2	39.4	36.5	35.0

*The median existing ambient (L₅₀) describes the acoustical environment as is, including both natural and extrinsic (human-caused) sounds. The natural ambient (L_{nat}) offers an estimation of what the acoustical environment would sound like in the absence of extrinsic sounds. Median L₁₀ is the sound level exceeded 10% of the sampling period, with 90% of measurements quieter than L₁₀. Median L₉₀ is the sound level exceeded 90% of the sampling period, with 10% of measurements quieter than L₉₀.

Overall, this study found that aircraft, especially high-altitude jets, were the most frequently audible extrinsic sound at nearly all BRCA monitoring locations. In backcountry locations, aircraft (jets and propeller planes) were responsible for virtually all extrinsic sound. Extrinsic sounds at frontcountry locations were comprised of varying combinations of aircraft, vehicle, and visitor noise with aircraft being the dominant extrinsic sound source at nearly all sites. Aircraft sounds were audible on average 21.2 percent of the time at frontcountry locations and 18.2 percent of the time at backcountry locations.

Peak aircraft activity occurred at most locations between the hours of 8:00 and 10:00 am, with some sites showing minor peaks in the evening between the hours of 7:00 and 10:00 pm. Aircraft were audible over 50 percent of the time at Inspiration Frontcountry from 8:00 am to 9:00 am, and at Inspiration Backcountry from 10:00 to 11:00 am and from 4:00 to 5:00 pm. Across all sites, low-elevation fixed wing aircraft were audible less than 5 percent of the time but had a more dramatic effect on L_{10} , which documents acute conditions. On-site listening results show that extrinsic sounds were audible nearly continuously (83.3%) at Farview Frontcountry. As a result, the mean noise free interval, or mean period of time between noise events, was only 40 seconds. By comparison, the longest mean noise free interval (5 min 55 sec) occurred during on-site listening sessions at Yovimpa Backcountry where extrinsic noise was audible 21.1 percent of time.

Peregrine falcons were detected at all territories over both years of monitoring with the exception of the Sheep/Swamp territory in 2009. Recruitment (visual or aural identification of juveniles) was recorded for two eyries in 2009 (2 juveniles observed) and two eyries in 2010 (3 juveniles observed). During over 100 hours of behavioral observations, no incidents of peregrine reacting severely to overflight events were recorded. Difficulty in sighting birds during overflight events as well as limited aircraft activity (helicopter tours were not in operation during both field seasons due to staffing limitations of those air tour operators) may have affected the monitoring results.

Future soundscape monitoring should focus on the main Bryce Amphitheater viewpoints as well as within the amphitheater. Extrinsic sound inputs from vehicles (specifically tour buses, shuttles, passenger cars and motorcycles) require further investigation and will help inform indicators and standards for soundscape management as developed in a future Soundscape Management Plan for Bryce Canyon.

Introduction

The purpose of this two year project was to jointly conduct acoustic monitoring and American peregrine falcon (*Falco peregrinus anatum*) monitoring at four historic peregrine nesting territories. One new territory was detected during the 2009 season. Therefore, five total nesting territories were monitored during both the 2009 and 2010 season at Bryce Canyon National Park. The project objectives included a combined effort to establish natural and existing ambient sound levels throughout the park as well as assess noise impacts at peregrine eyries (nesting sites), including the percent of time that mechanical and human-caused sounds are above natural ambient levels and audible to peregrines. Data from this report will provide baseline information in future Soundscape Management and Air Tour Management Plans for the park.

Historically, commercial helicopter air tours have operated frequently over Bryce Canyon. Helicopters have been observed by park staff below the rim and within close proximity to peregrines eyries. In response to noise from aviation and other sources, the park has attempted to monitor and assess the acoustic environment on many levels previous to this study including: collection of year-round acoustic data at Fairyland Point, consulting with the NPS Natural Sounds Program on a sound monitoring plan for the park, and conducting visitor surveys assessing perspectives and importance of the park's soundscape. The current study partnered acoustic monitoring with a behavioral study of a species of special management concern for the park and supports a natural resources conservation approach to soundscape and air tour planning.

This study utilizes the words “extrinsic and intrinsic” to describe different types of sounds in the environment. Intrinsic refers to sounds that occur in the natural environment that form part of the character of Bryce Canyon (e.g., rockfalls, wind, bird song, etc.). The word “extrinsic” refers to those sounds not forming an essential part of the park unit, or sounds originating from outside the park boundary (i.e., vehicles, visitors, airplanes, etc.). Some of these extrinsic sounds may be appropriate for a national park. This report documents the acoustic environment in the park over a two summer season; this information will be used to inform future decisions on appropriate sound levels through the development of indicators and standards for soundscape quality.

Study Objective

The objectives of this 2009-2010 acoustical monitoring study at BRCA were to:

- 1) Establish natural and existing ambient sound levels at front- and backcountry locations in proximity to known peregrine falcon breeding territories.
- 2) Determine occupancy and nest success of peregrine falcon at five breeding territories.
- 3) Assess noise impacts at peregrine eyries, including the percent of time that mechanical and human-caused sounds are above natural ambient levels and likely audible to peregrines (assuming hearing capability of peregrines is similar to human hearing), and
- 4) Analyze data and report findings for inclusion in future Soundscape Management and Air Tour Management Plans.

Background

The soundscape at Bryce Canyon National Park (BRCA) is recognized for its importance to the experiences of visitors (see Appendix A for a glossary of acoustical terminology used in this report). Bryce Canyon has a natural soundscape with ambient noise levels that are sometimes below the threshold or "noise floors" of measuring equipment. In the absence of strong winds or human-caused sounds, ambient sound levels frequently fall below 20 dBA, comparable to the quiet of a high quality recording studio (Foch and Oliver, 1980). These conditions provide a superb environment for experiencing the natural sounds of the park.

Direction for management of natural soundscapes is represented in NPS Management Policy 4.9:

The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts. Using appropriate management planning, superintendents will identify what levels and types of unnatural sound constitute acceptable impacts on park natural soundscapes. The frequencies, magnitudes, and durations of acceptable levels of unnatural sound will vary throughout a park, being generally greater in developed areas. In and adjacent to parks, the Service will monitor human activities that generate noise that adversely affects park soundscapes [acoustic resources], including noise caused by mechanical or electronic devices. The Service will take action to prevent or minimize all noise that through frequency, magnitude, or duration adversely affects the natural soundscape [acoustic resource] or other park resources or values, or that exceeds levels that have been identified through monitoring as being acceptable to or appropriate for visitor uses at the sites being monitored (NPS, 2006a).

It should be noted that "the natural ambient sound level—that is, the environment of sound that exists in the absence of human-caused noise—is the baseline condition, and the standard against which current conditions in a soundscape (acoustic resource) will be measured and evaluated" (NPS, 2006b). However, the desired acoustic condition may also depend upon the resources and the values of the park.

The peaceful settings of BRCA provide the opportunity to experience natural quiet which conveys a mood of solitude and enhances the visitor's experience. The General Management Plan (1987) reinforces the importance of the park's soundscape by stating the following:

"A large percentage of the park is also noted for its extremely low noise level. This has been evaluated and identified as an important park element especially for those visitors seeking opportunities for solitude. The elevation of the park in relation to the surrounding topography makes it highly vulnerable to impacts on solitude. As development increases, especially outside the park, noise levels as well as sources of artificial light will increase creating impacts on the solitude of the park."

Numerous studies have been conducted within the park that measure the amount of artificial sounds within the natural soundscape (see "Previous Soundscape Studies" below). In 2003,

BRCA documented Natural Soundscapes as an important vital sign in the Northern Colorado Plateau Vital Signs Network and Prototype Cluster Plan for Natural Resources Monitoring.

The NPS Natural Sounds Program (NSP) of the Natural Sounds and Night Skies Division was established in 2000 to help parks manage sounds in a way that balances access to the park with the expectations of park visitors and the protection of park resources. The NSP addresses acoustical issues raised by Congress, NPS Management Policies, and NPS Directors Orders. An important element of this mission is working with the Federal Aviation Administration (FAA) to implement the National Parks Air Tour Management Act of 2000 (NPATMA). Congress mandated that FAA and NPS jointly develop Air Tour Management Plans (ATMPs) for more than 106 parks where commercial air tours operate. The program also provides technical assistance to parks in the form of acoustic monitoring, data processing, park planning support, and comparative analyses of acoustic environments throughout the national park system.

Preparation of an ATMP for the park is required by the NPATMA. The NPATMA also requires commercial air tour operators to apply for authority to conduct air tours over national park units or within ½-mile outside the boundary of any national park unit. Existing operators (those providing air tours for 1 year prior to NPATMA) were required to report the greater of i) the number of commercial air tour operations conducted during the 12-month period preceding NPATMA, or ii) the average annual number of commercial air tour operations conducted by the operator during the three-year period preceding NPATMA, and apply for Interim Operating Authority (IOA) to continue this level of activity pending completion of an ATMP. Operators are legally allowed to fly up to the IOA level until 180 days after the ATMP, which sets operating authority, is completed. The NPATMA also contains provisions for granting IOA to operators who had not conducted air tours over a particular national park unit before NPATMA (new entrants) and for granting increases in IOA for existing operators over and above their pre-NPATMA level of activity.

Sixteen air tour operators have IOA to conduct a total of 3,528 annual enplanements over BRCA. Current flight activity in the ATMP planning area for BRCA is likely below IOA but the exact level is unknown. In 2008, one new entrant applied for 120 annual flights over BRCA. At this time, the new entrant application is still pending

Data from a 1995 study (Foster and Bryant, 1997) showed that aircraft could be heard 29% of the time from Fairyland Point and 19% of the time from other locations. Noise from aircraft is the number one complaint from visitors (reported verbally to park staff and using the visitor comment form) at BRCA. Two-hundred and thirty-four (234) complaints regarding aviation noise (from all sources) were received by the park during 1986-1994 and 1998-2004 (during this same period, 24 visitor comments were received in support of air tours in the park). Of particular concern to the park is the impact that helicopter tours over the Bryce Amphitheater have on visitor experience as well as the potential negative effects on wildlife (Delaney et al., 1999).

Visitor sensitivity to tour aircraft can vary considerably from one person to the next and from park to park, depending on visitor expectations and the sound environment (Miller, 1999). Although complaint records at BRCA are incomplete, they represent an expressed dissatisfaction from visitors that “noise” has impacted their park experience. The park has also investigated this

impact via a social science research study. Preliminary results are summarized in this report (see “Previous Soundscape Studies” below). Commercial high-altitude aviation represents some of the impact to visitors, but park managers believe that low-level flights from air tour operators have a greater negative effect on visitor experience and potentially wildlife.

The effects of noise on wildlife can be difficult to measure and interpret (Kempf and Hueppop, 1996), but most researchers agree that noise can affect an animal’s physiology and behavior, and if it becomes a chronic stress, can be injurious to an animal’s energy budget, reproductive success and long-term survival (Radle, 1997). While peregrine falcons have demonstrated some resilience to loud noises from low-level military overflights (e.g., Ambrose et al., 2005) the measurable behavioral response of peregrines to overflights is only one aspect of how noise may affect wildlife. Other species in the animal community, including prey species for peregrine falcons, may be impacted by noise. Certain species that rely on hearing for foraging (e.g., owls) or for interspecific communication may also be negatively affected by loud and/or persistent noises. The habitats that peregrine falcons use for roosting and foraging are typical for many other park species, including other raptors and the California condor.

The park’s strategy for protecting the natural soundscapes of the park are: 1) to gather information on impacts to visitors from extrinsic sounds using human dimension studies, 2) implement a soundscape monitoring plan to characterize the different acoustical zones of the park, and 3) to characterize soundscapes at areas of special interest (i.e., this study) to enable a biological science approach to soundscape management. These three components will allow the park to move forward with a Soundscape Monitoring Plan and an ATMP that rely on credible scientific data to protect ecological resources, visitor solitude and natural quiet.

Previous Soundscape Studies at BRCA

Ambient Measurement Studies

In 1980, Foch and Oliver conducted the first study to measure soundscapes at BRCA. As noted above, this study found that during both day and night, in the absence of strong winds, ambient sound levels in the park frequently fell below 20 dBA which is comparable to sound levels found in high-quality recording studios. In fact, in many areas of the park, the authors noted that the natural ambient level in the park was often below the noise floors of their equipment. The study also noted that noise pollution from aircraft was present in 1980, but had a small effect on the ambient sound levels in the park. Further, the study indicated that even the *detection* of human-caused noise in protected environments (such as Bryce Canyon National Park) can be a substantial annoyance to people and threaten the intended use and future integrity of public lands.

In the summer of 1995, Foster and Bryant conducted noise monitoring surveys at BRCA. Park staff monitored five sites and recorded noise levels from helicopters, fixed-wing aircraft, jets, and other mechanical sources, as well as natural sounds. The study found that aircraft were audible park-wide an average of 18.8% of the time with an average sound pressure level of 36.4 dBA. Table 2 offers a summary of site specific percent time audibility of aircraft. Note that the category “aircraft” included jets, fixed-wing aircraft, and helicopters.

Table 2. Percent of time aircraft were audible at 1995 monitoring sites.

	Fairyland	Water Tanks	Swamp Canyon	Agua Canyon	Bristlecone
Aircraft	29.2	19.3	21.8	12.4	11.4

A soundscape monitoring program began at BRCA in 2000 with equipment purchase and research initiation in 2001. Between May 2002 and September 2003, acoustic data were collected at two locations in the park - Fairyland and Farview. Both measurement locations were located in open Ponderosa Pine habitat; however, the Farview location was near the rim of the plateau and acoustic data were strongly influenced by high winds. The Fairyland location was positioned farther from the rim and was therefore more sheltered from strong wind events. The NSP helped direct data gathering and analyzed data from the Fairyland monitoring station.

The median hourly existing ambient was 29.3 dBA in summer and 26.1 dBA in the winter (Table 3). October - February were considered “winter” months, with March-September considered “summer” months. Minimum sound levels for all months were at or near the noise floor of the measuring equipment, thus actual minimum sound levels were likely lower than reported. There were significant differences between seasons for all variables. Figure 1 illustrates seasonal variability in a yearlong data set from the Fairyland Area. The median (L_{50}) of all hours from 0700-1700 for all months shows differences between summer and winter months (it is considerably quieter in the winter).

Table 3. 2002 – 2003 Fairyland median, minimum, and maximum existing ambient (L_{50}) and L_{90} sound levels (dBA)*.

	Summer Months		Winter Months	
	L_{50}	L_{90}	L_{50}	L_{90}
Median	29.3	24.8	26.1	22.3
Min	17.8	17.6	17.9	17.8
Max	55.3	52.2	61.6	58.8

*The median existing ambient (L_{50}) describes the acoustical environment as is, including both natural and extrinsic (human-caused) sounds. Median L_{90} is the sound level exceeded 90% of the sampling period, with 10% of measurements quieter than L_{90} .

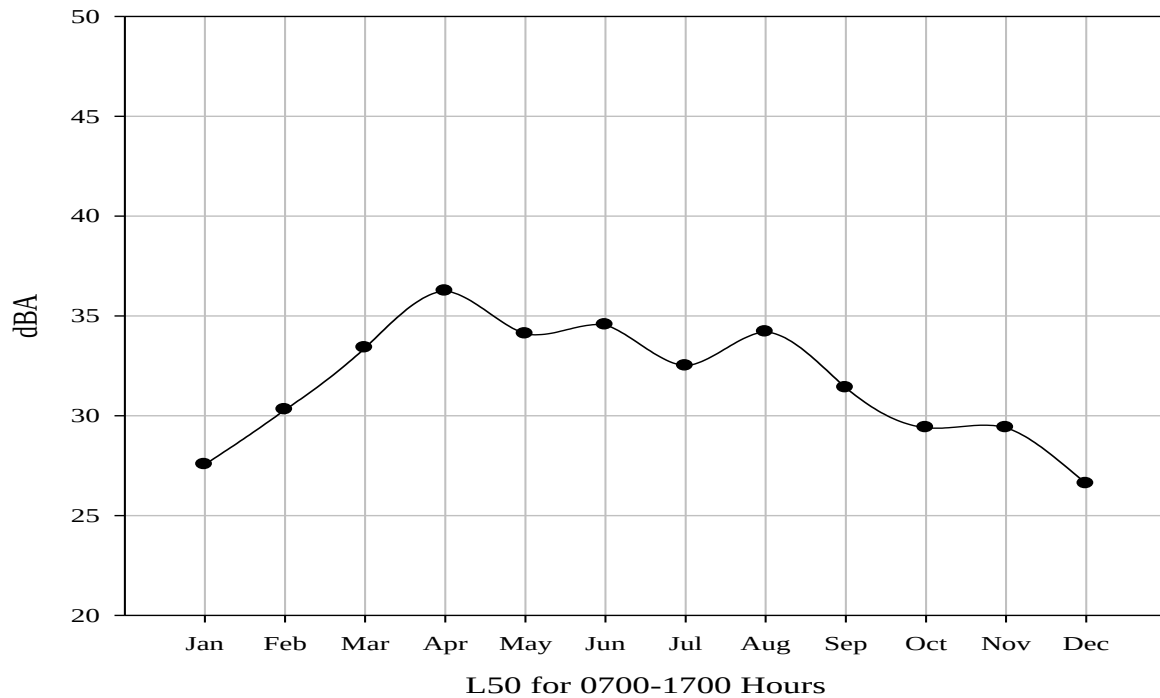


Figure 1. Monthly sound levels (L_{50} dBA for 0700-1700) for BRCA, Fairyland area, May 2002 to April 2003. (Adapted from Acoustics and Soundscape Studies in National Parks: Draft, NPS Natural Sounds Program, 2005, Fort Collins, CO).

Dose-Response Studies

In the summer of 1997, a study by Fleming et al. (1998) investigated the relationship between aviation noise dose and visitor response at BRCA. Over 900 visitor interviews were collected in conjunction with acoustical and meteorological data. The study utilized the Queen's Garden Trail - a popular frontcountry hike - to conduct visitor interviews. Respondents were subjected to noise from helicopters, propeller, and jet aircraft, including a wide range of actual sound levels and durations (i.e., time during which aircraft were audible). The study found that approximately one-quarter of the survey respondents expressed annoyance as a result of overflight noise, which included contributions from high-altitude jets, general aviation, and air tour operations at BRCA. The level of visitor annoyance was mediated by the phenomenon of "base level of annoyance", indicating an apparent predisposition by a certain percentage of visitors who expressed annoyance yet in effect experienced no noise from overflights.

Social Science Research

Effects of Natural and Anthropogenic Sounds on Visitor Experience

A multi-method social science research project was conducted by Mace et al. during 2008-2010 to examine the effects of natural and anthropogenic sounds, including air tours, on the human experience of the park's soundscape. The first method employed the use of personal data assistants (PDA's) with software developed by the NPS Natural Sounds Program to collect attended audibility logging data in locations throughout the park. Sixteen sites were identified in BRCA to reflect a spectrum of acoustic zones of the park. Audibility logging and digital sound recording were completed at eight of these sites during different times of the day in the spring, summer, and fall seasons.

Audibility data collected from the 8 sites (6 frontcountry and 2 backcountry) show variations in the type, frequency, and duration of anthropogenic and natural sounds. Some areas of the park with high density (popular lookouts close to busy parking lots) were found to have sounds created by people (voices, footsteps, vehicles) over 90% of the time. More remote frontcountry viewpoints and hiking trails had a much lower audibility percentage of these types of human caused sounds; however other sounds such as high altitude passenger jets were readily apparent 25-30% of the time. Natural sounds were audible at a higher frequency in the more remote frontcountry and backcountry sites, with the most detected sounds being wind, insects, and bird calls. 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.

The second method used on-site sound recordings and audibility results to examine the impact of anthropogenic and natural sounds on a variety of human dimensions. Percent-time audibility of aircraft overflights (helicopters, prop planes, high altitude jets) was manipulated in a series of audio recordings of simulated park soundscapes and tested in the laboratory with undergraduate subjects to assess a variety of aesthetic, cognitive, and affective indicators of environmental quality. As the percentage of time aircraft was audible increased, ratings of scenic beauty, serenity, and naturalness declined, while annoyance levels increased. Ongoing laboratory research is currently assessing differences between aircraft type on these indicators of quality to aid in the development of soundscape standards for the park.

Importance of Natural Sounds to Visitors

A visitor study at BRCA was conducted from July 26 to August 1, 2009 by the National Park Service Visitor Services Project, part of the Park Studies Unit at the University of Idaho. A total of 860 questionnaires were distributed to visitor groups. Of those, 626 questionnaires were returned, resulting in a 73% response rate. The study evaluated a wide variety of visitor services and park attributes and their perceived importance to visitors. Results showed that 68% of visitors felt that natural quiet / the sounds of nature were either “extremely important” or “very important” park resources to them or their personal group. Additionally, the study found that of the 22% of visitor groups who experienced detractions from enjoying the park, noise from loud visitors was the third most commonly listed factor that contributed to a negative experience (crowding was ranked first and inclement weather was second). Human-caused sounds (traffic, motorcycles, shuttle buses, generators) were also cited as detractions from visitor enjoyment.

Previous Peregrine Monitoring at BRCA

American peregrine falcons (*Falco peregrinus anatum*) were delisted (formerly endangered) in 1999 but are still monitored under provisions of the Endangered Species Act to ensure that their recovery is complete. Since the time of formal delisting, Bryce Canyon National Park has managed peregrine falcons as a species of management concern (park goal Ia2B).

Peregrine falcon monitoring at BRCA has occurred at three historic territories (Paria, Rainbow, and Farview) at varying degrees, from 1982-1997, 1999-2005, and again from 2009-2010. An intensive survey was first completed in the park in 1982. From 1983-1988, survey effort diminished and limited data on territory occupancy and productivity was collected. Not until 1989 was another thorough survey undertaken. In 1991, a fourth territory at Sheep Creek was located. From 1989 – 1997, surveys in the park were complete and focused on establishing the location of breeding pairs and determining the productivity of each. No surveys were completed in 1998. From 1999-2005 survey effort again diminished and incomplete data was collected. Prior to this report, the last year in which all four sites were monitored during the breeding season was in 2002. Surveys outside of the known historic territories have not been performed since the early 1990s. Figure 2 below shows peregrine reproductive history at BRCA from 1982 – 2010.

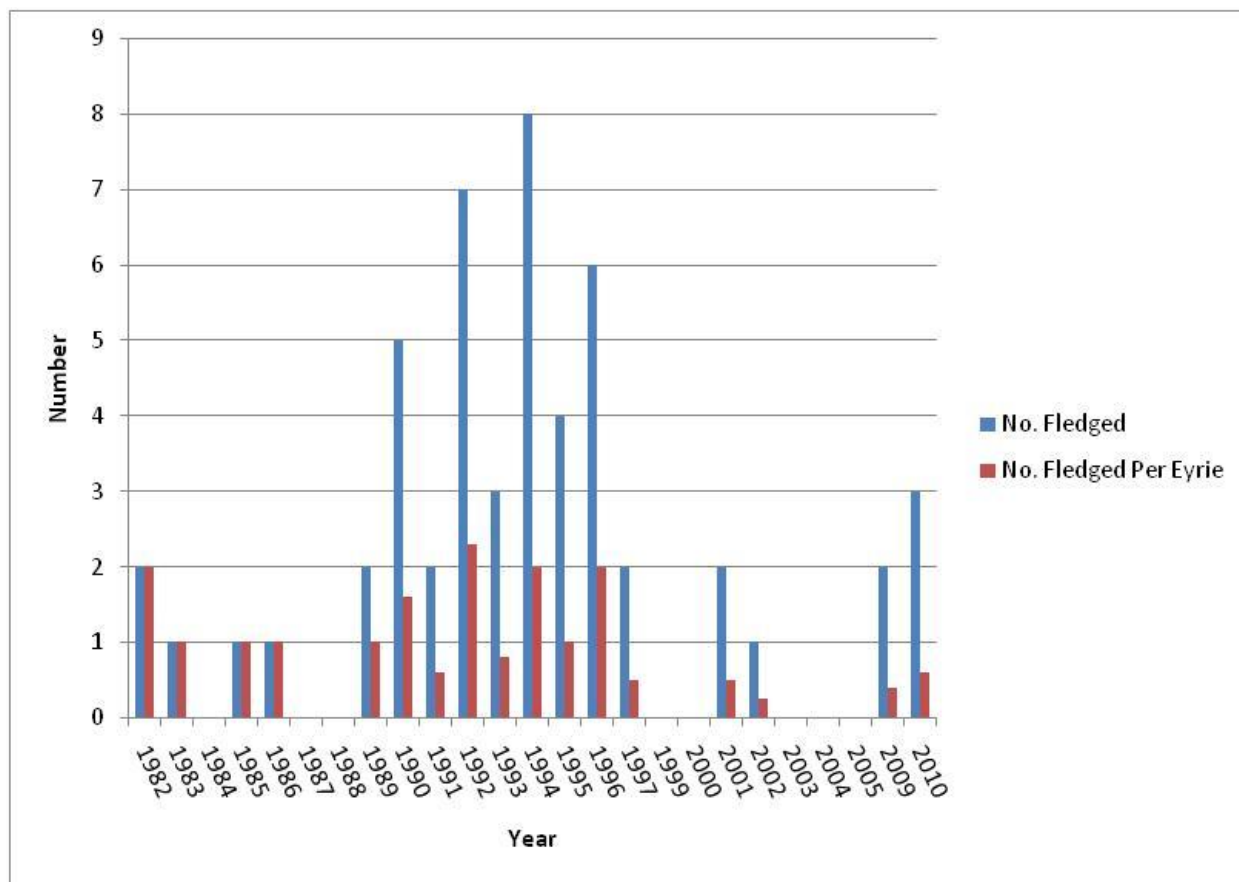


Figure 2. Peregrine Falcon Reproductive History at BRCA, 1982 – 2010*.

*Note that where dates are missing (1998, 2006-2008) surveys were not conducted that year. CAUTION: Figure 2 represents the documented reproductive history of peregrine at Bryce Canyon National Park only. Survey and monitoring effort varied widely throughout each monitoring year. As a result, this figure does not indicate population change over time or trends in reproductive success.

Formal peregrine falcon territory/eyrie monitoring was conducted as a part of this study by implementing a protocol developed for the Northern Colorado Plateau parks (Daw et al., 2004). The protocol, co-developed by the Northern Colorado Plateau Network Inventory (NCPN) and Monitoring Program and the Natural Sounds Program, is based on the national monitoring plan developed by the U.S. Fish and Wildlife Service (USFWS, 2003). The monitoring objectives were to collect detailed information on peregrine territory occupancy, nest success, and productivity. Surveys included the five known territories throughout the park. The status and trends of these parameters are essential information for the park, and will contribute to regional and national understanding of the species' recovery.

Study Area

Bryce Canyon National Park is located in the Colorado Plateau region of the southwestern United States (Figure 3). The park was created as a National Monument in 1923 to recognize and preserve the unique geological features and sweeping stone amphitheaters at the top of Utah's Grand Staircase, a series of topographic cliffs and terraces that rise in elevation from the Grand Canyon in the south and extend north through Zion National Park to Bryce Canyon. In 1928, the park received increased protection when it was established as Utah's second National Park. Stretching from 6,000 feet to 9,100 feet in elevation, Bryce Canyon embraces three distinct life zones within its 35,835 acres and contains a wide array of flora and fauna. With a road spanning nearly its entire 24 mile length, the park is primarily a frontcountry, day-use area, receiving around 1.5 million visitors annually.



Figure 3. Southern Utah Area National Parks.

Methods

Acoustic monitoring units were deployed at seventeen sites at BRCA during the 2009 and 2010 spring/summer season (Figure 4). These sites focused on both backcountry and frontcountry locations near five known peregrine falcon territories: Inspiration, Paria, Sheep/Swamp, Farview and Yovimpa. Table 4 lists the seventeen sites, their locations (UTM coordinates), habitat type, elevation, and the year in which the monitoring took place. The acoustic systems were placed within active peregrine falcon territories to establish natural and existing ambient sound levels and to assess noise impacts, including the percentage of time that mechanical and human-caused sounds were above natural ambient levels.

Sound sources at monitoring sites varied depending on the time of year and location in which units were deployed. For example, the early spring is associated with windy days with high gusts. Additionally, fewer fixed-wing aircraft tours occur on the shoulders of the summer season. Although the acoustic environment varied throughout the season and between sites, monitoring units were deployed to record the soundscape during high activity months (in regard to both visitor use and biologic [peregrine falcon nesting] activities).

Table 4. Sites monitored in 2009-2010.

Site Location and Territory	Habitat	Acoustic Zone	Elevation (meters)	UTM Coord (12S)		Year
				East	North	
BRCA005 – Paria	Ponderosa pine forest	Frontcountry	2525	0397283	4161575	2009
BRCA006 – Farview	Mixed conifer forest	Frontcountry	2689	0389788	4155879	2009
BRCA007 – Sheep/Swamp	Ponderosa pine forest	Frontcountry	2435	0393008	4160667	2009
BRCA008 – Yovimpa	White fir forest	Frontcountry	2766	0390580	4147992	2009
BRCA009 – Paria	Mixed conifer forest	Backcountry	2207	0397328	4160846	2009
BRCA012 – Yovimpa	Mixed conifer forest	Backcountry	2462	0390484	4147477	2009
BRCA013 – Inspiration	Mixed conifer forest	Frontcountry	2527	0397060	4162949	2009
BRCA014 – Inspiration	Mixed conifer forest	Backcountry	2363	0397182	4163222	2009
BRCA015 – Inspiration	Mixed conifer forest	Frontcountry	2524	0397058	4162954	2009
BRCA016 – Paria	Ponderosa pine forest	Frontcountry	2504	0397373	4161653	2010
BRCA017 – Farview	Mixed conifer forest	Frontcountry	2689	0389773	4155868	2010
BRCA018 – Inspiration	Mixed conifer forest	Frontcountry	2524	0397053	4162950	2010
BRCA019 – Yovimpa	White fir forest	Frontcountry	2769	0390561	4148015	2010
BRCA020 – Paria	Mixed conifer forest	Backcountry	2230	0397395	4161051	2010
BRCA021 – Sheep/Swamp	Burned conifer forest	Backcountry	2323	0392475	4159640	2010
BRCA022 – Farview	Mixed conifer forest	Backcountry	2482	0389963	4155495	2010
BRCA023 – Yovimpa	Mixed conifer forest	Backcountry	2460	0390375	4147537	2010

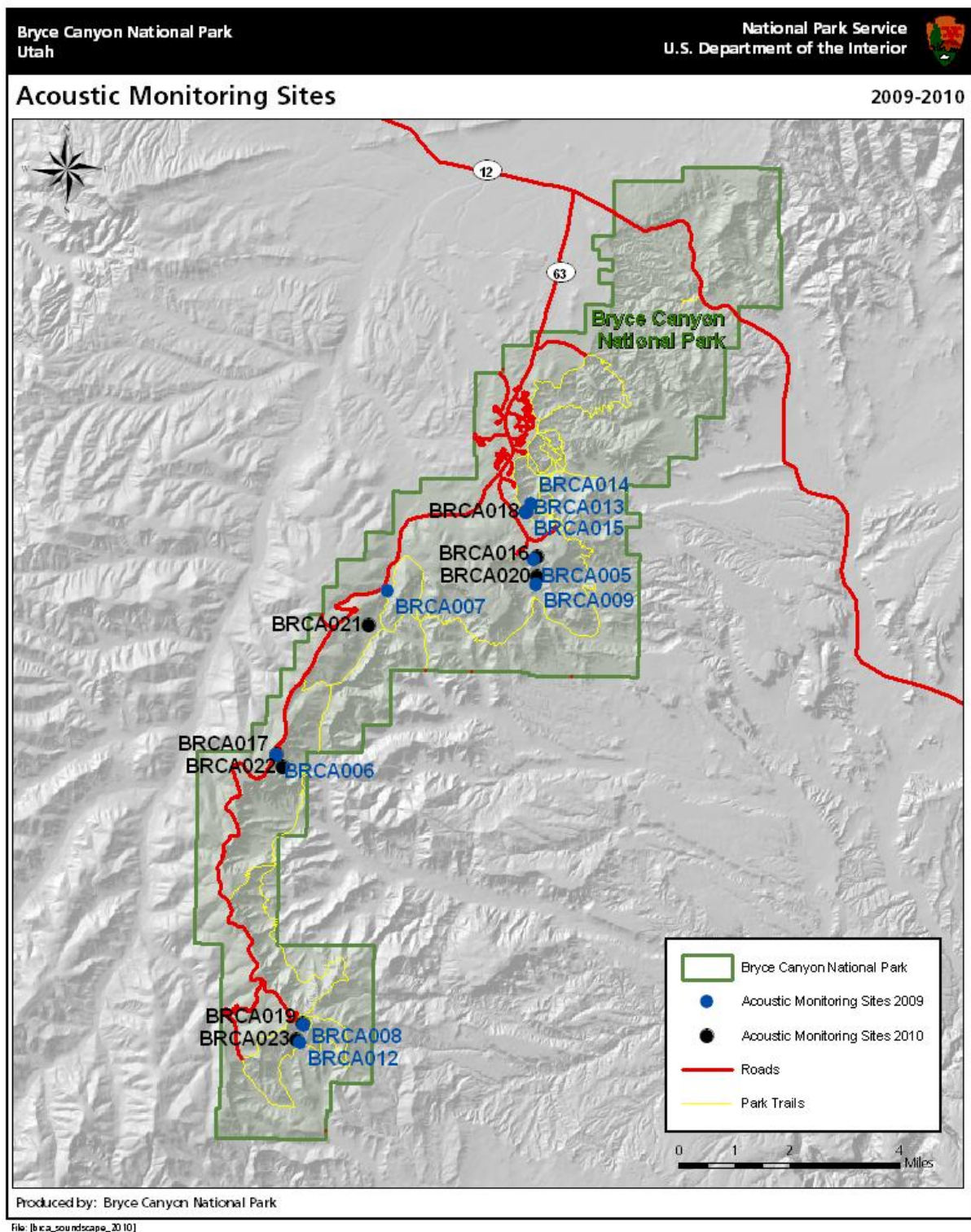


Figure 4. Acoustic Monitoring Sites 2009-2010.

All frontcountry locations were within 2000m of park viewpoints (Figure 5) and captured the acoustic environment of those areas. Vegetation communities varied slightly between sites (elevation dependent) but were representative of the dominant ponderosa pine and mixed conifer habitats throughout the park's front and backcountry locations.

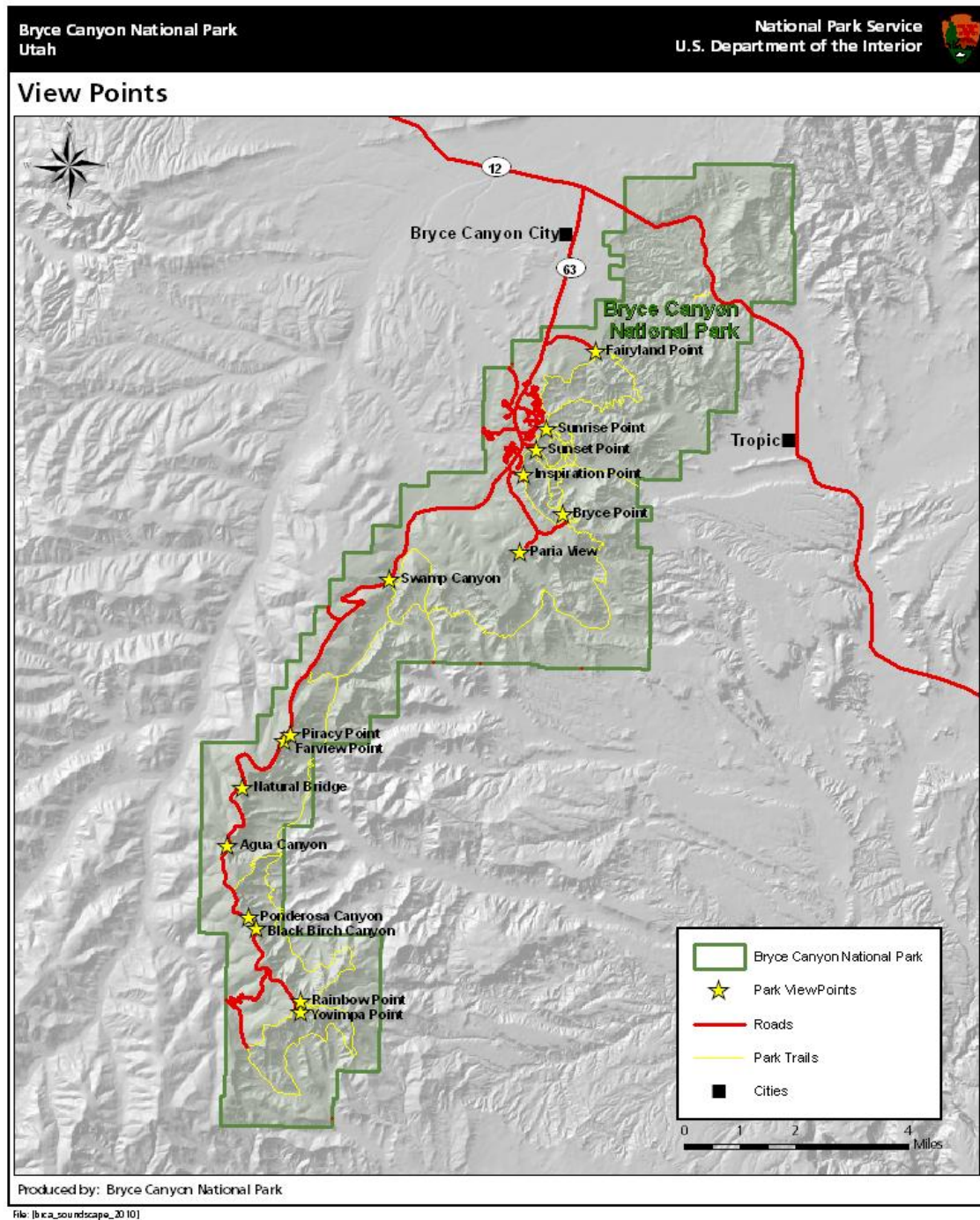


Figure 5. Bryce Canyon National Park Viewpoint Locations.

Automatic Monitoring

Larson Davis 831 sound level meters (SLM) were deployed over approximately thirty day monitoring periods at frontcountry locations and approximately fifteen day periods at backcountry locations. Monitoring periods were developed with guidance from the NSP. To produce existing and ambient data with a margin of error of less than 3 dB at backcountry sampling sites, the NSP has determined that sound monitors should remain at sampling sites for a minimum of 25 days (NPS NSP, 2005). However, the length of time appropriate for backcountry deployment will vary from park to park and can be adjusted based on the acoustic environment of a specific location. NSP suggests a 10 day minimum sample period for frontcountry sites, where a full range of natural variability is not expressed. Frontcountry locations were deployed for 26 – 38 days during this study. Due to limitations imposed by backcountry locations, the relative quiet of backcountry areas in the park based on park staff knowledge of the local environment, and previous studies conducted at BRCA, acoustic stations were deployed for 15 – 22 days at backcountry locations.

The Larson Davis SLM is a hardware-based, real-time analyzer which constantly records one-second sound pressure level (SPL) and 1/3 octave band data (Figure 6). These Larson Davis-based acoustic systems meet American National Standards Institute (ANSI) Type 1 standards. An Edirol sound recorder was used in association with the SLM to record continuous audio data at each monitoring station.

Each Larson Davis sampling station consisted of:

- Microphone with environmental shroud
- Preamplifier
- Solar panel and batteries
- MP3 recorder
- Anemometer



Figure 6. Larson Davis and Edirol MP3 Recorder Acoustic Monitoring Equipment.

Each acoustic sampling station collected:

- SPL data in the form of A-weighted decibel readings (dBA) every second
- Continuous digital audio recordings
- One third octave band data every second ranging from 12.5 Hz – 20,000 Hz

Off-Site Listening

From the approximately 375 days of monitoring, BRCA staff analyzed a selected subset of audio samples (eight days per site) to identify durations and sources of audible sound¹. Audio samples were selected at random from monitoring days with a minimal amount of wind interference (wind gusts below 5 meters/second) based on NSP analysis protocols. Monitoring locations were selected based on proximity to known peregrine falcon territories and were deployed throughout the park over the duration of the 2009/2010 breeding season, which corresponds with the spring and summer seasons. Two hours (10 seconds every 2 minutes) of each sub-sampled day was listened to and coded with audible sounds by acoustic technicians. Noise canceling headphones were used for off-site audio playback to minimize limitations imposed by the office acoustic environment. Sites with minimum extrinsic sounds (most backcountry locations) were analyzed using daily spectrogram coding methods (see Appendix B for further information on visual analysis). Following complete analysis of a monitoring location, the total percentage of time that extrinsic sounds were audible was used to calculate the natural ambient sound level (see Calculation of Metrics below).

On-Site Listening (Attended Logging)

On-site listening is the practice of placing an observer near the acoustic monitoring station with a handheld PDA to document all audible. The observer listens for a designated period of time (generally limited to one hour-long session), and identifies all audible sound sources and their corresponding duration. On-site listening takes full advantage of human binaural hearing capabilities, and most closely matches the experience of park visitors.

Variation in human listening capabilities and human fatigue constrain this technique. Additional logistical constraints prevent comprehensive sampling by this technique, but selective samples of on-site listening provide a basis for relating the results of off-site listening to the probable auditory perception of events by park visitors and wildlife.

Periods of on-site listening were conducted in order to discern the type, timing, and duration of sound sources during sound-level data collection at BRCA. As recommended by Natural Sound

¹The NSP and Volpe decided that 2.5 percent of the total measurement period should be analyzed in order to identify sources of audible noise at a monitoring location. Data analyzed for such a sample period generally results in a margin of error of $\pm 15\%$ for percent time audible, and insures that metrics computed from percent time audible data (such as Lnat) are ± 1 dBA of actual levels (NSP and Volpe, unpublished data). Therefore, for a 25 day monitoring duration (600 hours), investigators should conduct 15 hours of observer logging. To accomplish this, NPS staff listened to a subset of data, using the 10 second / 2 minute sampling scheme developed by the NSP. When placed end-to-end, these 10 second samples constitute 2 hours per day of audio recordings. To reach an equivalent 15 hours of observer logging, BRCA staff analyzed 8 days of sub sampled audio (totaling 16 hours). These listening sessions provided the basis for the calculation of metrics such as natural ambient.

Program protocol (NPS NSP, 2006) these sessions lasted for one hour. Staff recorded the beginning and ending times of all audible sound sources using custom-designed PDA software.

The on-site listening sessions provided the basis for the calculation of metrics including the period of time between noise events (average noise free interval [NFI]); percent time each sound source was audible (PA); and maximum, minimum, mean length (in seconds), and standard deviation of sound source events. Software created by the NSP was used to generate these statistics based on the on-site listening data collected at each site. On-site listening tables are reported under the results section and compiled in Appendix C and provide a sound inventory of each site. They reveal the sounds one is likely to hear at or near the specified location.

Calculation of Metrics

Since sound levels fluctuate, several metrics are calculated in order to provide some detail about the characteristics of the acoustical environment. The current status of the acoustical environment can be characterized by a number of measurements including sound levels across the 1/3 octave band spectrum (from 12.5 Hz to 20,000 Hz), overall sound levels, and percent time audible durations for various sound sources. Two fundamental descriptors of the acoustical environment are the existing and natural ambient sound levels which are presented as exceedence levels (L_x). They represent the dBA exceeded for a specified percentage of the time during the given measurement period. For example, measured in dBA, the existing ambient (L_{50}) is the sound level exceeded 50% of the time, or median sound level. It is the uncensored composite of all sounds at a site, both human-caused and natural. NSP also calculates L_{10} and L_{90} , which describe the sound levels exceeded 10% and 90% of the time, respectively. L_{50} level is the composite of all sounds at a site, both human caused and natural. Median sound level metrics (dBA by hour and 1/3 OB data by hour) are reported for each site under Appendix D.

The natural ambient estimates what the acoustic environment would be without the contribution of anthropogenic sounds. The differences between L_{50} and L_{nat} values allow NPS to answer the following questions:

1. What are the listening opportunities in the absence of human development and activities?
2. How are these listening opportunities compromised by increased sound levels due to noise?

To calculate L_{nat} , the following procedure is used:

- Calculate the percentage of all samples containing extrinsic sounds for each hour of the day (P_H) by either listening to samples, or analyzing daily spectrograms, for eight days.
- P_H is used to complete this formula for every hour: $x = \frac{1 - P_H}{2} + P_H$
- Hourly x_H values are entered into a database of all octave band information.
- Example: if extrinsic sounds are audible 50% of the time ($P_H = 0.5$), then x_H is 0.75.
- L_{nat} is computed as the sound level that is exceeded $100 * x_H$ percent of the time.
- (In practice, L_{nat} is calculated by sorting the relevant sound level measurements and using x_H to extract the appropriate order statistic).

This procedure approximates the sound levels that would have been measured in the absence of extrinsic noise. The procedure has been demonstrated to produce an estimate that is equal to or below the existing ambient sound levels, and the results of this calculation have produced consistent results at most backcountry sites.

Median Hourly Exceedence

In order to determine the effect extrinsic noise audibility has on the acoustic environment, the median hourly exceedence metrics were calculated for each site. This metric displays the existing ambient (or median) level for each hour and the contribution of anthropogenic noise to the existing ambient sound levels at each site. This metric is displayed in graphical form using gray scale boxes; the size of these boxes is directly related to the percentage of time that human-caused sounds are audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. Exceedence metrics figures also show the L_{10} and L_{90} values which essentially mark the average maximum and minimum levels over the 15 or 30 day monitoring periods.

Time Above

Time above metrics were calculated for each monitoring location and provide information about the proportion of time that sound levels are above decibel values that have known impacts on human experiences or health (35, 45, 52, and 60 dBA). By comparing the amount of time that sound levels are above certain values, variations in sound levels - as well as their implications - can be illustrated.

In order to understand the implications of the acoustic data fully, it is important to describe the distribution of sound levels in relation to potential functional effects since this information may be useful in resource management decisions. The decibel (dBA) is used to develop a compressed scale that represents the large dynamic range of sounds experienced by people, and also to acknowledge that humans—and presumably other animals—perceive increases in loudness in a logarithmic, rather than linear, fashion (Chapman and Ellis, 1998) As decibel measures are often not easily comprehended by the lay person, Table 5 presents park sound sources and common sound sources with their corresponding A-weighted decibel levels (dBA) to provide a frame of reference.

Table 5. Interpreting sound levels.

Park Sound Sources	Common Sound Sources	dBA
Crater (HALE)	Human breathing at 3m	10
Leaves rustling (CANY)	Whispering	20
Crickets at 5m (ZION)	Residential area at night	40
Conversation at 5m (WHMI)	Busy restaurant	60
Snowcoach at 30m (YELL)	Curbside of busy street	80
Thunder (ARCH)	Jackhammer at 2m	100
Military jet at 100m AGL(YUCH)	Train horn at 1m	120

Note: At a minimum, each 10 dB increase in SPL causes a doubling of perceived loudness (Crocker, 1997, p.1481)

Percent Time Audibility

Percent time audible graphics were generated for each site using an hourly average. The percentage of time that aircraft and other extrinsic sounds were audible during each hour of the day/night were calculated. These statistics were determined using Off-site Listening for frontcountry sites and Sound Pressure Level Annotation Tool (SPLAT) for most backcountry sites. Using NSP sound code lists, NPS staff analyzed the eight selected days by assigning specific numerical codes for each of the sound sources they heard (see Appendix E). The total percentage of time extrinsic sounds were audible and the total percentage of time that aircraft were audible during the off-site listening were calculated. In the percent time audible graphics presented in the results section, note that the sound source “artifact” arises from equipment noise such as audio distortion at high-wind speeds or rain falling on the microphone.

Peregrine Falcon Monitoring

Acoustic monitoring locations were selected based on proximity to known peregrine breeding territories within the park (Figure 7). Four historical territories were known with a fifth territory located and monitored in 2009 and 2010. In accordance with established protocol mentioned previously, Biological Technicians monitored each known and potential nest territory for a minimum of four hours unless falcons were present and territory status was determined sooner. If one or more peregrines were not detected during the first monitoring session (occurring between March 15th and April 15th), a second monitoring session was required at least 2 weeks after, but not more than 4 weeks following the first session. If peregrines were detected at the first monitoring session, a second protocol monitoring session was not conducted until fledglings could be detected (July – August) to determine successful productivity. Monitoring began in late March each year. Additionally, each territory was visited for non-protocol/behavioral monitoring purposes throughout the season and for various lengths of time to establish/dismantle sound equipment, conduct on-site listening, download data and for incidental purposes. All territory visits, regardless of purpose, were documented on Attachment A of the NCPN protocol monitoring guidelines.

In addition to protocol monitoring, BRCA staff conducted behavioral observations on nesting peregrine falcons to determine if noise from low flying aircraft (helicopters and propeller planes) caused behavioral responses from individuals within their breeding territories. Behavioral monitoring took place from June through August of 2009 and 2010, corresponding with the peak of the tourist season at BRCA, with sessions generally lasting four hours. Behavioral responses of peregrine, distance from overflight to known/suspected eyrie locations, and the time overflights were audible were documented when aircraft were within approximately 3000 meters of active nesting areas or perch sites. Behavioral responses were classified using a qualitative scale and were recorded as either 1 = no reaction/alert (none to mild), 2 = Moderate (pre-flight intentions, cowering, mild vocalizations), or 3 = severe (flying, escape, protest calls). Distances were estimated with the aid of a Bushnell Scout 1000 range finder with an approximate 1000 meter range. Care was taken by park staff never to point range finding equipment directly at aircraft. Overflights in excess of 3000 meters from active eyries were documented, but were generally too far to estimate horizontal or vertical distance or impact on peregrine behavior.

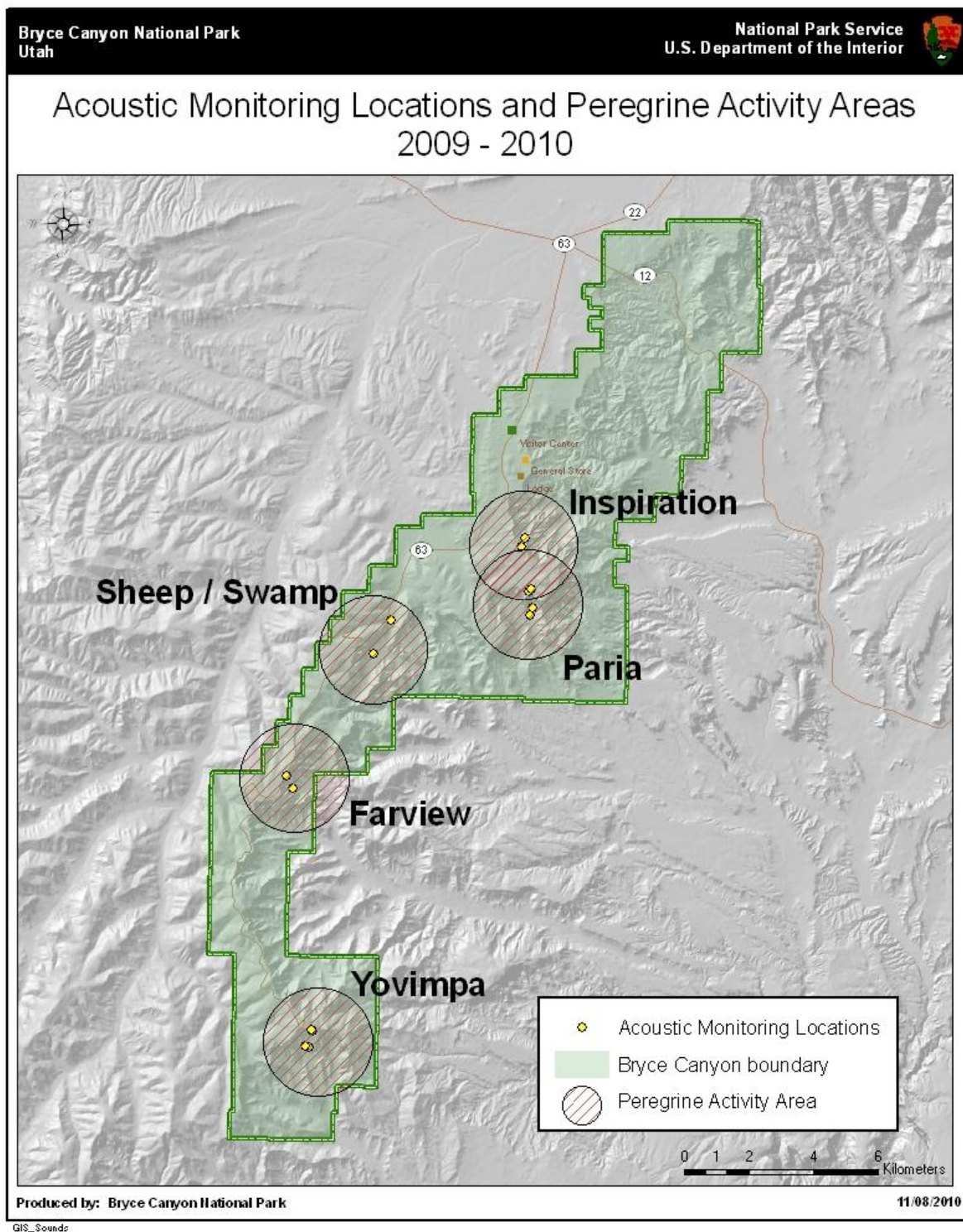


Figure 7. Acoustic Monitoring Sites and Peregrine Falcon Activity Areas 2009-2010.

Results

Acoustic monitoring systems were deployed at seventeen sites during the spring and summer of 2009 and 2010 in proximity to five known peregrine falcon territories within the park. One site (BRCA015) failed to produce useful data due to excessive artifact noise caused by a faulty wire connection between the microphone and the MP3 recorder. The remaining sampling areas spanned various vegetation types, seasons, and management zones; they are representative of acoustic conditions throughout the park. The on-site listening effort is summarized below while the results for the off-site data analysis are separated into the five geographic sites corresponding to the peregrine falcon territories monitored.

Table 6. On-Site Listening: Summary of Results.

Site Location	Session (n hours)	% time extrinsic sources audible	% time aircraft audible	Mean noise free interval (min:sec)
FRONTCOUNTRY				
BRCA005: Paria Frontcountry	9	52.5	44.8	2:24
BRCA006: Farview Frontcountry	7	59.5	28.0	1:12
BRCA007: Sheep / Swamp Frontcountry	8	55.8	17.8	48
BRCA008: Yovimpa Frontcountry	8	49.2	34.9	1:14
BRCA013: Inspiration Frontcountry	16	82.6	55.6	45
BRCA016: Paria Frontcountry	9	49.2	34.0	1:55
BRCA017: Farview Frontcountry	8	83.3	41.7	40
BRCA018: Inspiration Frontcountry	7	79.2	52.8	58
BRCA019: Yovimpa Frontcountry	10	69.9	43.3	50
BACKCOUNTRY				
BRCA009: Paria Backcountry	6	44.0	39.0	2:41
BRCA012: Yovimpa Backcountry	6	66.3	30.7	1:12
BRCA014: Inspiration Backcountry	5	48.8	35.5	1:05
BRCA020: Paria Backcountry	4	38.4	38.4	3:31
BRCA021: Swamp Canyon Backcountry	3	38.5	38.1	4:16
BRCA022: Farview Backcountry	3	24.7	23.4	4:40
BRCA023: Yovimpa Backcountry	4	21.1	20.8	5:55

Table 6 presents the results for on-site listening sessions at each monitoring station. At Farview Frontcountry 2010 extrinsic sounds were audible nearly continuously (83.3%). As a result, the mean noise free interval, or mean period of time between noise events was only 40 seconds. This result was largely due to the proximity of the monitoring equipment from the park road where vehicle noise was audible.

By comparison, the longest mean noise free interval (5 min 55 sec) occurred during on-site listening sessions at Yovimpa Backcountry 2010 where extrinsic noise was audible 21.1 percent of time. At most backcountry sites, the sound of aircraft was by far the most commonly heard extrinsic noise. The only backcountry sites with substantial extrinsic noise other than aircraft were the 2009 Inspiration and Yovimpa Backcountry sites. At Inspiration Backcountry, this result was due to the location of the monitoring station directly below the rim where extrinsic sound sources originating from the rim, such as visitors and vehicles, were audible. At Yovimpa Backcountry 2009, noise associated with heavy equipment (NPS Bristlecone Loop Trail work) was audible 34.0 percent of time and constituted more than half of all extrinsic sound audible at the site (noise produced from this type of non-routine maintenance activity is generally absent).

Inspiration Monitoring Results

Overview

The Inspiration monitoring area was located in the northern part of the park within the heavily visited Bryce Amphitheater near the popular Rim Trail. Three frontcountry units located near the rim and one backcountry unit located under the rim were deployed in the 2009-2010 seasons. No useful data was collected from BRCA015 (due to excessive artifact from faulty wiring) and it was therefore not analyzed for this study. Due to the close proximity of all monitoring units with the Rim Trail, the park roadway, and associated park shuttle stops and parking areas, data analysis was completed using office listening to capture all extrinsic sounds. Table 7 below summarizes the monitoring effort at Inspiration. Figure 8 through Figure 10 below show photographs of each site.

Table 7. Soundscape Monitoring at Inspiration 2009-2010.

Site Name	Acoustic Zone	Year	Dates of deployment	Total days of acoustic monitoring	Hours of Attended Listening
BRCA013	Frontcountry	2009	6/4-7/1	29	16
BRCA014	Backcountry	2009	8/10-8/28	18	5
BRCA018	Frontcountry	2010	5/12-6/7	27	7

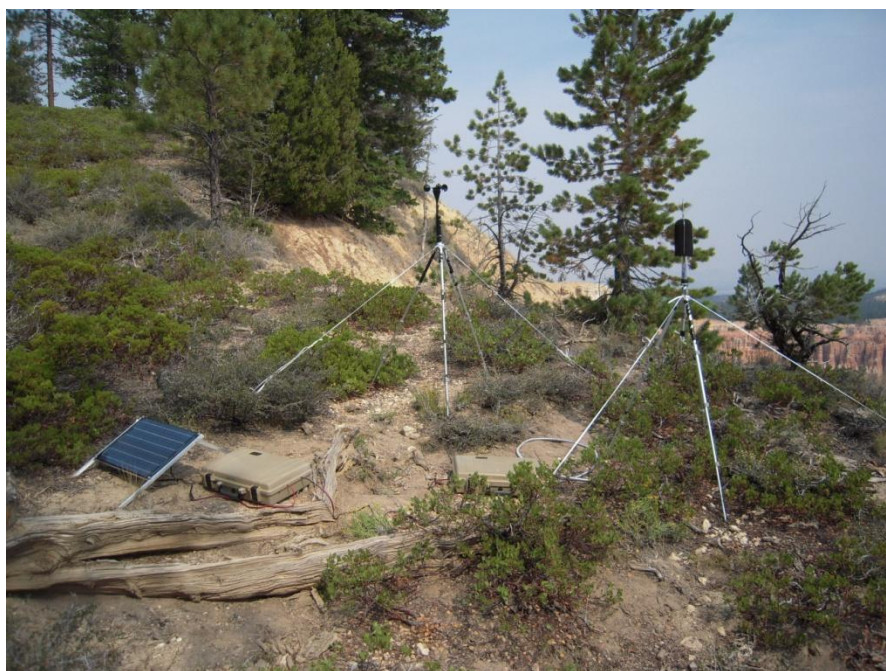


Figure 8. BRCA013 (Inspiration Frontcountry 2009) acoustic monitoring site.

BRCA013, the 2009 Inspiration Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2527 meters at the transition zone between mixed conifer forest and cliff edge habitats. This frontcountry site was located near a section of the Rim Trail and was monitored in June of 2009.



Figure 9. BRCA014 (Inspiration Backcountry 2009) acoustic monitoring site.

BRCA014, the 2009 Inspiration Backcountry acoustic monitoring site, was located below the rim at an elevation of 2363 meters. The site was located near a seasonal wash with habitat characterized by spruce, ponderosa pine, Douglas fir, and manzanita. This backcountry site was monitored in August of 2009.



Figure 10. BRCA018 (Inspiration Frontcountry 2010) acoustic monitoring site.

BRCA018, the 2010 Inspiration Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2524 meters in habitat characterized by ponderosa pine, limber pine, fir, juniper, and manzanita. This cliff side, frontcountry site was monitored from May through June 2010 and was located near a section of the Rim Trail.

Mean Percent Time Audibility

The graphs below show the mean percent time audible statistics for each site (24 hour mean). These statistics were determined using off-site listening for frontcountry sites and SPLAT for most backcountry sites. In all cases, these figures show the mean percent time each sound source was audible during the monitoring period. Individual sound sources are represented with blue (non-natural), green (natural), and black (unknown) bars while red bars represent the total non-natural sound sources. Artifact sounds include equipment noise such as audio distortion at high-wind speeds or rain falling on the microphone.

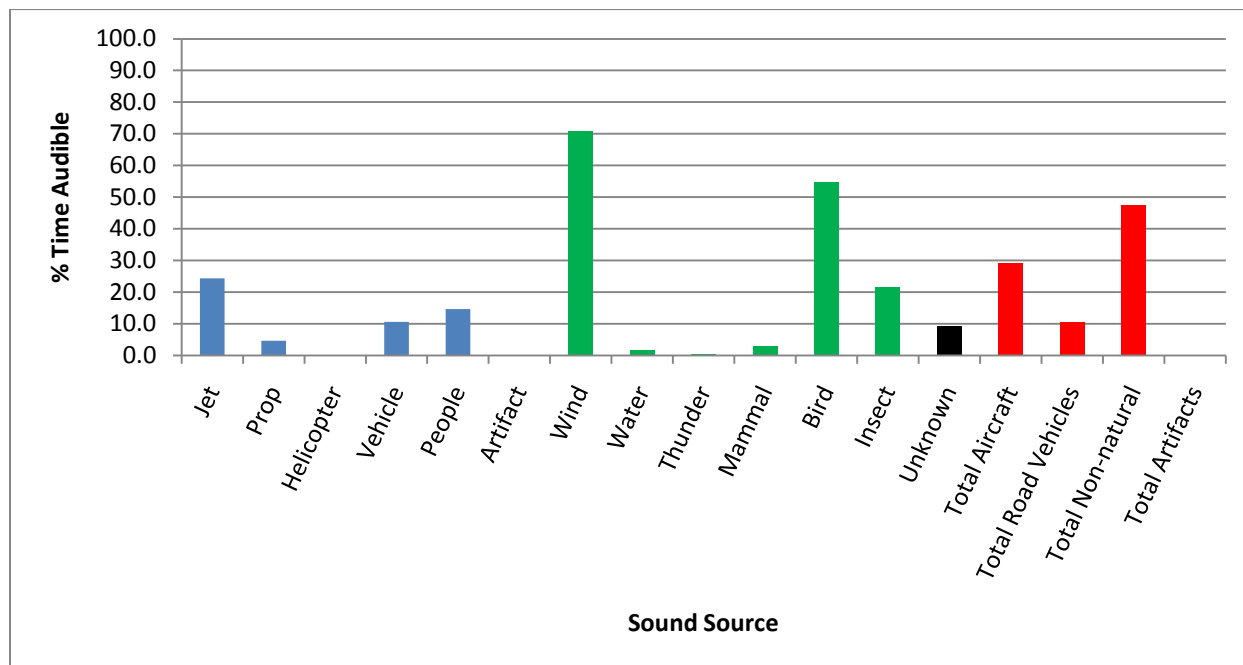


Figure 11. Mean percent time audibility of sound sources at BRCA013 (Inspiration Front-country) for June 4 – July 1 sampling period.

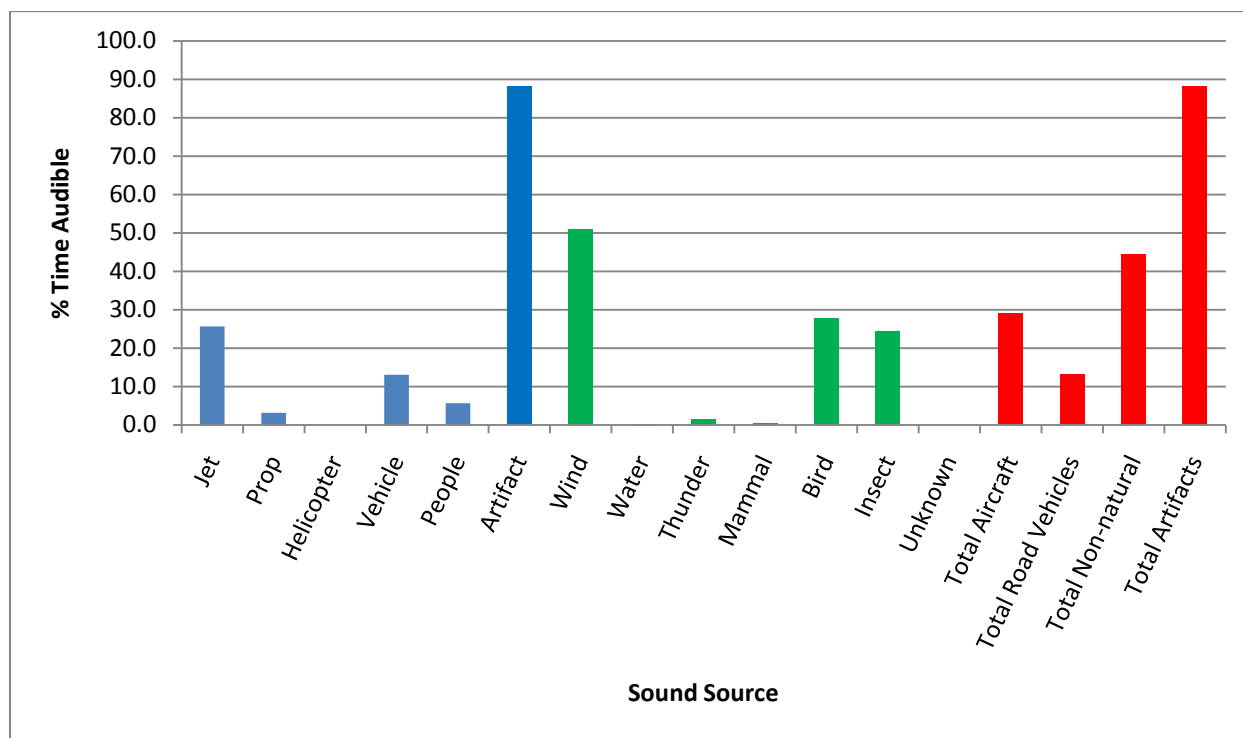


Figure 12. Mean percent time audibility of sound sources at BRCA014 (Inspiration Backcountry) for August 10 – 28 sampling period.

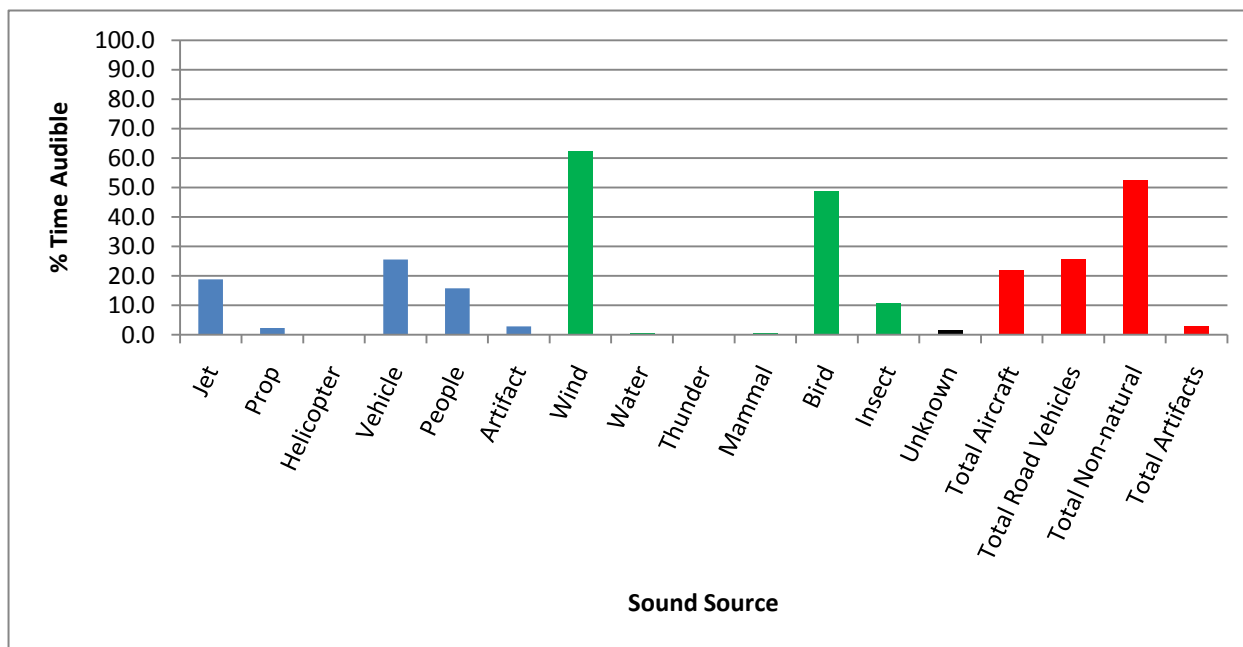


Figure 13. Mean percent time audibility of sound sources at BRCA018 (Inspiration Frontcountry) for May 12 – June 7 sampling period.

Hourly Exceedence Levels

In order to determine the effect extrinsic noise has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. The figures below show existing ambient levels and natural ambient levels. The existing ambient (L_{50}) level for each hour is marked by the upper limit of the gray boxes while the natural ambient level (L_{nat}) is marked by the lower limit of the gray boxes. The height of the box is a measure of the contribution of anthropogenic noise to the existing ambient sound level at each site. The size of these boxes is directly related to the percent time that human caused sounds were audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. These figures also show exceedence metrics L_{10} and L_{90} , which essentially mark the average maximum and minimum levels over the monitoring period. Note that the decibel scale of these figures is not uniform and varies for each site.

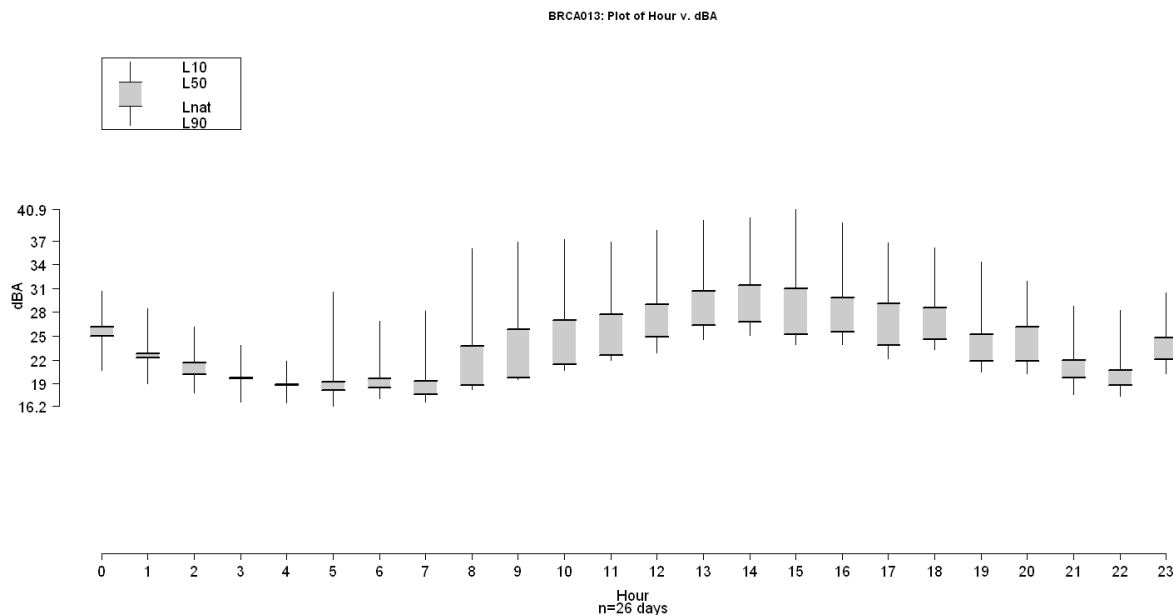


Figure 14. Hourly exceedence levels at BRCA013 (Inspiration Frontcountry) for June 4 – July 1 sampling period.

Figure 14 shows that human-caused or extrinsic sounds contributed to SPL most during the period of 8:00 am to 8:00 pm. This is likely due to aircraft, visitor, and vehicle noise that was audible within the heavily visited Bryce Amphitheater, where multiple popular viewpoints and trails are located.² Additionally, BRCA013 was located within close proximity to the popular Rim Trail, where visitor sounds were often audible. When the boxes do not appear, human-caused sounds are not contributing to the SPL. Wind was audible over 70% of the time at this site and could be contributing to the SPL during all hours. Figure 15 and Figure 16 also depict hourly exceedence levels and can be interpreted in a similar fashion.

² A recent study at BRCA showed that a large percentage of visitors stop at viewpoints in the Bryce Amphitheater (89% at Sunset, 84% at Sunrise, 73% at Bryce Point, and 68% at Inspiration).

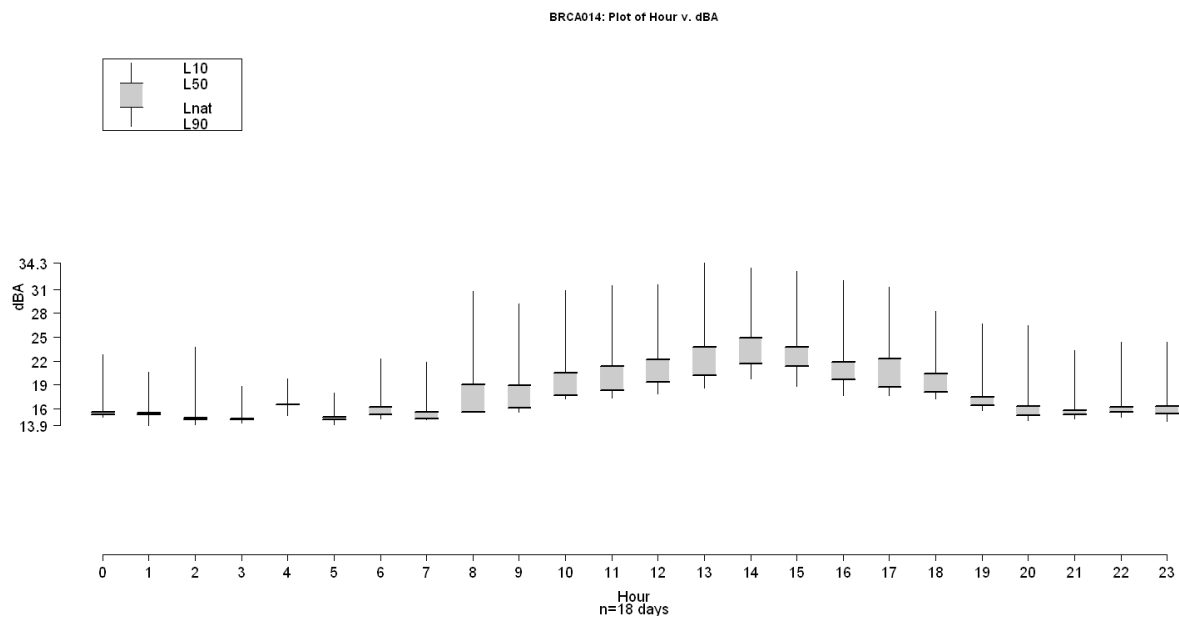


Figure 15. Hourly exceedence levels at BRCA014 (Inspiration Backcountry) for August 10 – 28 sampling period.

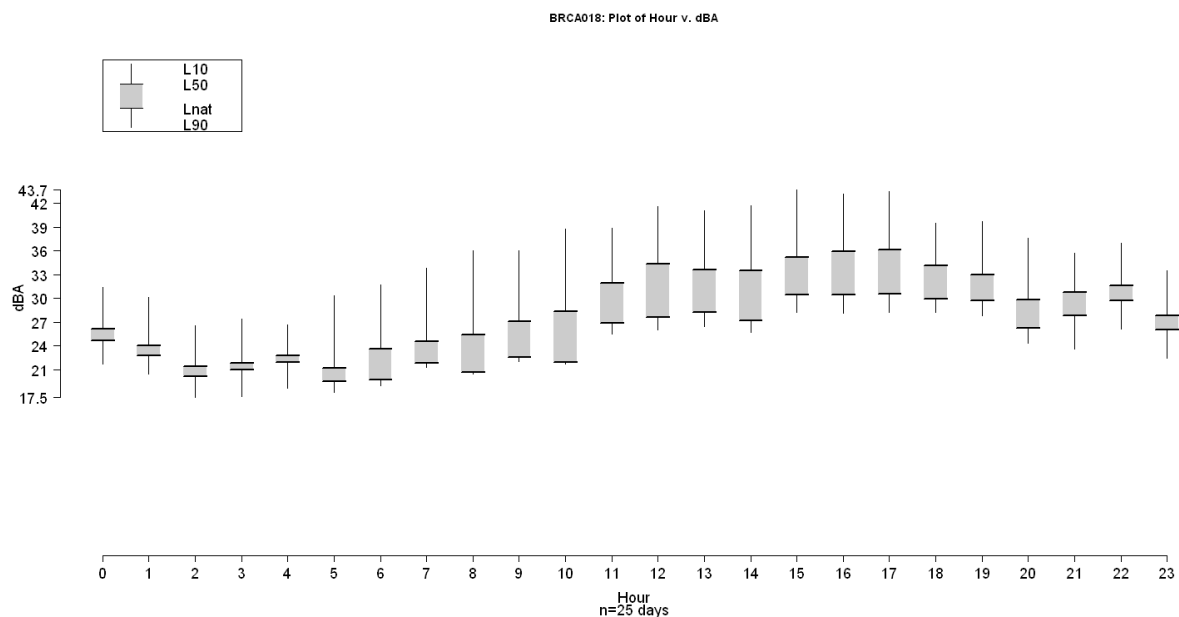


Figure 16. Hourly exceedence levels at BRCA018 (Inspiration Frontcountry) for May 12 – June 7 sampling period.

Audibility of Sounds by Hour

The graphs below show the mean percent time audible statistics for each site (hourly average). Each graphic shows the percentage of time that aircraft and extrinsic sounds were audible during each hour of the day/night. These statistics were determined using off-site listening for frontcountry sites and SPLAT for backcountry sites. These figures also show the total percentage of time extrinsic sounds were audible (light gray) and the total percentage of time that aircraft were audible (dark gray) during the off-site listening.

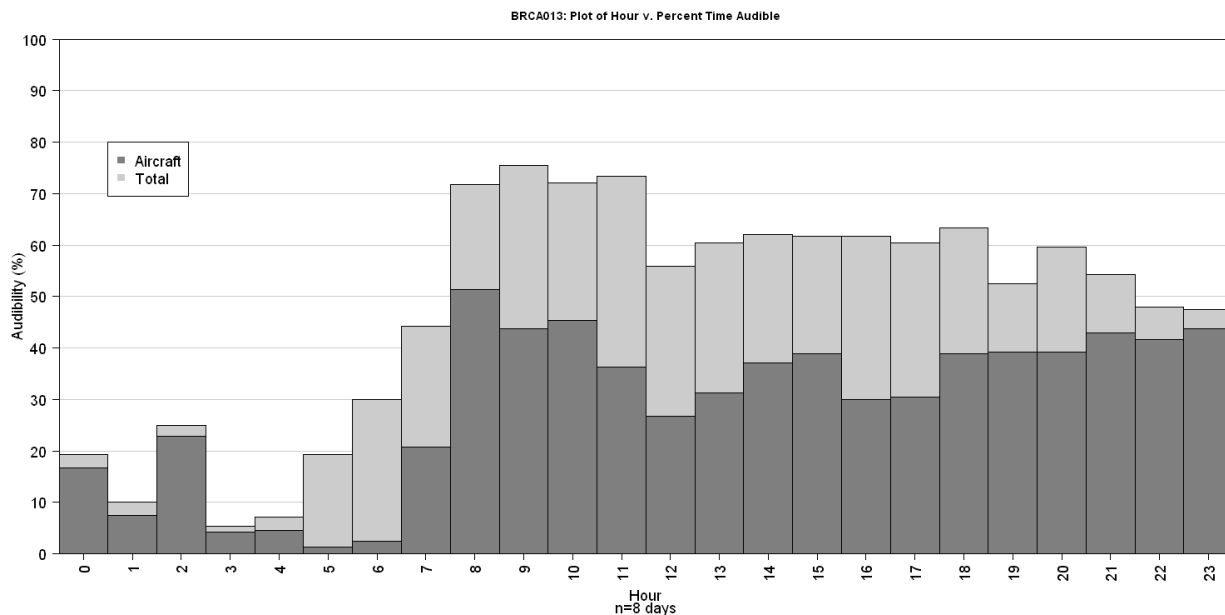


Figure 17. Audibility of extrinsic and aircraft sounds by hour at BRCA013 (Inspiration Frontcountry) for June 4 – July 1 sampling period.

Figure 17 shows the total percentage of time that all extrinsic sounds (light gray) and aircraft sounds (dark gray) were audible for each hour of the day/night. The percentage of time during which all extrinsic sounds were audible always exceeded the time that aircraft were audible at this site. A similar pattern was common for frontcountry sites where other sounds such as vehicles and people are audible. However, in backcountry locations, it can be expected that aircraft will be the dominant extrinsic sound. From 8:00 to 11:00 am, extrinsic sounds were audible greater than 70% of the time at the Inspiration Frontcountry site and were audible greater than half the time from 8:00 am to 9:00 pm. Figure 18 and Figure 19 also depict audibility of extrinsic and aircraft sounds and can be interpreted in a similar fashion.

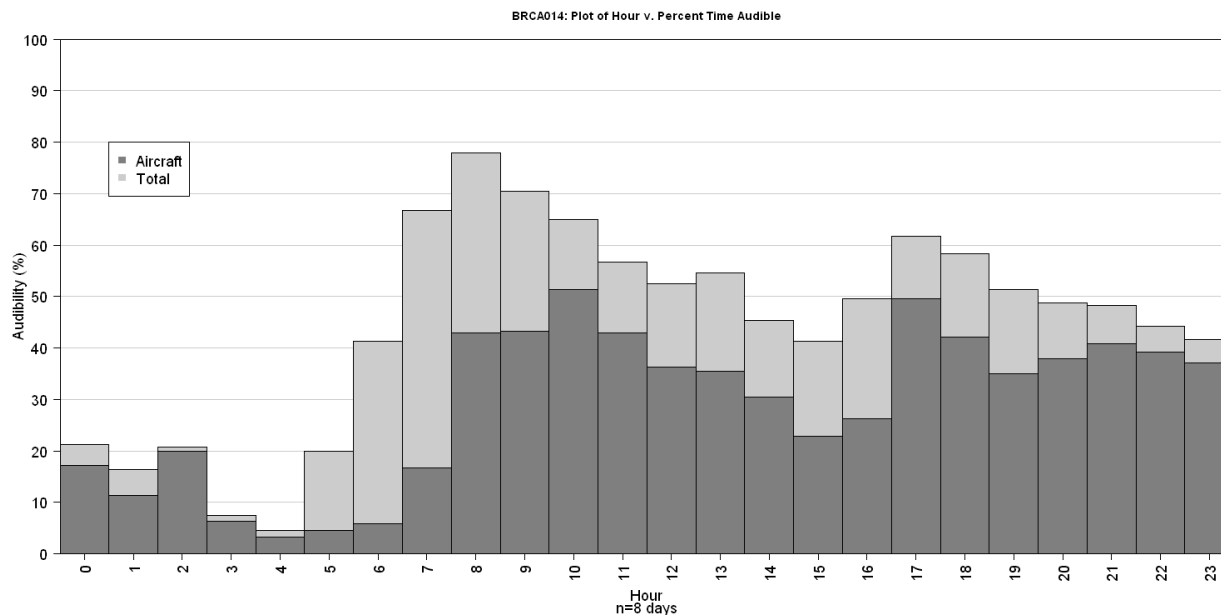


Figure 18. Audibility of extrinsic and aircraft sounds by hour at BRCA014 (Inspiration Backcountry) for August 10 – 28 sampling period.

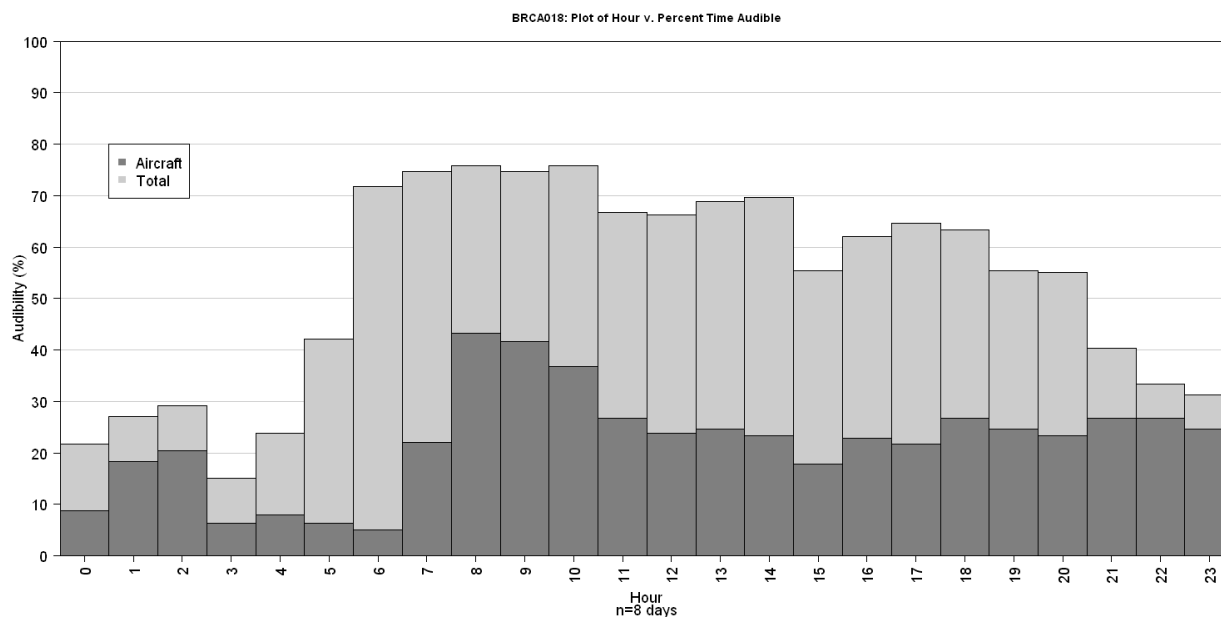


Figure 19. Audibility of extrinsic and aircraft sounds by hour at BRCA018 (Inspiration Frontcountry) for May 12 – June 7 sampling period.

Inspiration Acoustic Summary

Across all Inspiration monitoring sites, extrinsic sounds elevated the existing ambient sound level more during the daylight hours than at night. Wind was audible at least 50% of the time at all sites and likely elevated the overall SPL at each site. Further, wind masking could have occurred at all sites and concealed other natural and extrinsic sounds intermittently. Peak aircraft activity occurred at the 2009 sites between the hours of 8:00 am and 11:00 am, and between 8:00 am and 10:00 am at the 2010 site. Although low-elevation fixed wing aircraft were audible less than 5% of the time across all sites, the short-duration, high-decibel events had a more dramatic effect on L_{10} which documents acute conditions.

Frontcountry Sites (BRCA013, BRCA018)

At BRCA013, aircraft noise was the predominant extrinsic sound, especially high-altitude jet aircraft. In contrast, while BRCA018 was impacted by aircraft (20%), vehicle noise was the dominant extrinsic sound and was audible nearly 30% percent of the time. At both frontcountry locations, visitor noise was audible approximately 15% of the time. This result is likely the due to the proximity of the Rim Trail to the monitoring locations. However, noise originating from the Inspiration viewpoint and park road was also audible at times.

Backcountry Site (BRCA014)

In the absence of extrinsic sound, the Inspiration Backcountry site proved to be remarkably quiet, having an existing ambient level below 18 dBA between 12:00 am and 5:00 am. BRCA014 was the only backcountry site in this report that showed significant levels of extrinsic noise other than jet aircraft. This result is likely two-fold. First, due to the location of the acoustic station within the heavily visited Bryce Amphitheater, extrinsic noise was audible more often compared to other backcountry locations. Second, BRCA014 was located in close proximity to the rim (~300m) where extrinsic noise originating from viewpoints, parking areas, and roads was audible under the rim. Visitor noise was audible at the site approximately 10% of the time.

Paria Monitoring Results

Overview

The Paria monitoring area was located in the northern part of the park adjacent to the Paria View point and associated park roadway. Two frontcountry units located near the rim and two backcountry units located under the rim were deployed in the 2009-2010 seasons. Frontcountry sites where visitor and vehicle noise was audible were analyzed using office listening, while the quieter backcountry sites were analyzed using SPLAT. Table 8 below summarizes the monitoring effort at Inspiration. Figure 20 through Figure 23 below show photographs of each site.

Table 8. Soundscape Monitoring at Paria 2009-2010.

Site Name	Acoustic Zone	Year	Dates of deployment	Total days of acoustic monitoring	Hours of Attended Listening
BRCA005	Frontcountry	2009	4/1-4/27	27	9
BRCA009	Backcountry	2009	8/5-8/20	15	6
BRCA016	Frontcountry	2010	4/12-5/12	31	9
BRCA020	Backcountry	2010	6/15-6/30	15	4



Figure 20. BRCA005 (Paria Frontcountry 2009) acoustic monitoring site.

BRCA005, the 2009 Paria Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2525 meters at the transition zone between mixed conifer forest and cliff edge habitats. BRCA005 was located within 500 meters of the Paria viewpoint and associated park road. Monitoring took place in April of 2009.



Figure 21. BRCA009 (Paria Backcountry 2009) acoustic monitoring site.

BRCA009, the 2009 Paria Backcountry acoustic monitoring site, was located below the rim, and at an elevation of 2207 meters, was the lowest site monitored throughout the 2009-2010 seasons. The habitat was characterized by ponderosa pine dominated conifer forest with a juniper and manzanita understory. This backcountry site was monitored in August of 2009.



Figure 22. BRCA016 (Paria Frontcountry 2010) acoustic monitoring site.

BRCA016, the 2010 Paria Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2504 meters in ponderosa pine dominated forest habitat. This frontcountry site was located within 500 meters of the Paria overlook and park roadway. As the above photograph shows, snow was present at the site throughout the April 2010 monitoring period.



Figure 23. BRCA020 (Paria Backcountry 2010) acoustic monitoring site.

BRCA020, the 2010 Paria Backcountry acoustic monitoring site, was located below the rim at an elevation of 2230 meters in mixed habitat characterized by ponderosa pine, gamble oak, juniper, pinyon pine, and manzanita. This backcountry site was adjacent to a meadow and a seasonal wash and was monitored in June 2010.

Mean Percent Time Audibility

The graphs below show the mean percent time audible statistics for each site (24 hour mean). These statistics were determined using off-site listening for frontcountry sites and SPLAT for most backcountry sites. In all cases, these figures show the mean percent time each sound source was audible during the monitoring period. Individual sound sources are represented with blue (non-natural), green (natural), and black (unknown) bars while red bars represent the total non-natural sound sources. Artifact sounds include equipment noise such as audio distortion at high-wind speeds or rain falling on the microphone.

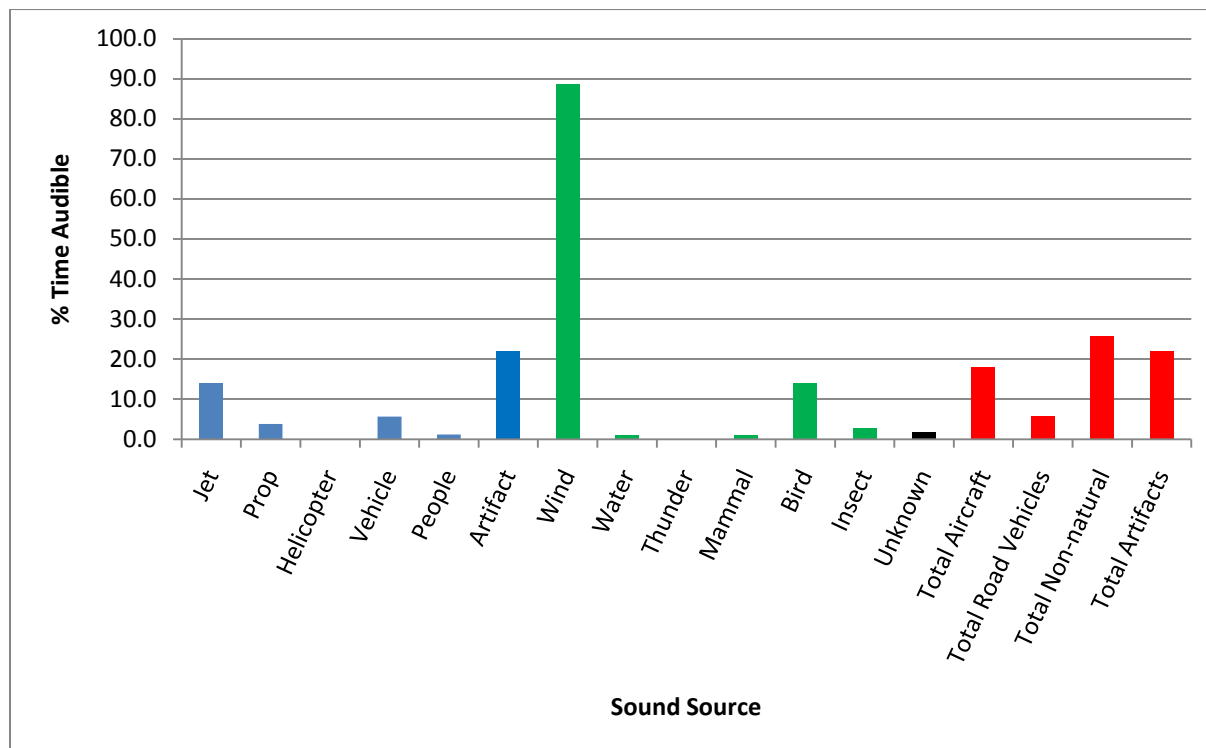


Figure 24. Mean percent time audibility of sound sources at BRCA005 (Paria Frontcountry) for April 1 – 27 sampling period.

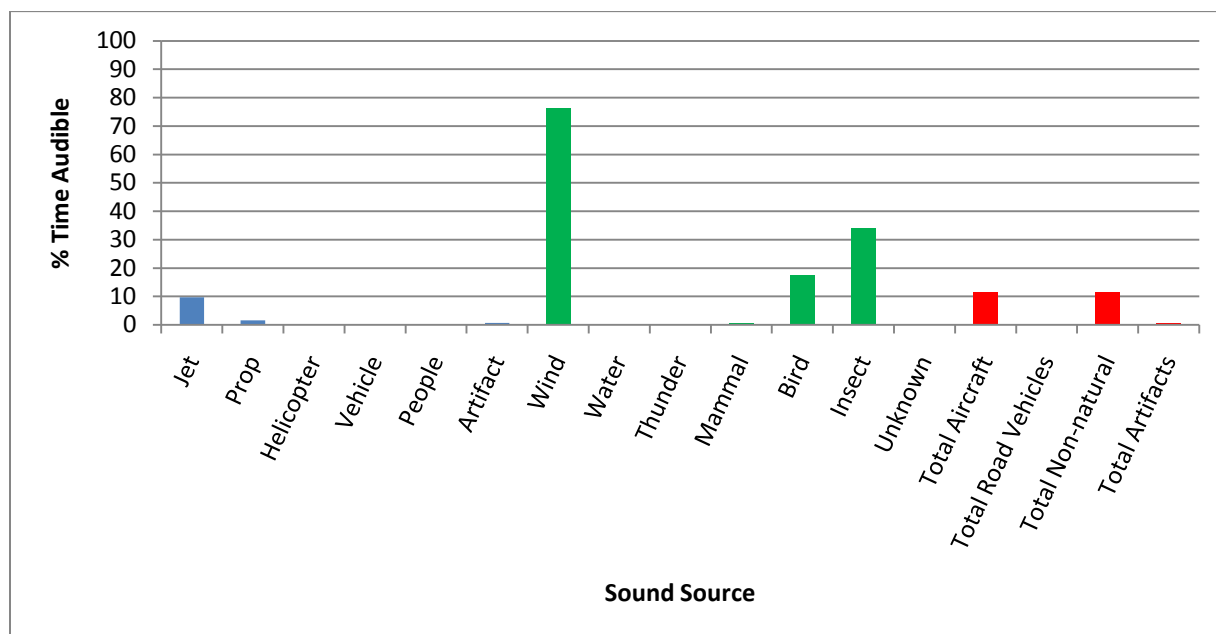


Figure 25. Mean percent time audibility of sound sources at BRCA009 (Paria Backcountry) for the August 8 – 20 sampling period.

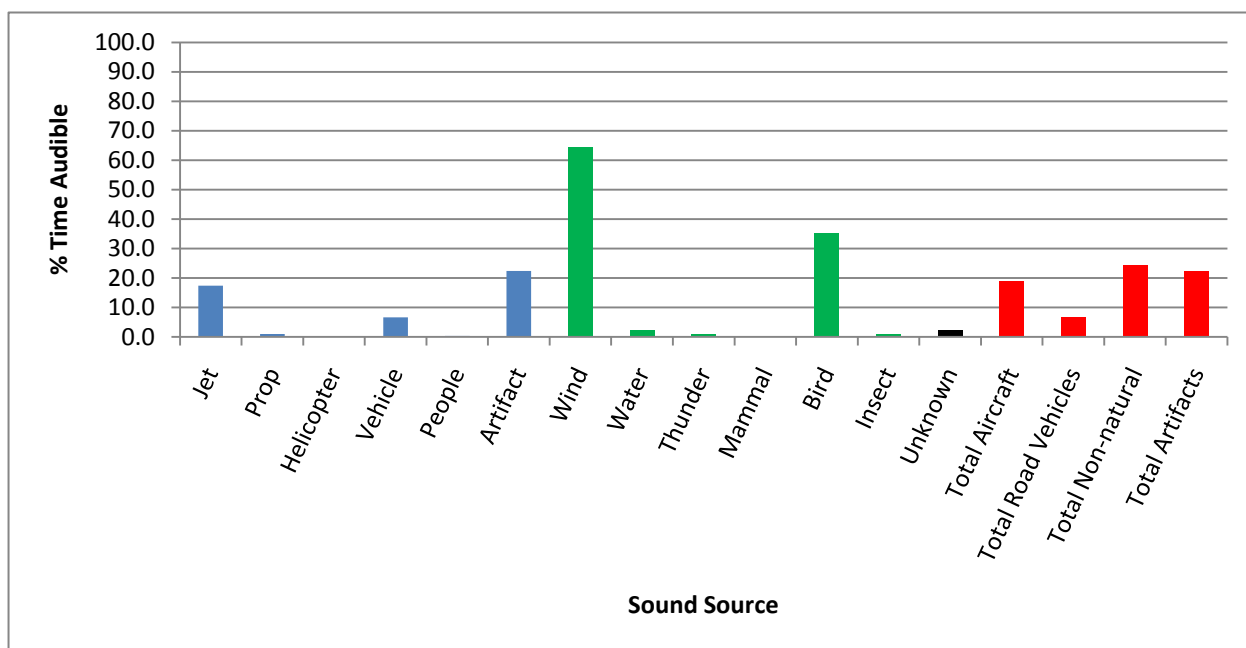


Figure 26. Mean percent time audibility of sound sources at BRCA016 (Paria Frontcountry) for the April 12 – May 12 sampling period.

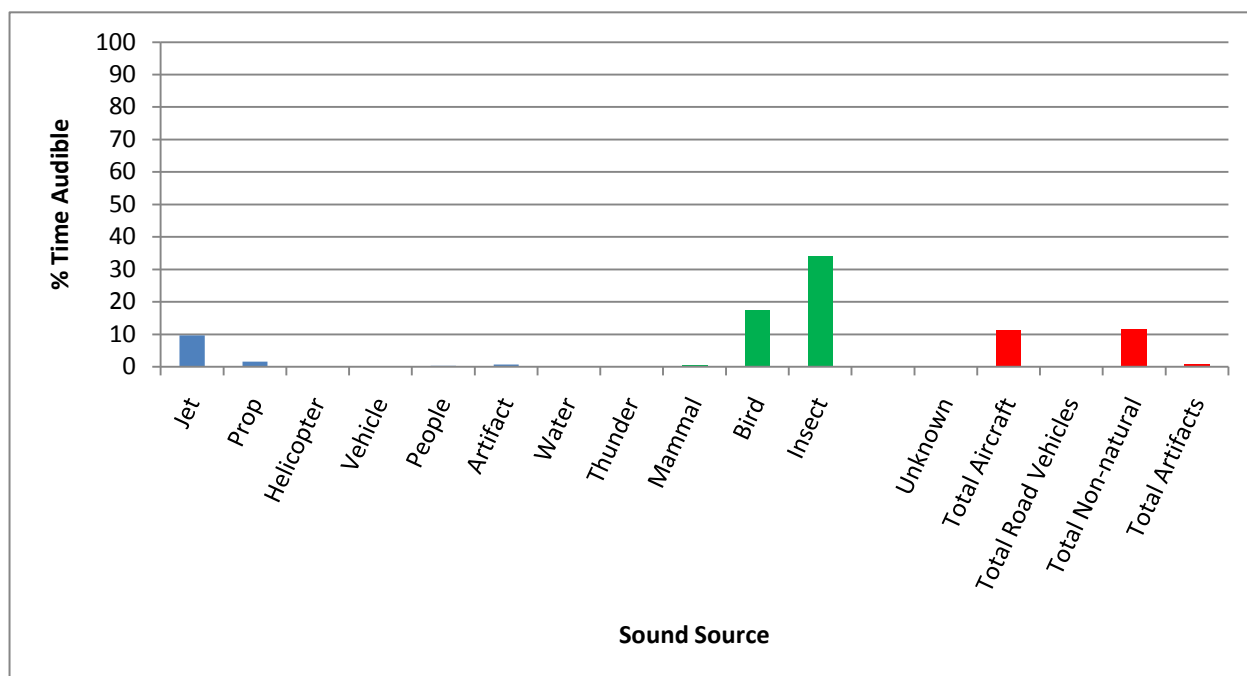


Figure 27. Mean percent time audibility of sound sources at BRCA020 (Paria Backcountry) for the June 15 – 30 sampling period.

Hourly Exceedence Levels

In order to determine the effect extrinsic noise has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. The figures below show existing ambient levels and natural ambient levels. The existing ambient (L_{50}) level for each hour is marked by the upper limit of the gray boxes while the natural ambient level (L_{nat}) is marked by the lower limit of the gray boxes. The height of the box is a measure of the contribution of anthropogenic noise to the existing ambient sound level at each site. The size of these boxes is directly related to the percent time that human caused sounds were audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. These figures also show exceedence metrics L_{10} and L_{90} , which essentially mark the average maximum and minimum levels over the monitoring period. Note that the decibel scale of these figures is not uniform and varies for each site.

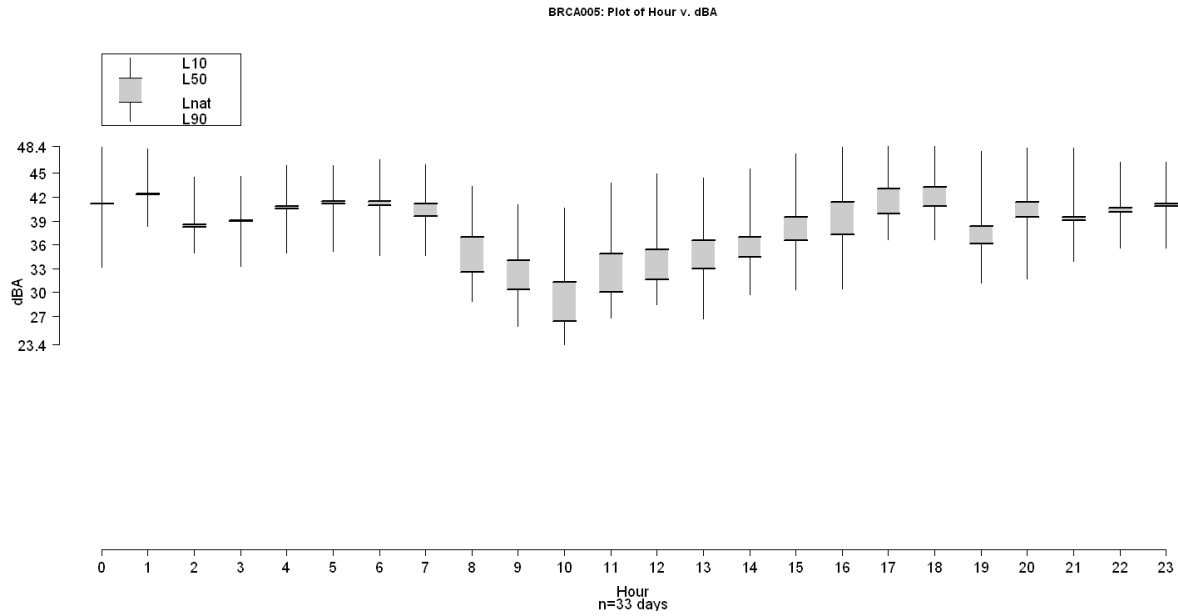


Figure 28. Hourly exceedence levels at BRCA005 (Paria Frontcountry) for April 1 – 27 sampling period.

Figure 28 shows that human-caused or extrinsic sounds contributed to SPL most during the 7:00 am and 7:00 pm hours as indicated by the gray boxes. This is likely due to both vehicle traffic and aircraft overflights near Paria viewpoint. When the boxes do not appear, human-caused sounds are not contributing to the sound pressure level. Wind was audible nearly 90% of the time at this site and could be contributing to the SPL during all hours. Figure 29 through Figure 31 also depict hourly exceedence levels and can be interpreted in a similar fashion.

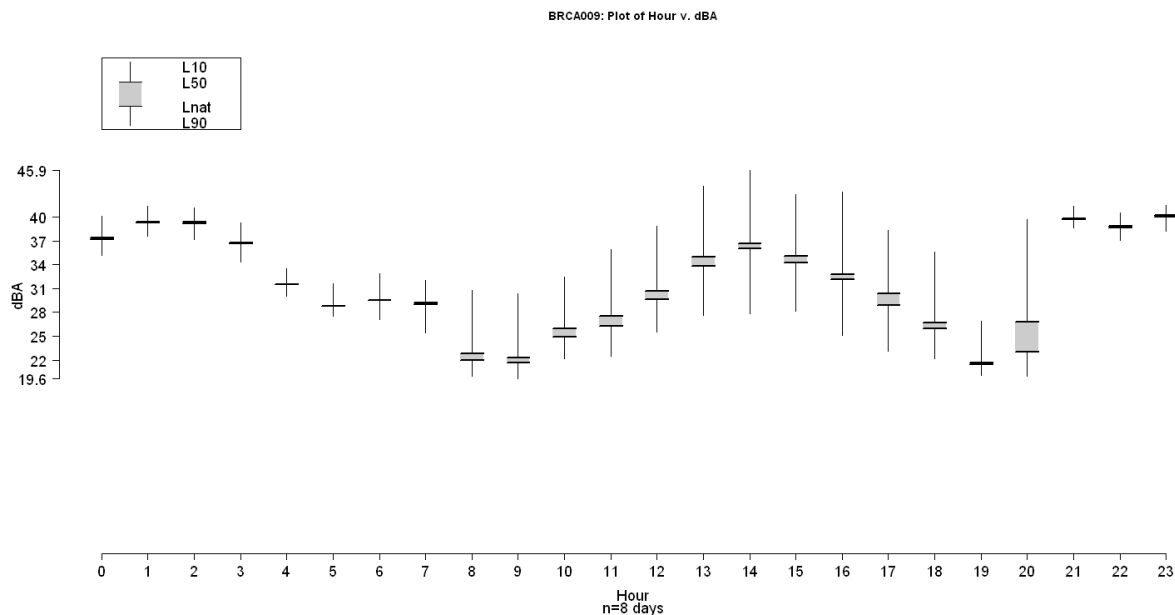


Figure 29. Hourly exceedence levels at BRCA009 (Paria Backcountry) August 8 – 20 sampling period.

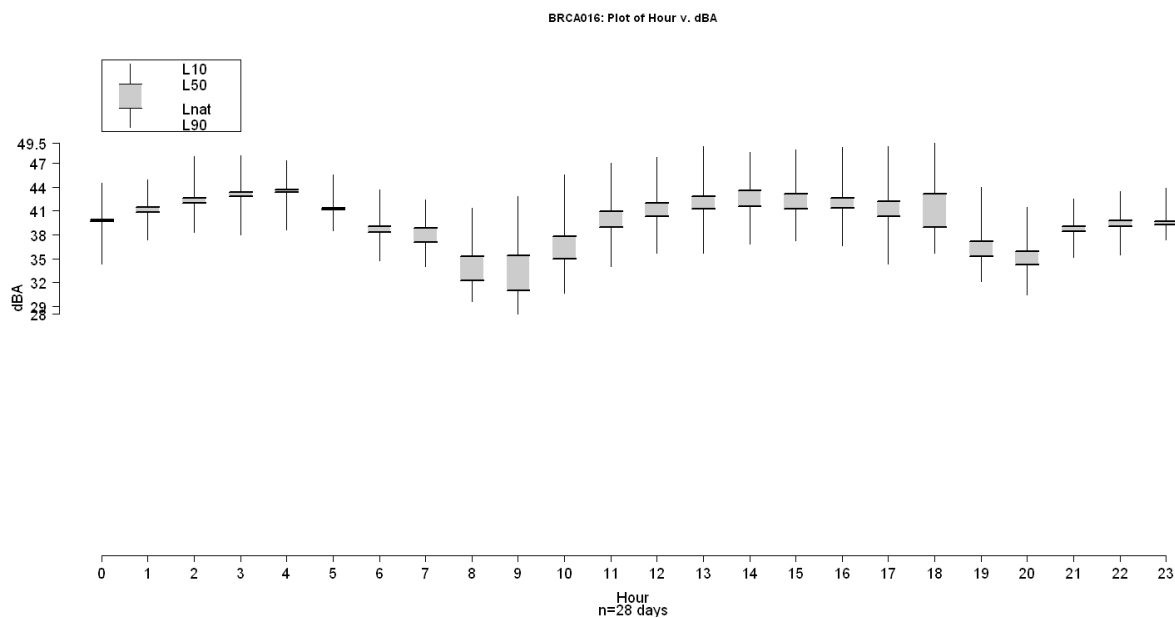


Figure 30. Hourly exceedence levels at BRCA016 (Paria Frontcountry) for the April 12 – May 12 sampling period.

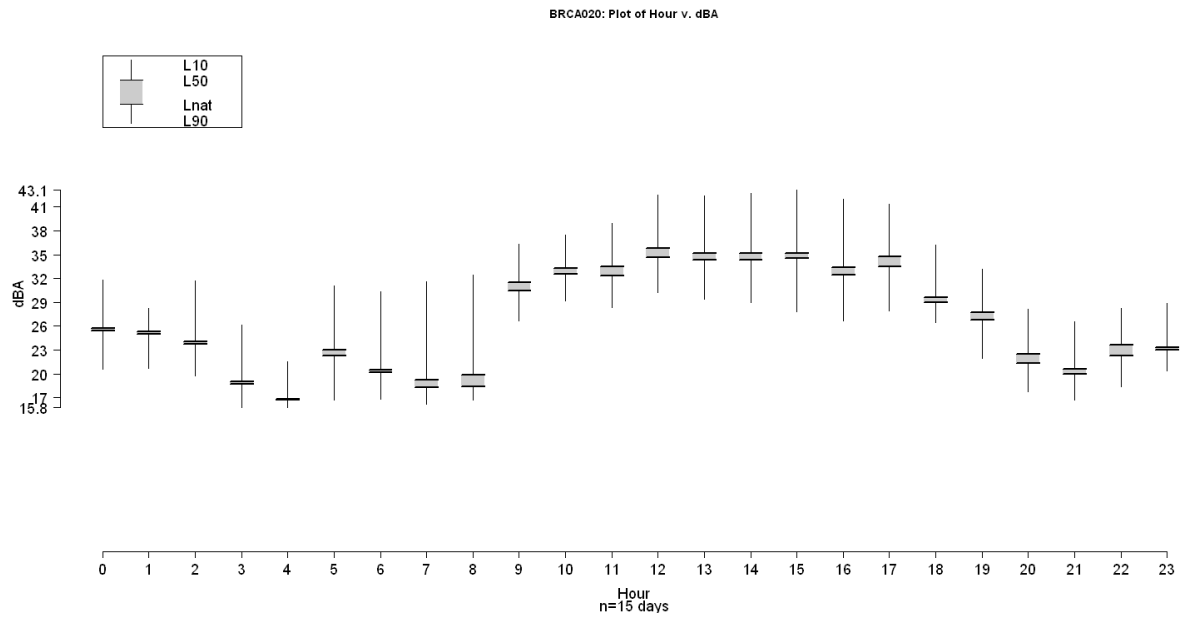


Figure 31. Hourly exceedence levels at BRCA020 (Paria Backcountry) for the June 15 – 30 sampling period.

Audibility of Sounds by Hour

The graphs below show the mean percent time audible statistics for each site (hourly average). Each graphic shows the percentage of time that aircraft and extrinsic sounds were audible during each hour of the day/night. These statistics were determined using off-site listening for frontcountry sites and SPLAT for backcountry sites. These figures show the total percentage of time extrinsic sounds were audible (light gray) and the total percentage of time that aircraft were audible (dark gray) during the off-site listening.

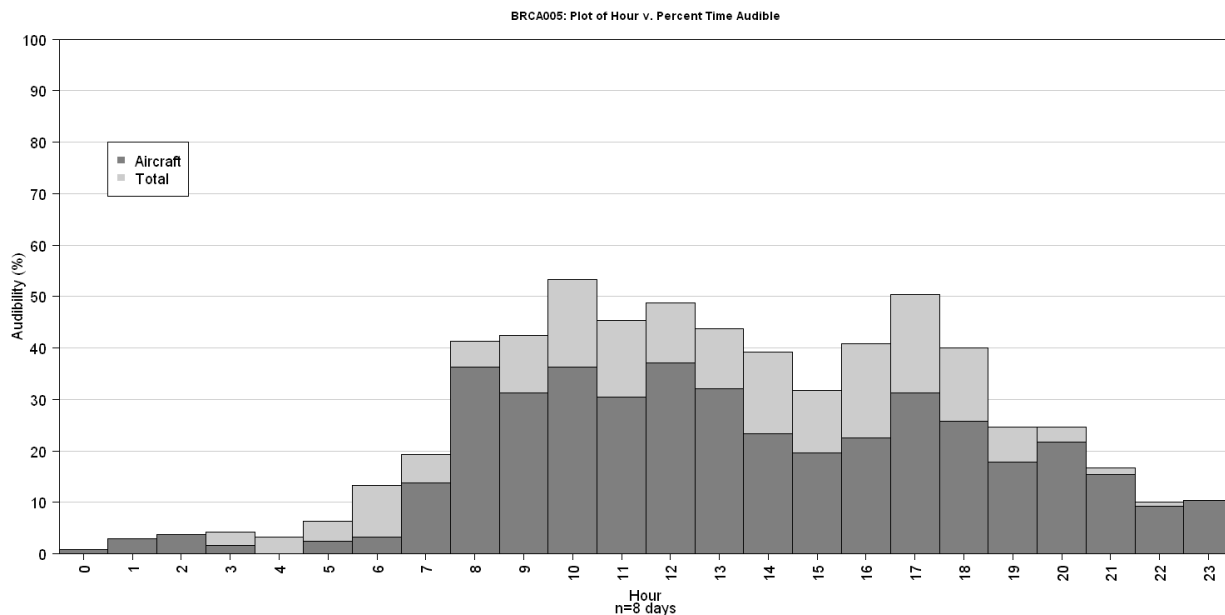


Figure 32. Audibility of extrinsic and aircraft sounds by hour at BRCA005 (Paria Frontcountry) for April 1 – 27 sampling period.

Figure 32 shows the total percentage of time that all extrinsic sounds (light gray) and aircraft sounds (dark gray) were audible for each hour of the day/night. The percentage of time during which all extrinsic sounds were audible often exceeds the time that aircraft were audible. This pattern is common for frontcountry sites where other sounds such as vehicles and people are audible. However, in backcountry locations, it can be expected that aircraft will be the dominant extrinsic sound. From 8:00 am to 1:00 pm, aircraft were audible nearly a third of the time at the Paria Frontcountry site. Extrinsic sounds were most audible at 10:00 am, being heard just over 50% of the time. Figures 33 through 35 also depict audibility of extrinsic and aircraft sounds by hour and can be interpreted in a similar fashion.

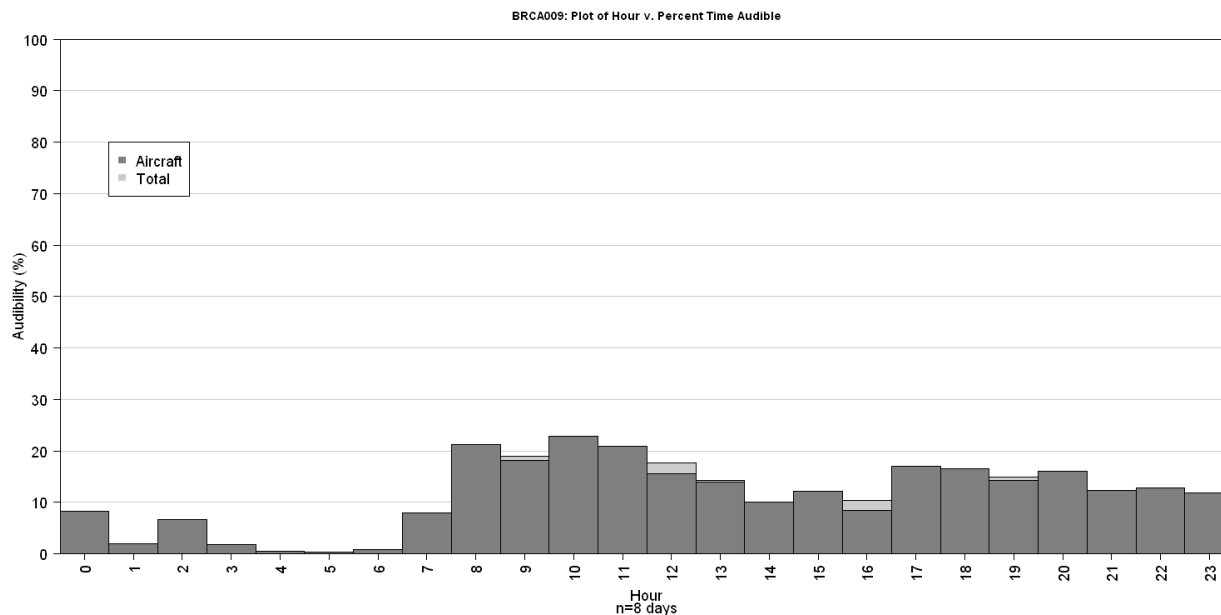


Figure 33. Audibility of extrinsic and aircraft sounds by hour at BRCA009 (Paria Backcountry) August 8 – 20 sampling period.

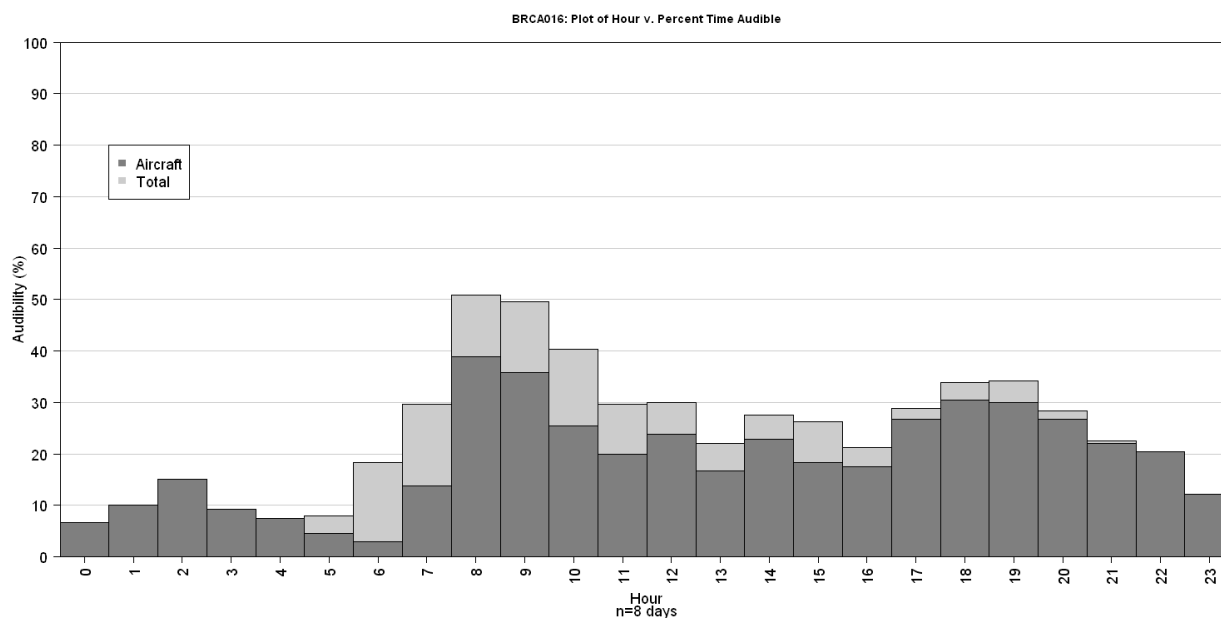


Figure 34. Audibility of extrinsic and aircraft sounds by hour at BRCA016 (Paria Frontcountry) for the April 12 – May 12 sampling period.

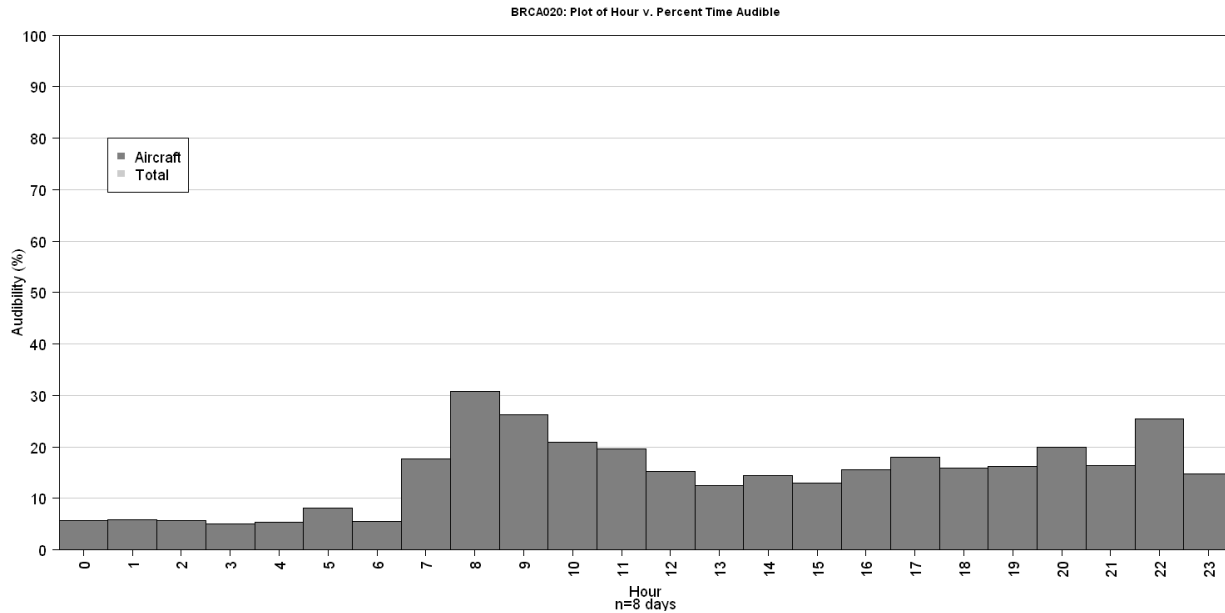


Figure 35. Audibility of extrinsic and aircraft sounds by hour at BRCA020 (Paria Backcountry) for the June 15 – 30 sampling period.

Paria Acoustic Summary

At all Paria sites, aircraft noise, especially high-altitude jet aircraft, was the dominant extrinsic sound. Further, extrinsic sounds elevated the existing ambient sound level more during the daylight hours than at night for all locations. Wind was audible over 60% of the time at all sites and likely increased SPL at each site. Further, wind masking could have occurred at all sites and may have concealed other natural and extrinsic sounds intermittently. Peak aircraft activity occurred between 8:00 am and 11:00 am for most sites. Although low-elevation fixed wing aircraft were audible less than 5% of the times across all Paria sites, the short-duration, high-decibel events have a more dramatic effect on L_{10} which documents acute conditions.

Frontcountry Locations (BRCA005, BRCA016)

From 8:00 am to 1:00 pm, aircraft were audible nearly a third of the time at the 2009 Paria Frontcountry site (BRCA005) with the 2010 frontcountry site (BRCA016) showing a similar spike in activity for these hours. Both sites showed elevated hourly exceedence levels for early morning and late evening hours when wind was more prevalent.

Backcountry Locations (BRCA009, BRCA020)

At backcountry sites, aircraft was the only consistently audible extrinsic sound source. Because of the remote nature of the backcountry sites, other extrinsic sound sources such as vehicle and visitor sounds were virtually absent. The 2009 backcountry location (BRCA009) showed dramatically elevated hourly exceedence levels for early morning and late evening hours when wind was more prevalent.

Sheep / Swamp Monitoring Results

Overview

The Sheep / Swamp monitoring area was located in the central portion of the park and included one frontcountry and one backcountry monitoring site. The 2009 frontcountry unit was located slightly below the rim near the Swamp Canyon viewpoint and associated parking area and roadway, while the 2010 backcountry unit was located under the rim, near the junction of the Swamp Canyon Connector and Under the Rim trails. The frontcountry site was analyzed using office listening, while the quieter backcountry site was analyzed using SPLAT. Table 9 below summarizes the monitoring effort at Sheep / Swamp monitoring locations. Figure 36 and Figure 37 below show photographs of each site.

Table 9. Soundscape Monitoring at Sheep / Swamp Locations 2009-2010.

Site Name	Acoustic Zone	Year	Dates of deployment	Total days of acoustic monitoring	Hours of Attended Listening
BRCA007	Frontcountry	2009	4/29-6/8	38	8
BRCA021	Backcountry	2010	6/18-7/6	19	3



Figure 36. BRCA007 (near Sheep / Swamp Frontcountry 2009) acoustic monitoring site.

BRCA007, the 2009 Sheep / Swamp Canyon monitoring site, was located slightly below the rim at an elevation of 2435 meters in a ponderosa pine dominated conifer forest. This frontcountry site was positioned below the Swamp Canyon overlook and associated parking area and roadway. The site was monitored from late April through early June of 2009.



Figure 37. BRCA021 (Swamp Canyon Backcountry 2010) acoustic monitoring site.

BRCA021, the 2010 Swamp Canyon Backcountry acoustic monitoring site, was located below the rim at an elevation of 2323 meters in a ponderosa pine community that burned in 2009. Regenerating understory plants consisted of manzanita and gamble oak. This backcountry site was monitored from June through July of 2010.

Mean Percent Time Audibility

The graphs below show the mean percent time audible statistics for each site (24 hour mean). These statistics were determined using off-site listening for frontcountry sites and SPLAT for most backcountry sites. In all cases, these figures show the mean percent time each sound source was audible during the monitoring period. Individual sound sources are represented with blue (non-natural), green (natural), and black (unknown) bars while red bars represent the total non-natural sound sources. Artifact sounds include equipment noise such as audio distortion at high-wind speeds or rain falling on the microphone.

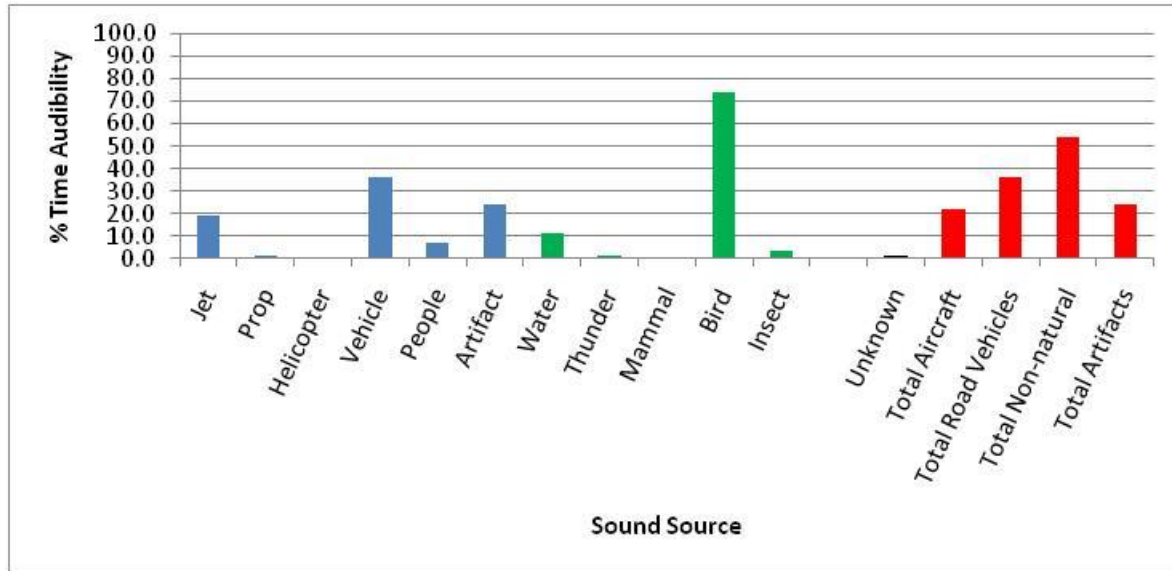


Figure 38. Mean percent time audibility of sound sources at BRCA007 (Sheep/Swamp Frontcountry) for the April 29 – June 8 sampling period.

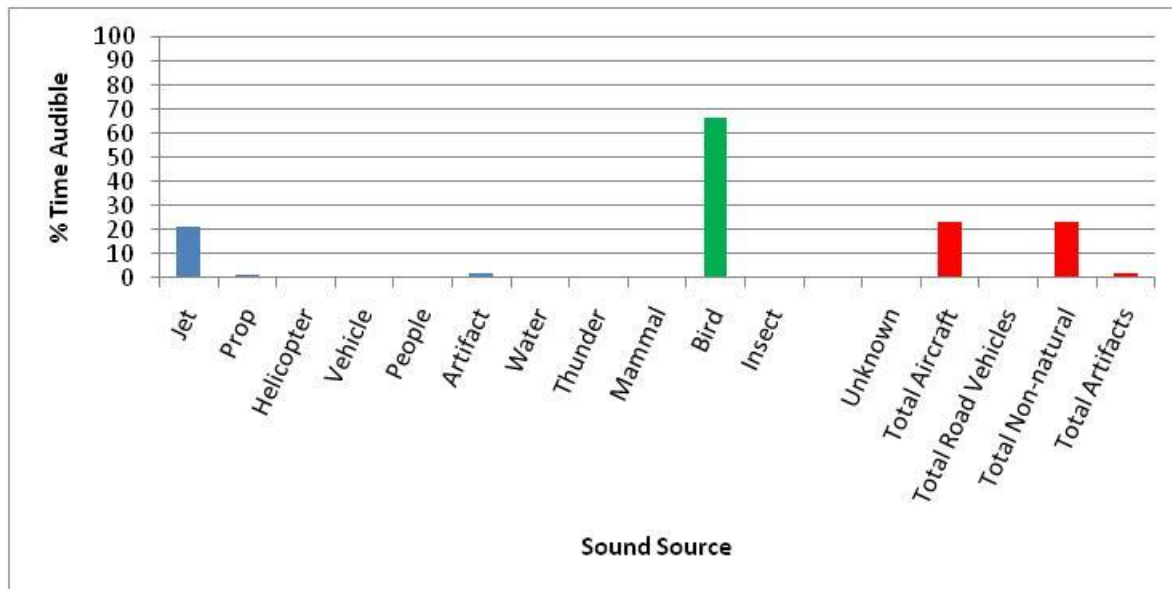


Figure 39. Mean percent time audibility of sound sources at BRCA021 (Swamp Canyon Backcountry) for the June 18 – July 6 sampling period.

Hourly Exceedence Levels

In order to determine the effect extrinsic noise has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. The figures below show existing ambient levels and natural ambient levels. The existing ambient (L_{50}) level for each hour is marked by the upper limit of the gray boxes while the natural ambient level (L_{nat}) is marked by the lower limit of the gray boxes. The height of the box is a measure of the contribution of anthropogenic noise to the existing ambient sound level at each site. The size of these boxes is directly related to the percent time that human caused sounds were audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. These figures also show exceedence metrics L_{10} and L_{90} , which essentially mark the average maximum and minimum levels over the monitoring period. Note that the decibel scale of these figures is not uniform and varies for each site.

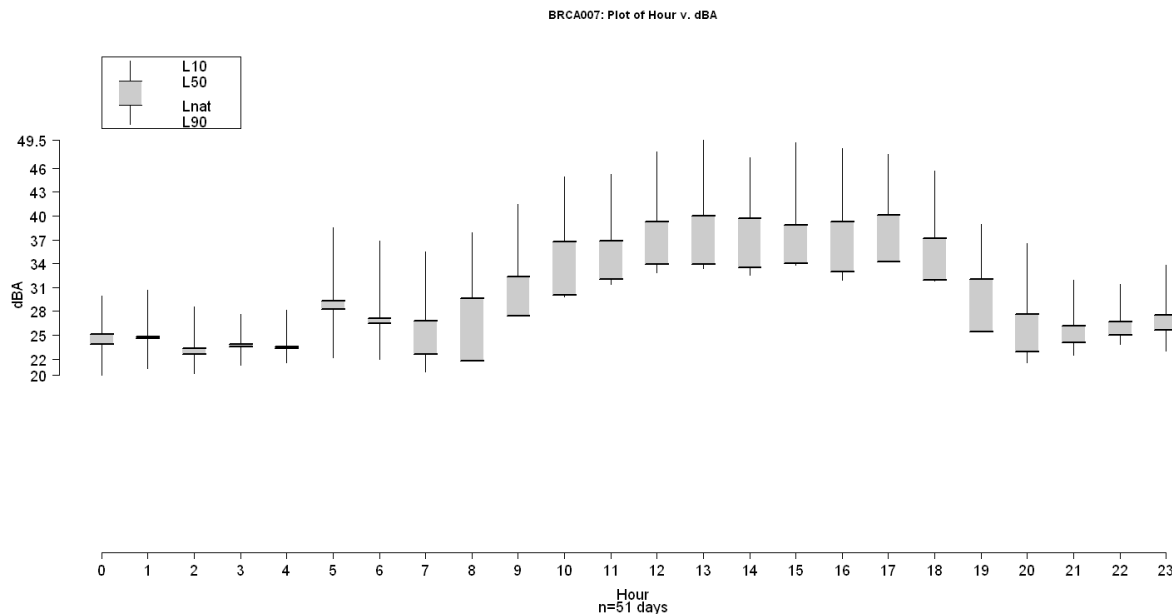


Figure 40. Hourly exceedence levels at BRCA007 (Sheep/Swamp Frontcountry) for the April 29 – June 8 sampling period.

Figure 40 shows that human-caused or extrinsic sounds contributed to SPL levels most from 7:00 am to 8:00 pm as indicated by the gray boxes. When visitors were most likely present at the location (8:00 am to 8:00 pm), the measured difference between L_{nat} and L_{50} for each hour was at least 5 decibels. This is likely due to vehicle, aircraft, and visitor noise near the Swamp Canyon overlook. When the boxes do not appear, human-caused sounds are not contributing to the sound pressure level. Wind was audible over 70% of the time at this site and could be contributing to the SPL during all hours. Figure 41 also depicts hourly exceedence levels and can be interpreted in a similar fashion.

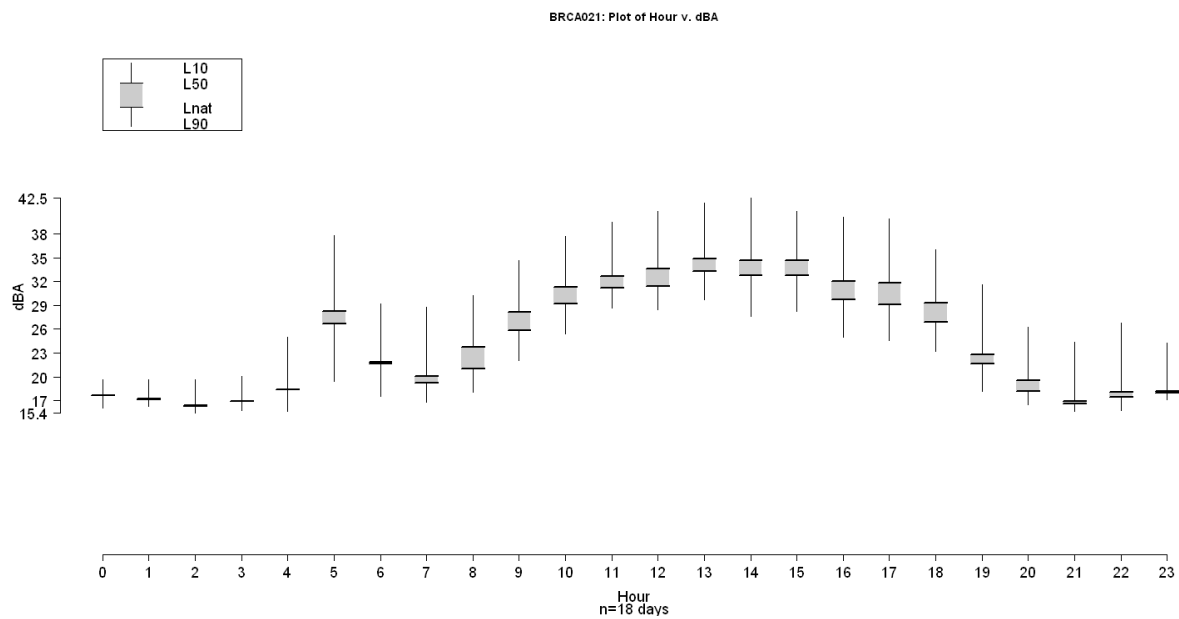


Figure 41. Hourly exceedence levels at BRCA021 (Swamp Canyon Backcountry) for the June 18 – July 6 sampling period.

Audibility of Sounds by Hour

The graphs below show the mean percent time audible statistics for each site (hourly average). Each graphic shows the percentage of time that aircraft and extrinsic sounds were audible during each hour of the day/night. These statistics were determined using off-site listening for frontcountry sites and SPLAT for backcountry sites. These figures show the total percentage of time extrinsic sounds were audible (light gray) and the total percentage of time that aircraft were audible (dark gray) during the off-site listening.

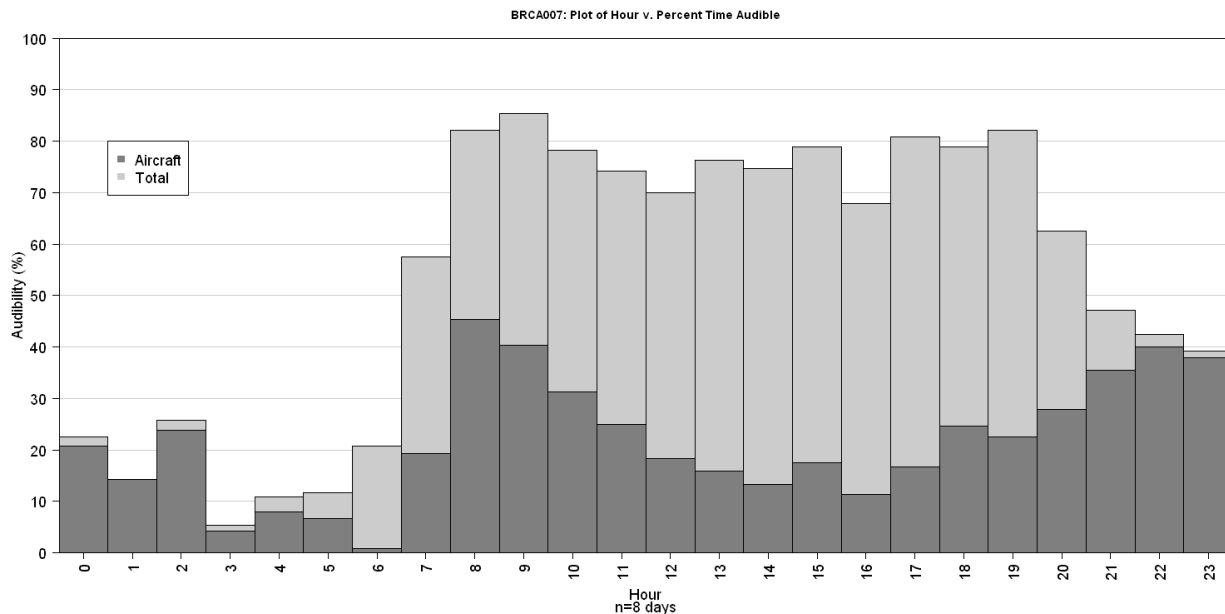


Figure 42. Audibility of extrinsic and aircraft sounds by hour at BRCA007 (Sheep/Swamp Frontcountry) for the April 29 – June 8 sampling period.

Figure 42 shows the total percentage of time that all extrinsic sounds (light gray) and aircraft sounds (dark gray) were audible for each hour of the day/night. The percentage of time during which all extrinsic sounds were audible often exceeds the time that aircraft were audible. This pattern is common for frontcountry sites where other sounds such as vehicles and people are audible. However, in backcountry locations, it can be expected that aircraft will be the dominant extrinsic sound. From 7:00 am to 8:00 pm, extrinsic sounds were audible over 50% of the time at the Sheep/Swamp Frontcountry site. Extrinsic sounds were audible the greater than 80% of the time from 8:00 to 9:00 am, as well as the hours of 5:00 and 7:00 pm. Figure 43 also depicts extrinsic and aircraft sounds by hour and can be interpreted in a similar fashion.

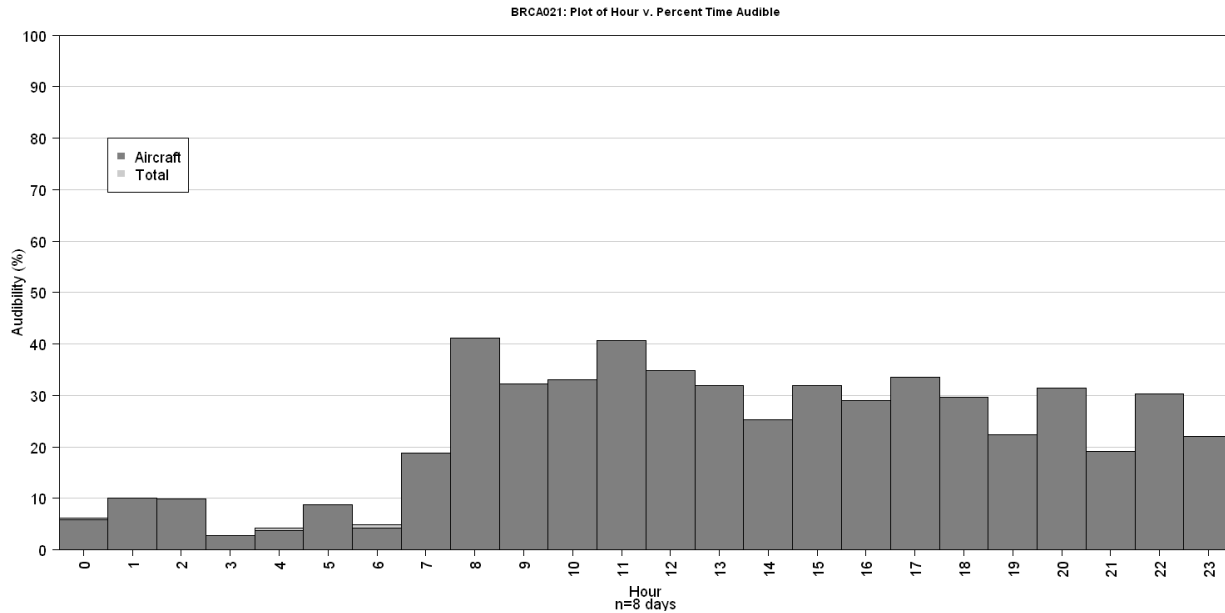


Figure 43. Audibility of extrinsic and aircraft sounds by hour at BRCA021 (Swamp Canyon Backcountry) for the June 18 – July 6 sampling period.

Sheep / Swamp Acoustic Summary

At both Sheep / Swamp monitoring locations, extrinsic sounds contributed to existing ambient levels more during the day than at night. Aircraft, especially high-altitude jets, were also a substantial source of extrinsic sound, being audible over 20% of the time at both sites. Wind was audible greater than half the time and could have contributed to SPL at both sites. Further, wind likely played a role in masking other extrinsic and natural sounds that would have otherwise been audible. Although low-elevation fixed wing aircraft were audible less than 5% of the time at both sites, the short-duration, high-decibel events have a more dramatic effect on L_{10} which documents acute conditions.

Frontcountry Location (BRCA007)

At the frontcountry site, vehicle noise was audible over 35% percent of the time. At BRCA007, aircraft activity peaked between the hours of 8:00 am and 10:00 am, and again between 9:00 pm and 11:00 pm.

Backcountry Location (BRCA021)

Aircraft noise was the only audible extrinsic sound at the backcountry site which was located away from park roads and viewpoints. Aircraft activity increased notably at 8:00 am and then remained fairly constant throughout the rest of the day. In the absence of extrinsic sounds, the backcountry location proved to be remarkably quiet with an existing ambient level of around 18 dBA between the hours of 12:00 am and 4:00 am.

Farview Monitoring Results

Overview

The Farview monitoring area was located in the southern half of the park adjacent to the Farview viewpoint and park roadway. Units were deployed at two frontcountry locations near the rim and at one backcountry location under the rim in the 2009-2010 seasons. Frontcountry sites were analyzed using office listening, while backcountry sites were analyzed using SPLAT. Table 10 below summarizes the monitoring effort at Farview monitoring locations. Figure 44 through Figure 46 below show photographs of each site.

Table 10. Soundscape Monitoring at Farview Locations 2009-2010.

Site Name	Acoustic Zone	Year	Dates of deployment	Total days of acoustic monitoring	Hours of Attended Listening
BRCA006	Frontcountry	2009	4/ 2- 4/28	26	7
BRCA017	Frontcountry	2010	4/14 - 5/11	28	8
BRCA022	Backcountry	2010	7/19 - 8/13	26	3



Figure 44. Near BRCA006 (Farview Frontcountry 2009) acoustic monitoring site.

BRCA006, the 2009 Farview Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2689 meters in mixed conifer forest and near cliff edge habitat. This frontcountry site was monitored in April of 2009 and was located within 30 meters of the park roadway and within 350 meters of the Farview viewpoint.



Figure 45. BRCA017 (Farview Frontcountry 2010) acoustic monitoring site.

BRCA017, the 2010 Farview Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2689 meters in ponderosa pine dominated forest habitat. This frontcountry site was monitored from April through May of 2010 and utilized the same location as BRCA006. As the above photograph shows, snow was present at the site for a portion of the monitoring period.



Figure 46. BRCA022 (Farview Backcountry 2010) acoustic monitoring site.

BRCA022, the 2010 Farview Backcountry acoustic monitoring site, was located below the rim at an elevation of 2482 meters in a mixed conifer forest near cliff habitat. This backcountry site was monitored from July through August of 2010.

Mean Percent Time Audibility

The graphs below show the mean percent time audible statistics for each site (24 hour mean). These statistics were determined using off-site listening for frontcountry sites and SPLAT for most backcountry sites. In all cases, these figures show the mean percent time each sound source was audible during the monitoring period. Individual sound sources are represented with blue (non-natural), green (natural), and black (unknown) bars while red bars represent the total non-natural sound sources. Artifact sounds include equipment noise such as audio distortion at high-wind speeds or rain falling on the microphone.

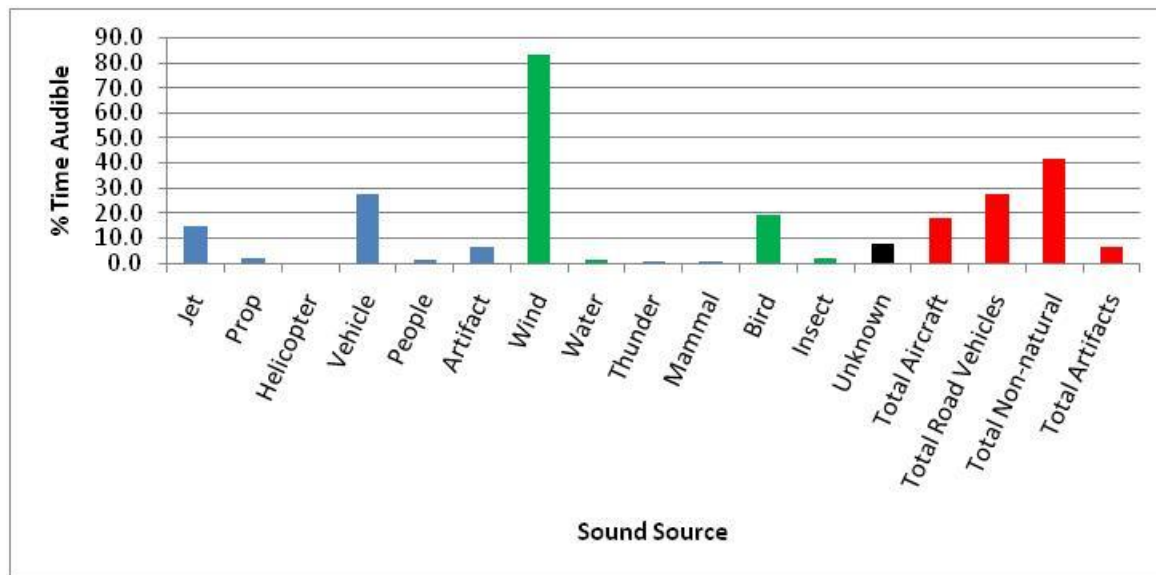


Figure 47. Mean percent time audibility of sound sources at BRCA006 (Farview Frontcountry) for the April 2 – 28 sampling period.

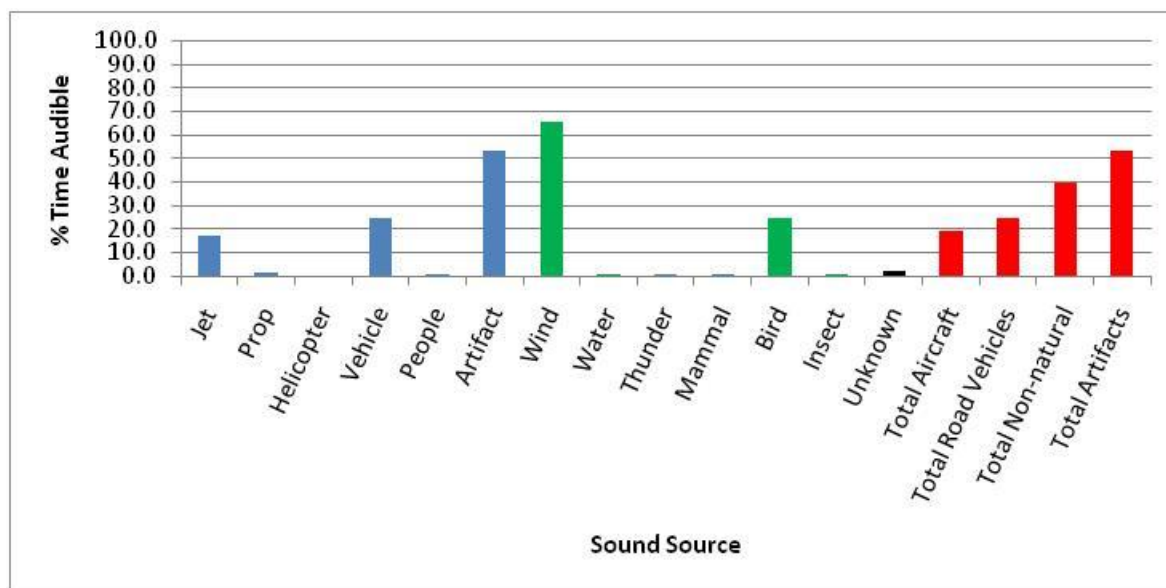


Figure 48. Mean percent time audibility of sound sources at BRCA017 (Farview Frontcountry) for the April 14 – May 11 sampling period.

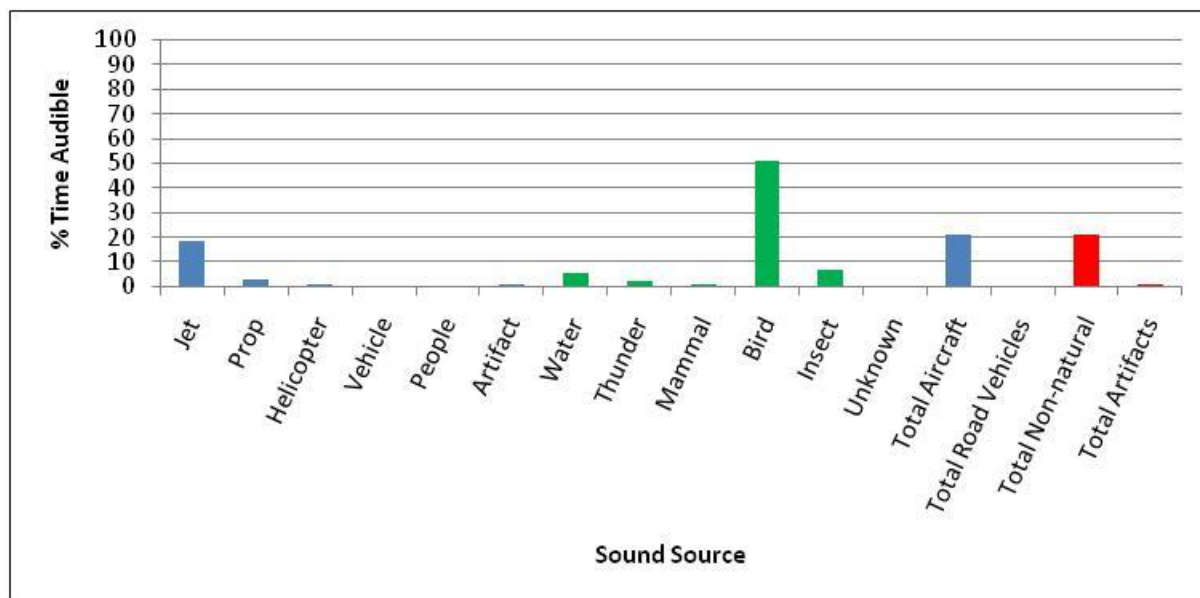


Figure 49. Mean percent time audibility of sound sources at BRCA022 (Farview Backcountry) for the July 19 – August 13 sampling period.

Hourly Exceedence Levels

In order to determine the effect extrinsic noise has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. The figures below show existing ambient levels and natural ambient levels. The existing ambient (L_{50}) level for each hour is marked by the upper limit of the gray boxes while the natural ambient level (L_{nat}) is marked by the lower limit of the gray boxes. The height of the box is a measure of the contribution of anthropogenic noise to the existing ambient sound level at each site. The size of these boxes is directly related to the percent time that human caused sounds were audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. These figures also show exceedence metrics L_{10} and L_{90} , which essentially mark the average maximum and minimum levels over the monitoring period. Note that the decibel scale of these figures is not uniform and varies for each site.

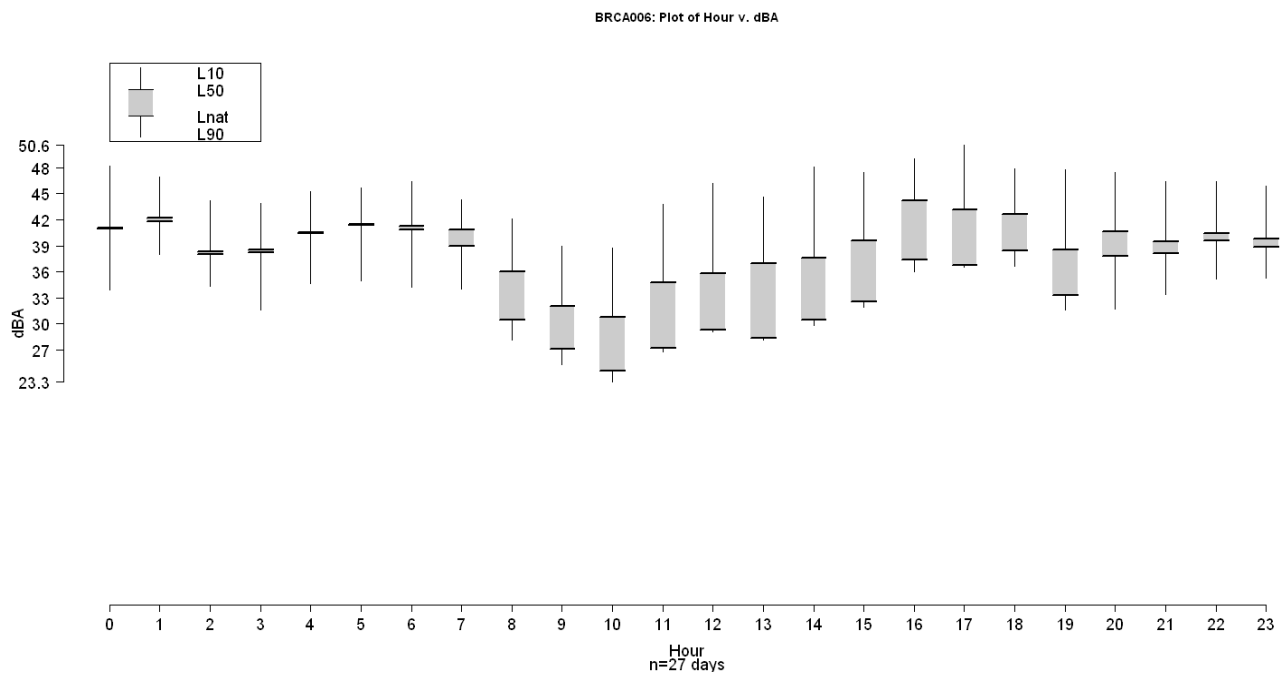


Figure 50. Hourly exceedence levels at BRCA006 (Farview Frontcountry) for the April 2 – 28 sampling period.

Figure 50 shows that human-caused or extrinsic sounds contributed to SPL levels mostly from 8:00 am to 9:00 pm as indicated by the gray boxes. When visitors were most likely present at the location (8:00 am to 8:00 pm), the measured difference between L_{nat} and L_{50} for each hour was at substantial. This is likely due to the predominance of vehicle noise near the monitoring location. Aircraft and visitor noise also contributed to SPL at the site. When the boxes do not appear, human-caused sounds are not contributing to the sound pressure level. Wind was audible over 80% of the monitoring period at the Farview Frontcountry location and could be contributing to the SPL during all hours. Figure 51 and Figure 52 also depict hourly exceedence levels and can be interpreted in a similar fashion.

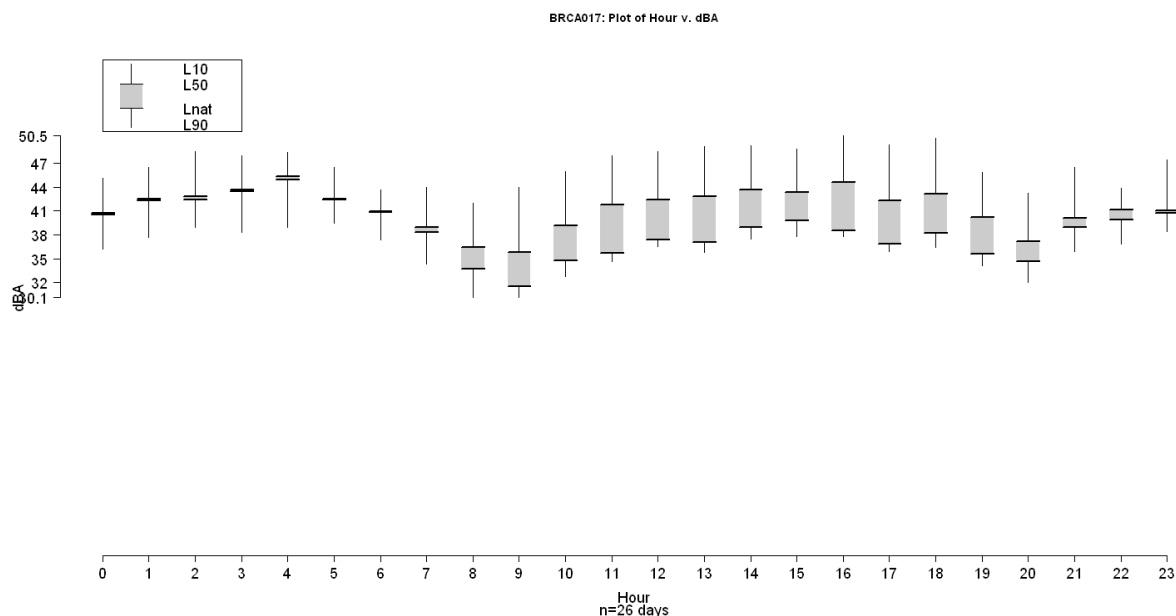


Figure 51. Hourly exceedence levels at BRCA017 (Farview Frontcountry) for the April 14 – May 11 sampling period.

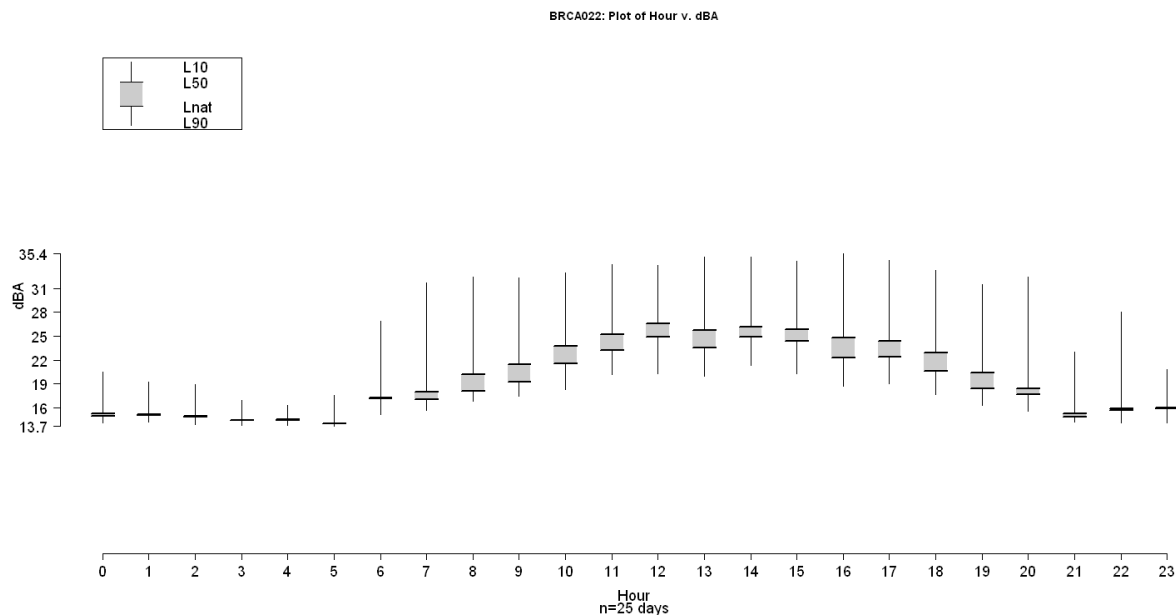


Figure 52. Hourly exceedence levels at BRCA022 (Farview Backcountry) for the July 19 – August 13 sampling period.

Audibility of Sounds by Hour

The graphs below show the mean percent time audible statistics for each site (hourly average). Each graphic shows the percentage of time that aircraft and extrinsic sounds were audible during each hour of the day/night. These statistics were determined using off-site listening for frontcountry sites and SPLAT for backcountry sites. These figures show the total percentage of time extrinsic sounds were audible (light gray) and the total percentage of time that aircraft were audible (dark gray) during the off-site listening.

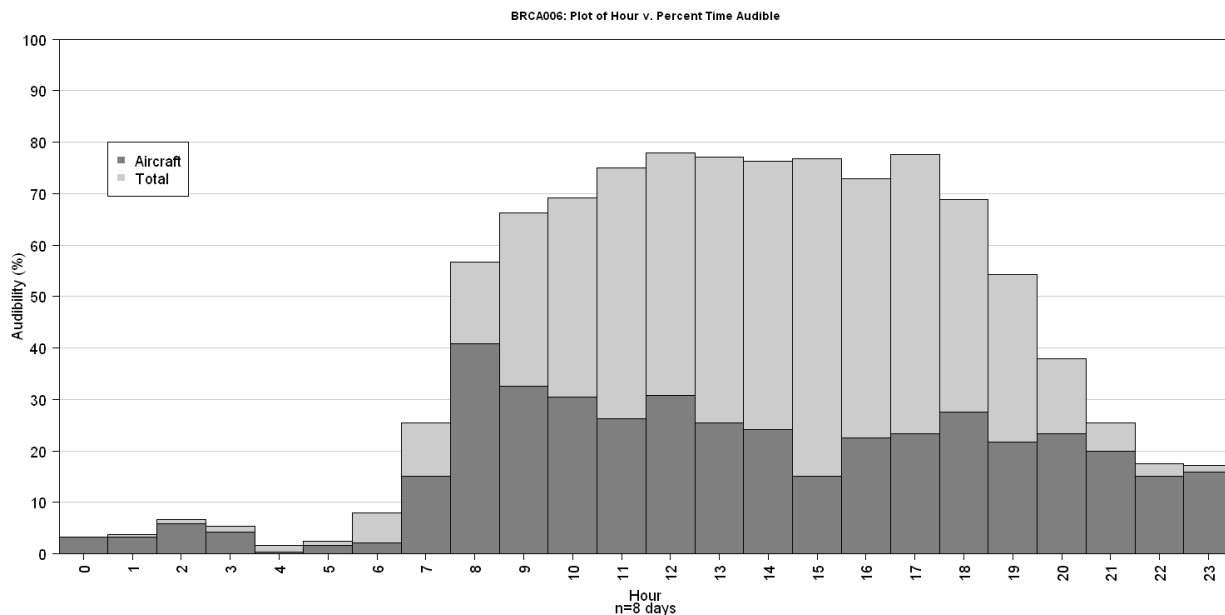


Figure 53. Audibility of extrinsic and aircraft sounds by hour at BRCA006 (Farview Frontcountry) for the April 2 – 28 sampling period.

Figure 53 illustrates that the proportion of extrinsic sound associated with aircraft (dark gray bars) represents a relatively smaller proportion of the total extrinsic sound present at the Farview Frontcountry site (light gray bars) than found at most frontcountry sites. This is due to the sites close proximity to an adjacent roadway and the resulting large contribution of vehicle noise to the total extrinsic sound value. Additionally, extrinsic sound was audible greater than 60% of the time between the hours of 9:00 am and 6:00 pm during the sampling period. Figure 54 and 55 also depict audibility of extrinsic and aircraft noise by hour and can be interpreted in a similar fashion.

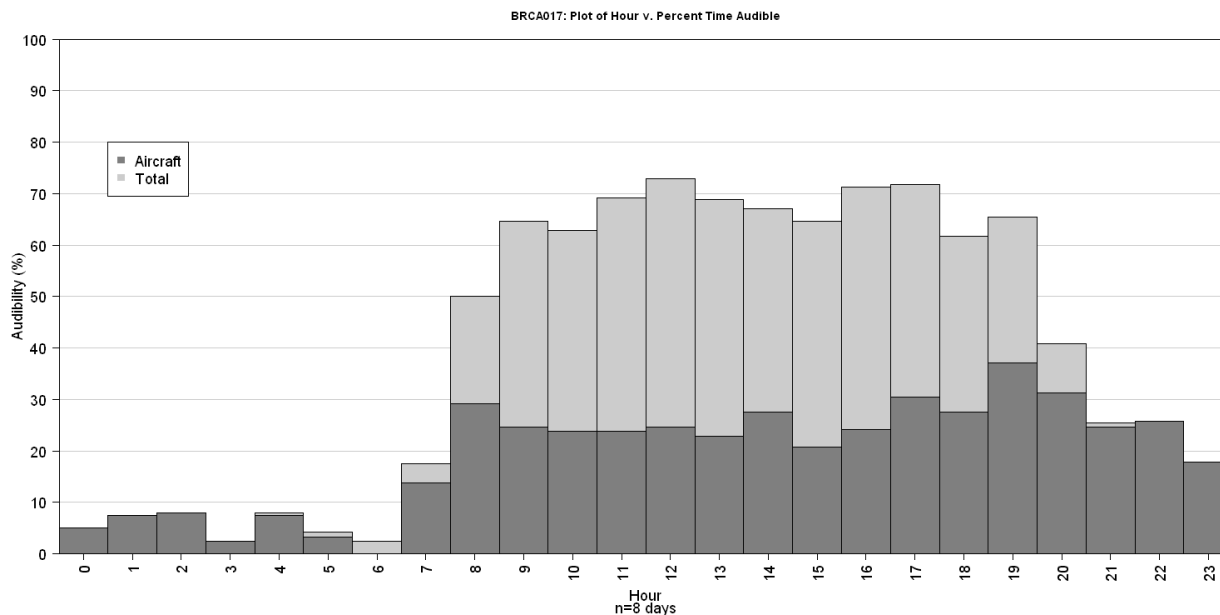


Figure 54. Audibility of extrinsic and aircraft sounds by hour at BRCA017 (Farview Frontcountry) for the April 14 – May 11 sampling period.

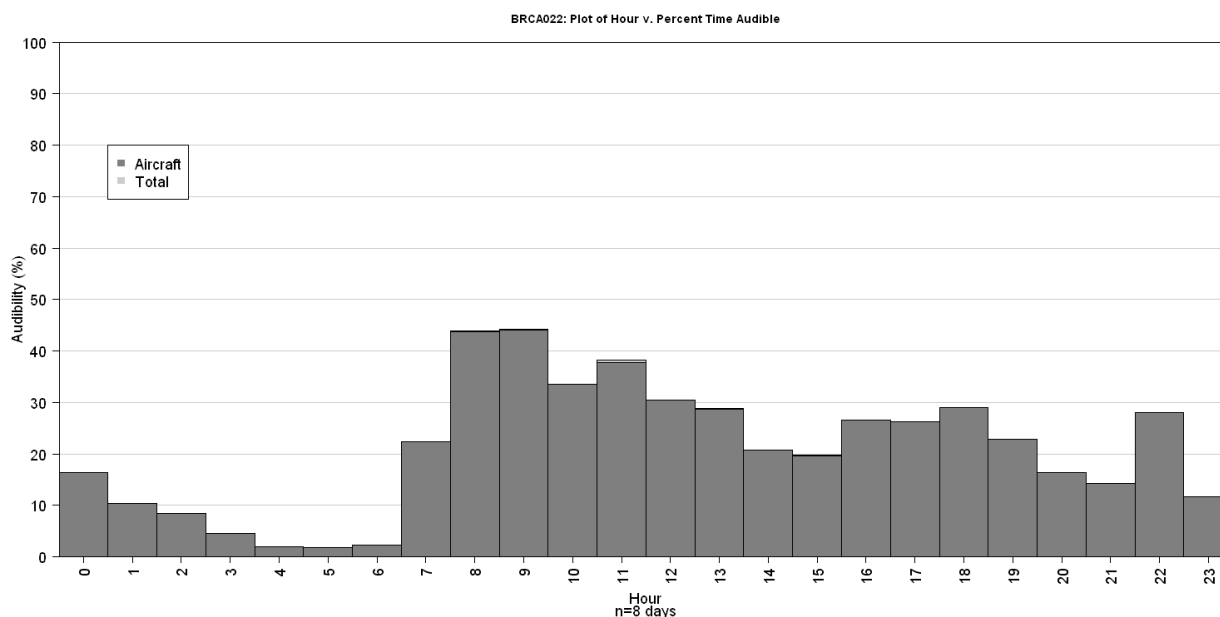


Figure 55. Audibility of extrinsic and aircraft sounds by hour at BRCA022 (Farview Backcountry) for the July 19 – August 13 sampling period.

Farview Acoustic Summary

At all Farview sites, aircraft, especially high-altitude jets, were a primary source of extrinsic sound, being audible nearly 20% of the time. Across monitoring locations, extrinsic sounds contributed to existing ambient levels more during the day than at night. Wind was audible greater than 50% of the time and could have contributed to SPL at all sites. Additionally, wind likely played a role in masking other extrinsic and natural sounds that would have otherwise been audible. Although low-elevation fixed wing aircraft were audible less than 5% of the time at all sites, the short-duration, high-decibel events have a more dramatic effect on L_{10} which documents acute conditions.

Frontcountry Locations (BRCA00, BRCA017)

At both the 2009 and 2010 frontcountry sites, vehicle noise was the dominant extrinsic sound source and was audible more than 25% of the time. Further, extrinsic sound was audible greater than 60% of the time between the hours of 9:00 am and 6:00 pm at both frontcountry locations. Peak aircraft activity at BRCA006 generally occurred between the hours of 8:00 am and 10:00 am, with BRCA017 showing minor peaks at 8:00 am and again between 7:00 pm and 8:00 pm. Because the 2009 and 2010 Farview frontcountry sites were deployed in the same location, and because monitoring took place at the same time of year, both sites show similar patterns of audibility.

Backcountry Location (BRCA022)

Aircraft noise was the only audible extrinsic sound at the backcountry site which was located away from park roads and viewpoints. Aircraft activity increased notably at 8:00 am and then remained fairly constant throughout the rest of the day with a peak in activity between 8:00 am and 10:00 am. In the absence of extrinsic sounds, BRCA022 proved to be one of the quietest locations in the park, with an existing ambient level of around 16 dBA between the hours of 12:00 am and 5:00 am, and again between 9:00 pm and 11:00 pm.

Yovimpa Monitoring Results

Overview

The Yovimpa monitoring area was located at the southern terminus of the park and included two frontcountry and two backcountry monitoring locations in the 2009-2010 seasons. The frontcountry locations were on the rim between the Yovimpa and Bristlecone viewpoints, adjacent to the Bristlecone Loop Trail. One unit was deployed in the backcountry for each of the 2009 and 2010 seasons and both were located under the rim. The frontcountry sites where visitor and vehicle noise was audible were analyzed using office listening, while the quieter backcountry sites were analyzed using SPLAT. Table 11 below summarizes the monitoring effort at Yovimpa monitoring locations. Figure 56 through Figure 59 below show photographs of each site.

Table 11. Soundscape Monitoring at Yovimpa Locations 2009-2010.

Site Name	Acoustic Zone	Year	Dates of deployment	Total days of acoustic monitoring	Hours of Attended Listening
BRCA008	Frontcountry	2009	4/30 - 6/3	38	8
BRCA012	Backcountry	2009	7/8 - 7/29	22	6
BRCA019	Frontcountry	2010	5/12 - 6/14	34	10
BRCA023	Backcountry	2010	7/20 - 8/11	18	4

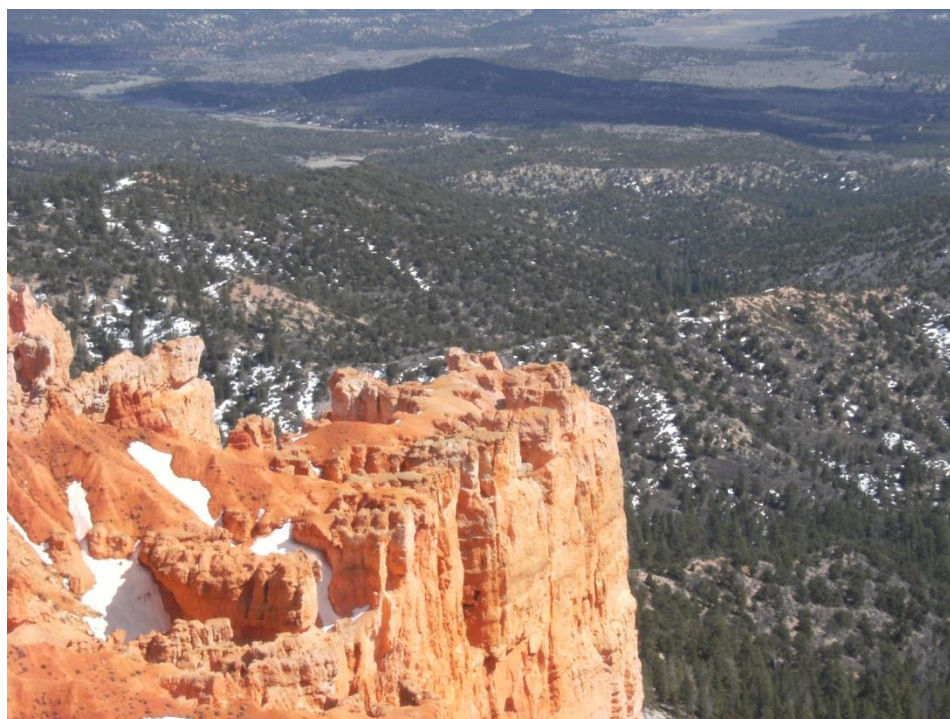


Figure 56. BRCA008 (near Yovimpa Frontcountry 2009) acoustic monitoring site.

BRCA008, the 2009 Yovimpa Frontcountry acoustic monitoring site, was located on the rim at an elevation of 2766 meters in white fir dominated conifer forest and near cliff edge habitat. The site was adjacent to a section of the Bristlecone Loop Trail and was located near both Bristlecone

Point and Yovimpa overlooks. This frontcountry site was monitored from late April through early June of 2009.



Figure 57. BRCA012 (near Yovimpa Backcountry 2009) acoustic monitoring site.

BRCA012, the 2009 Yovimpa Backcountry acoustic monitoring site, was located below the rim at an elevation of 2462 meters. The habitat was characterized by mixed conifer forest with large rock outcroppings and associated cliff habitat. This backcountry site was near the Riggs Springs Trail and was monitored in July of 2009.



Figure 58. BRCA019 (near Yovimpa Frontcountry 2010) acoustic monitoring site.

BRCA019, the 2010 Yovimpa Frontcountry acoustic monitoring site, was located on the rim and at an elevation of 2769 meters, was the highest site monitored throughout the 2009-2010 seasons. Site habitat was characterized by ponderosa pine, Douglas fir, and manzanita. The Bristlecone

Loop Trail, Bristlecone and Yovimpa overlooks were nearby. This cliff side, frontcountry site was monitored from May through June 2010.



Figure 59. BRCA023 (Yovimpa Backcountry 2010) acoustic monitoring site.

BRCA023, the 2010 Yovimpa Backcountry acoustic monitoring site, was located below the rim at an elevation of 2460 meters in a mixed conifer forest near cliff habitat. The site was located adjacent to and above a small seasonal stream with slow-moving water. This backcountry site was monitored from July through August of 2010.

Mean Percent Time Audibility

The graphs below show the mean percent time audible statistics for each site (24 hour mean). These statistics were determined using off-site listening for frontcountry sites and SPLAT for most backcountry sites. In all cases, these figures show the mean percent time each sound source was audible during the monitoring period. Individual sound sources are represented with blue (non-natural), green (natural), and black (unknown) bars while red bars represent the total non-natural sound sources. Artifact sounds include equipment noise such as audio distortion at high-wind speeds or rain falling on the microphone.

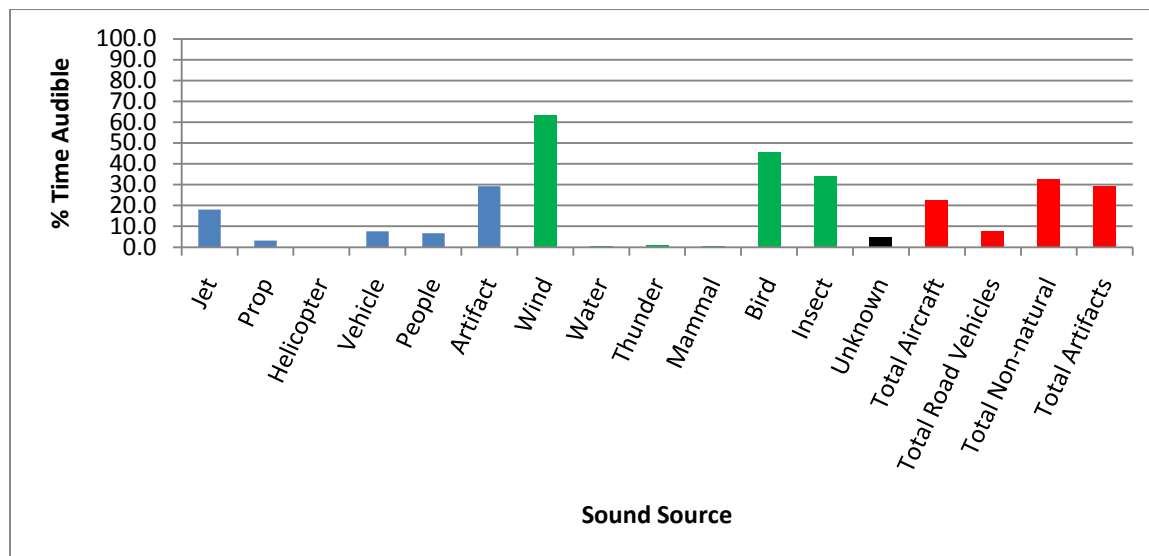


Figure 60. Mean percent time audibility of sound sources at BRCA008 (Yovimpa Frontcountry) for the April 30 – June 3 sampling period.

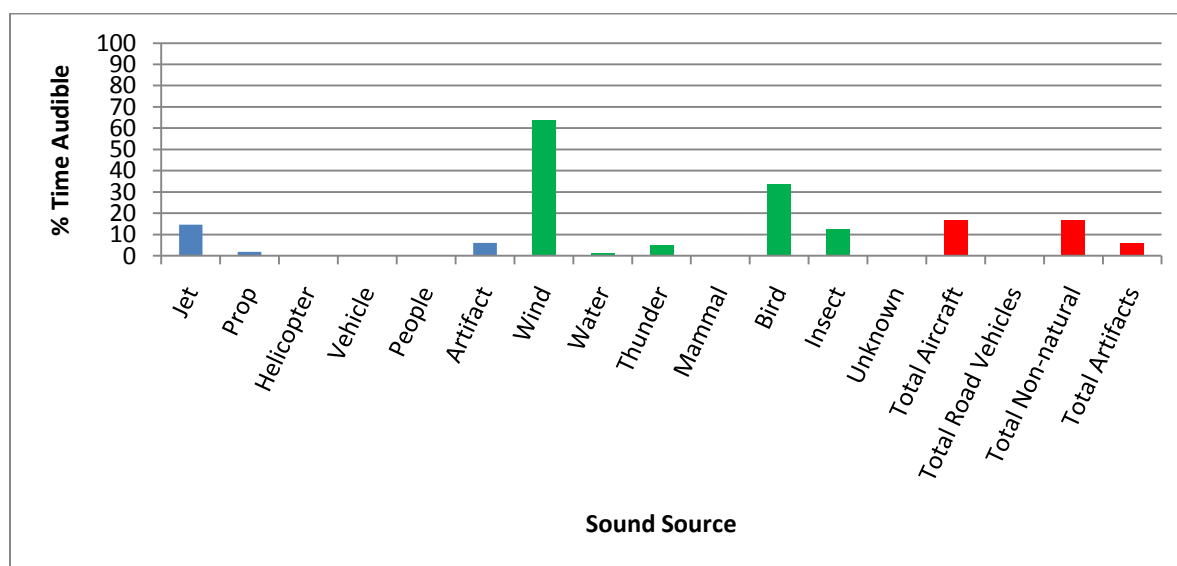


Figure 61. Mean percent time audibility of sound sources at BRCA012 (Yovimpa Backcountry) for the July 8 – 29 sampling period.

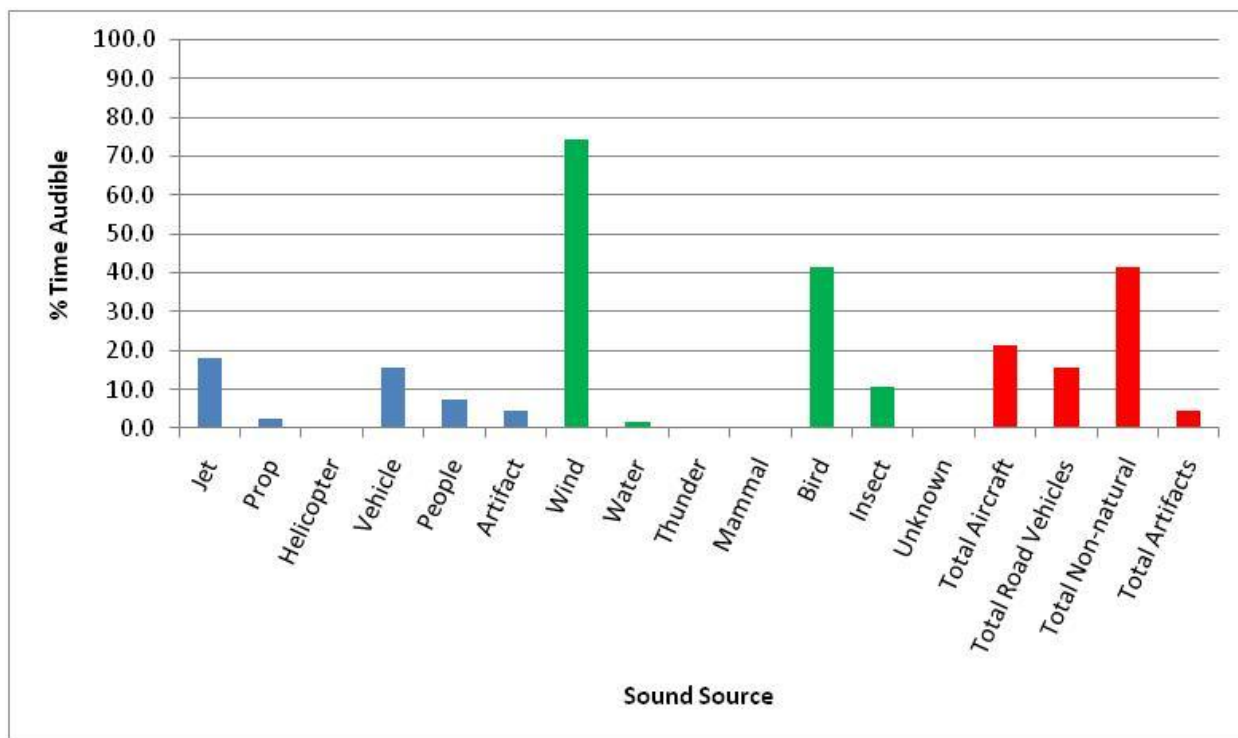


Figure 62. Mean percent time audibility of sound sources at BRCA019 (Yovimpa Frontcountry) for the May 12 – June 14 sampling period.

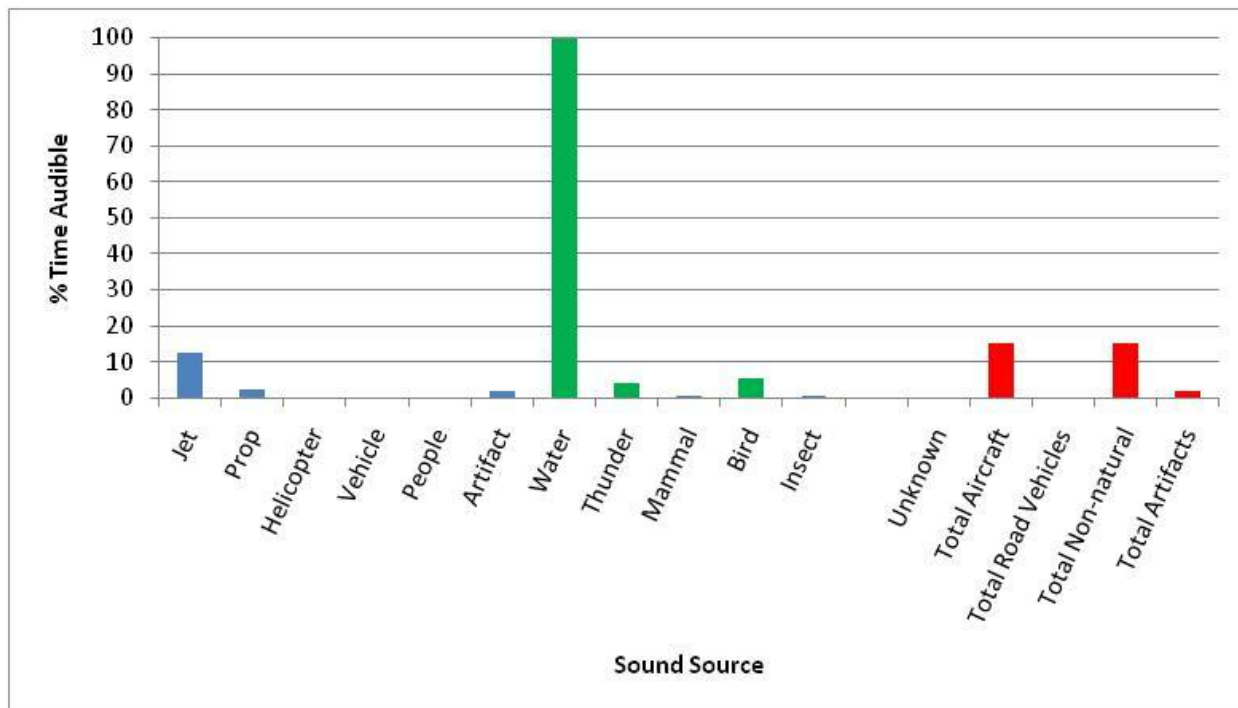


Figure 63. Mean percent time audibility of sound sources at BRCA023 (Yovimpa Backcountry) for the July 20 – August 11 sampling period.

Hourly Exceedence Levels

In order to determine the effect extrinsic noise audibility has on the acoustic environment, it is useful to examine the median hourly exceedence metrics. The figures below show existing ambient levels and natural ambient levels. The existing ambient (L_{50}) level for each hour is marked by the upper limit of the gray boxes while the natural ambient level (L_{nat}) is marked by the lower limit of the gray boxes. The height of the box is a measure of the contribution of anthropogenic noise to the existing ambient sound level at each site. The size of these boxes is directly related to the percent time that human caused sounds were audible. When boxes do not appear, the natural and existing ambient levels were either very close to each other, or equal for that hour. These figures also show exceedence metrics L_{10} and L_{90} , which essentially mark the average maximum and minimum levels over the monitoring period. Note that the decibel scale of these figures is not uniform and varies for each site.

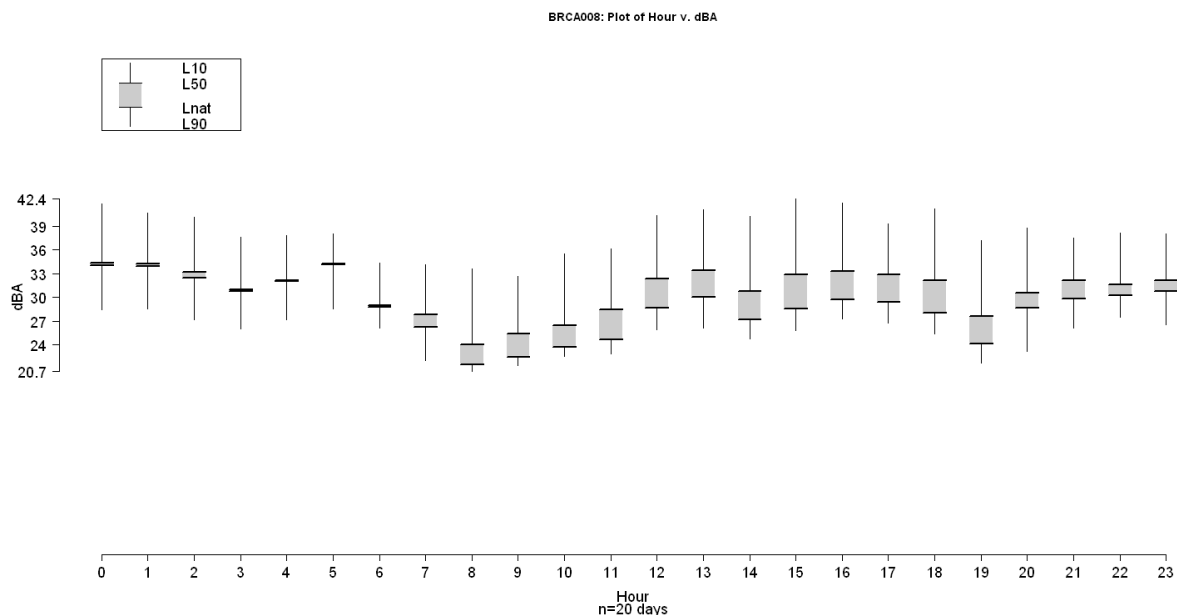


Figure 64. Hourly exceedence levels at BRCA008 (Yovimpa Frontcountry) for the April 30 – June 3 sampling period.

Figure 64 shows that human-caused or extrinsic sounds contributed to SPL levels mostly during the 7:00 am and 11:00 pm hours as indicated by the gray boxes. This is likely due to aircraft overflight, vehicle, and people noise at the Yovimpa overlook. When the boxes do not appear, human-caused sounds are not contributing to the sound pressure level. Wind was audible over 60% of the time at this site and could be contributing to the SPL during all hours. Figures 65 through 67 also depict hourly exceedence levels and can be interpreted in a similar fashion.

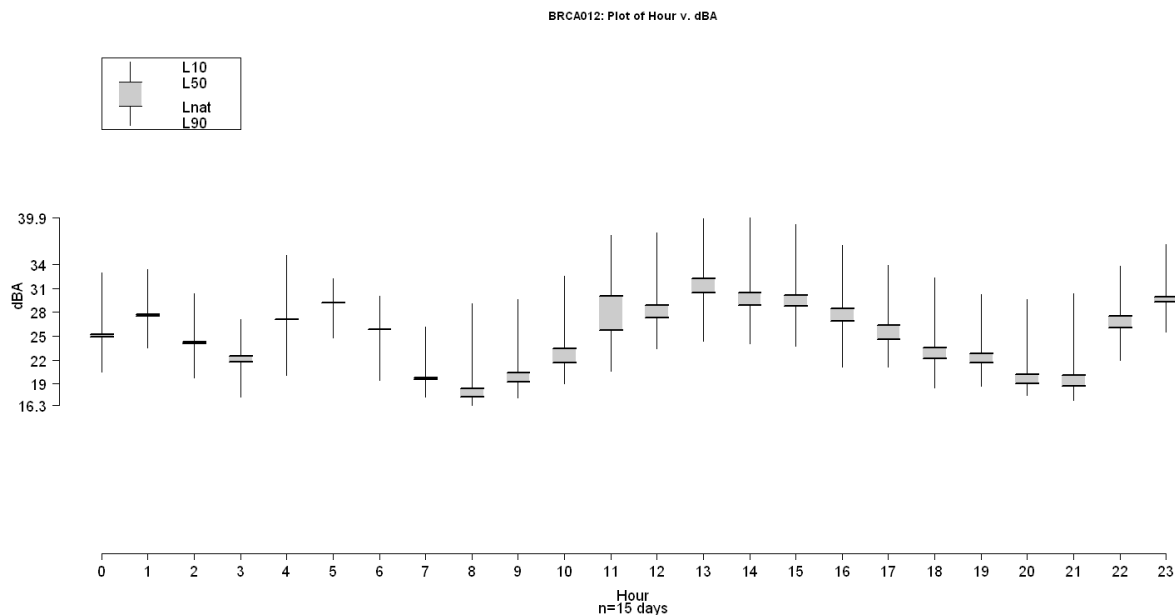


Figure 65. Hourly exceedence levels at BRCA012 (Yovimpa Backcountry) for the July 8 – 29 sampling period.

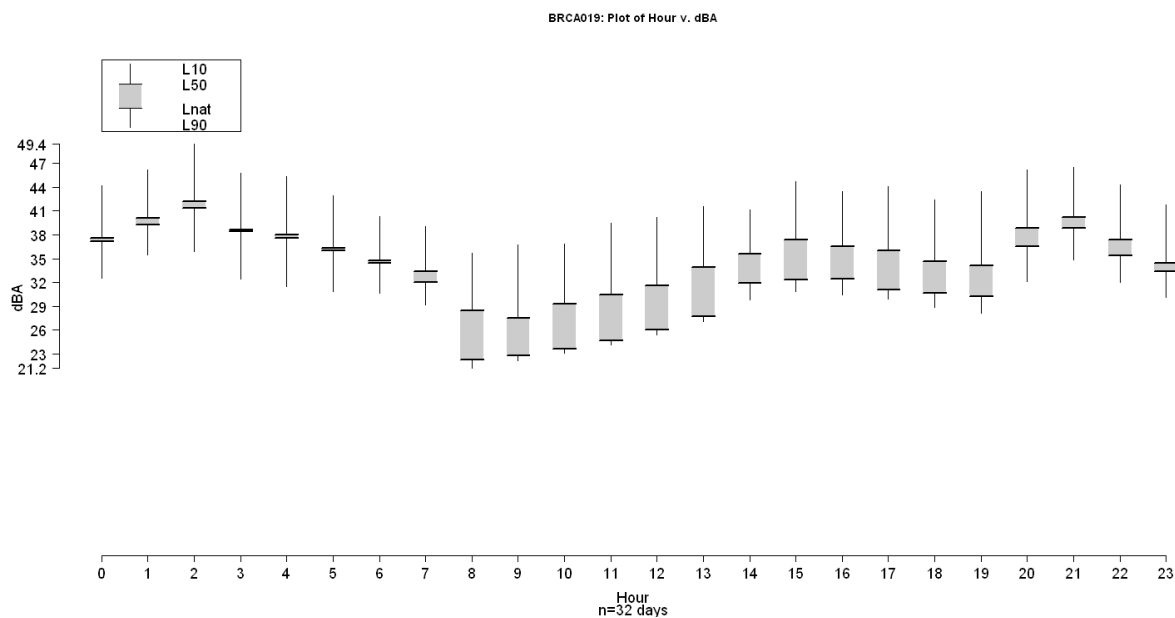


Figure 66. Hourly exceedence levels at BRCA019 (Yovimpa Frontcountry) for the May 12 – June 14 sampling period.

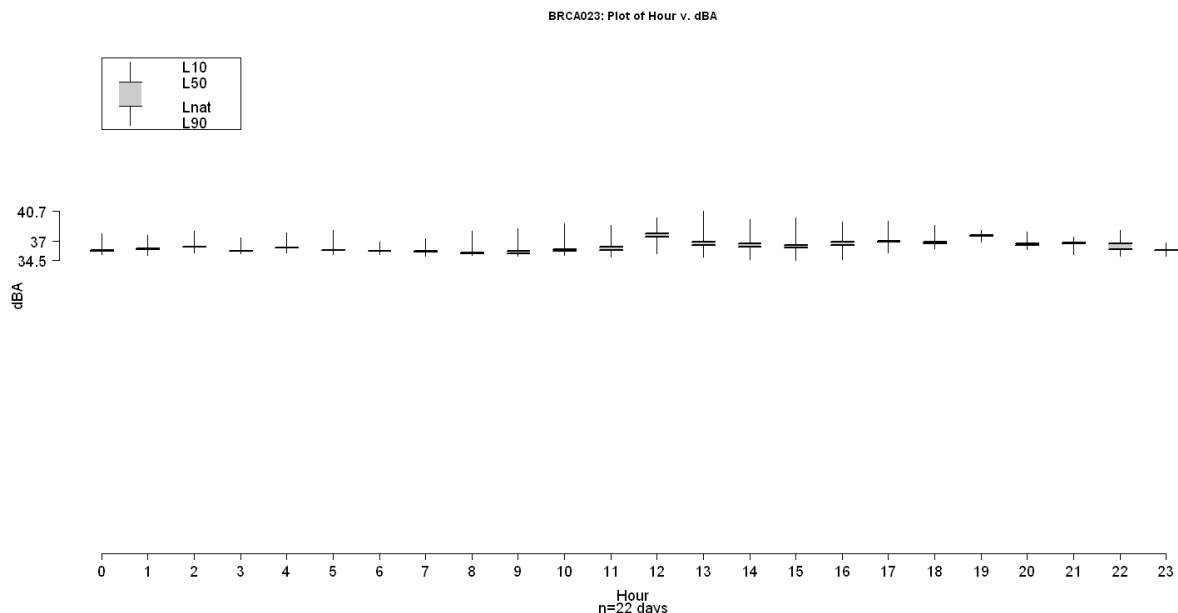


Figure 67. Hourly exceedence levels at BRCA023 (Yovimpa Backcountry) for the July 20 – August 11 sampling period.

Note that BRCA023 was located close to a flowing (trickling) stream, which can be recognized by the nearly constant dBA levels across all hours.

Audibility of Sounds by Hour

The graphs below show the mean percent time audible statistics for each site (hourly average). Each graphic shows the percentage of time that aircraft and extrinsic sounds were audible during each hour of the day/night. These statistics were determined using off-site listening for frontcountry sites and SPLAT for backcountry sites. These figures show the total percentage of time extrinsic sounds were audible (light gray) and the total percentage of time that aircraft were audible (dark gray) during the off-site listening.

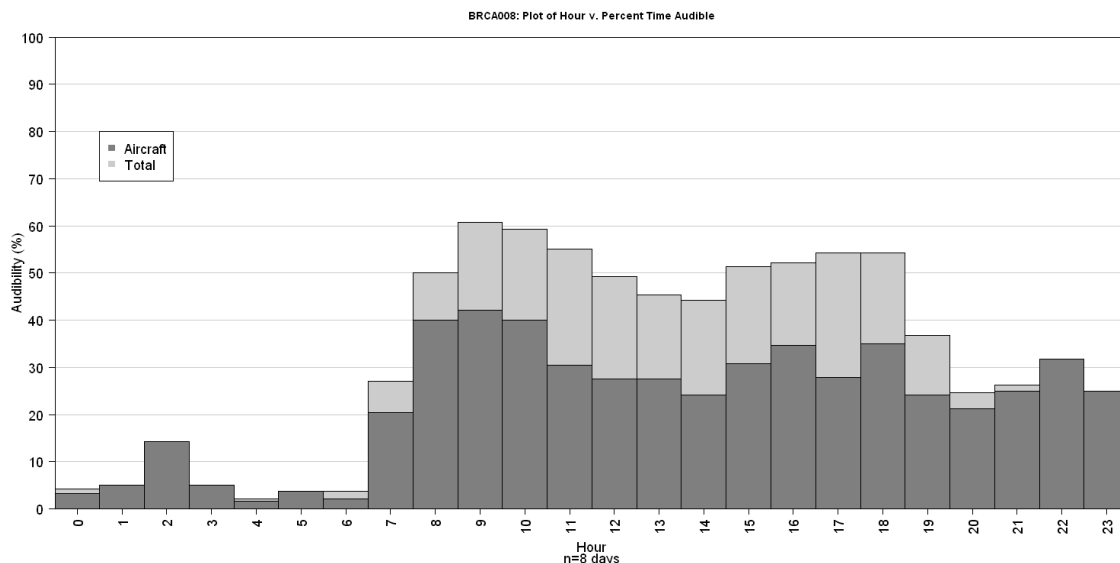


Figure 68. Audibility of extrinsic and aircraft sounds by hour at BRCA008 (Yovimpa Frontcountry) for the April 30 – June 3 sampling period.

Figure 68 shows the total percentage of time that all extrinsic sounds (light gray) and aircraft sounds (dark gray) were audible for each hour of the day/night. The percentage of time during which all extrinsic sounds were audible often exceeds the time that aircraft were audible. This pattern is common for frontcountry sites where other sounds such as vehicles and people are audible. However, in backcountry locations, it can be expected that aircraft will be the dominant extrinsic sound. From 8:00 to 11:00 am and from 3:00 to 6:00 pm, extrinsic sounds were audible over 50% of the time. Wind was audible greater than 60% of the time at the site and could be contributing to SPL levels for all hours. Figures 69 through 71 also depict audibility of extrinsic and aircraft sounds by hour and can be interpreted in a similar fashion.

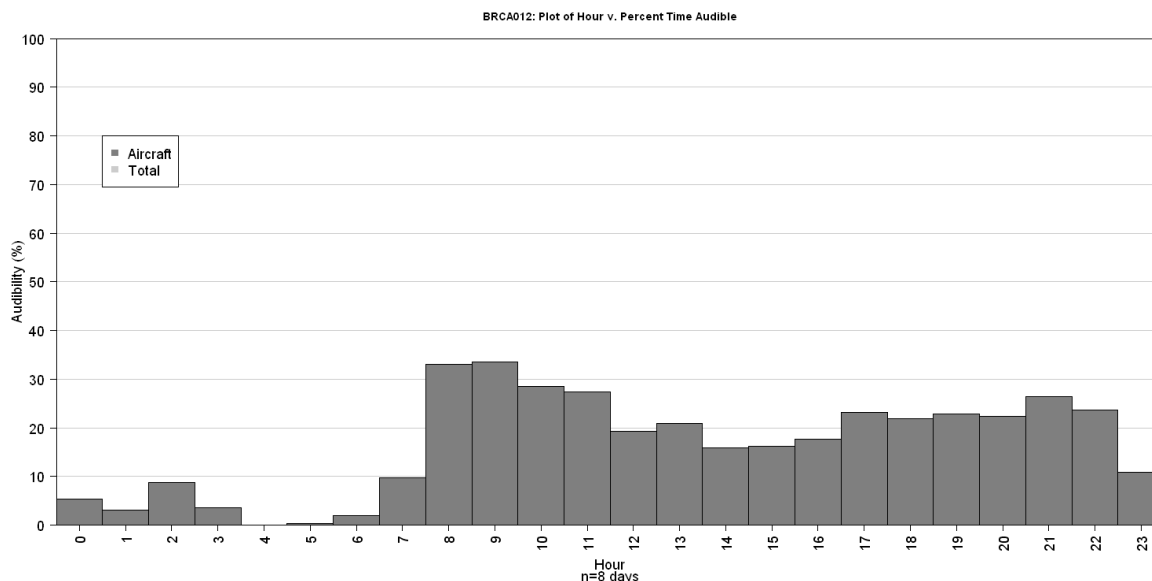


Figure 69. Audibility of extrinsic and aircraft sounds by hour at BRCA012 (Yovimpa Backcountry) for the July 8 – 29 sampling period.

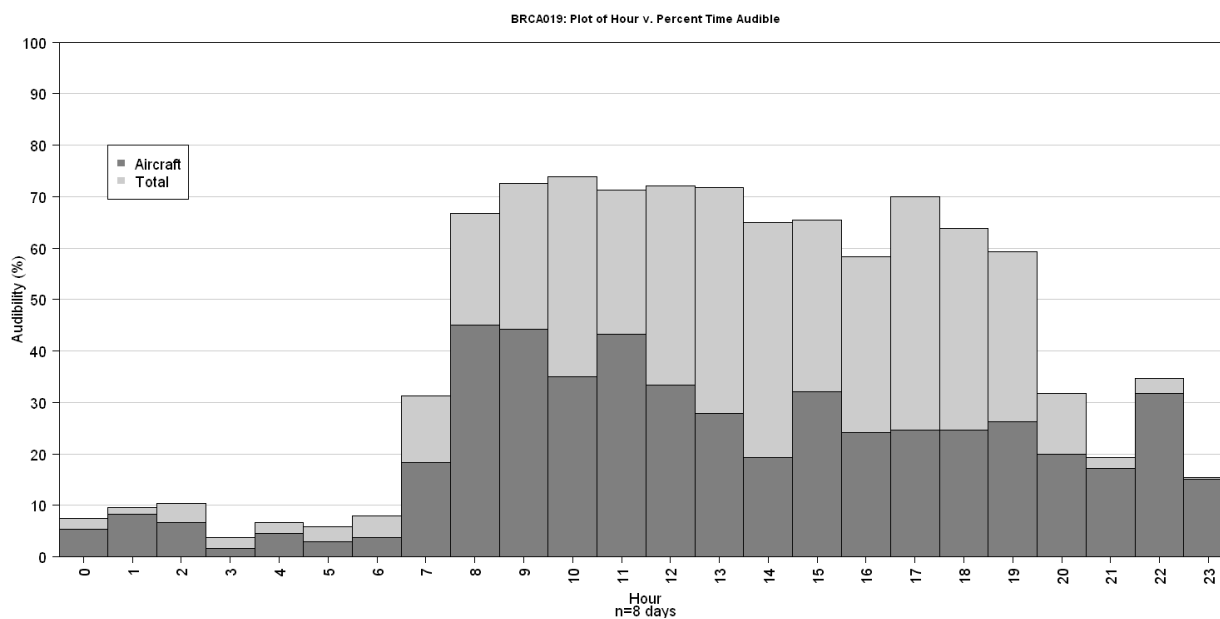


Figure 70. Audibility of extrinsic and aircraft sounds by hour at BRCA019 (Yovimpa Frontcountry) for the May 12 – June 14 sampling period.

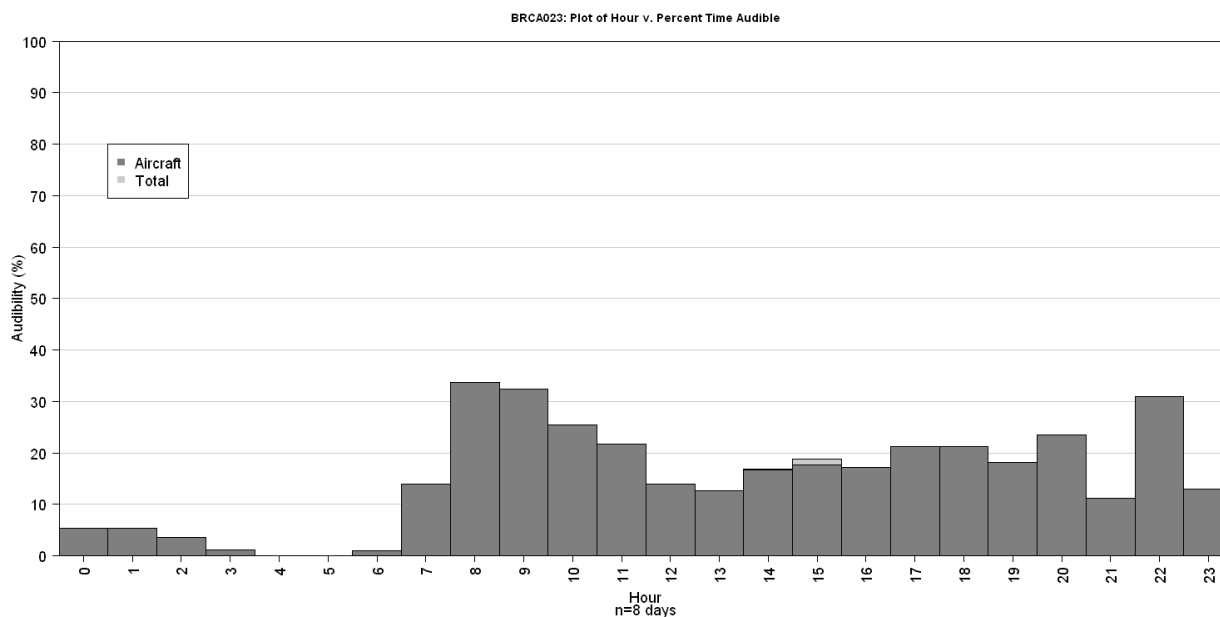


Figure 71. Audibility of extrinsic and aircraft sounds by hour at BRCA023 (Yovimpa Backcountry) for the July 20 – August 11 sampling period.

Yovimpa Acoustic Summary

At all Yovimpa monitoring locations (except BRCA023) wind was audible over 60% of the time and likely elevated SPL at these sites. Additionally, the prevalence of wind at these sites likely concealed other natural and extrinsic sounds that would have been audible otherwise. Peak aircraft activity was similar for all sites and generally occurred between the hours of 8:00 am and 10:00 am, with another peak at 10:00 pm for most sites. Although low-elevation fixed wing aircraft were audible less than 5% of the times at all sites, the short-duration, high-decibel events have a more dramatic effect on L_{10} which documents acute conditions. Across all sites, extrinsic sounds contributed to existing ambient levels more during the day than at night.

Frontcountry Location (BRCA008, BRCA019)

Aircraft, especially high-altitude jets, were the dominant extrinsic sound source at both frontcountry sites (greater than 20% audibility). Both frontcountry locations showed high levels of extrinsic sound from visitors and their vehicles.

Backcountry Location (BRCA012, BRCA023)

Aircraft, especially high-altitude jets, were the dominant extrinsic sound source at both backcountry sites (greater than 15% audibility). Aircraft noise was the only predominant audible extrinsic sound at both backcountry sites which were located away from park roads and viewpoints. BRCA023, the 2010 Yovimpa Backcountry site, showed very little variability in SPL levels across all hours of the day. This was likely due to both its proximity to a small, flowing stream that produced a constant sound pressure level throughout the day and to its relatively sheltered location from Plateau winds.

Peregrine Falcon Monitoring Results

Overview

Protocol monitoring of peregrine falcon territories began in March of 2009 and 2010 and continued through the duration of the breeding season (~mid-August). Each territory was monitored at least twice during the breeding season and three times for eyries determined to be active. Active eyries were selected to acquire information on peregrine behaviors in response to overflight events (“behavioral monitoring”) during the peak months of BRCA’s tourist season (June – August). Selection of territories for behavioral monitoring was based on the occupancy of the eyrie and proximity to the observer, therefore effort was not equal between sites or years. Table 12 below summarizes the protocol monitoring effort for the study period, as well as eyrie occupancy, recruitment results, and behavioral monitoring effort.

Table 12. Peregrine Falcon Monitoring Effort 2009-2010.

Peregrine Territory	<u>Number of Protocol Monitoring Sessions</u>		<u>Occupancy Status</u>		<u>Number Juveniles Observed</u>		<u>Hours of Behavioral Monitoring</u>	
	2009	2010	2009	2010	2009	2010	2009	2010
Inspiration	3	3	Present	Present	0	0	46.25	6.5
Paria	3	3	Present	Present	1	0	2	17
Sheep/Swamp	2	3	Absent	Present	0	1	0	4
Farview	4	2	Present	Present	0	2	0.5	10.5
Yovimpa	3	2	Present	Present	1	0	2	20
TOTAL	15	13			2	3	50.75	58

Proximity of the acoustic monitoring units to active eyries varied throughout the study area. Sound equipment was often established prior to determination of eyrie locations. Proximity of equipment to known/estimated eyries ranged from ~200 m (Farview Backcountry) to ~650m (Yovimpa Frontcountry). Depending on the location of the eyrie, topography, safety concerns and accessibility, observer proximity to peregrine falcon activity during behavioral monitoring also varied. Several territories provided excellent vantage points to observe peregrine throughout the breeding season. Figure 72 through Figure 75 were captured using a camera through a spotting scope during monitoring sessions.



Figure 72. Peregrine falcon adult, Paria territory, April 2010



Figure 73. Peregrine falcon adult, Paria territory, August 2010



Figure 74. Peregrine falcon adult, Inspiration territory, April 2010



Figure 75. Peregrine falcon juveniles, Farview territory, August 2010

Behavioral Monitoring Results

NPS staff conducted ~109 hours of peregrine falcon behavioral monitoring from June - August of 2009 and 2010 (Figure 76). Staff documented 20 low elevation fixed-wing overflight events in proximity to peregrine falcon activity centers (territories and active or historic eyries) and behavioral responses were recorded. Distances of aircraft to birds/eyries were estimated using topographic features with the aid of a Bushnell Scout 1000 range finder with an approximate 1000 meter range. Observers classified behavioral responses to these events as either 1 = no reaction/alert (none to mild), 2 = moderate (pre-flight intentions, cowering, mild vocalizations), or 3 = severe (flying, escape, protest calls).

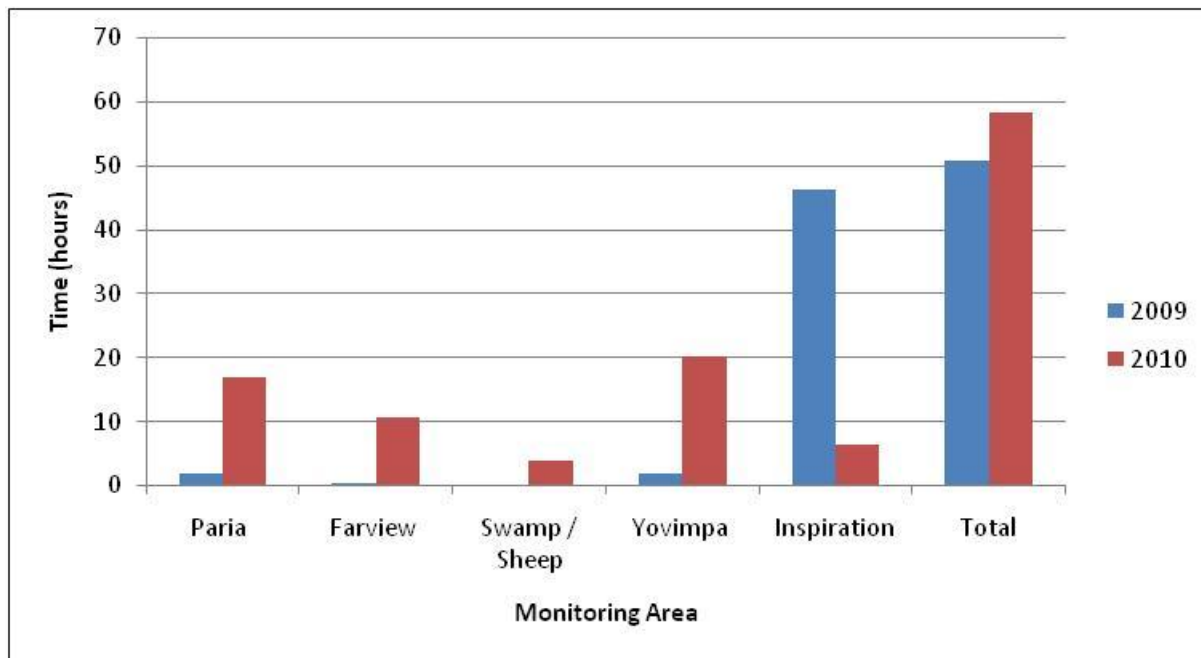


Figure 76. Total hours of behavioral monitoring 2009 – 2010.

Behavioral monitoring occurred for 50.75 hours in 2009 and 58 hours in 2010. In more than 100 hours of monitoring, four events occurred in which observers documented a propeller plane overflight within 1500 m of a visible falcon. All behavioral responses were documented as no reaction/alert. Five overflights occurred within 1500 m of a present, but not visible falcon. Observers classified these events as no reaction/alert based on either the absence of vocalizations or the lack of detectable change in vocalization before, during, and after the flyover event. Two propeller plane overflight events where the aircraft was 3000 m or more from a visible falcon occurred and elicited no detectable response. One overflight event occurred within an unknown distance (plane not visible) from an eyrie occupied by a falcon and appeared to elicit a moderate reaction based on vocalizations. Additionally, eight overflights of unknown distances from either visible or present but not visible falcons occurred during both monitoring seasons and elicited no response. No helicopter overflights were documented during the 2009 -2010 behavioral monitoring effort.

Territory Summaries

Paria Territory Results

Peregrine falcons were detected at the Paria territory on 29 out of 40 visits (72.5% detection rate) from 17 March to 8 August, 2009 and from 30 March to 18 August, 2010. Territory occupancy was confirmed for both monitoring seasons. The 2009 eyrie was located and confirmation of recruitment (observation of 1 juvenile) occurred on 17 July, 2009 with no documented recruitment in 2010. Courtship behavior, mating, and nesting behavior (adults perched in cavity, potential incubation exchange) was documented in 2010. Staff identified the core activity area in 2010, but were unable to identify the eyrie location. Two suspected eyrie locations were documented with photographs.

During 19 hours of behavioral monitoring no incidents of peregrine reacting to aircraft occurred. During the 2010 season, two propeller plane overflights occurred more than 3000 m away from a visible peregrine and elicited no detectable response.

Inspiration Territory Results

Peregrine falcons were detected at the Inspiration territory on 22 out of 32 visits (68.7% detection rate) from 8 June to 22 September, 2009 and from 6 April to 29 July, 2010. Territory occupancy was confirmed for both monitoring seasons. Staff was able to identify the eyrie location in 2009. In 2010, staff identified the core activity area and documented a potential but unconfirmed incubation exchange. No recruitment was detected for either monitoring season.

During 52.75 hours of behavioral monitoring, one incident of a peregrine reacting to an aircraft overflight occurred. On 24 June, 2009 a propeller plane at unknown distance from the eyrie flew over head and appeared to elicit vocalizations from a peregrine inside the nest cavity (not visible) for two minutes (14:09 – 14:11). This reaction was documented as moderate. Three propeller plane overflights within 1500 m of a visible peregrine elicited no response. Additionally, three propeller plane overflights of unknown distance (plane not visible) from a visible peregrine occurred during the monitoring period and elicited no detectable response.

Sheep / Swamp Territory Results

Peregrine falcons were detected at the Sheep/Swamp monitoring area on 4 out of 11 visits (36.4% detection rate) from 17 March to 22 April, 2009 and 13 April to 18 August, 2010. Historical records at BRCA indicate that the core territory was along the Sheep Creek drainage area, therefore monitoring effort focused on this area during protocol monitoring. The Sheep Creek drainage territory was determined to be unoccupied for the 2009 and 2010 monitoring season. In 2010, NPS staff detected a pair of peregrine in an area within one mile of the historical territory in Swamp Canyon and considered the new activity area to be within the historical territory, probably an alternate breeding location. Staff observed paired hunting, identified the core activity area, and confirmed recruitment (observation of 1 juvenile) on August 18, 2010.

During 4 hours of behavioral monitoring, no incidents of peregrine reacting to aircraft occurred. One propeller plane overflight occurred within an unknown distance (plane not visible) to two perched peregrines and elicited no detectable response.

Farview Territory Results

Peregrine falcons were detected at the Farview territory on 31 out of 46 visits (67.4% detection rate) from 17 March to 8 August, 2009 and from 1 April to 13 August, 2010. Territory occupancy was confirmed for both monitoring seasons. A lone peregrine was observed on multiple occasions in 2009, but a pair was never documented. In 2010, staff documented courtship behavior, mating, and nesting behavior (adults perched in cavity, potential incubation exchange). The location of the 2010 eyrie was determined and confirmation of recruitment (observation of 2 juveniles) occurred on August 5th, 2010.

During 19 hours of behavioral monitoring no incidents of peregrine reacting to aircraft occurred. During the 2010 season, two propeller plane overflights occurred more than 3000 m away from a visible peregrine and elicited no detectable response.

Yovimpa Territory Results

Peregrine falcons were detected at the Yovimpa territory on 21 out of 37 visits (56.7% detection rate) from 17 March to 8 August, 2009 and from 8 April to 10 August, 2010. Territory occupancy was confirmed for both monitoring seasons. Staff identified the 2009 eyrie location and confirmed recruitment (observation of 1 juvenile) on 27 August, 2009. In 2010, staff identified the core activity area and documented mating but were unable to determine the eyrie location.

During 22 hours of behavioral monitoring at Yovimpa, no overflights were observed within 3000 m of visible falcons throughout the 2009 – 2010 monitoring period. Therefore, no behavioral responses could be documented.

Peregrine Falcon Audibility

In addition to the percent time audible metrics, off-site analysis of acoustic (.wav) samples yielded a number of interesting wildlife sound recordings. In the process of listening to eight selected days for each site, NPS staff located multiple, high-quality recordings of peregrine falcon vocalizations. These recordings encompassed a multitude of diverse vocalizations ranging from wailing, cacking, and “ee-chup” calls to juvenile and juvenile-adult interaction calls (See Appendix F for spectrograms of peregrine vocalizations).

Peregrine vocalizations were detected during analysis of acoustical data for all monitoring locations except BRCA009 and BRCA020 (Paria backcountry 2009/2010) and BRCA023 (Yovimpa backcountry 2010). Total percent time audible statistics were calculated for each site where falcons were audible (Figure 77).

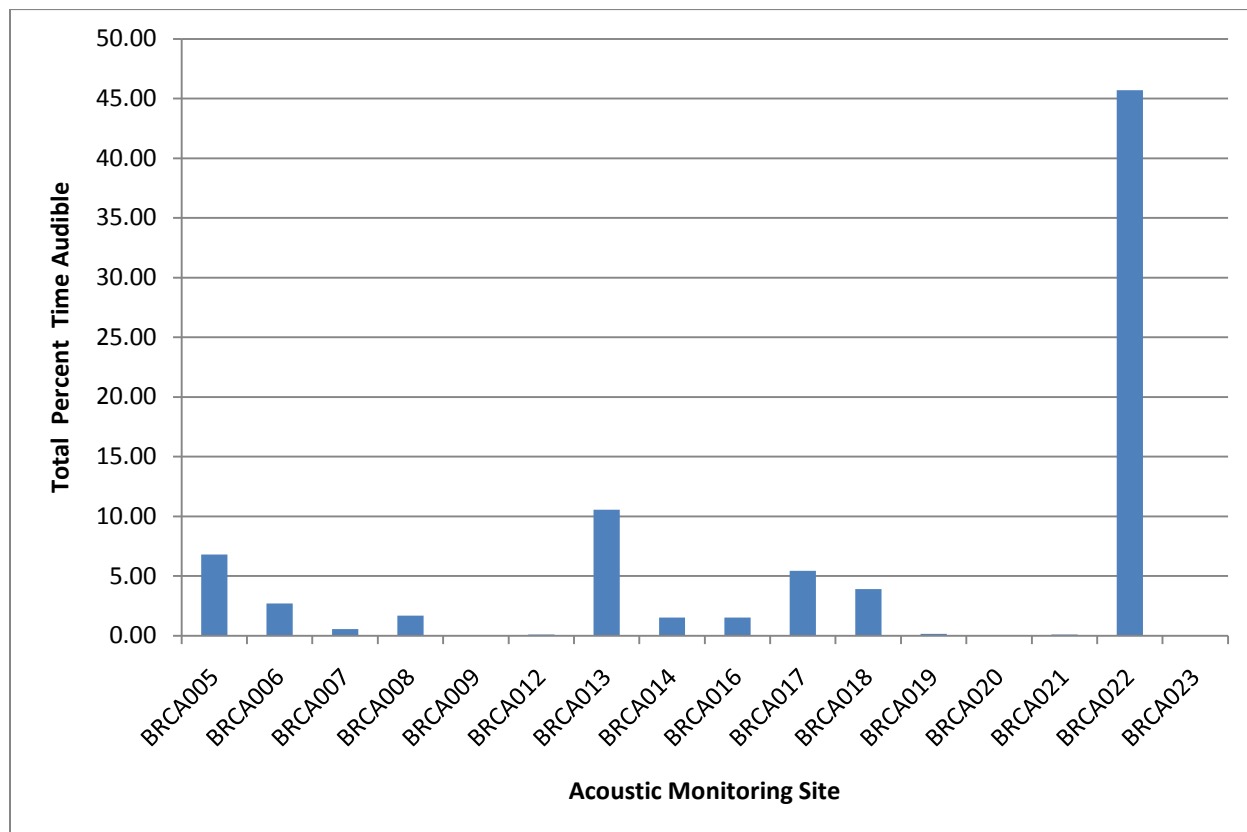


Figure 77. Percent time audibility of peregrine falcon calls, 2009 – 2010.

Figure 77 represents the total percent time peregrine falcons were audible during the 8 selected monitoring days at each site. Proximity of the sound systems to the eyries (e.g., BRCA022 - Farview backcountry, 2010) strongly influenced the detection of vocalizations. The 2010 Farview backcountry sound monitoring equipment was located within close proximity (~200m) to an active eyrie where two peregrine juveniles vocalized frequently.

Additional Observations

On 17 July 2009, one helicopter and two retardant planes associated with containment activities for the Bridge Fire were observed flying at very low altitudes over the Paria eyrie (not during a behavioral monitoring session). During the same observation period, NPS staff detected a juvenile peregrine at the Paria monitoring location. No behavioral responses to the overflights were documented; however, observation periods were limited due to restrictions from fire activity. Three additional site visits on 27 July, 3 August, and 17 August failed to produce further observations of the juvenile falcon.

On 15 May 2009, a helicopter was incidentally observed at the Farview monitoring area (not during a behavioral monitoring session). The airship was flying within approximately 50 – 100 feet of the rim (BRCA requests a minimum 1500 foot overflight [vertical and horizontal] of air tour operators). No observations of peregrine occurred during the time that the overflight occurred.

On July 1 2010, a commercial propeller plane was observed flying over the Paria amphitheater within approximately 900 feet of the rim near the 2010 suspected eyrie location (during a behavioral monitoring session). No observations of peregrine occurred during the period of time when the overflight was detected. However, peregrine were observed during the monitoring session.

Acoustic Results Summary and Discussion

Natural Ambient

The natural ambient levels at all sites were highest during the day when bird song and wind sounds occurred most frequently. The 2010 Paria Frontcountry site proved to have the loudest daytime natural ambient levels (39.0 dBA) where fierce spring winds were common. The quietest natural ambient levels among frontcountry sites (23.7 dBA) occurred at the 2010 Inspiration Frontcountry location. Among backcountry sites, the quietest daytime sound levels occurred at the 2009 Inspiration Backcountry site (18.7 dBA) and were loudest at the 2010 Yovimpa Backcountry site (36.2 dBA) where a small stream elevated SPL levels for all hours. Wind was audible over 50 percent of the time at nearly all sites and likely reduced the percent time extrinsic and natural sounds were audible due to masking and increased SPL at all sites.

Existing Ambient

Across all sites, the existing ambient sound levels during the day were highest at Farview Frontcountry 2010, Paria Frontcountry 2009, and Paria Frontcountry 2010 and lowest at Inspiration Backcountry 2009, Farview Backcountry 2010, and Yovimpa Backcountry 2009. The combination of extrinsic sounds at the frontcountry sites, especially aircraft, vehicle, and visitor noise as well as the prevalence of high spring winds at the Paria locations likely contributed to this result.

Contribution of Extrinsic Sound

Across all sites, human-caused sounds raised the existing ambient levels more during the daytime hours than at night. Aircraft, especially high altitude jets, were the dominant extrinsic sound source at all backcountry locations (see Appendix G for a comparison of audibility of extrinsic and aircraft sounds by hour at all sites). All frontcountry monitoring areas, except Farview and Sheep / Swamp (which were located next to the park roadway and were dominated by vehicle noise) showed aircraft to be the dominant source of extrinsic sounds. Peak aircraft activity occurred at most locations between the hours of 8:00 and 10:00 am, with some sites showing minor peaks in the evening between the range of 7:00 and 10:00 pm.

Aircraft were audible over 50 percent of the time at the 2009 Inspiration Frontcountry site from 8:00 am to 9:00 am, and at the 2009 Inspiration Backcountry site from 10:00 to 11:00 am and from 4:00 to 5:00 pm. Across all sites, low-elevation fixed wing aircraft were audible less than 5 percent of the time but had a more dramatic effect on L_{10} , which documents acute conditions.

The contribution of extrinsic sound was greatest at Sheep / Swamp Frontcountry 2009, Inspiration Frontcountry 2009, and Inspiration Frontcountry 2010 and lowest at Paria Frontcountry 2009, Paria Frontcountry 2010, and Yovimpa Frontcountry 2009. This is likely due, in part, to both the combination of aircraft, vehicle, and visitor noise audible at each site and to the distance of sites from roads, viewpoints, and parking areas. Among the quieter backcountry sites, the contribution of extrinsic sound was by far greatest at Inspiration Backcountry followed by Sheep / Swamp Backcountry, and Farview Backcountry. This finding

is likely due the location of the Inspiration Backcountry site below the heavily visited Bryce Amphitheater, where extrinsic sound sources such as visitors and their vehicles were audible even under the rim.

The backcountry sites with the lowest contribution of extrinsic sounds were Paria Backcountry 2009, Paria Backcountry 2010, and Yovimpa Backcountry 2010. During the early morning hours at several of the backcountry sites (Inspiration 2009, Swamp Canyon, and Farview 2010) the existing and natural ambient levels were within 10.0 – 15.0 dBA of the noise floor of the recording equipment, indicating that these sites were, at times, very quiet. In the absence of natural sounds such as wind and flowing water, which led to increased natural and existing ambient levels, it is likely that other backcountry locales would have displayed similar results.

It is interesting to note that, among the backcountry locations, the 2009 Inspiration Backcountry (BRCA014) site had both the lowest daytime existing ambient level (L_{50}) *and* the highest contribution of extrinsic sound. This paradox can be explained in part by examining wind data for the backcountry sites. High winds tend to elevate SPL levels and therefore can increase both existing and natural ambient levels. Among all backcountry locations, BRCA014 had the *lowest* percent time audibility of wind, except for the 2010 Yovimpa Backcountry (BRCA023) site. However, since BRCA023 was located next to a small stream that produced nearly continuous SPL levels for all hours, the L_{50} level at that site was higher than that at BRCA014. So, although BRCA014 was impacted most by extrinsic sound, the greater prevalence of wind at all other backcountry locations led to L_{50} levels that were higher than those found at BRCA014.

There was considerable variation in the percent time extrinsic sounds were audible across sites. For example, at Sheep / Swamp Frontcountry, extrinsic sounds were audible nearly 54 percent of the time, while they were only audible 11.6 percent of the time at both the 2009 and 2010 Paria Backcountry locations. This variation is largely due to the proximity of roads or trails to the frontcountry locations where visitors and their vehicles are in close proximity. The presence of wind, which was ubiquitous at all sites, also reduced the percent time extrinsic sounds were audible.

Table 13 reports the percentage of time that measured levels were above sound levels that have known impacts on human experiences or health (35, 45, 52, and 60 dBA). These values should not be construed as thresholds of impact but rather sound levels which have been identified in scientific literature (see Table 14) as having relevance to the human or wildlife experience in parks.

Table 13. Percent time above metrics for night and day.

Site Name	% Time above sound level (7pm - 7am)				% Time above sound level (7am - 7pm)			
	35 dBA	45 dBA	52 dBA	60 dBA	35 dBA	45 dBA	52 dBA	60 dBA
<u>FRONTCOUNTRY</u>								
BRCA005	76.47	23.11	8.93	0.42	56.49	11.64	3.97	0.39
BRCA006	71.46	27.87	8.05	0.35	55.03	12.31	4.21	0.42
BRCA007	16.82	0.39	0.01	0.00	59.27	14.65	2.70	0.10
BRCA008	32.72	2.66	0.16	0.00	31.95	3.13	0.36	0.02
BRCA013	5.53	0.24	0.02	0.00	20.45	1.79	0.20	0.01
BRCA016	69.41	33.98	4.66	0.02	74.35	27.09	3.55	0.10
BRCA017	72.13	37.38	5.64	0.06	77.48	29.73	3.99	0.11
BRCA018	18.77	0.34	0.01	0.00	33.88	2.81	0.27	0.03
BRCA019	57.18	22.39	2.84	0.03	39.45	7.94	0.79	0.05
<u>BACKCOUNTRY</u>								
BRCA009	61.12	0.80	0.00	0.00	22.51	2.88	0.56	0.01
BRCA012	16.17	0.33	0.01	0.00	18.06	1.01	0.18	0.01
BRCA014	1.51	0.05	0.00	0.00	5.74	0.47	0.07	0.00
BRCA020	5.61	0.20	0.00	0.00	35.57	3.04	0.23	0.00
BRCA021	3.59	0.05	0.00	0.00	29.25	1.82	0.13	0.00
BRCA022	2.30	0.13	0.00	0.00	11.94	1.30	0.18	0.02
BRCA023	95.24	0.25	0.01	0.00	83.72	2.27	0.39	0.06

When interpreting sound pressure level data, it should be noted that the decibel scale is logarithmic. The logarithmic dB scale can be difficult to interpret, and the effects of a seemingly small change in sound pressure level can be greater than anticipated. When noise interferes with hearing natural sounds, the noise is said to mask the natural sounds, and this affects the extent of the listening area. For example, if the ambient SPL is 30 dB, and transportation noise raises the ambient to 33 dB (a 3 dB increase), the listening area or auditory horizon for humans (and many birds and mammals) would be reduced by 50%. Increasing the ambient SPL an additional 3 dB (to 36 dB) would reduce the listening area by half again, to 25% of the initial area (when the frequencies of the transportation sounds are the same frequencies of the natural sounds of interest). Note however, that changes in SPL do not proportionately translate to changes in perceived loudness. The rate of change of loudness is complex and dependent on the stimulus itself (SPL, frequency, bandwidth, duration, background, etc.). At a minimum, each 10 dB increase in SPL causes a doubling of perceived loudness (Crocker, 1997).

Table 14 summarizes sound level values that relate to human health and speech, as documented in the scientific literature.

Table 14. Explanation of sound level values.

Sound Levels (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans (Haralabidis et al., 2008)
45	World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund, Lindvall, and Schwela, 1999)
52	Speech interference for interpretive programs (U.S. Environmental Protection Agency, 1974)
60	Speech interruption for normal conversation (U.S. Environmental Protection Agency, 1974)

The effects of noise on wildlife can be difficult to measure and interpret and can take many forms (Kempf and Hueppop, 1996; Pater et al., 2009). Most researchers agree that noise can affect an animal's physiology and behavior, and if it becomes a chronic stress, can be injurious to an animal's energy budget, reproductive success, and long-term survival (Radle, 1997). Previous research on the effects of aircraft overflights on peregrine falcon parental behavior detected subtle differences in activity budgets between overflight and control areas, but found no evidence that overall attendance patterns differed depending on exposure to overflights (Palmer et al., 2003). While it is unclear if human-caused sounds can impact peregrine breeding success, continuous overflights over breeding territories may represent a chronic stress to animals and could impact other important life cycle activities such as the importance of interspecific interactions for breeding-site selection (Sergio et al., 2004). Additionally, analysis of soundscape impacts on human hearing and experience may serve as a proxy for the potential impacts to other vertebrates because humans have more sensitive hearing at low frequencies than most species (Dooling and Popper, 2007). When these results are coupled to the fact that a large percentage of park visitors (68%) value natural quiet *and* that unwanted noise has led to detractions from visitor experience, it is clear that management decisions that attempt to minimize potential negative impacts to both visitors and wildlife are warranted at BRCA.

Conclusion & Management Implications

The results from this study present current information on the acoustic environment at five peregrine falcon territories at Bryce Canyon National Park. Due to the distribution of these territories, detailed records of ambient sound pressure levels in BRCA were documented at both front and backcountry locations throughout the park and are a good representation of the overall soundscape. In conjunction with the percent time audible statistics, these data have been used to report existing ambient levels and have helped to estimate natural ambient levels in many areas of the park. As would be expected, frontcountry locations generally have higher existing ambient levels as compared with backcountry locations. This result is consistent with visitor use patterns and the concentration of visitation at the park's viewpoints in the main Bryce Amphitheater.

The location of Bryce Canyon on the Pansaugunt Plateau creates windy conditions, especially along the rim of the park. Based on protocols developed by the Natural Sounds Program, excessively windy days were not analyzed at each monitoring location. Many of the days excluded from analysis were eliminated because they exceeded the threshold for wind gusts ($>5\text{m/s}$) for at least some of the day. However, many days included in the analyzed data contained wind events below 5 m/s for part or most of the day which was captured in hourly metrics data. It is difficult to quantify the level of wind masking of sounds throughout the park without comparing the audibility of human caused sounds from excessively windy days with calmer days. That analysis was not a part of this study. However, it should be noted that although windy conditions can mask extrinsic sounds, in the absence of constant high-intensity winds, those sounds are likely to be experienced on some level by visitors and wildlife. The fact that more calm days were used to analyze the soundscape of Bryce Canyon should not detract from the value of the data presented in this study.

Anecdotal data from park staff indicate that low-flying helicopters may negatively influence peregrine breeding success. Helicopter tours were not operating during the 2009 and 2010 seasons at BRCA, therefore the impacts of helicopters on peregrine falcon could not be assessed to any degree. However, if helicopter tours resume in the near future, this study has provided excellent baseline information on the acoustic environment in the absence of helicopter flights. This study documented only one moderate reaction of a peregrine falcon to an overflight event during over 100 hours of observation in peregrine falcon activity areas. This result should not be interpreted to indicate that peregrine falcons are not influenced by overflights or noise associated with them. However, based on two years of observations of successful territory establishment and some breeding success within the park, as well as historic monitoring records, the population of peregrine falcons at BRCA appears to be breeding successfully.

Automated acoustic monitoring in BRCA not only offers insight into the prevalence of extrinsic sounds, but also allows for investigation of natural events in the park to a greater extent than would be possible using staff observations alone. Both on-site and off-site listening sessions produced a number of interesting biologic, meteorological, and geologic sound recordings such as rock fall, thunderstorms, and a variety of interesting wildlife vocalizations. Analysis of the acoustic data revealed multiple, high-quality recordings of peregrine falcon vocalizations as well as an array of song bird, owl, hummingbird and nightjar songs, sounds and calls. Biological monitoring with the use of continuous recording acoustic equipment offers many opportunities to

extend surveys to places and intervals when it is inconvenient or impossible for observers to be present. Furthermore, many animals may react to the presence of an observer, whereas a small piece of equipment presents a much smaller potential for disturbance.

This study used a biological approach to answer questions about the impacts of extrinsic noise on a valuable resource in Bryce Canyon. Monitoring locations were selected based on proximity to peregrine falcon breeding territories. Although one territory – Inspiration – is located within the main Bryce Amphitheater, the study did not produce enough baseline information on the soundscape of the park’s most popular and visited area. Future data collection should focus on this area including popular viewpoints such as Sunset and Bryce Points as well as locations under the rim (e.g., Navajo Loop and Queen’s Garden Trail) where visitation is highest during the summer months. Additional soundscape monitoring at the Visitor Center and within the park’s historical district (specifically the soundscape of the Bryce Canyon Lodge area) should also be conducted to assess noise impacts in those locations.

Several questions and soundscape conservation issues remain for the park to address in future studies and as management plans are developed. The presence of high altitude aircraft was identified as a predominant extrinsic sound source in this study. The flight patterns, duration and frequency of sounds, and impacts to park visitors and resources are unlikely to be altered in the near future since they are outside of NPS jurisdiction. However, there are several extrinsic sound sources that the park may choose to address and manage in the future including idle of tour buses and RV engines, NPS shuttle system sounds, motorcycle tours, and sounds associated with large tour groups. Additionally, the impacts of air tours over the park have been identified as a contributor to extrinsic sounds and have generated numerous visitor complaints. Fixed wing and helicopter tours over the park have been a visitor service provided by air tour operators for decades and they present a different opportunity to experience the park. However, impacts from air tours on visitors, as well as wildlife, should be taken into consideration when addressing the appropriate timing, duration, and frequency of these flights. Baseline information documented in this report will assist the park in meeting its responsibilities to protect park resources while working cooperatively with air tour operators and the FAA in future air tour management planning.

Acoustical monitoring efforts at BRCA have yielded valuable results that will allow park managers to better understand the existing acoustic environment of the park and plan for the challenges associated with soundscape conservation. Monitoring existing conditions and trends allows managers to take action to move towards desired future conditions. Contributions of and impacts to the park’s soundscape from aircraft, vehicles, visitors, and NPS directed activities within the park will require additional research and will be influenced by management decisions from park leadership and NPS directives. The acoustic data in this report provides the necessary information for the development of acoustical indicators and standards in upcoming Soundscape and Air Tour Management Plans.

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Appendix A. Glossary of acoustic terms

Acoustical Environment

The actual physical sound resources, regardless of audibility, at a particular location.

Amplitude

The instantaneous magnitude of an oscillating quantity such as sound pressure. The peak amplitude is the maximum value.

Audibility

The ability of animals with normal hearing, including humans, to hear a given sound. Audibility is affected by the hearing ability of the animal, the masking effects of other sound sources, and by the frequency content and amplitude of the sound.

dBA

A-weighted decibel. A-Weighted sum of sound energy across the range of human hearing. Humans do not hear well at very low or very high frequencies. Weighting adjusts for this.

Decibel

A logarithmic measure of acoustic or electrical signals. The formula for computing decibels is: $10(\log_{10}(\text{sound level}/\text{reference sound level}))$. 0 dB represents the lowest sound level that can be perceived by a human with healthy hearing. Conversational speech is about 65 dB.

Diel

A 24-hour period usually consisting of a day and the adjoining night.

Existing Ambient

The acoustical environment as is, including both natural and extrinsic sounds. Often expressed as L_{50} (the decibel level exceeded 50% of the time)

Extrinsic Sound

Extrinsic sound refers to any sound not forming an essential part of the park unit, or a sound originating from outside the park boundary. These could include the voices of school children visiting the park, or jets fly-ing thousands of feet above the park unit. As used in this report, extrinsic sounds are defined as any human-caused sound (e.g., vehicles, airplanes, helicopters, motorcycles, human voices). **Note:** some extrinsic sound may be appropriate for a park and are supported in the enabling legislation of a park unit. Bryce Canyon has not yet defined sound sources that are inappropriate or appropriate for the park; this task will be accomplished via the planning process and will involve public scoping. Human sounds defined as “extrinsic” in this report were intended to support the data analysis process and do not confer judgment on this sound source or sound levels as appropriate or inappropriate for the park.

Eyrie

The nesting site of a bird of prey, built in a high inaccessible place; peregrine falcon eyries consist of scapes on cliffs and ledges or the use of abandoned nests built by other bird species.

Frequency

The number of times per second that the sine wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz). Frequency equals Speed of Sound/ Wavelength.

Hearing Range (frequency)

By convention, an average, healthy, young person is said to hear frequencies from approximately 20 Hz to 20000 Hz.

Hertz

A measure of frequency, or the number of pressure variations per second. A person with normal hearing can hear between 20 Hz and 20,000 Hz.

Human-Caused Sound

Any sound that is attributable to a human source.

Intrinsic sound

A sound which belongs to a park by its very nature, based on the park unit purposes, values, and establishing legislation. As used in this report, a sound from the natural environment in the absence of humans (e.g., wind, bird song, rockfall, thunder, flowing water, etc.).

Listening Horizon

The range or limit of one's hearing capabilities. Just as smog limits the visual horizon, so noise limits the acoustic horizon.

 L_{eq}

Energy Equivalent Sound Level. The level of a constant sound over a specific time period that has the same sound energy as the actual (unsteady) sound over the same period.

 L_x

A metric used to describe acoustic data. It represents the level of sound exceeded x percent of the time during the given measurement period. Thus, L_{50} is the level exceeded 50% of the time (it is also referred to as existing ambient).

 L_{nat} - the Natural Ambient

An estimate of what the acoustical environment might sound like without the contribution of extrinsic (anthropogenic) sounds.

Masking

The process by which the threshold of audibility for a sound is raised by the presence of another sound.

Noise-Free Interval

The period of time between noise events (not silence).

Noise

Sound which is unwanted, either because of its effects on humans, its effect on fatigue or malfunction of physical equipment, or its interference with the perception or detection of other sounds (Source: McGraw Hill Dictionary of Scientific and Technical Terms).

Off-site Listening

The systematic identification of sound sources using digital recordings previously collected in the field.

On-site Listening

The systematic identification of sound sources at a specific monitoring site using a personal digital assistant (PDA). Custom PDA software records begin and end times of audible sound sources. These sessions often last for one hour.

Sound

Variations in local pressure that propagate through a medium (e.g. the atmosphere) in space and time.

Soundscape

Human perception of the acoustical environment.

Sound Pressure

The difference between instantaneous pressure and local barometric pressure. Measured in Pascals (Pa), Newtons per square meter, which is the metric equivalent of pounds per square inch.

Sound Pressure Level (SPL)

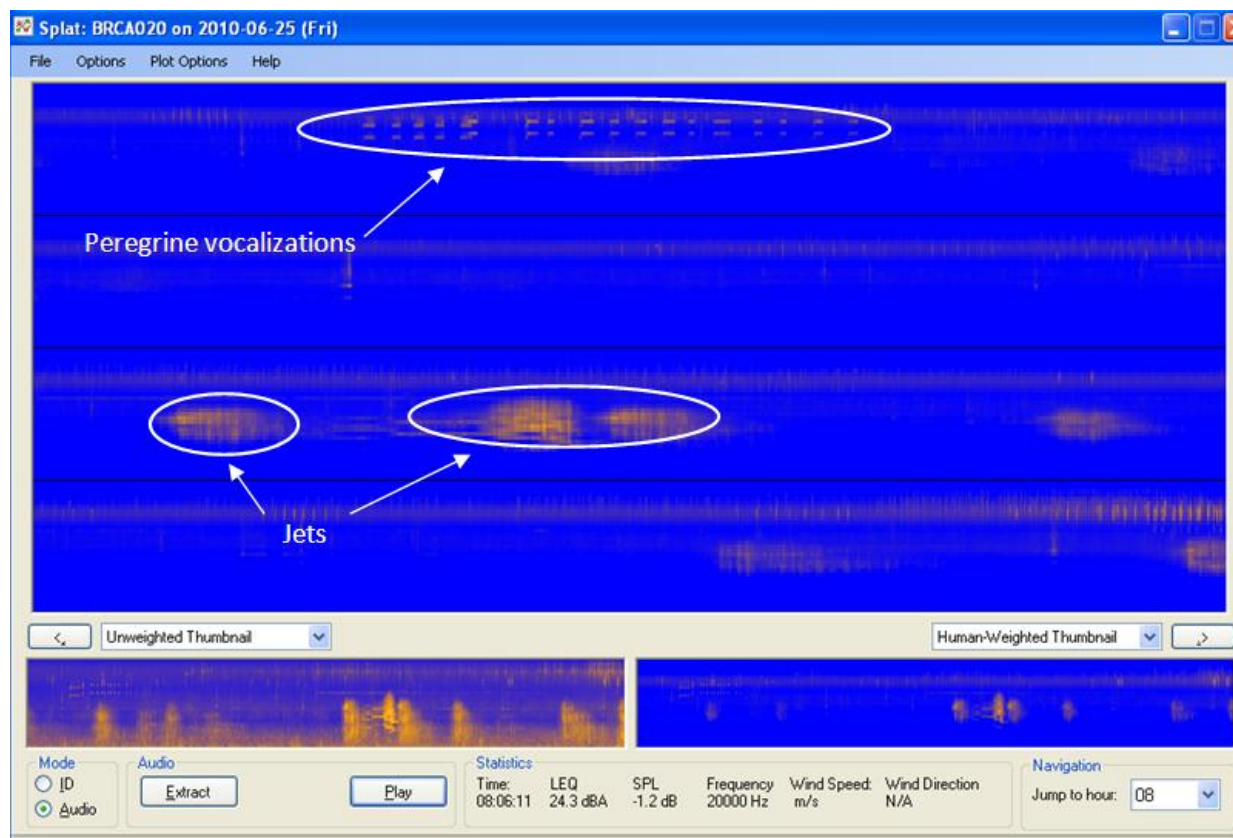
A calibrated measure of sound level, expressed in decibels, and referred to an atmospheric standard of 20 micro Pascals.

Time Audible

The amount of time that a sound source is audible to an animal with normal hearing.

Appendix B. Analyzing audibility with visual tools

Sound pressure levels (SPL) from a one hour sample at Bryce Canyon National Park are shown below. One hour of human-weighted SPL data is displayed over four lines. Each line shows SPL values from low frequency 12.5 Hz (bottom of line) to high frequency 20 kHz (top of line). Values are represented with a color scale, where dark blue is quiet and orange/white is loud. The 1st white oval marks peregrine falcon vocalizations and the other two ovals mark high altitude jets. As shown, individual events stand out against the quiet blue background, and can be annotated and incorporated into the custom analysis software to determine percent time audibility of sounds.



Appendix C. On-site listening reports³

On-Site Listening Results for BRCA005: Paria Frontcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	1.0	154	122	89	46	2
Jet	39.0	1,320	124	<0.1	190	99
Aircraft, Propeller	7.0	384	122	1	100	17
Vehicle	15.0	1,135	93	2	169	52
Heavy Equipment	<0.1	88	48	7	57	2
Grounds Care	<0.1	16	16	16		1
People	1.0	242	242	242		1
Portable Audio Devices	<0.1	60	21	<0.1	34	3
Non-natural Unknown	<0.1	14	14	14		1
Wind	92.0	6,272	625	<0.1	1,146	47
Thunder	<0.1	32	32	32		1
Mammal	<0.1	13	13	13		1
Bird	50.0	3,521	369	1	813	43
Raven	2.0	341	75	3	112	8
Peregrine Falcon	5.0	1,037	231	1	368	7
Insect	13.0	3,470	364	1	1,033	11
Natural Unknown	<0.1	45	9	<0.1	14	10
All Aircraft	44.8					
All Road Vehicles	15.5					
All Non-natural Sources	52.5					
All Natural Sources	88.9					
Noise Free Interval	47.5	3,302	144	1	363	105

**Sound events are recorded in seconds.*

³ These tables were generated in an Access database using custom software created by the NSP. Zero (0.0) values as generated by the automated summaries were modified to "<0.1" in the tables for clarification of interpretation.

On-Site Listening Results for BRCA006: Farview Frontcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	<0.1	51	51	51		1
Jet	27.0	441	91	1	83	74
Aircraft, Propeller	1.0	122	32	<0.1	44	10
Vehicle	35.0	795	77	<0.1	128	116
Motorcycle	1.0	165	63	<0.1	89	3
Motor	<0.1	8	3	<0.1	3	5
Dumpster / Trashcan	<0.1	4	1	<0.1	1	43
People	11.0	303	38	<0.1	53	73
People, Voices	6.0	824	94	<0.1	211	15
People, Walking	<0.1	42	12	1	20	4
Domestic Animal	<0.1	2	2	2		1
Non-natural Unknown	<0.1	94	13	<0.1	31	9
Wind	105.0	7,200	1,318	1	1,764	20
Water	<0.1	1	1	1		1
Bird	25.0	3,499	315	0	788	20
Raven	2.0	318	111	1	149	4
Peregrine Falcon	1.0	134	37	4	47	7
Amphibian	<0.1	1	1	1		1
Insect	3.0	319	83	1	108	8
Natural Unknown	<0.1	117	117	117		1
All Aircraft	28.0					
All Road Vehicles	35.4					
All Non-natural Sources	59.5					
All Natural Sources	97.8					
Noise Free Interval	40.7	4,004	72	1	339	143

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA007: Sheep / Swamp Frontcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	<0.1	30	11	1	13	4
Jet	12.0	332	77	4	67	45
Aircraft, Propeller	5.0	172	104	5	49	15
Helicopter	<0.1	95	95	95		1
Vehicle	39.0	1,064	41	1	74	273
Motorcycle	8.0	139	41	6	29	54
Bus (capacity > 9 people)	<0.1	35	35	35		1
Motor	<0.1	31	31	31		1
People	16.0	303	50	1	64	90
People, Walking	1.0	90	32	4	37	8
Dog	<0.1	4	3	1	2	3
Non-natural Unknown	<0.1	38	27	12	11	4
Wind	91.0	3,600	533	<0.1	794	49
Rain/Fog Drip	<0.1	2	2	1	1	2
Thunder	1.0	82	21	6	24	15
Bird	54.0	1,275	77	<0.1	144	204
Raven	1.0	109	28	3	32	10
Insect	10.0	433	33	1	59	87
Natural Unknown	1.0	117	30	5	35	9
All Aircraft	17.8					
All Road Vehicles	43.4					
All Non-natural Sources	55.8					
All Natural Sources	98.0					

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA008: Yovimpa Frontcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	<0.1	56	56	56		1
Jet	29.0	385	87	4	74	95
Aircraft, Propeller	6.0	298	187	22	89	10
Vehicle	7.0	443	31	3	55	66
Motorcycle	1.0	56	40	14	20	4
People	12.0	445	35	2	53	100
People, Voices	2.0	599	178	25	281	4
People, Walking	1.0	206	49	4	88	5
Non-natural Unknown	1.0	90	25	4	29	8
Wind	79.0	3,600	345	<0.1	728	66
Bird	72.0	2,613	125	<0.1	331	165
Raven	12.0	1,640	103	2	373	33
Peregrine Falcon	3.0	506	76	2	148	12
Insect	58.0	3,595	134	4	466	125
Natural Unknown	<0.1	5	4	4	1	2
All Aircraft	34.9					
All Road Vehicles	7.6					
All Non-natural Sources	49.2					
All Natural Sources	98.8					
Noise Free Interval	51.1	586	74	1	100	199

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA009: Paria Backcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Jet	31.0	421	96	3	97	69
Aircraft, Propeller	8.0	370	149	5	121	11
Helicopter	2.0	295	122	32	150	3
Vehicle	8.0	393	180	10	148	10
Bus (capacity > 9 people)	<0.1	72	72	72		1
People, Voices	1.0	110	80	54	28	3
Non-natural Unknown	1.0	305	108	5	171	3
Wind	63.0	3,600	797	18	967	17
Rain/Fog Drip	14.0	933	201	10	253	15
Squirrel	2.0	189	75	24	65	6
Chipmunk	10.0	504	153	15	162	14
Bird	39.0	1,798	175	7	368	48
Insect	55.0	3,573	214	16	607	56
Animal (Natural)	<0.1	7	7	7		1
Natural Unknown	1.0	98	51	4	47	3
All Aircraft	39.0					
All Road Vehicles	8.3					
All Non-natural Sources	44.0					
All Natural Sources	97.7					
Noise Free Interval	57.5	979	161	1	206	77

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA012: Yovimpa Backcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	<0.1	22	16	9	9	2
Jet	27.0	236	94	2	68	62
Aircraft, Propeller	5.0	261	98	12	74	11
Vehicle	5.0	141	35	7	35	28
Motorcycle	5.0	364	60	3	87	17
Heavy Equipment	34.0	1,493	254	8	428	29
People	12.0	170	42	7	31	62
People, Voices	1.0	130	69	5	56	4
People, Walking	4.0	133	42	11	36	20
Non-natural Unknown	1.0	43	26	9	14	5
Wind	78.0	3,599	599	17	726	28
Rain/Fog Drip	1.0	121	121	121		1
Thunder	3.0	66	29	10	14	20
Chipmunk	6.0	347	101	11	116	12
Bird	52.0	1,061	100	9	138	113
Raven	11.0	646	66	11	106	36
Insect	79.0	1,556	160	8	271	107
Natural Unknown	1.0	293	104	9	164	3
All Aircraft	30.7					
All Road Vehicles	39.5					
All Non-natural Sources	66.3					
All Natural Sources	99.7					
Noise Free Interval	33.8	783	72	1	135	101

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA013: Inspiration Frontcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	<0.1	134	45	20	50	5
Jet	50.0	729	140	4	120	206
Aircraft, Propeller	9.0	367	135	12	88	39
Vehicle	13.0	595	63	7	80	124
Motorcycle	5.0	252	57	8	50	49
Bus (capacity > 9 people)	<0.1	84	48	17	34	3
Heavy Equipment	5.0	1,434	371	26	453	8
People	22.0	929	64	4	91	194
People, Voices	14.0	486	98	4	87	84
People, Walking	7.0	302	60	6	52	71
Portable Audio Devices	<0.1	<0.1	<0.1	<0.1		1
Dog	<0.1	32	15	<0.1	15	6
Non-natural Other	<0.1	84	30	6	34	5
Non-natural Unknown	2.0	116	38	2	26	32
Wind	72.0	3,599	328	<0.1	621	126
Rain/Fog Drip	2.0	404	191	32	130	7
Mammal	<0.1	15	15	15		1
Squirrel	1.0	211	90	15	92	4
Chipmunk	<0.1	140	54	7	74	3
Bird	87.0	3,581	269	5	523	187
Raven	6.0	625	70	8	100	50
Peregrine Falcon	1.0	339	48	8	85	14
Insect	54.0	3,589	153	3	357	204
Natural Unknown	3.0	788	114	11	215	16
All Aircraft	55.6					
All Road Vehicles	21.4					
All Non-natural	82.6					
All Natural Sources	99.0					
Noise Free Interval	18.2	316	45	1	61	235

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA014: Inspiration Backcountry 2009

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Jet	27.0	187	66	3	45	75
Aircraft, Propeller	9.0	206	89	5	60	19
Vehicle	10.0	154	29	5	27	59
Motorcycle	1.0	33	24	14	8	8
Heavy Equipment	1.0	40	27	11	10	7
People	2.0	38	24	12	7	18
Non-natural Unknown	2.0	149	34	10	44	9
Wind	98.0	3,397	1,260	13	1,219	14
Chipmunk	15.0	1,108	189	17	312	14
Bird	25.0	381	60	7	73	74
Peregrine Falcon	<0.1	17	17	17		1
Insect	36.0	436	57	12	57	113
Natural Unknown	<0.1	34	19	11	13	3
All Aircraft	35.5					
All Road Vehicles	11.6					
All Non-natural Sources	48.8					
All Natural Sources	99.9					
Noise Free Interval	52.7	476	65	1	97	146

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA016: Paria Frontcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	4.0	294	61	2	66	20
Jet	22.0	536	107	1	85	67
Aircraft, Propeller	9.0	460	162	4	130	19
Helicopter	<0.1	<0.1	<0.1	<0.1		1
Vehicle	18.0	260	66	6	56	90
Motorcycle	1.0	87	47	21	32	4
Cat	<0.1	1	1	1		1
Non-natural Unknown	<0.1	16	6	1	6	5
Wind	89.0	3,600	657	1	1,107	44
Melting Snow	<0.1	1	1	1		1
Mammal	1.0	101	58	25	35	5
Chipmunk	1.0	154	54	4	68	4
Bird	50.0	783	85	<0.1	142	193
Raven	<0.1	5	4	2	2	4
Peregrine Falcon	1.0	38	12	1	9	18
Insect	6.0	218	14	0	27	146
Animal (Natural)	<0.1	5	5	5		1
Geothermal / Mass Move	1.0	41	10	1	9	18
Avalanche / Rockslide	<0.1	4	4	3	1	2
Natural Unknown	7.0	225	35	<0.1	53	61
All Aircraft	34.0					
All Road Vehicles	18.7					
All Non-natural Sources	49.2					
All Natural Sources	98.5					
Noise Free Interval	50.9	817	115	1	175	143

*Sound events are recorded in seconds.

On-Site Listening Results for BRCA017: Farview Frontcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	2.0	164	51	<0.1	54	10
Jet	34.0	590	122	<0.1	116	79
Aircraft, Propeller	9.0	422	169	51	103	16
Vehicle	69.0	1,309	119	<0.1	180	167
Motorcycle	1.0	112	31	2	34	9
People	2.0	83	14	1	17	31
Non-natural Unknown	<0.1	9	4	<0.1	3	14
Wind	78.0	3,599	434	9	738	52
Bird	52.0	1,909	73	<0.1	211	203
Peregrine Falcon	1.0	166	38	5	56	9
Insect	2.0	68	8	<0.1	12	88
Natural Unknown	<0.1	39	5	<0.1	9	17
All Aircraft	41.7					
All Road Vehicles	69.3					
All Non-natural Sources	83.3					
All Natural Sources	98.1					
Noise Free Interval	16.7	350	40	1	63	119

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA018: Inspiration Frontcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	8.0	299	121	<0.1	108	17
Jet	33.0	692	198	29	141	42
Aircraft, Propeller	17.0	589	228	25	161	19
Helicopter	<0.1	3	3	3		1
Vehicle	20.0	571	64	2	81	80
Motorcycle	2.0	143	43	<0.1	44	9
Bus (capacity > 9 people)	<0.1	10	8	5	4	2
People	43.0	757	113	<0.1	156	95
People, Voices	5.0	403	27	1	63	49
People, Walking	4.0	110	30	2	27	33
Portable Audio Devices	<0.1	15	15	15		1
Gunshot	<0.1	3	1	1	1	10
Non-natural Other	<0.1	6	2	<0.1	1	21
Non-natural Unknown	<0.1	3	3	3		1
Wind	88.0	3,599	790	15	1,199	28
Chipmunk	<0.1	7	7	7		1
Bird	78.0	3,600	173	<0.1	599	114
Peregrine Falcon	<0.1	10	6	3	3	4
Reptile	<0.1	1	1	<0.1	1	3
Insect	17.0	2,021	43	<0.1	211	98
Natural Unknown	<0.1	29	10	1	16	3
All Aircraft	52.8					
All Road Vehicles	21.3					
All Non Natural	79.2					
All Natural Sources	97.6					
Noise Free Interval	20.8	481	58	1	81	91

*Sound events are recorded in seconds.

On-Site Listening Results for BRCA019: Yovimpa Frontcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	2.0	156	64	1	53	11
Jet	35.0	367	129	4	82	98
Aircraft, Propeller	7.0	362	134	7	93	20
Vehicle	24.0	421	52	<0.1	57	163
Motorcycle	4.0	290	72	2	70	21
Bus (capacity > 9 people)	<0.1	141	141	141		1
People	22.0	1,256	70	<0.1	153	111
People, Voices	6.0	421	28	1	71	71
People, Walking	<0.1	62	21	3	25	7
Gunshot	<0.1	24	21	17	4	3
Non-natural Other	<0.1	27	12	<0.1	13	5
Non-natural Unknown	2.0	359	74	2	120	9
Wind	72.0	3,599	258	1	597	101
Rain/Fog Drip	<0.1	25	14	4	9	6
Bird	80.0	2,636	154	1	381	186
Peregrine Falcon	1.0	197	54	1	70	8
Insect	38.0	2,836	107	<0.1	356	128
Natural Unknown	<0.1	16	6	<0.1	6	10
All Aircraft	43.3					
All Road Vehicles	26.4					
All Non-natural Sources	69.9					
All Natural Sources	98.3					
Noise Free Interval	30.5	819	50	1	91	220

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA020: Paria Backcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Aircraft	2.0	84	68	47	19	4
Jet	35.0	336	141	34	76	36
Aircraft, Propeller	2.0	137	108	55	46	3
Non-natural Unknown	<0.1	5	5	5		1
Wind	94.0	3,600	747	2	1,310	18
Bird	97.0	3,599	993	<0.1	1,247	14
Peregrine Falcon	3.0	72	25	2	22	18
Insect	92.0	3,548	1,100	4	1,059	12
Natural Unknown	<0.1	3	3	3		1
All Aircraft	38.4					
All Non-natural Sources	38.4					
All Natural Sources	99.9					
Noise Free Interval	61.6	960	211	2	218	42

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA021: Swamp Canyon Backcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Jet	29.0	363	125	2	97	25
Aircraft, Propeller	11.0	356	172	59	93	7
Vehicle	1.0	48	40	33	11	2
People	<0.1	7	7	7		1
People, Voices	<0.1	35	14	3	18	3
Non-natural Unknown	<0.1	2	2	2		1
Wind	77.0	3,598	298	8	682	28
Bird	96.0	3,599	414	3	976	25
Raven	<0.1	6	6	6		1
Insect	10.0	313	12	<0.1	36	89
Natural Unknown	<0.1	1	1	1	<0.1	2
All Aircraft	38.1					
All Road Vehicles	0.7					
All Non Natural	38.5					
All Natural Sources	99.7					
Noise Free Interval	61.5	1551	256	1	362	26

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA022: Farview Backcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Jet	19.0	357	121	3	77	17
Aircraft, Propeller	5.0	180	101	29	64	5
Vehicle	<0.1	22	21	20	1	2
Motorcycle	1.0	32	19	<0.1	13	5
Wind	70.0	3,599	472	27	861	16
Chipmunk	1.0	59	20	2	23	7
Bird	51.0	2,061	69	<0.1	276	81
Raven	<0.1	4	2	1	1	12
Peregrine Falcon	21.0	831	191	2	221	12
Insect	64.0	1,387	106	1	237	65
Natural Unknown	<0.1	1	1	1		1
All Aircraft	23.4					
All Road Vehicles	1.3					
All Non-natural	24.7					
All Natural Sources	99.0					
Noise Free Interval	75.3	1,038	280	1	272	29

**Sound events are recorded in seconds.*

On-Site Listening Results for BRCA023: Yovimpa Backcountry 2010

Sound Source	% Time Audible	Max Event Length*	Mean Event Length*	Min Event Length*	SD Event Length*	Count
Jet	17.0	198	103	12	56	24
Aircraft, Propeller	4.0	182	132	42	66	4
People	<0.1	41	41	41		1
Non-natural Unknown	<0.1	3	3	3		1
Wind	97.0	3,600	1,557	83	1,540	9
Water	75.0	3,588	2,689	719	1,352	4
Thunder	<0.1	5	4	2	2	4
Mammal	<0.1	23	23	23		1
Chipmunk	1.0	152	56	5	83	3
Bird	32.0	469	55	<0.1	101	84
Insect	18.0	311	23	<0.1	42	112
Natural Unknown	<0.1	4	3	2	1	3
All Aircraft	20.8					
All Non-natural	21.1					
All Natural Sources	99.9					
Noise Free Interval	79.0	1,163	355	1	302	32

**Sound events are recorded in seconds.*

Appendix D. Median sound level metrics (dBA by hour and 1/3 OB data by hour) for each monitoring location

Metrics for BRCA005 – Paria Frontcountry 2009
n = 791 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	27.4	29.4	33.2	41.2	41.2	48.3	54.3	57.9	44.9
01	33.4	36.0	38.3	42.3	42.4	48.1	52.0	56.9	44.9
02	29.6	32.2	35.0	38.2	38.5	44.5	49.7	56.4	41.3
03	27.0	28.9	33.3	39.0	39.1	44.6	49.9	55.6	41.7
04	30.6	32.0	35.0	40.5	40.8	46.0	49.6	54.8	43.4
05	29.7	31.6	35.2	41.2	41.5	46.0	50.8	55.8	42.9
06	28.3	30.7	34.6	40.9	41.5	46.7	50.8	54.8	42.8
07	27.7	31.3	34.7	39.6	41.2	46.1	51.2	54.9	42.9
08	22.6	24.6	28.9	32.5	37.0	43.4	48.9	57.7	40.7
09	19.9	21.2	25.7	30.3	34.0	41.0	48.2	55.7	40.7
10	18.5	20.0	23.4	26.4	31.3	40.6	47.2	53.8	37.2
11	20.7	21.7	26.8	30.0	34.9	43.8	50.1	60.5	42.2
12	21.6	22.7	28.5	31.6	35.4	44.9	53.4	58.0	41.7
13	21.4	23.4	26.7	33.0	36.5	44.4	53.0	61.0	41.4
14	23.0	24.3	29.7	34.4	37.0	45.6	52.6	62.3	42.3
15	23.1	25.1	30.3	36.5	39.5	47.4	53.0	58.7	43.3
16	24.2	25.4	30.4	37.3	41.4	48.3	56.7	62.5	44.5
17	27.3	30.7	36.6	39.9	43.0	48.4	54.9	61.9	45.7
18	27.9	29.5	36.6	40.8	43.3	48.4	52.4	57.9	45.2
19	25.0	27.7	31.2	36.1	38.3	47.8	53.4	58.7	43.8
20	23.8	26.9	31.7	39.5	41.4	48.2	53.8	60.2	44.6
21	28.9	30.9	33.9	39.1	39.5	48.2	53.3	58.2	43.9
22	31.0	32.6	35.6	40.1	40.6	46.4	52.6	58.0	43.5
23	30.6	33.0	35.6	40.8	41.2	46.4	53.6	60.2	45.3

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	26.1	28.2	31.6	39.4	39.4	47.1	52.6	56.3	43.1
01	32.0	33.8	36.2	40.1	40.3	45.8	50.3	55.9	43.2
02	28.7	30.9	33.7	36.6	36.7	42.5	47.5	55.0	39.0
03	25.1	27.3	32.0	36.9	37.2	42.7	47.8	53.6	40.1
04	29.0	30.3	33.5	39.1	39.4	44.0	48.5	54.5	41.1
05	27.9	29.6	33.5	39.7	40.0	45.0	48.9	53.4	41.8
06	27.3	29.8	33.3	38.9	39.9	45.2	49.3	53.6	41.7
07	26.8	29.8	33.6	38.4	40.0	44.6	49.1	54.9	41.9
08	21.7	23.8	27.8	31.4	36.0	41.9	46.1	56.8	38.8
09	18.4	19.9	24.8	29.3	33.2	39.6	47.6	54.8	38.5
10	16.7	18.6	22.8	25.7	30.5	38.4	46.6	53.7	35.4
11	19.1	20.2	25.2	28.8	33.6	41.9	48.7	56.4	40.3
12	20.1	21.3	27.4	30.0	33.9	43.3	50.9	56.7	39.8
13	19.4	21.7	25.9	31.8	35.4	42.7	50.4	57.5	39.8
14	22.2	23.3	28.6	33.0	34.8	43.8	50.4	57.8	39.9
15	21.7	23.7	29.6	35.2	37.2	45.1	51.2	58.0	41.3
16	22.3	24.0	29.5	35.9	39.6	45.8	53.2	58.8	42.1
17	26.3	28.7	34.8	37.8	40.4	46.4	53.1	59.2	43.4
18	25.8	28.2	35.5	38.5	40.9	45.9	50.4	55.7	42.7
19	23.6	26.2	29.6	35.0	37.1	45.2	51.4	57.4	41.3
20	22.2	25.1	30.3	37.4	39.7	46.3	52.1	58.3	42.8
21	27.4	29.5	32.3	37.0	37.6	46.2	51.7	58.4	42.0
22	29.0	30.9	33.6	37.6	38.2	44.9	51.0	56.7	41.4
23	29.4	31.2	34.1	38.9	39.6	44.5	53.0	57.8	44.2

Metrics for BRCA006 – Farview Frontcountry 2009
n = 637 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	27.7	29.7	33.9	40.9	41.1	48.2	53.5	57.6	44.4
01	31.5	35.7	38.0	41.8	42.2	46.9	51.9	56.5	44.2
02	29.1	31.4	34.3	38.0	38.3	44.2	48.7	55.9	41.1
03	26.1	27.9	31.6	38.2	38.5	43.9	48.9	55.3	40.9
04	30.0	31.2	34.7	40.4	40.5	45.2	48.8	54.5	42.4
05	28.5	30.1	35.0	41.4	41.5	45.7	50.5	55.0	42.7
06	27.6	30.1	34.2	40.8	41.3	46.4	50.3	54.9	42.7
07	27.6	31.1	34.0	38.9	40.8	44.3	51.1	54.6	41.7
08	22.4	24.5	28.1	30.4	36.0	42.1	47.9	55.3	39.8
09	18.5	19.5	25.3	27.1	32.0	39.0	46.5	55.4	40.1
10	17.8	19.6	23.3	24.6	30.8	38.7	47.2	53.7	35.6
11	20.7	21.7	26.8	27.2	34.8	43.8	50.1	60.5	42.3
12	21.9	23.4	29.1	29.3	35.8	46.2	53.8	58.5	42.5
13	21.6	23.5	28.1	28.4	37.0	44.6	54.0	61.2	42.9
14	23.9	25.3	29.8	30.5	37.6	48.1	55.3	62.5	45.0
15	24.1	25.6	31.9	32.5	39.6	47.5	52.7	58.7	43.6
16	24.7	26.9	36.0	37.4	44.2	49.0	56.7	64.0	45.8
17	28.8	30.7	36.5	36.7	43.1	50.6	55.3	61.9	47.7
18	27.9	30.7	36.6	38.4	42.6	47.9	52.4	57.9	44.7
19	25.4	28.1	31.6	33.3	38.5	47.8	53.4	58.7	43.8
20	23.8	26.9	31.7	37.8	40.6	47.5	52.0	59.4	44.5
21	28.7	30.2	33.4	38.1	39.5	46.4	52.7	55.7	43.1
22	29.6	30.4	35.2	39.6	40.4	46.4	52.4	57.3	43.3
23	30.4	32.1	35.3	38.8	39.8	45.9	50.2	54.9	42.8

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	26.8	28.8	32.3	38.3	38.4	46.5	52.2	56.0	43.0
01	29.6	33.4	36.1	39.9	40.0	45.7	50.1	54.7	42.3
02	28.6	29.9	32.4	35.9	36.1	42.4	47.2	54.4	38.9
03	24.5	27.2	31.0	35.9	36.6	41.7	47.7	53.4	39.0
04	28.3	29.4	33.3	39.2	39.3	43.8	47.6	54.2	40.9
05	26.8	28.2	33.1	39.7	39.8	44.8	48.6	53.3	41.7
06	27.2	28.9	32.9	38.9	39.6	44.8	49.0	53.4	41.2
07	26.3	29.2	33.4	37.5	39.9	43.9	48.7	54.9	41.1
08	21.5	23.5	27.5	29.5	34.6	41.3	45.5	55.2	38.0
09	17.0	18.5	24.7	26.4	31.3	37.5	46.6	53.4	38.2
10	15.8	18.2	22.3	23.8	30.1	37.3	46.2	53.7	34.7
11	19.1	20.2	25.2	25.8	33.6	41.9	48.7	56.4	40.4
12	20.5	22.3	27.6	27.8	34.5	44.4	51.3	57.0	40.6
13	20.1	21.9	27.0	27.5	35.8	43.1	51.9	58.7	41.6
14	22.9	24.4	28.8	29.5	35.8	44.1	50.7	58.3	40.2
15	22.4	24.1	30.8	31.4	37.7	44.6	51.1	57.8	41.1
16	24.3	26.1	34.5	35.9	41.3	45.8	52.6	59.2	42.4
17	27.0	28.8	34.9	35.1	40.4	46.4	51.7	57.5	43.4
18	26.8	29.5	35.0	36.2	39.8	44.4	49.7	55.4	41.7
19	23.8	27.0	29.6	31.8	37.1	45.2	51.0	56.5	41.3
20	22.2	25.1	30.3	36.4	38.1	44.5	49.8	56.9	42.1
21	27.2	29.5	32.0	35.9	37.4	44.3	48.9	54.9	40.7
22	27.9	29.0	33.6	37.2	38.1	44.6	50.4	56.0	41.3
23	28.7	31.0	33.4	36.8	37.7	44.0	48.5	53.5	41.0

Metrics for BRCA007 – Sheep Creek Frontcountry 2009
n = 1232 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	18.7	19.2	20.0	23.8	25.1	29.9	34.0	40.2	28.8
01	18.6	19.1	20.8	24.6	24.8	30.7	35.3	40.0	27.5
02	18.5	19.0	20.2	22.6	23.3	28.6	35.1	40.3	26.4
03	19.5	20.4	21.2	23.5	23.8	27.6	33.8	37.5	24.7
04	19.7	20.5	21.5	23.3	23.5	28.1	32.1	36.4	24.9
05	20.1	20.7	22.2	28.2	29.3	38.5	43.3	46.5	35.1
06	18.1	19.5	22.0	26.5	27.1	36.9	45.7	51.9	34.7
07	16.8	17.9	20.4	22.6	26.8	35.5	43.2	51.1	33.6
08	16.9	18.4	21.9	21.7	29.6	37.9	47.3	53.4	36.1
09	20.7	23.2	28.0	27.4	32.3	41.5	47.1	53.8	38.7
10	23.1	25.0	29.8	30.0	36.7	44.9	49.8	56.6	41.5
11	25.6	27.5	31.4	32.0	36.8	45.2	52.0	58.2	41.2
12	28.6	30.1	32.9	33.9	39.3	48.1	55.6	61.0	46.2
13	28.7	30.2	33.4	33.9	40.0	49.5	55.8	60.7	45.9
14	26.7	28.9	32.6	33.5	39.7	47.3	54.1	62.8	44.8
15	28.3	30.1	33.8	34.0	38.8	49.2	56.0	65.3	47.9
16	26.6	28.1	31.9	33.0	39.3	48.5	55.1	59.5	46.0
17	29.4	30.6	34.2	34.2	40.1	47.8	53.4	60.0	44.1
18	25.1	27.1	31.8	31.9	37.2	45.7	52.7	58.1	42.6
19	20.1	21.0	25.7	25.4	32.0	39.0	44.6	53.1	35.6
20	17.6	19.7	21.5	22.9	27.6	36.5	43.3	51.5	33.3
21	19.7	20.2	22.5	24.0	26.1	31.9	38.8	45.5	29.2
22	19.8	21.1	23.8	25.0	26.7	31.4	39.7	45.1	29.3
23	20.6	21.3	23.0	25.6	27.5	33.8	37.6	43.6	30.9

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	17.1	17.8	18.6	22.6	24.1	29.0	33.6	38.5	27.8
01	17.0	17.6	19.9	23.7	24.0	29.8	34.8	39.7	26.6
02	16.9	17.6	19.0	21.3	22.0	27.8	34.9	40.0	25.6
03	18.2	19.0	20.0	21.9	22.1	26.8	33.5	36.7	23.7
04	17.4	18.0	19.3	22.2	22.4	26.6	30.9	32.8	23.9
05	17.4	17.8	18.9	21.7	21.9	25.1	29.6	35.0	23.5
06	16.2	16.8	18.4	21.0	22.4	26.9	34.0	40.2	25.2
07	14.1	14.8	17.2	18.9	22.6	29.4	38.0	44.0	27.3
08	13.7	14.7	18.4	18.1	25.2	34.0	42.2	51.4	32.8
09	18.9	21.1	25.9	24.4	31.2	39.0	45.0	49.7	35.4
10	21.3	23.0	26.9	27.2	34.8	43.1	48.5	54.2	39.2
11	23.8	25.8	29.5	30.0	35.4	43.4	50.2	56.3	40.0
12	26.3	28.1	31.2	32.2	37.2	45.8	52.2	57.3	43.5
13	27.5	28.8	31.8	32.3	38.4	47.2	52.3	56.4	43.4
14	25.2	27.0	30.5	31.3	38.3	45.8	50.8	58.3	42.8
15	26.3	28.4	32.0	32.3	36.8	46.5	51.4	57.9	42.8
16	25.5	26.8	30.5	31.7	38.3	46.5	51.2	56.4	42.6
17	27.9	29.3	32.4	32.4	38.8	45.6	50.3	56.0	41.9
18	23.8	25.6	30.0	30.2	35.7	43.9	49.3	53.5	40.1
19	18.8	19.7	23.8	23.5	30.3	36.6	42.6	49.5	33.5
20	15.8	17.7	19.4	20.9	24.5	32.2	40.0	46.3	31.0
21	18.2	19.0	21.5	23.0	25.2	30.9	37.6	45.3	28.3
22	18.3	19.3	22.0	23.9	26.0	31.1	38.3	43.9	28.9
23	18.8	19.7	21.7	24.5	26.8	32.6	37.6	42.4	29.5

Metrics for BRCA008 – Yovimpa Frontcountry 2009
n = 476 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	25.1	26.4	28.5	34.0	34.3	41.8	46.7	51.1	37.9
01	23.9	25.4	28.6	33.9	34.2	40.6	46.1	48.8	37.1
02	23.6	24.7	27.2	32.4	33.2	40.1	44.5	48.5	36.6
03	21.6	22.6	26.0	30.8	31.0	37.6	40.7	44.2	34.9
04	21.2	23.4	27.2	32.0	32.1	37.8	42.6	45.9	34.4
05	23.2	25.4	28.6	34.1	34.2	38.0	43.0	47.7	35.3
06	22.8	24.4	26.2	28.8	29.0	34.3	41.0	47.9	31.6
07	15.7	17.3	22.1	26.3	27.8	34.1	43.9	51.2	34.9
08	17.5	18.7	20.7	21.5	24.1	33.6	41.0	50.9	31.2
09	19.1	20.3	21.4	22.5	25.4	32.7	42.0	49.7	31.4
10	20.2	21.2	22.6	23.7	26.5	35.5	43.6	53.4	33.6
11	20.5	21.4	22.9	24.7	28.5	36.1	44.5	51.5	34.0
12	21.0	22.5	25.9	28.7	32.3	40.3	46.0	52.0	37.0
13	21.5	22.7	26.2	30.0	33.4	41.1	47.7	54.2	37.7
14	21.5	22.5	24.8	27.2	30.8	40.2	45.7	54.1	36.7
15	21.0	22.7	25.8	28.6	32.9	42.4	49.5	54.7	38.8
16	21.7	23.9	27.3	29.7	33.3	41.9	48.5	54.2	38.6
17	21.7	23.4	26.8	29.4	32.9	39.3	45.4	51.8	36.1
18	19.5	21.3	25.4	28.0	32.1	41.2	48.0	53.3	37.5
19	17.2	18.1	21.7	24.2	27.6	37.2	46.3	53.4	36.9
20	17.7	19.2	23.2	28.7	30.6	38.7	45.4	48.7	34.7
21	20.9	23.0	26.1	29.8	32.1	37.5	43.9	48.2	33.8
22	22.6	24.2	27.5	30.2	31.6	38.1	43.6	48.3	35.1
23	21.4	23.3	26.6	30.8	32.1	38.0	41.5	45.9	34.5

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	23.7	25.1	27.1	31.9	32.1	38.8	43.4	46.6	34.9
01	23.1	24.3	26.7	31.5	31.7	37.7	41.3	45.0	34.3
02	21.9	23.0	25.6	30.3	31.3	36.7	40.3	44.9	33.7
03	19.8	21.0	24.4	29.0	29.2	34.4	37.1	42.0	32.2
04	19.7	21.8	25.4	30.0	30.0	35.0	39.1	41.9	31.8
05	21.8	23.2	26.4	32.0	32.1	35.5	40.1	43.4	32.9
06	21.2	22.7	24.4	27.0	27.1	31.7	35.9	40.3	28.7
07	12.6	15.1	20.3	24.3	26.1	31.3	40.4	44.3	32.5
08	14.4	15.4	17.6	19.2	21.6	32.0	38.2	45.7	28.7
09	15.3	16.4	18.2	19.9	23.4	31.7	38.5	44.5	30.1
10	16.0	17.3	19.6	20.8	24.2	33.3	40.3	47.9	30.8
11	16.2	17.5	19.8	22.4	26.6	34.2	42.4	50.2	31.8
12	17.7	19.3	23.5	26.4	29.9	37.0	42.8	49.9	33.6
13	17.7	19.5	24.1	27.5	30.9	37.8	44.4	49.7	34.8
14	17.2	18.8	22.2	25.2	28.2	35.9	41.9	51.2	33.0
15	18.7	20.5	23.5	25.7	30.1	39.0	44.9	50.5	35.2
16	19.3	21.0	25.0	27.3	30.9	38.0	44.0	50.2	35.2
17	19.7	21.3	24.7	27.3	30.5	36.9	43.3	50.1	33.8
18	17.4	19.3	23.3	26.0	29.9	37.6	44.1	49.9	34.0
19	15.0	16.3	19.7	22.4	25.3	34.8	42.7	49.7	34.5
20	15.7	17.6	21.7	26.9	29.0	35.9	40.9	46.7	32.0
21	19.0	21.3	24.8	28.2	30.2	35.2	40.7	45.6	31.5
22	20.9	22.5	25.7	28.2	29.5	35.4	40.6	45.2	31.7
23	19.9	22.1	25.3	28.8	30.0	35.6	38.7	44.0	32.2

Metrics for BRCA009 – Paria Backcountry 2009
n = 182 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	33.0	34.1	35.2	37.2	37.4	40.1	42.4	43.9	38.0
01	36.0	36.6	37.6	39.3	39.4	41.4	42.2	42.7	39.9
02	35.4	36.1	37.2	39.2	39.4	41.2	42.2	43.3	39.7
03	32.8	33.4	34.3	36.6	36.7	39.3	41.3	42.3	37.3
04	27.2	28.6	30.0	31.5	31.5	33.5	38.2	41.5	32.0
05	25.6	26.1	27.5	28.8	28.8	31.6	35.3	38.5	29.9
06	25.6	26.2	27.1	29.5	29.5	32.9	36.4	42.3	31.1
07	22.5	23.3	25.4	29.0	29.2	32.0	38.4	43.0	32.7
08	17.8	18.4	20.0	22.0	22.8	30.8	43.6	51.0	31.6
09	18.5	18.8	19.6	21.6	22.3	30.3	42.5	54.9	32.0
10	19.8	20.3	22.2	24.9	25.9	32.4	38.8	45.3	29.0
11	20.1	20.8	22.5	26.3	27.5	35.9	43.1	55.0	33.6
12	21.9	22.9	25.5	29.6	30.7	38.8	50.0	57.0	38.4
13	24.1	25.2	27.6	33.8	35.0	43.9	50.3	54.9	39.9
14	23.7	24.5	27.8	36.0	36.6	45.9	53.1	56.5	43.1
15	23.9	24.8	28.1	34.2	35.1	42.8	49.3	53.7	39.1
16	21.3	21.9	25.1	32.1	32.8	43.1	49.7	55.6	39.5
17	20.7	21.4	23.1	28.9	30.3	38.3	46.5	52.4	35.6
18	20.0	20.4	22.2	25.9	26.7	35.6	43.2	50.4	32.2
19	18.9	19.4	20.1	21.4	21.6	26.9	36.7	45.4	25.6
20	18.9	19.3	20.0	23.0	26.8	39.7	42.8	44.2	34.2
21	36.7	37.5	38.6	39.7	39.8	41.4	43.6	45.3	40.1
22	34.6	35.7	37.1	38.6	38.8	40.5	42.5	45.2	39.0
23	35.9	37.0	38.2	40.0	40.2	41.5	42.1	43.5	40.5

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	22.2	23.2	26.7	30.2	30.5	33.5	37.1	41.5	31.1
01	23.5	24.5	26.7	29.6	29.7	33.2	36.0	40.2	30.7
02	25.4	26.2	27.7	30.5	30.6	33.8	36.2	40.0	31.4
03	25.1	25.9	27.0	30.8	30.9	35.2	37.8	39.1	32.0
04	23.3	24.5	25.4	26.8	26.8	30.2	36.1	39.7	27.9
05	24.4	25.0	25.9	27.3	27.3	29.8	34.0	36.8	28.1
06	24.7	25.2	26.0	26.9	26.9	31.4	34.6	37.9	29.9
07	20.9	21.7	23.5	27.6	27.8	30.0	36.1	39.7	31.2
08	14.8	15.5	17.8	20.2	21.0	29.6	40.9	50.5	28.7
09	14.1	14.6	15.7	19.4	20.4	28.2	39.2	47.5	26.3
10	16.9	17.7	19.6	23.5	24.6	31.5	38.2	43.3	27.9
11	17.3	17.8	20.7	24.8	26.1	35.0	42.5	51.6	32.1
12	19.9	20.8	23.8	28.7	29.9	37.8	48.3	55.8	36.5
13	22.5	23.8	26.4	32.1	33.1	41.9	46.8	50.4	37.7
14	22.4	23.2	26.1	34.7	35.3	43.6	48.5	51.7	39.8
15	22.4	23.7	27.1	32.9	33.9	40.9	46.3	50.6	37.0
16	18.7	19.4	23.3	30.7	31.5	41.2	46.8	52.4	37.0
17	17.9	19.0	21.4	27.9	29.4	37.1	44.4	49.7	33.9
18	16.5	17.2	20.0	24.7	25.5	34.7	40.9	50.1	30.9
19	15.4	16.1	16.9	18.4	18.8	25.5	36.6	43.6	24.3
20	13.9	14.5	16.7	19.1	20.0	26.8	34.4	42.3	23.5
21	15.2	15.7	16.8	21.6	22.1	29.0	37.4	41.5	28.7
22	17.6	18.6	20.5	24.1	24.7	32.8	36.5	41.6	29.1
23	19.2	20.1	23.6	27.3	27.5	30.3	34.5	39.3	28.0

Metrics for BRCA012 – Yovimpa Backcountry 2009
n = 371 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	18.0	18.8	20.5	24.9	25.2	33.0	39.9	43.2	29.3
01	19.3	20.8	23.5	27.5	27.7	33.4	38.3	44.9	30.2
02	17.6	18.0	19.8	24.0	24.3	30.3	40.3	45.3	29.9
03	15.1	15.6	17.3	21.7	22.5	27.1	30.7	40.4	23.4
04	18.2	18.8	20.1	27.1	27.1	35.2	39.3	44.3	31.5
05	19.5	20.1	24.8	29.2	29.2	32.2	36.9	42.3	29.7
06	16.7	17.2	19.4	25.8	25.8	30.0	38.1	43.8	28.2
07	16.0	16.4	17.3	19.5	19.8	26.2	35.7	42.9	26.5
08	15.5	15.7	16.3	17.3	18.4	29.1	38.3	48.5	26.9
09	16.1	16.5	17.2	19.2	20.4	29.6	39.3	49.0	27.7
10	17.4	17.9	19.0	21.6	23.4	32.6	42.5	52.0	31.9
11	18.5	19.4	20.6	25.7	30.0	37.7	43.7	49.6	34.3
12	19.3	20.0	23.4	27.3	28.9	38.0	45.5	52.3	35.8
13	19.7	20.4	24.4	30.5	32.2	39.8	46.1	54.5	36.5
14	19.0	20.2	24.1	28.9	30.4	39.9	48.0	53.0	36.9
15	19.4	20.5	23.7	28.8	30.1	39.1	46.1	53.9	35.6
16	18.1	18.8	21.1	26.9	28.5	36.4	44.7	51.4	35.2
17	18.1	19.0	21.1	24.6	26.4	33.9	42.5	50.6	32.2
18	17.1	17.4	18.5	22.2	23.5	32.3	42.2	49.5	32.8
19	16.7	17.3	18.7	21.6	22.8	30.2	39.1	49.5	28.4
20	16.1	16.4	17.5	19.0	20.2	29.6	37.8	47.2	27.2
21	15.7	16.1	16.9	18.7	20.1	30.3	39.2	46.6	27.0
22	18.6	19.5	22.0	26.0	27.5	33.8	40.4	46.9	30.8
23	23.3	24.3	25.5	29.3	29.9	36.5	40.9	47.2	33.2

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	16.2	17.2	19.1	23.4	23.8	31.7	38.7	42.2	28.4
01	17.9	19.4	22.3	25.9	26.1	32.0	37.4	44.8	28.9
02	15.3	16.0	18.1	21.2	21.6	28.9	38.8	44.4	28.9
03	11.3	12.1	13.5	20.1	20.8	25.8	30.1	37.2	22.0
04	15.9	16.7	18.2	26.0	26.0	33.6	36.9	41.1	30.0
05	18.0	18.7	23.0	28.1	28.1	31.1	35.5	41.8	28.6
06	13.4	14.7	17.5	23.7	23.8	27.6	33.2	39.8	27.1
07	12.2	12.5	13.7	17.2	17.6	25.2	35.2	40.4	22.9
08	10.9	11.5	12.3	13.7	15.1	27.9	38.3	44.9	26.1
09	11.8	12.2	13.1	15.7	17.5	28.7	38.1	45.2	26.5
10	13.6	14.2	15.5	19.6	22.0	31.5	42.1	48.1	30.6
11	15.9	16.7	18.3	23.5	28.6	36.4	42.5	49.2	32.7
12	16.7	17.6	21.8	26.0	27.5	35.9	43.3	50.9	34.1
13	17.4	18.3	22.8	28.9	30.5	37.7	43.6	51.8	34.4
14	16.7	17.7	22.2	27.3	28.8	37.8	45.4	51.2	35.5
15	17.0	18.1	22.3	27.6	28.7	37.2	43.2	49.4	33.8
16	15.2	16.2	18.8	24.5	26.0	34.4	42.5	48.6	33.5
17	14.5	15.3	18.4	22.2	23.7	33.0	41.4	47.6	31.2
18	13.3	13.8	15.2	20.0	21.8	31.4	40.5	46.6	29.6
19	12.8	13.4	15.4	19.0	20.4	28.7	37.4	44.2	26.3
20	12.0	12.7	13.9	16.5	17.6	28.3	37.0	44.5	25.9
21	11.9	12.5	13.7	17.1	18.9	29.6	39.1	46.0	26.5
22	16.3	17.7	20.9	25.2	26.5	32.9	39.5	46.1	29.7
23	21.5	22.7	23.8	27.5	28.1	34.7	40.0	45.4	31.5

Metrics for BRCA013 – Inspiration Frontcountry 2009
n = 619 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	16.4	17.4	20.7	25.0	26.1	30.7	37.1	44.2	29.1
01	16.0	17.1	19.0	22.3	22.8	28.5	33.9	41.1	25.6
02	15.4	16.2	17.9	20.2	21.6	26.1	36.2	41.4	25.1
03	14.8	15.3	16.7	19.6	19.8	23.8	29.0	35.4	21.2
04	15.1	15.5	16.6	18.8	18.9	21.8	29.6	36.6	20.4
05	14.3	14.7	16.2	18.2	19.2	30.6	39.6	48.9	28.5
06	15.0	15.5	17.1	18.5	19.6	26.9	38.1	47.1	26.1
07	15.1	15.5	16.7	17.6	19.3	28.1	38.8	48.6	28.1
08	16.2	16.8	18.3	18.8	23.7	36.0	44.9	51.9	33.2
09	16.5	17.9	19.5	19.7	25.8	36.8	44.8	53.0	34.1
10	17.7	18.8	20.7	21.4	27.0	37.2	46.9	54.3	35.5
11	18.6	19.8	22.0	22.6	27.7	36.9	45.5	53.6	35.0
12	18.9	20.4	22.9	24.9	29.0	38.3	46.2	53.5	36.5
13	20.3	21.7	24.6	26.4	30.7	39.6	45.9	51.8	36.3
14	20.0	21.7	25.1	26.8	31.4	39.9	46.6	51.8	36.3
15	19.5	20.5	23.9	25.2	31.0	40.9	45.8	52.0	38.1
16	20.0	20.9	23.9	25.5	29.8	39.3	44.9	50.0	35.9
17	18.1	19.5	22.2	23.8	29.1	36.7	43.7	51.9	33.7
18	18.6	19.8	23.3	24.6	28.6	36.1	44.3	51.4	32.9
19	17.7	18.4	20.5	21.8	25.2	34.3	44.1	50.0	32.7
20	16.7	17.7	20.3	21.8	26.1	31.9	42.6	50.0	31.2
21	16.2	16.6	17.7	19.8	21.9	28.8	39.2	47.4	28.0
22	15.2	15.8	17.4	18.8	20.7	28.2	40.2	46.2	28.9
23	15.4	15.9	20.3	22.1	24.8	30.5	36.8	43.5	28.0

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	14.0	15.4	19.4	22.9	23.9	28.6	35.9	41.7	27.3
01	13.5	14.5	17.1	20.9	21.4	27.0	32.0	37.9	23.9
02	12.6	14.0	16.4	19.0	20.5	25.7	35.7	41.7	24.6
03	11.4	12.6	14.6	18.2	18.4	22.4	28.1	34.5	20.6
04	11.7	12.4	13.8	16.8	17.2	20.6	28.3	34.2	19.2
05	10.3	11.2	13.0	14.6	16.3	21.3	25.6	29.9	19.3
06	11.8	12.5	13.3	16.1	16.6	22.2	29.9	33.3	20.4
07	11.1	11.8	13.0	14.3	16.0	24.2	33.6	40.8	23.5
08	11.9	12.5	14.1	14.5	19.8	32.3	42.2	50.5	30.4
09	13.1	14.4	16.1	16.4	21.1	32.0	41.2	49.4	30.7
10	14.8	15.9	18.3	19.2	25.1	33.8	45.2	52.8	32.8
11	15.8	17.1	20.3	20.8	25.6	34.2	42.4	51.0	31.9
12	16.4	17.5	21.0	23.0	27.1	34.4	42.5	48.5	31.8
13	18.5	19.7	22.2	24.0	28.4	35.8	41.3	49.1	32.9
14	17.7	19.6	23.0	24.6	28.9	35.3	42.5	49.9	32.9
15	16.4	17.7	21.0	22.6	28.7	36.0	42.0	48.2	32.6
16	16.8	18.2	21.5	23.3	27.3	35.2	42.2	46.7	32.2
17	15.1	16.6	20.1	21.7	25.6	33.9	41.4	47.2	31.7
18	15.6	17.8	21.2	22.7	26.7	33.6	41.5	47.2	31.6
19	14.7	15.9	18.8	20.3	23.8	31.9	41.6	48.9	31.6
20	14.4	15.6	18.7	20.3	24.7	30.9	40.5	46.0	29.3
21	13.6	14.2	15.9	18.4	20.7	27.6	39.0	45.2	27.8
22	12.0	13.2	15.5	17.2	19.5	27.9	39.2	45.7	28.3
23	12.4	13.4	18.0	20.0	23.7	29.0	36.9	41.8	26.6

Metrics for BRCA014 – Inspiration Backcountry 2009
n = 427 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	14.5	14.6	14.9	15.2	15.5	22.8	29.5	35.9	22.3
01	13.7	13.8	13.9	15.2	15.4	20.6	33.2	38.4	21.2
02	13.8	13.8	14.0	14.6	14.8	23.7	35.9	42.4	24.5
03	14.0	14.1	14.2	14.6	14.7	18.8	28.9	32.6	20.8
04	14.4	14.6	15.1	16.5	16.5	19.8	28.6	32.6	17.6
05	13.8	13.9	14.0	14.6	14.9	18.0	25.4	34.7	18.0
06	14.2	14.4	14.7	15.2	16.2	22.3	30.2	37.5	20.2
07	14.1	14.3	14.6	14.7	15.6	21.8	33.4	41.3	21.1
08	14.6	14.9	15.6	15.6	19.0	30.8	40.0	47.4	27.9
09	14.8	15.0	15.6	16.1	18.9	29.2	37.7	46.8	27.5
10	15.6	16.0	17.2	17.7	20.5	30.9	40.5	48.7	28.7
11	15.8	16.3	17.3	18.3	21.3	31.5	42.1	50.5	29.7
12	16.1	16.7	17.9	19.3	22.2	31.6	41.6	48.5	29.8
13	16.3	17.0	18.6	20.2	23.7	34.3	43.8	51.4	31.2
14	17.0	17.7	19.8	21.6	24.9	33.7	42.7	49.2	31.6
15	16.9	17.5	18.8	21.3	23.7	33.3	44.1	54.6	33.3
16	15.7	16.3	17.6	19.6	21.8	32.1	40.6	47.3	28.9
17	15.9	16.4	17.7	18.7	22.3	31.3	40.6	48.1	30.7
18	15.5	16.0	17.2	18.1	20.4	28.3	37.9	46.3	26.7
19	15.1	15.3	15.8	16.4	17.4	26.7	38.6	46.7	27.1
20	14.0	14.1	14.5	15.1	16.3	26.5	36.6	44.0	24.2
21	14.1	14.2	14.7	15.2	15.8	23.3	33.8	40.1	22.1
22	14.1	14.3	14.9	15.5	16.2	24.4	33.8	41.2	22.5
23	13.9	14.0	14.4	15.3	16.3	24.4	34.8	42.4	22.7

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	10.3	10.7	11.2	11.7	12.2	21.9	29.0	35.9	20.4
01	8.6	8.8	9.1	11.9	12.3	19.1	32.8	38.2	20.6
02	8.6	9.0	9.4	10.7	10.9	23.0	35.8	41.9	24.1
03	9.3	9.5	9.8	10.7	10.8	15.5	27.6	31.4	17.5
04	10.3	10.9	11.6	13.6	13.7	16.6	26.7	32.2	15.1
05	8.7	9.2	9.6	11.1	11.6	13.9	24.6	31.7	16.4
06	9.8	10.2	10.9	11.6	12.7	17.2	27.2	33.0	16.6
07	9.4	9.7	10.2	10.4	11.4	18.7	30.2	39.3	18.4
08	10.0	10.5	11.6	11.7	16.2	29.9	39.4	46.1	27.4
09	10.4	10.9	11.7	12.1	16.5	28.1	37.4	44.3	26.1
10	11.9	12.5	14.2	15.0	18.5	30.4	40.3	47.8	28.2
11	12.1	12.8	14.2	15.4	19.4	29.8	40.6	48.1	28.8
12	12.5	13.2	14.8	16.6	20.0	30.4	40.6	46.9	28.7
13	12.9	13.9	16.2	18.2	22.0	33.1	42.8	49.1	30.6
14	14.1	15.0	17.1	19.5	22.8	31.8	42.6	48.8	30.2
15	13.9	14.9	16.5	19.3	22.4	32.5	42.5	50.6	31.5
16	12.2	12.9	14.8	16.8	20.2	30.6	40.0	47.4	28.1
17	12.1	13.1	14.9	16.4	20.2	30.3	39.6	47.1	27.6
18	12.1	12.7	14.3	15.4	18.4	26.8	38.0	45.5	25.8
19	11.0	11.6	12.4	13.4	14.7	25.0	37.7	45.3	25.0
20	9.2	9.7	10.5	11.4	12.9	25.9	36.5	43.6	23.8
21	9.5	9.9	10.9	11.5	12.6	21.9	33.7	40.0	21.7
22	9.6	10.1	10.8	12.1	13.2	23.4	33.5	41.1	21.6
23	9.0	9.3	10.3	12.0	13.0	23.5	34.6	42.0	21.8

Metrics for BRCA016 – Paria Frontcountry 2010
n = 674 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	30.6	31.8	34.3	39.7	39.9	44.5	48.5	51.8	41.8
01	32.7	34.2	37.4	40.8	41.5	44.9	48.3	51.5	42.5
02	32.2	35.0	38.3	42.0	42.6	47.9	51.5	54.6	44.6
03	33.7	35.3	38.0	42.8	43.4	48.0	52.1	54.4	45.2
04	33.9	35.4	38.6	43.4	43.7	47.3	50.1	53.7	45.1
05	34.6	36.4	38.5	41.2	41.4	45.6	49.3	51.6	42.6
06	30.8	32.4	34.8	38.3	39.1	43.7	46.3	50.7	40.6
07	30.0	31.7	34.0	37.1	38.8	42.4	48.8	53.8	40.2
08	24.2	25.4	29.6	32.2	35.3	41.4	47.7	54.3	38.1
09	23.6	24.9	28.0	31.0	35.4	42.8	49.0	54.3	39.4
10	24.5	25.5	30.7	35.0	37.8	45.6	51.4	57.1	42.3
11	28.1	30.2	34.0	39.0	40.9	47.0	51.7	56.7	44.3
12	28.8	31.8	35.7	40.3	42.0	47.8	51.7	57.5	44.5
13	29.7	31.2	35.7	41.3	42.8	49.1	53.1	58.6	45.8
14	28.8	31.0	36.8	41.6	43.6	48.4	52.8	58.0	45.6
15	29.9	31.4	37.3	41.3	43.1	48.7	52.9	57.7	45.1
16	29.0	31.6	36.6	41.4	42.6	49.0	53.5	57.3	45.3
17	27.0	28.1	34.3	40.3	42.2	49.1	53.9	57.3	45.4
18	27.9	30.5	35.7	38.9	43.2	49.5	53.9	58.2	46.0
19	25.7	27.4	32.1	35.3	37.2	44.0	49.6	55.1	40.4
20	26.9	28.0	30.4	34.2	35.9	41.5	47.8	53.7	38.2
21	31.4	32.9	35.2	38.4	39.1	42.5	46.4	53.1	39.8
22	31.8	33.2	35.5	39.1	39.8	43.5	47.0	50.4	40.6
23	32.5	33.7	37.4	39.3	39.7	43.9	47.7	51.5	41.3

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	29.8	31.0	32.5	37.1	37.4	40.9	43.8	45.9	38.7
01	31.4	32.8	35.4	38.1	38.5	41.4	43.1	45.5	39.3
02	30.5	33.1	35.9	39.3	39.7	43.8	46.1	49.4	41.0
03	32.2	33.4	35.8	39.9	40.3	43.8	46.1	47.8	41.3
04	32.2	33.5	36.2	40.2	40.5	43.2	45.2	48.7	41.2
05	33.1	34.7	36.5	38.5	38.7	41.5	44.5	46.8	39.3
06	29.2	31.3	33.5	36.2	36.9	40.4	42.6	45.4	37.7
07	28.4	30.3	32.4	35.1	36.4	39.3	45.1	48.9	37.4
08	22.6	24.1	28.2	30.5	33.6	39.0	44.6	51.3	35.5
09	21.9	23.6	26.3	29.2	33.4	39.6	45.2	51.2	36.6
10	22.9	23.9	29.1	33.1	35.6	41.9	46.8	53.0	39.1
11	26.3	28.5	32.1	36.4	38.4	43.9	47.8	52.4	40.7
12	26.5	29.5	33.9	37.7	39.1	44.0	48.3	54.5	40.9
13	28.2	29.9	33.4	38.4	39.6	45.1	48.8	53.1	41.5
14	27.5	29.6	34.8	38.8	40.3	44.4	48.1	53.1	41.4
15	28.4	29.8	35.2	38.6	40.1	44.8	48.6	53.9	41.5
16	27.6	30.0	34.3	38.7	39.7	44.9	48.5	52.2	41.4
17	25.8	26.7	32.2	37.5	39.2	44.5	48.1	51.6	41.3
18	26.2	28.7	33.6	36.4	39.9	45.4	48.7	52.9	42.1
19	24.5	26.2	30.6	33.4	35.1	40.9	45.9	51.7	37.7
20	26.0	27.2	29.4	32.7	34.1	38.4	44.8	49.8	35.6
21	29.6	31.0	33.4	36.4	36.9	39.8	44.6	48.4	37.6
22	30.5	31.8	33.8	37.2	37.7	40.7	43.4	46.6	38.2
23	31.5	32.4	35.6	37.5	37.8	41.0	45.1	49.1	38.5

Metrics for BRCA017 – Farview Frontcountry 2010
n = 622 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	31.3	33.1	36.2	40.5	40.7	45.1	49.5	52.3	42.3
01	33.3	35.1	37.7	42.3	42.5	46.5	48.8	52.4	43.5
02	33.9	35.8	38.9	42.4	42.8	48.5	52.3	56.2	45.7
03	33.8	35.5	38.3	43.5	43.7	48.0	52.2	54.8	45.4
04	34.4	35.4	38.9	44.9	45.3	48.4	50.2	54.1	46.8
05	35.8	37.3	39.5	42.4	42.5	46.5	49.8	52.3	43.7
06	31.7	32.9	37.4	40.8	40.9	43.7	46.9	51.4	41.5
07	30.3	32.1	34.3	38.3	38.9	44.0	48.8	54.9	41.3
08	25.3	26.8	30.1	33.7	36.4	42.0	48.5	54.7	39.1
09	25.1	26.4	30.1	31.5	35.8	44.0	49.3	54.5	40.5
10	26.9	29.0	32.8	34.8	39.2	46.0	51.8	58.3	42.9
11	28.4	30.4	34.7	35.7	41.8	48.0	52.8	57.1	44.6
12	29.7	32.1	36.5	37.4	42.4	48.5	52.5	57.8	44.9
13	29.8	31.9	35.8	37.1	42.8	49.1	54.4	58.8	46.3
14	29.1	31.5	37.5	39.0	43.7	49.2	53.9	58.0	45.6
15	30.9	32.9	37.8	39.8	43.4	48.8	52.9	58.0	45.5
16	30.5	32.4	37.8	38.5	44.6	50.5	54.8	57.7	47.0
17	29.5	31.8	35.9	36.9	42.3	49.3	54.7	58.7	45.5
18	29.7	31.3	36.4	38.2	43.2	50.2	54.6	58.6	46.4
19	28.1	30.9	34.1	35.6	40.2	45.9	50.0	55.8	42.4
20	27.5	29.7	32.0	34.7	37.2	43.3	48.6	54.5	40.2
21	31.7	33.2	35.9	39.0	40.1	46.5	51.7	55.3	43.0
22	33.7	35.0	36.9	39.9	41.2	43.9	47.7	51.8	41.7
23	32.5	33.7	38.4	40.7	41.1	47.4	52.1	54.2	42.4

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	29.9	31.8	34.3	38.1	38.2	41.5	44.0	45.9	38.9
01	31.8	33.4	35.8	39.1	39.4	42.2	44.0	46.6	39.8
02	32.5	34.1	36.7	39.6	39.7	43.9	46.6	49.2	41.3
03	32.4	33.6	36.1	40.6	40.7	44.0	46.4	48.6	41.5
04	32.3	33.6	36.3	41.5	41.8	44.3	45.3	49.9	42.5
05	33.8	35.4	37.3	39.5	39.6	42.2	44.6	46.8	40.1
06	31.1	31.8	35.1	38.2	38.3	40.4	42.9	46.7	38.6
07	28.8	31.3	33.3	36.0	37.0	40.6	45.3	49.3	38.3
08	24.0	25.2	28.7	31.8	34.5	39.8	46.1	51.4	36.8
09	23.6	25.3	28.7	30.1	33.8	40.9	45.8	51.8	37.8
10	25.9	27.6	31.0	32.8	36.8	42.8	47.5	53.9	40.4
11	26.9	29.0	32.5	33.5	38.9	44.3	48.6	53.4	41.5
12	27.7	30.4	34.3	35.2	39.7	44.4	48.4	54.6	41.3
13	28.2	30.2	33.6	34.9	39.6	45.4	48.9	53.3	41.7
14	27.6	29.7	35.2	36.5	40.5	45.1	48.3	53.1	42.0
15	30.0	31.6	35.5	37.4	40.9	44.8	49.2	53.9	41.8
16	28.8	30.3	35.6	36.4	41.0	45.9	49.1	52.9	42.7
17	28.5	30.7	33.9	34.8	39.4	45.0	48.7	52.1	41.4
18	28.4	30.0	34.3	35.8	40.1	45.4	48.9	53.4	42.1
19	26.9	29.4	32.5	33.8	37.5	41.9	46.4	52.2	38.9
20	26.4	28.1	30.3	32.9	35.1	40.3	45.5	50.0	36.7
21	30.2	31.6	34.2	36.8	37.7	43.0	46.7	48.8	39.9
22	31.9	33.3	35.2	37.2	38.6	40.8	43.8	47.9	39.1
23	31.7	32.4	35.7	38.2	38.4	43.3	46.3	49.2	38.6

Metrics for BRCA018 – Inspiration Frontcountry 2010
n = 595 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	16.7	17.9	21.7	24.7	26.2	31.4	37.4	40.9	28.4
01	17.2	18.5	20.5	22.8	24.0	30.1	36.6	41.7	27.6
02	15.5	16.2	17.5	20.2	21.4	26.6	34.1	39.7	25.0
03	15.5	15.8	17.6	21.0	21.8	27.4	33.2	38.2	25.0
04	15.7	16.6	18.7	22.0	22.8	26.7	34.9	40.8	25.7
05	15.7	16.3	18.2	19.5	21.2	30.3	39.3	44.5	27.8
06	16.0	17.2	19.0	19.7	23.6	31.7	41.0	47.9	29.8
07	16.5	18.1	21.3	21.8	24.6	33.8	40.8	48.0	30.5
08	17.6	18.8	20.5	20.7	25.4	36.0	42.6	50.7	33.6
09	17.7	18.9	22.1	22.6	27.1	36.0	45.2	54.4	34.5
10	18.7	19.7	21.7	22.0	28.4	38.7	45.8	54.9	35.6
11	20.6	22.4	25.5	26.9	31.9	38.8	44.8	53.6	35.9
12	20.6	22.0	26.0	27.6	34.3	41.6	46.3	53.3	37.9
13	20.6	22.3	26.5	28.2	33.6	41.0	46.7	53.8	37.1
14	20.5	22.6	25.7	27.2	33.5	41.7	47.5	55.2	39.1
15	22.4	24.2	28.2	30.4	35.2	43.7	49.6	55.2	40.6
16	20.9	23.0	28.1	30.4	35.9	43.2	48.4	53.8	39.9
17	22.3	23.7	28.2	30.6	36.1	43.5	47.1	51.1	39.4
18	22.9	24.4	28.2	29.9	34.1	39.5	46.0	52.8	37.1
19	21.4	23.8	27.8	29.7	33.0	39.7	44.5	48.4	35.9
20	19.8	21.3	24.4	26.3	29.8	37.6	42.6	48.7	34.4
21	18.8	20.7	23.6	27.8	30.8	35.7	41.1	45.5	32.9
22	20.1	22.0	26.2	29.7	31.6	37.0	42.1	46.0	34.4
23	18.3	19.6	22.5	26.0	27.8	33.5	41.1	44.8	30.1

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	13.9	16.0	20.4	23.3	24.4	30.4	34.8	37.9	27.1
01	14.4	16.6	19.0	21.6	23.0	28.6	34.7	40.4	26.1
02	11.3	12.5	15.1	18.6	20.0	25.5	34.1	39.3	23.8
03	10.8	11.8	15.3	19.3	20.2	26.2	32.2	36.7	23.7
04	12.1	13.9	17.0	20.9	21.6	24.0	32.4	38.3	24.1
05	11.7	13.0	15.8	17.3	18.8	23.6	32.5	39.6	23.3
06	10.9	11.9	15.6	16.3	20.5	24.8	33.4	37.4	23.7
07	13.3	14.6	18.2	19.1	22.1	29.1	35.7	40.1	25.7
08	13.4	14.5	16.9	17.9	22.6	31.4	39.3	47.7	30.1
09	14.7	16.2	19.4	20.1	25.1	33.9	43.3	50.0	32.1
10	14.9	16.4	19.2	19.7	26.3	35.5	44.6	50.5	33.8
11	18.8	20.6	24.1	25.5	29.8	35.9	42.8	50.2	33.6
12	17.8	19.3	24.7	26.1	32.5	38.0	43.7	51.1	34.8
13	17.8	20.0	24.4	26.2	31.1	37.6	42.5	48.6	33.8
14	18.4	20.0	24.2	25.7	31.2	37.9	42.8	50.6	35.1
15	19.8	21.8	25.7	28.1	33.0	38.8	43.6	50.4	36.1
16	18.5	21.1	26.8	28.8	33.7	39.6	43.7	50.5	36.1
17	20.1	21.6	25.7	27.5	31.6	38.1	43.0	48.2	34.9
18	21.3	22.6	26.2	27.6	31.3	36.6	41.9	47.9	34.0
19	19.9	21.9	26.2	28.1	30.8	36.6	40.9	44.9	33.5
20	17.4	19.0	22.4	24.0	26.8	31.9	39.1	46.3	30.6
21	16.8	19.2	22.3	26.4	28.5	32.1	38.2	43.7	30.0
22	18.7	20.9	25.2	27.8	29.4	34.7	39.0	42.1	32.1
23	16.2	17.6	21.2	24.8	26.5	32.2	37.9	42.4	29.5

Metrics for BRCA019 – Yovimpa Frontcountry 2010
n = 759 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	28.9	29.9	32.5	37.2	37.6	44.2	50.0	55.5	40.7
01	31.0	32.1	35.5	39.3	40.1	46.2	50.5	55.0	43.1
02	31.1	32.9	35.9	41.4	42.2	49.4	53.7	57.2	46.1
03	28.2	29.6	32.4	38.4	38.6	45.8	51.6	56.4	42.4
04	27.1	28.9	31.5	37.6	38.0	45.3	49.7	54.5	41.8
05	26.6	28.5	30.9	36.0	36.3	42.9	47.9	51.5	39.5
06	26.7	28.2	30.7	34.4	34.8	40.3	46.4	51.9	37.0
07	23.5	25.7	29.2	32.0	33.4	39.1	47.5	52.6	37.4
08	17.7	18.9	21.2	22.3	28.5	35.7	44.6	51.6	33.8
09	18.8	20.1	22.2	22.8	27.5	36.7	46.2	51.5	33.7
10	19.0	20.8	23.1	23.6	29.3	36.9	46.0	54.5	36.9
11	20.4	22.3	24.2	24.7	30.5	39.5	46.6	53.6	37.3
12	20.8	22.8	25.4	26.0	31.6	40.2	47.4	54.8	39.7
13	23.5	24.4	27.1	27.7	33.9	41.6	48.7	56.1	39.3
14	23.0	26.3	29.8	31.9	35.6	41.2	47.7	56.0	38.3
15	24.8	27.1	30.9	32.3	37.4	44.7	51.6	57.7	42.9
16	23.9	25.8	30.4	32.4	36.5	43.5	49.4	56.4	39.8
17	24.0	26.0	29.9	31.1	36.0	44.1	52.0	58.0	41.9
18	23.3	25.6	28.9	30.7	34.7	42.4	48.6	55.9	38.8
19	23.6	24.8	28.1	30.2	34.1	43.5	49.6	57.9	39.8
20	24.8	27.6	32.1	36.5	38.8	46.2	50.6	54.9	42.1
21	29.2	31.4	34.9	38.8	40.2	46.5	51.1	54.5	42.8
22	27.2	28.0	32.0	35.4	37.4	44.3	50.3	53.8	41.0
23	25.0	27.7	30.1	33.4	34.4	41.8	47.3	54.1	38.6

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	27.3	28.4	30.3	34.5	35.0	40.9	45.6	49.7	37.1
01	28.8	29.9	33.0	36.5	36.8	41.1	44.9	49.1	38.2
02	28.9	30.5	33.4	37.8	38.5	44.4	47.9	50.9	41.5
03	26.4	27.9	30.4	34.7	34.9	41.2	46.4	50.3	38.0
04	25.7	27.2	29.5	34.8	35.2	41.2	44.9	48.6	37.2
05	24.6	26.5	28.9	33.6	33.9	39.6	43.9	46.8	36.5
06	24.8	26.2	28.6	32.2	32.5	36.7	41.6	45.9	33.7
07	21.4	23.6	27.3	29.8	31.1	35.5	41.0	46.7	32.5
08	13.3	14.7	17.8	19.2	26.6	33.2	41.5	49.1	32.2
09	15.0	16.5	18.9	19.8	25.8	35.2	43.3	49.8	32.6
10	15.1	17.7	20.9	21.6	27.8	34.6	42.7	49.8	32.6
11	17.3	18.7	21.9	22.9	29.0	37.3	43.8	49.6	34.0
12	18.1	19.7	22.7	23.7	28.6	36.9	44.2	51.0	35.4
13	20.4	21.5	24.1	24.8	30.9	37.6	45.6	50.5	36.5
14	20.4	23.9	27.1	28.8	31.5	37.2	43.7	49.8	34.4
15	22.4	24.6	28.0	29.3	33.2	41.3	47.1	52.8	38.9
16	21.8	23.8	27.5	29.1	33.1	38.9	45.6	52.1	35.6
17	21.6	23.8	27.4	28.4	32.7	40.3	47.0	53.1	37.6
18	21.0	23.1	26.4	28.1	32.5	39.2	45.8	51.4	35.6
19	21.3	22.4	26.0	27.8	31.6	39.7	46.9	52.4	36.5
20	23.1	25.4	29.4	33.6	35.9	42.3	45.8	49.6	38.5
21	27.0	29.2	32.5	36.1	37.4	42.7	46.1	49.9	39.2
22	25.4	26.6	29.9	32.8	34.3	41.1	45.5	50.1	37.5
23	23.9	25.8	28.2	31.4	32.3	38.8	44.4	51.3	35.2

Metrics for BRCA020 – Paria Backcountry 2010
n = 358 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	18.2	19.0	20.6	25.4	25.7	31.8	36.8	42.2	29.5
01	18.0	18.9	20.7	25.0	25.3	28.3	37.4	42.7	26.9
02	17.0	18.2	19.8	23.7	24.0	31.7	35.6	41.8	28.5
03	15.1	15.4	15.8	18.7	19.0	26.1	28.3	34.4	24.0
04	14.9	15.2	15.8	16.7	16.8	21.5	31.8	35.8	19.8
05	15.3	15.9	16.7	22.3	23.0	31.1	38.7	44.5	29.2
06	15.6	15.9	16.8	20.2	20.5	30.3	43.1	50.4	30.9
07	15.1	15.5	16.2	18.3	19.2	31.6	44.6	51.2	30.8
08	15.1	15.8	16.7	18.4	19.9	32.4	44.5	53.8	32.1
09	18.6	21.1	26.7	30.4	31.5	36.3	45.2	51.8	34.4
10	23.1	26.2	29.2	32.5	33.3	37.5	44.5	51.7	35.9
11	24.0	25.8	28.4	32.3	33.5	39.0	45.0	52.2	36.1
12	24.9	26.9	30.2	34.7	35.8	42.5	49.2	53.4	40.2
13	23.5	25.2	29.4	34.3	35.2	42.4	47.8	52.5	38.6
14	24.4	26.0	29.0	34.3	35.2	42.7	49.1	54.8	39.5
15	22.3	24.0	27.8	34.5	35.2	43.1	49.1	54.4	39.6
16	22.8	24.0	26.7	32.4	33.4	42.0	47.7	52.5	38.7
17	21.2	23.7	27.9	33.5	34.8	41.4	47.6	55.1	38.2
18	21.8	24.6	26.5	29.0	29.6	36.2	43.3	48.4	33.4
19	18.5	19.4	22.0	26.8	27.7	33.2	42.7	48.7	31.2
20	15.9	16.3	17.8	21.3	22.5	28.1	35.7	41.1	25.3
21	15.6	15.9	16.7	20.0	20.6	26.6	34.0	40.7	23.4
22	16.7	17.2	18.4	22.3	23.6	28.2	34.9	39.0	25.8
23	17.8	18.6	20.4	23.0	23.3	28.9	37.9	42.9	26.7

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	15.9	17.0	19.1	24.2	24.5	30.8	35.8	40.7	28.5
01	15.9	17.1	19.4	23.7	24.1	27.6	36.8	42.0	25.6
02	13.9	15.8	18.2	22.7	22.9	31.1	34.9	40.3	27.6
03	9.6	10.6	12.0	16.9	17.3	24.7	27.2	32.8	22.9
04	7.9	8.5	10.1	12.4	12.6	18.0	29.7	34.6	18.3
05	8.1	8.8	9.7	12.0	12.2	20.0	27.8	36.2	17.1
06	7.9	8.5	8.9	11.8	12.2	17.8	30.2	36.5	19.4
07	7.9	8.3	9.3	11.2	12.1	23.3	40.5	49.6	27.2
08	8.4	8.8	10.4	12.0	12.9	28.1	43.8	51.8	29.4
09	11.5	12.7	14.7	19.9	21.3	30.1	41.1	51.0	29.5
10	16.3	17.4	19.7	24.9	26.0	34.4	41.8	49.9	31.7
11	19.9	21.3	24.1	27.8	28.8	36.5	43.7	50.1	33.4
12	21.7	23.1	26.9	32.1	33.1	39.3	46.0	53.0	37.3
13	21.5	22.7	26.9	32.7	33.4	39.9	45.2	49.1	36.3
14	21.9	24.0	26.7	32.6	33.3	40.4	45.4	50.6	36.9
15	20.1	21.4	25.0	30.9	31.9	41.1	45.7	49.4	36.9
16	19.9	21.6	24.5	31.0	32.1	38.5	44.4	51.0	35.7
17	17.6	18.5	20.8	28.7	30.6	39.1	44.4	49.8	36.0
18	15.0	16.4	19.9	25.1	26.5	33.9	41.1	46.1	30.1
19	12.2	12.8	15.4	20.5	22.0	31.7	39.7	46.1	28.4
20	9.5	10.2	12.0	14.3	15.7	24.5	34.6	40.6	22.1
21	8.8	9.7	11.8	14.3	15.3	23.9	32.7	39.5	21.4
22	12.3	12.7	14.2	17.9	20.3	27.6	34.6	38.6	24.7
23	14.3	15.4	18.8	21.6	22.0	28.0	37.8	41.9	25.1

Metrics for BRCA021 – Swamp Canyon Backcountry 2010
n = 429 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	15.5	15.7	16.1	17.6	17.6	19.6	28.8	36.2	19.8
01	15.6	15.9	16.3	17.1	17.2	19.6	28.5	37.0	18.9
02	15.0	15.1	15.4	16.3	16.4	19.6	29.8	37.1	20.2
03	15.2	15.4	15.8	16.9	16.9	20.1	23.4	28.9	18.1
04	15.0	15.3	15.7	18.4	18.4	25.0	32.0	37.1	23.1
05	16.3	18.3	19.4	26.7	28.3	37.8	41.0	43.7	33.3
06	15.4	16.0	17.5	21.6	21.8	29.2	36.6	48.5	27.4
07	15.1	15.6	16.8	19.2	20.1	28.8	38.6	47.9	27.2
08	15.2	15.9	18.1	21.0	23.7	30.2	40.7	50.3	29.1
09	17.7	18.8	22.1	25.8	28.1	34.7	41.3	51.3	32.1
10	21.3	22.5	25.4	29.2	31.3	37.7	43.3	50.8	34.9
11	24.1	25.2	28.7	31.2	32.7	39.5	44.9	48.9	36.1
12	24.3	25.2	28.5	31.4	33.6	40.8	46.5	50.6	37.1
13	25.2	26.6	29.7	33.3	34.9	41.9	47.1	51.9	38.3
14	23.1	24.3	27.6	32.8	34.7	42.5	48.9	54.5	39.2
15	22.0	23.7	28.2	32.8	34.7	40.8	47.2	52.1	37.4
16	20.3	21.4	25.0	29.7	32.0	40.1	46.2	51.9	37.2
17	19.9	21.0	24.6	29.1	31.8	39.9	46.9	51.5	38.2
18	19.3	20.8	23.2	26.9	29.3	36.0	42.7	49.6	32.9
19	16.2	16.7	18.2	21.6	22.8	31.6	37.6	45.2	28.1
20	15.4	15.7	16.5	18.2	19.5	26.3	34.7	41.2	23.8
21	14.9	15.2	15.7	16.6	16.9	24.4	33.3	40.9	22.0
22	14.7	14.9	15.8	17.4	18.1	26.8	33.8	39.4	23.8
23	16.0	16.5	17.1	18.0	18.2	24.3	33.7	39.7	24.0

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	10.9	11.4	12.2	14.8	14.8	18.1	28.8	34.2	18.1
01	10.2	11.2	12.3	14.2	14.4	18.2	28.1	35.5	16.7
02	8.1	8.8	9.9	12.1	12.3	18.2	29.7	36.1	19.0
03	9.4	10.0	10.9	14.0	14.1	18.3	22.4	27.1	15.9
04	7.3	8.6	10.5	12.5	12.6	16.0	22.7	31.8	14.5
05	8.9	9.5	10.9	13.0	13.6	16.5	21.3	28.7	15.3
06	9.6	10.5	11.6	13.5	13.6	18.4	26.3	33.9	17.3
07	5.4	5.8	6.6	10.1	10.8	23.4	36.7	44.6	23.6
08	6.7	7.6	10.1	15.0	19.2	28.3	39.2	50.2	27.2
09	14.1	16.4	20.5	24.3	26.2	33.8	40.5	48.4	31.0
10	19.4	20.7	23.8	28.0	29.6	35.9	40.9	47.6	33.0
11	22.4	23.8	27.2	29.9	31.4	37.5	42.2	47.3	33.9
12	22.8	24.1	27.3	30.2	32.1	38.2	43.4	48.1	35.0
13	23.2	25.0	28.3	31.6	33.1	39.3	43.2	47.3	36.0
14	21.9	23.2	26.5	31.1	32.9	39.8	45.5	49.0	36.2
15	20.1	21.5	26.6	31.3	33.1	38.6	43.3	46.4	35.1
16	18.5	19.4	23.6	28.4	30.7	38.0	43.3	47.9	34.7
17	17.9	19.0	23.4	28.0	30.7	37.8	44.0	47.9	35.5
18	16.5	18.3	21.6	25.4	27.7	34.6	40.9	45.2	31.0
19	10.0	10.8	13.7	18.6	21.0	30.3	36.7	42.2	26.7
20	7.4	8.1	9.5	11.9	14.1	24.2	34.3	40.7	21.8
21	6.0	6.6	8.4	12.3	13.0	22.9	33.4	39.6	21.1
22	7.3	8.0	10.6	14.2	15.5	26.4	33.6	39.2	23.2
23	11.5	12.6	13.7	15.2	15.7	23.6	33.5	39.5	23.3

Metrics for BRCA022 – Farview Backcountry 2010
n = 596 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	13.8	13.9	14.1	14.9	15.2	20.5	30.1	37.9	20.2
01	13.8	13.9	14.2	15.0	15.1	19.2	31.1	39.4	20.0
02	13.6	13.7	13.9	14.8	14.9	18.9	27.5	36.4	19.1
03	13.5	13.6	13.8	14.4	14.4	16.9	28.4	36.2	17.1
04	13.6	13.7	13.8	14.4	14.5	16.3	24.5	34.4	17.3
05	13.6	13.6	13.7	14.0	14.0	17.5	25.5	37.0	18.0
06	14.2	14.5	15.1	17.1	17.2	26.9	36.5	43.6	26.2
07	14.7	15.1	15.7	17.0	18.0	31.7	42.4	49.6	30.0
08	15.3	15.7	16.8	18.1	20.2	32.4	41.4	48.8	30.1
09	15.5	16.3	17.4	19.2	21.4	32.3	42.9	49.4	31.0
10	16.6	17.1	18.3	21.5	23.7	33.0	42.4	52.2	30.8
11	17.3	18.0	20.2	23.2	25.2	34.0	43.1	53.0	32.4
12	17.6	18.3	20.3	24.9	26.6	33.9	43.0	51.7	33.6
13	17.6	18.4	20.0	23.5	25.7	35.0	42.9	50.4	32.2
14	18.1	19.3	21.3	24.9	26.2	35.0	43.2	52.2	32.5
15	17.4	18.3	20.3	24.4	25.8	34.4	41.2	51.2	31.3
16	16.3	17.0	18.7	22.3	24.8	35.4	43.5	51.5	32.6
17	16.6	17.4	19.0	22.4	24.4	34.5	43.9	50.3	32.1
18	15.9	16.5	17.7	20.6	22.9	33.3	40.8	46.5	30.3
19	15.1	15.6	16.3	18.4	20.4	31.5	38.6	46.5	27.5
20	14.7	15.0	15.6	17.7	18.4	32.4	40.8	47.3	29.0
21	14.0	14.1	14.2	14.8	15.2	23.0	36.9	44.0	23.8
22	13.8	13.9	14.1	15.7	15.9	28.0	37.2	42.7	25.9
23	13.8	13.9	14.1	15.9	16.0	20.8	34.3	41.9	23.4

Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	4.1	4.6	5.3	8.4	9.5	19.3	29.1	35.5	18.2
01	3.7	4.3	5.5	8.4	8.7	17.0	31.4	38.5	18.4
02	2.4	2.8	3.8	8.8	9.2	15.8	26.9	34.9	17.7
03	2.2	2.7	4.0	7.1	7.4	13.3	27.5	34.6	14.6
04	2.3	2.6	3.5	6.7	6.7	11.9	21.3	25.2	14.2
05	2.1	2.6	3.2	5.3	5.3	11.3	20.9	29.1	12.2
06	5.8	6.7	7.6	10.0	10.0	14.9	24.5	33.5	17.1
07	6.4	7.3	8.4	10.2	10.8	25.4	39.9	48.6	26.9
08	7.8	8.7	10.0	11.3	14.3	28.5	40.4	48.4	27.9
09	8.8	9.9	11.9	14.9	17.8	30.9	39.6	47.0	28.1
10	10.8	11.6	13.6	17.4	19.7	29.6	41.7	49.1	29.0
11	12.3	13.2	16.7	20.6	22.7	31.1	42.0	51.4	30.4
12	13.4	14.5	17.7	21.7	23.4	31.5	41.5	50.8	31.6
13	12.8	14.0	16.7	21.1	23.2	33.4	41.3	48.3	30.2
14	13.9	15.7	18.7	22.7	23.8	32.9	39.0	46.4	30.0
15	12.8	13.8	16.1	21.8	23.2	32.0	40.9	49.5	29.6
16	11.1	11.9	14.5	19.3	21.6	31.9	40.6	48.3	30.1
17	11.5	12.2	14.6	18.2	20.0	29.9	40.1	48.8	29.0
18	9.4	10.5	12.4	15.0	17.9	29.7	38.5	45.7	26.5
19	7.7	8.5	10.4	13.0	13.5	26.1	36.5	42.4	25.5
20	7.0	7.9	9.6	12.9	13.2	26.0	38.4	42.9	24.8
21	4.0	4.5	5.3	8.4	9.4	21.5	35.2	41.8	21.4
22	3.0	3.7	5.7	7.9	9.8	28.1	37.2	42.1	25.5
23	4.2	4.7	5.5	8.0	9.0	19.0	34.2	40.6	22.7

Metrics for BRCA023 – Yovimpa Backcountry 2010
n = 528 hours

Median dBA values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	34.7	34.9	35.3	35.7	35.8	37.9	40.1	44.3	36.9
01	34.6	34.9	35.2	35.9	36.0	37.7	40.4	43.5	36.2
02	34.8	35.2	35.5	36.2	36.2	38.2	40.0	44.3	37.2
03	34.4	35.1	35.4	35.7	35.7	37.4	39.7	43.6	35.9
04	34.8	35.2	35.5	36.1	36.1	38.0	39.6	41.9	37.0
05	34.7	35.1	35.3	35.8	35.8	38.3	39.2	40.6	37.3
06	34.5	35.0	35.3	35.7	35.7	36.8	39.4	43.8	36.1
07	34.6	34.9	35.1	35.6	35.7	37.3	43.6	51.5	36.7
08	34.5	35.0	35.2	35.4	35.5	38.2	45.2	54.1	37.8
09	34.2	34.7	35.1	35.4	35.7	38.5	43.4	49.4	36.9
10	33.8	34.5	35.2	35.7	35.9	39.2	44.7	52.7	37.6
11	33.5	34.2	35.0	35.8	36.2	38.9	45.1	54.5	38.7
12	34.2	34.9	35.4	37.5	37.9	39.9	46.4	52.3	39.2
13	34.0	34.4	35.0	36.4	36.9	40.7	44.9	54.1	39.2
14	33.4	34.1	34.7	36.2	36.6	39.7	44.8	52.3	38.6
15	33.4	33.8	34.5	36.1	36.4	39.9	44.1	51.9	38.8
16	34.0	34.3	34.7	36.4	36.8	39.4	46.7	54.3	38.7
17	34.5	35.1	35.5	36.8	37.0	39.5	45.0	51.9	38.6
18	35.1	35.4	36.0	36.6	36.9	39.0	42.4	49.3	38.2
19	36.1	36.5	36.9	37.6	37.7	38.3	40.9	48.0	37.9
20	35.1	35.5	35.9	36.4	36.6	38.1	43.3	48.9	37.7
21	34.7	35.1	35.3	36.6	36.7	37.5	40.3	45.8	37.0
22	34.4	34.8	35.1	35.9	36.6	38.3	42.6	46.2	37.2
23	34.4	34.8	35.1	35.8	35.8	36.7	40.0	43.9	36.1

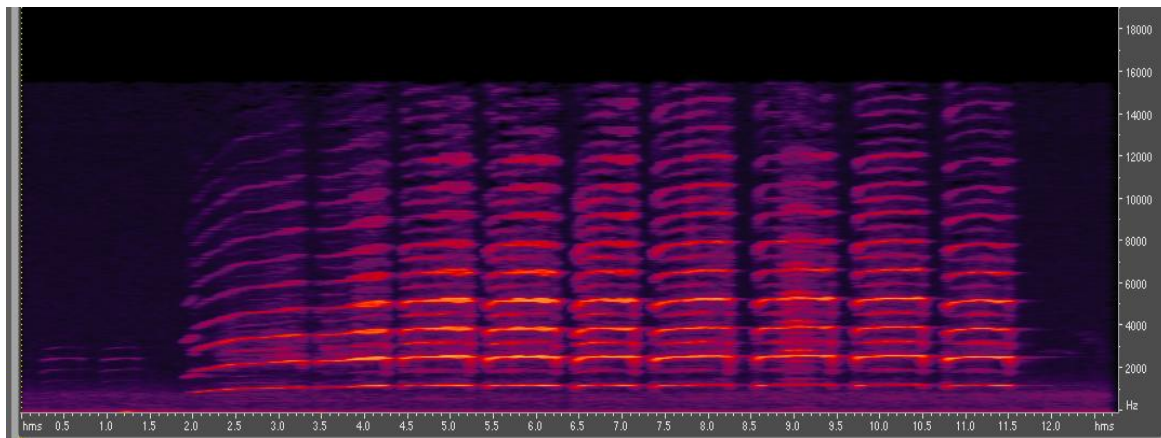
Median dBT (20Hz - 800Hz) values by Hour

Hr	Lmin	L099	L090	Lnat	L050	L010	L001	Lmax	Leq
00	23.0	23.6	24.2	24.9	25.0	26.5	35.7	43.1	27.2
01	23.0	23.5	24.1	24.9	25.0	26.4	33.5	40.4	26.5
02	23.3	23.8	24.4	25.4	25.5	27.3	35.7	42.2	27.0
03	22.9	23.6	24.3	25.3	25.3	26.8	34.4	42.3	26.9
04	23.0	23.6	24.2	25.1	25.1	26.4	28.8	34.6	25.5
05	23.3	23.8	24.3	25.1	25.1	26.1	27.9	30.0	25.7
06	23.0	23.6	24.2	25.1	25.1	26.6	28.4	35.7	25.8
07	23.1	23.5	24.1	24.8	25.0	29.1	41.6	47.7	29.2
08	23.0	23.6	24.1	24.7	25.2	31.4	44.0	52.4	32.0
09	23.0	23.6	24.1	24.8	25.4	32.3	40.9	46.7	30.9
10	23.4	24.1	24.9	26.0	26.4	32.9	42.6	51.8	32.5
11	23.3	24.4	25.5	26.9	27.8	35.3	43.7	51.9	33.2
12	23.8	24.6	26.1	28.6	29.0	35.6	42.9	49.9	33.8
13	23.8	24.7	25.7	29.8	30.0	35.9	42.0	48.2	33.5
14	23.4	24.2	25.4	27.7	28.7	35.5	43.2	49.5	32.5
15	23.1	23.7	24.6	27.1	27.6	34.6	42.2	47.6	32.0
16	22.9	23.6	24.7	26.7	27.3	34.6	44.5	51.3	33.5
17	23.0	23.9	24.7	26.2	27.1	35.3	42.3	49.2	32.9
18	23.4	23.9	24.9	25.8	26.1	32.4	39.8	44.2	29.9
19	23.0	23.5	24.1	25.1	25.6	30.3	38.0	43.9	28.7
20	22.7	23.3	23.8	24.6	24.8	29.9	40.9	46.4	29.6
21	23.0	23.5	24.0	24.6	24.7	28.8	37.4	44.1	27.8
22	22.9	23.5	24.2	24.8	25.3	32.9	39.8	44.8	29.6
23	23.0	23.7	24.2	24.9	25.0	27.0	37.2	43.0	27.5

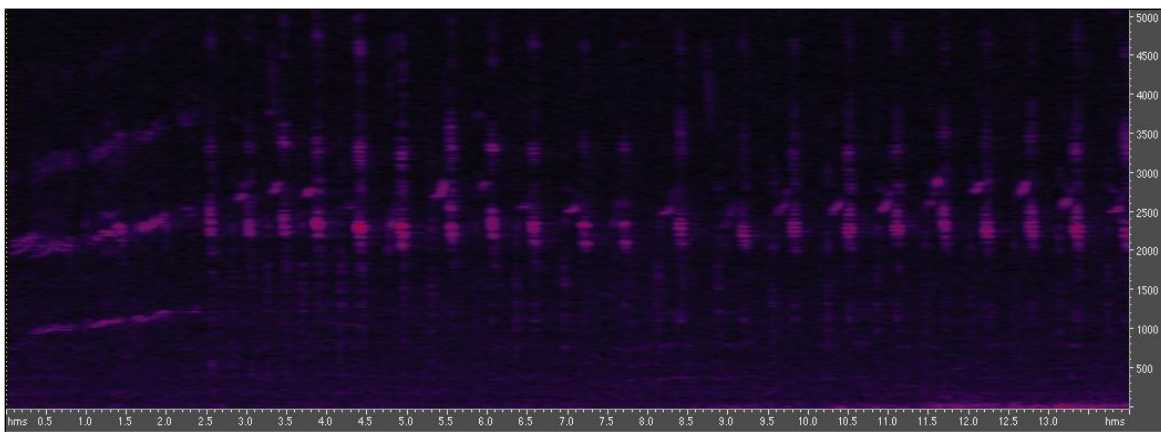
Appendix E. Natural Sounds Program sound code list

Code version: 2006-01-13			
0	No Sound Audible	0	No Sound Audible
41	Artifacts	41	Artifacts
		41.1	Wind distortion
		41.2	Static/interference- quiet
		41.3	Static/interference- loud
		41.4	Precipitation
		41.5	Field Personnel
99	Unknown	No 10	Second File
Code		Non-Natural Sounds Codes (1-20)	
1	Aircraft	1	Aircraft
		1.1	Jet
		1.11	Jet, Air Tour
		1.12	Jet, Commercial
		1.13	Jet, G/A
		1.14	Jet, Military
		1.2	Prop
		1.21	Prop, Air Tour
		1.22	Prop, Commercial
		1.23	Prop, G/A
		1.24	Prop, Military
		1.25	Prop, Ultralight
		1.3	Helicopter
		1.31	Helicopter, Air Tour
		1.32	Helicopter, Commercial
		1.33	Helicopter, G/A
		1.34	Helicopter, Military
2	Vehicles	2	Vehicle
		2.1	Automobile (car, van, light truck)
		2.2	Motorcycle
		2.3	Bus (vehicle with capacity > 9 people)
		2.4	Truck (6+ tires)
		2.41	Truck Medium (2 ax 6 tire, 10K-26K lbs)
		2.42	Truck Heavy (3+ ax 6+ tire, >26K lbs)
		2.5	Heavy Equipment
		2.6	Rotary Snow Plow
		2.7	Other Snow Plow
		2.8	RV
		2.81	RV < 20 ft
		2.82	RV >20 ft
		2.9	ATV
		2.11	Farm Equipment
		2.12	Alarm, Horn
		2.13	Door
		2.14	Brakes
		2.15	Rumble Strip
3	Watercraft	3	Watercraft
		3.1	Outboard
		3.11	Outboard 2-stroke
		3.12	Outboard 4-stroke
		3.13	Outboard Jet Drive
		3.2	Inboard
		3.21	Inboard 2-stroke
		3.22	Inboard 4-stroke
		3.23	Inboard Jet Drive
		3.3	Jet Ski (PWC)
		3.31	Jet Ski 2-stroke
		3.32	Jet Ski 4-stroke
		3.4	Pontoon Boat/Houseboat
		3.41	Pontoon Boat/Houseboat 2-stroke
		3.42	Pontoon Boat/Houseboat 4-stroke
		3.5	Motorized Raft
		3.51	Motorized Raft 2-stroke
		3.52	Motorized Raft 4-stroke
		3.6	Non-motorized Craft
		3.7	Sail Boat
		3.8	Boat Wake (on shore)
		3.9	Air Boat
4	Over-snow Vehicles	4	Over-snow
		4.1	Snowmobile
		4.11	Snowmobile 2-stroke
		4.12	Snowmobile 4-stroke
		4.2	Snowcoach
		4.3	Snowmobile or Snowcoach
		4.4	Snow Groomer
		4.5	Snowplane
5	Trains	5	Train
		5.1	Train Rumble
		5.2	Train Whistle
6	Motors	6	Motor
		6.1	Generator
		6.2	Pump
		6.3	Ice Auger
7	Grounds Care	7	Grounds Care
		7.1	Lawnmower
		7.2	Leaf Blower
		7.3	Sprinkler
		7.4	Dumpster / Trashcan
8	People	8	People
		8.1	Voices
		8.2	Walking
		8.3	Skating
		8.4	Portable Audio Devices
		8.5	Gunshot
		8.6	Using Boardwalk
		8.7	Bicycling
		8.8	Segway
9	Domestic animals	9	Domestic animal
		9.1	Dog
		9.2	Cow
		9.3	Horse
10	Buildings	10	Building Sounds
		10.1	Utilities (HVAC, Alarm, etc.)
		10.2	Door
11	Construction	11	Construction
19	Non-natural Other	19	Non-natural Other
		19.1	Wind-induced Non-natural
20	Non-natural Unknown	20	Non-natural Unknown
Code		Natural Sounds Codes (21-40)	
21	Wind	21	Wind
		21.1	Wind, Light (not mask most other sounds)
		21.2	Wind, Strong (masks most other sounds)
22	Water	22	Water
		22.1	Rain, Fog Drip
		22.2	Flowing Water
		22.21	Flowing Water, Rapids
		22.22	Flowing Water, Ripples
		22.3	Snowfall
		22.4	Waterfall
		22.5	Waves (natural)
23	Thunder	23	Thunder
24	Mammals	24	Mammal
		24.1	Squirrel
		24.2	Chipmunk
		24.3	Coyote
		24.4	Wolf
		24.5	Elk
		(pending further revision)	
25	Birds	25.3	PEREGRINE
26	Reptiles	26	Reptile
27	Amphibians	27	Amphibian
28	Insects	28	Insect
29	Animals	29	Animal
		(Unknown non-human sound from any species in the animal kingdom)	
30	Geothermal / Mass Movement	30	Geothermal / Mass Movement
		30.1	Aval/Rockslide
		30.2	Geyser/thermal Activity
39	Natural Other	39	Natural Other
		39.1	Wind-induced Natural
40	Natural Unknown	40	Natural Unknown

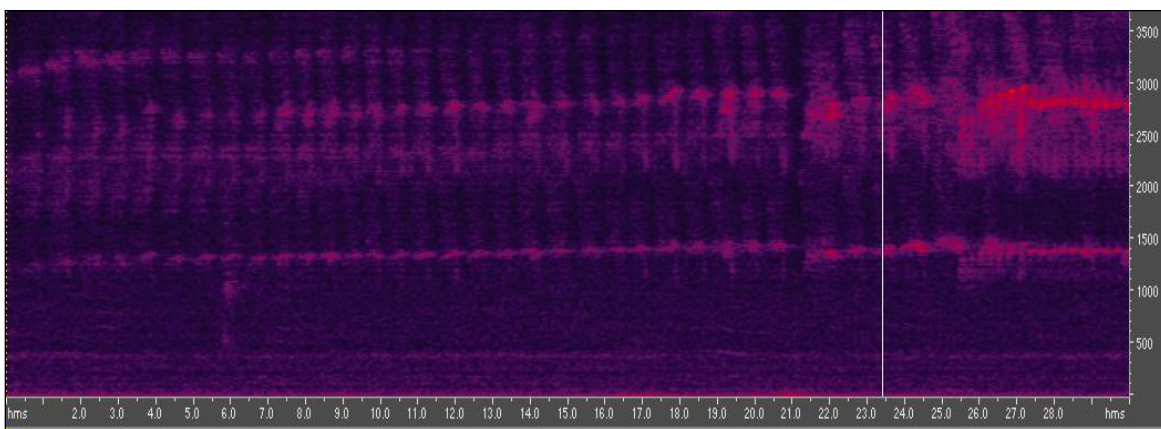
Appendix F. Spectrograms of peregrine falcon vocalizations (taken from Adobe Audition 3 spectrograms)



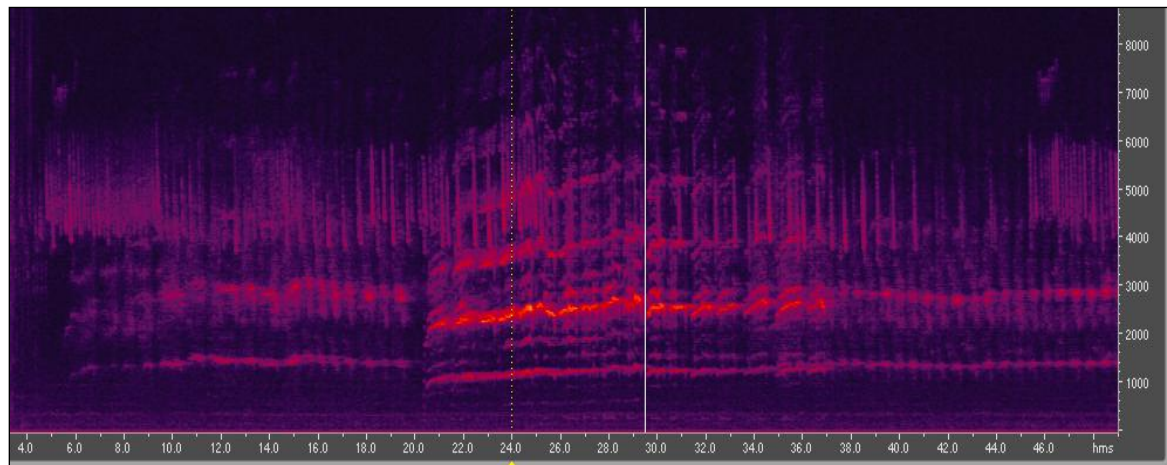
CD Track 1. Peregrine adult wailing. Farview Frontcountry, May 3rd 2010.



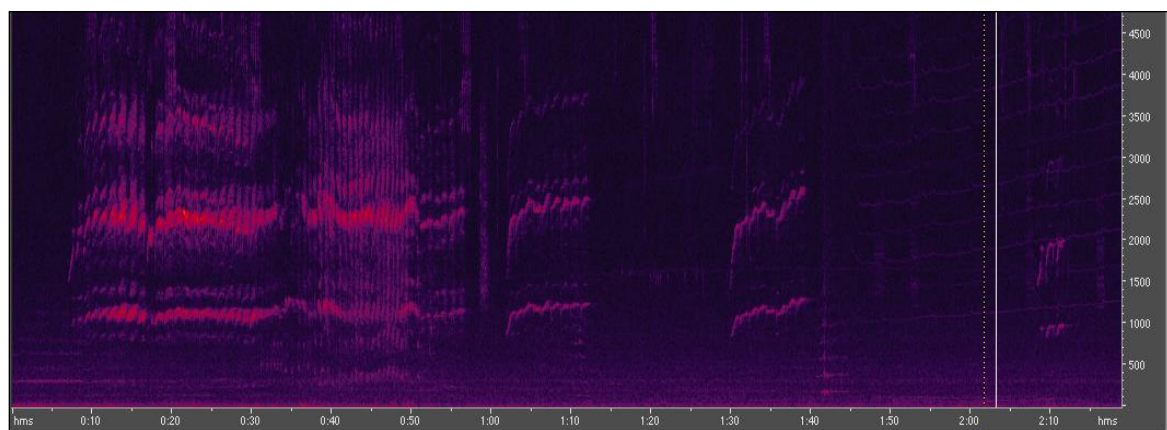
CD Track 2. Peregrine adult wail to ee-chup. Yovimpa Backcountry, July 15th 2009.



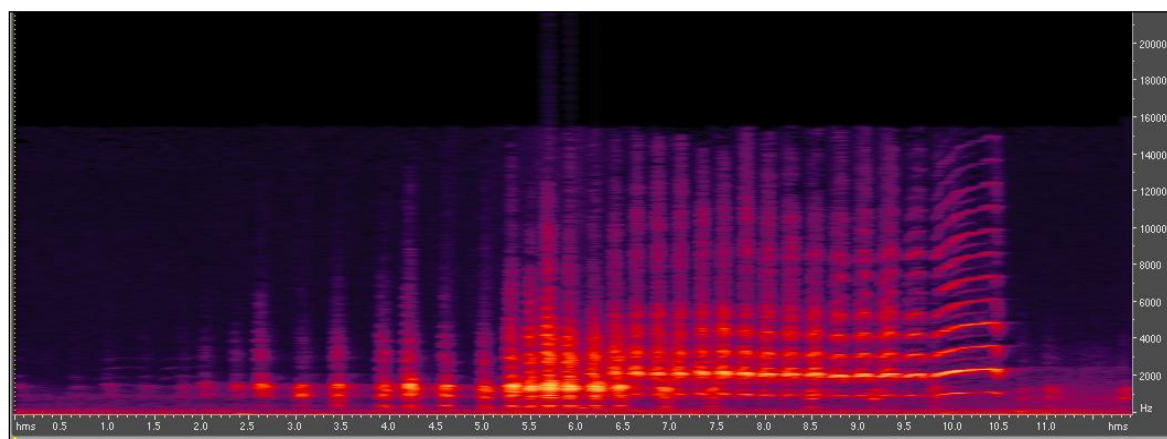
CD Track 3. Peregrine juvenile. Farview Backcountry, July 20th 2010.



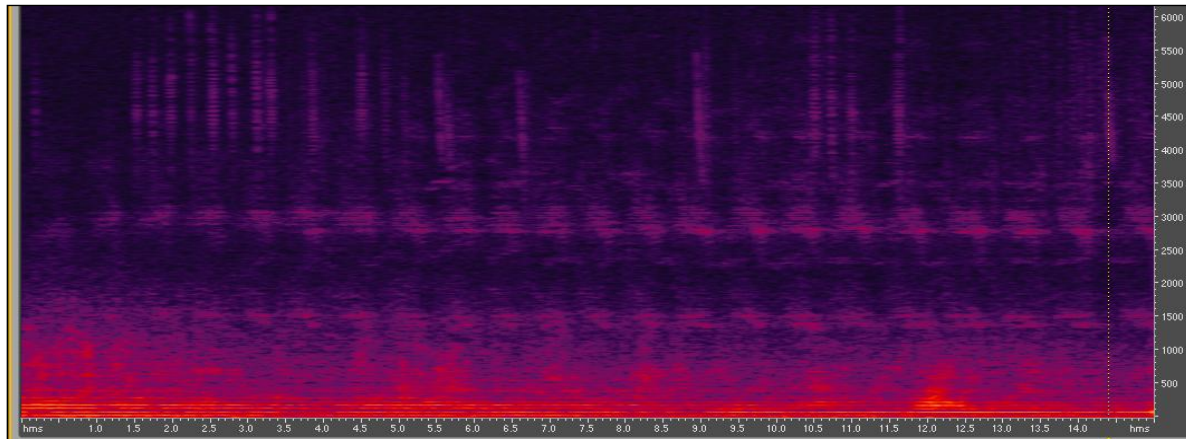
CD Track 4. Peregrine juvenile and adult overlap. Recorded at Farview Backcountry, July 7th 2010.



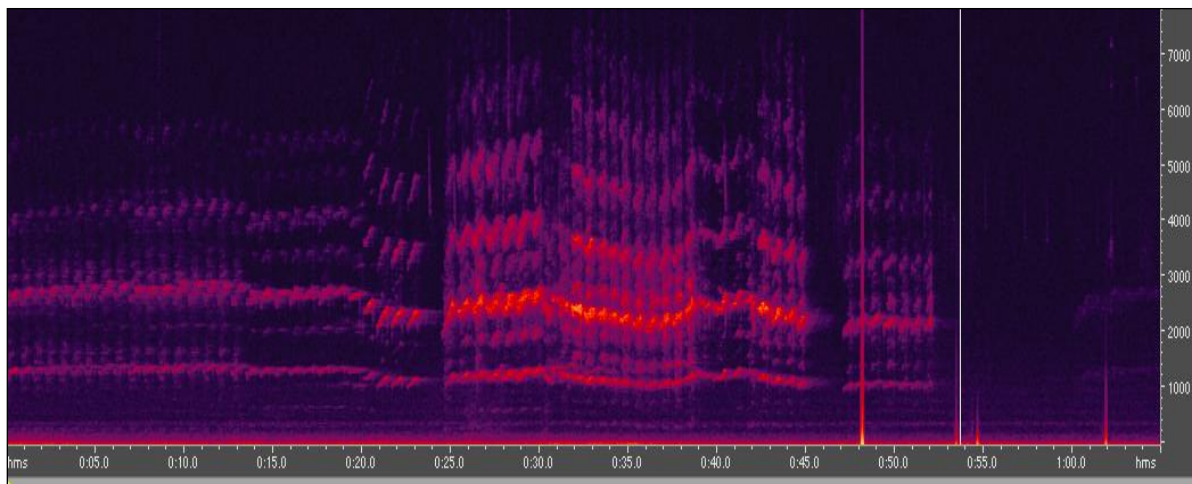
CD Track 5. Two peregrine adults. Wail to ee-chup. Recorded at Paria Backcountry, June 23rd 2010.



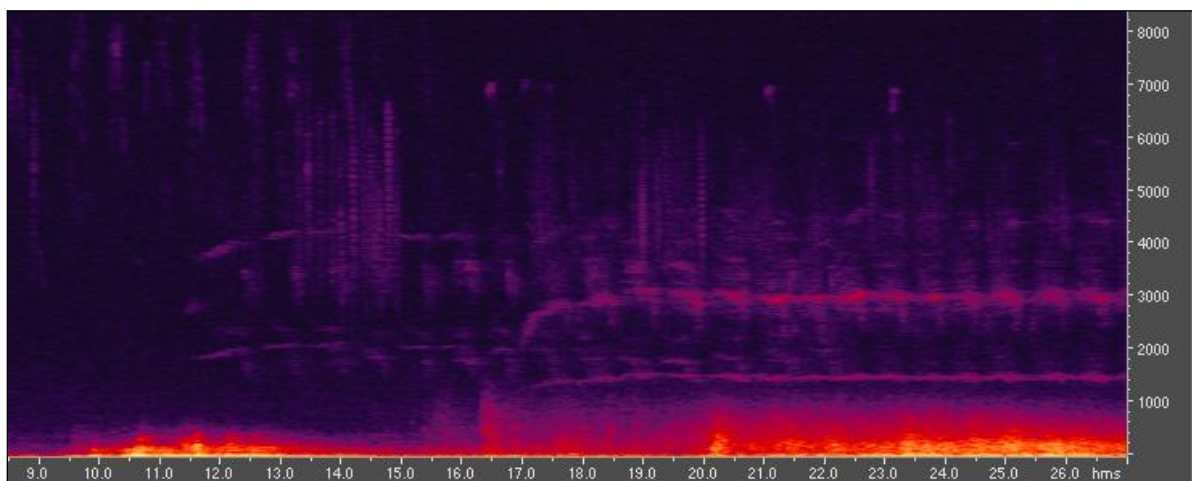
CD Track 6. Territorial raven calling simultaneously with peregrine adult cackling and wail. Recorded at Farview Frontcountry, May 3rd 2010.



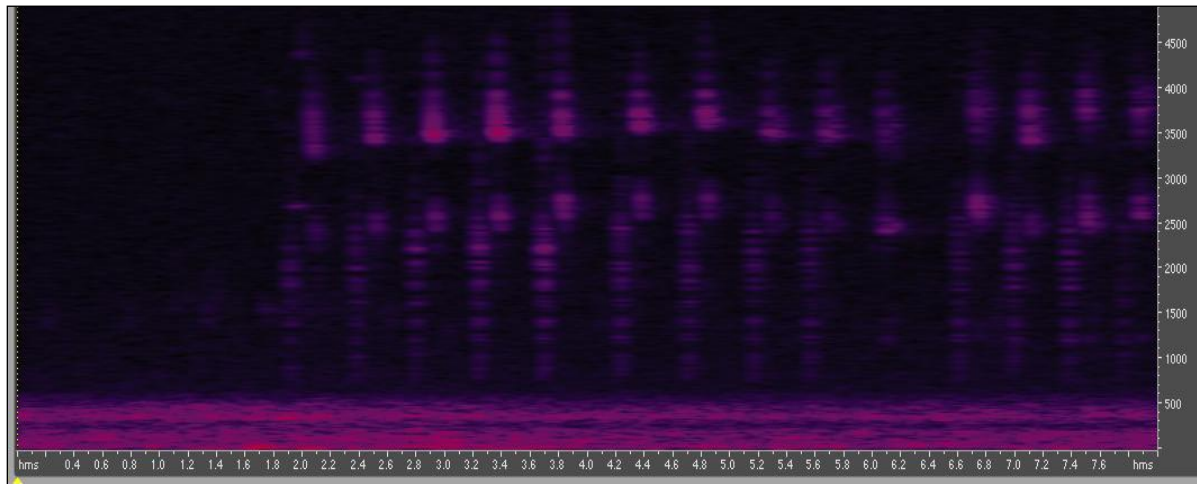
CD Track 7. Peregrine juvenile and propeller plane overlap. Recorded at Farview Backcountry, July 20th 2010.



CD Track 8. Peregrine juvenile / adult cacophony. Recorded at Farview Backcountry, July 25th 2010.

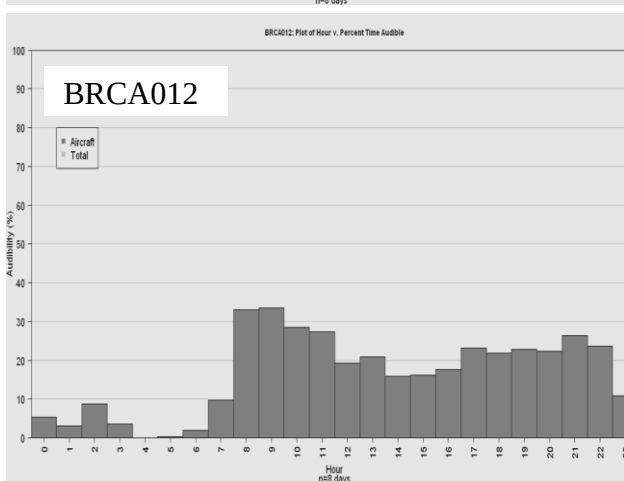
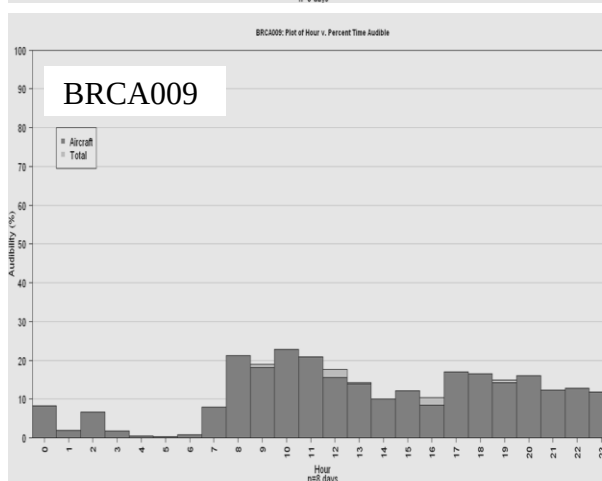
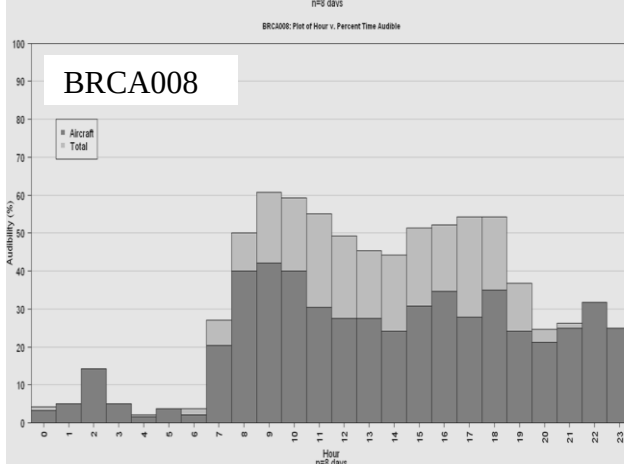
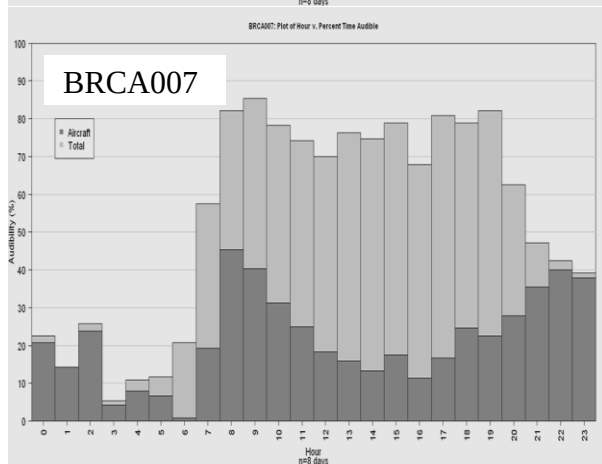
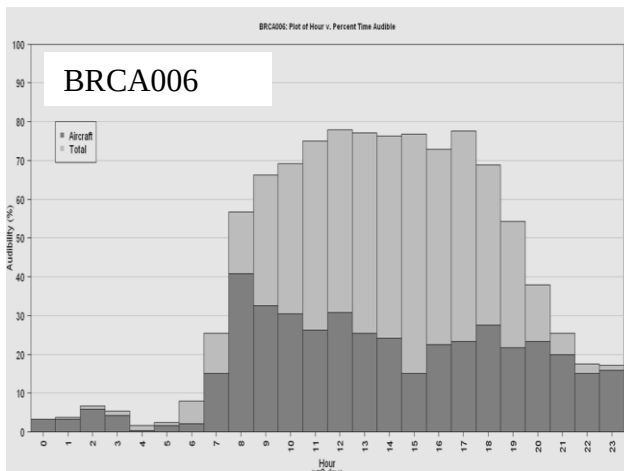
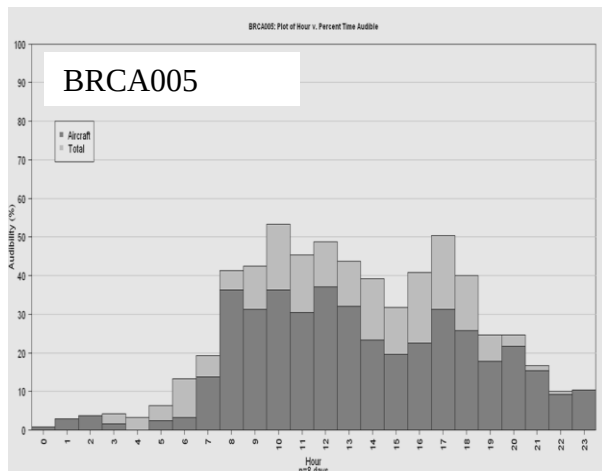


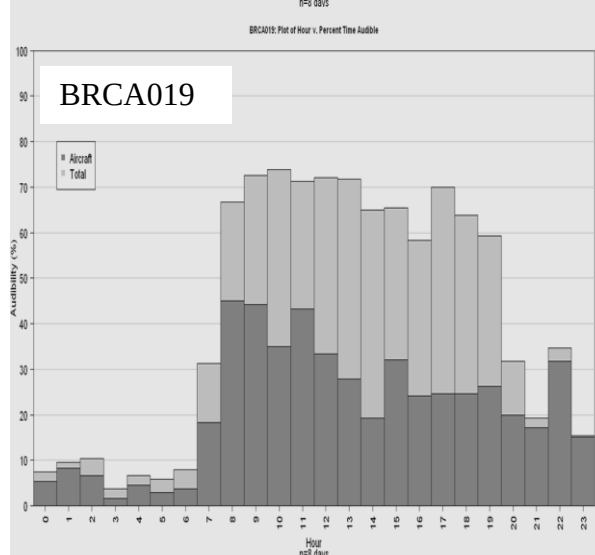
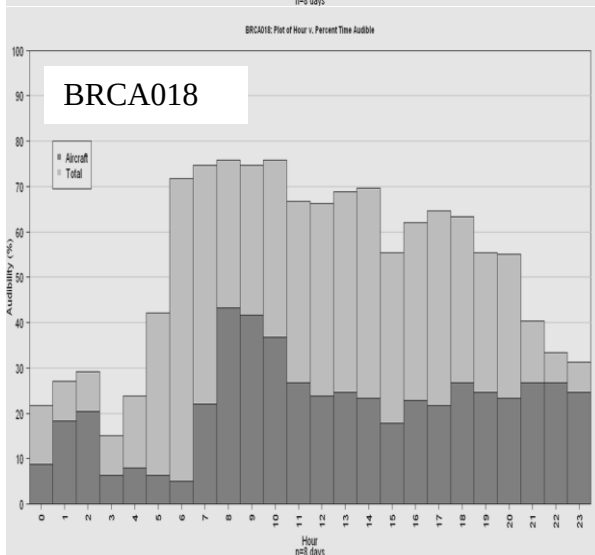
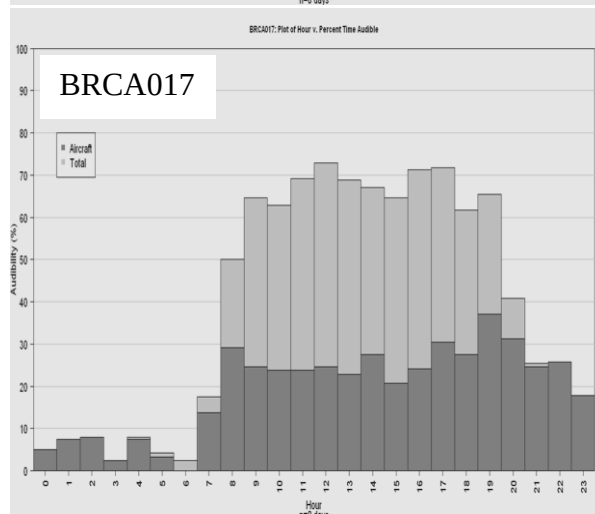
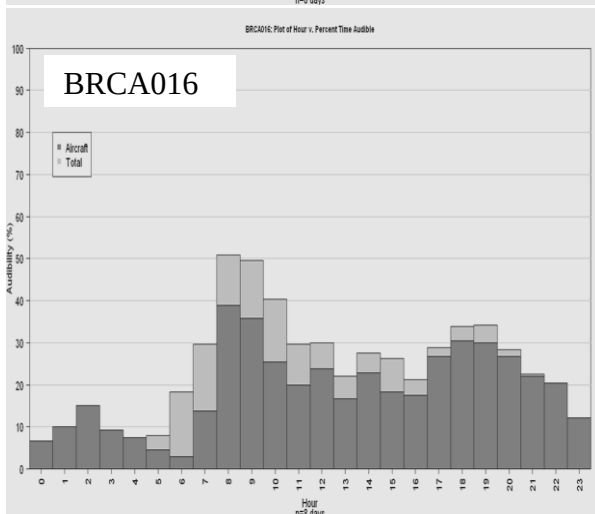
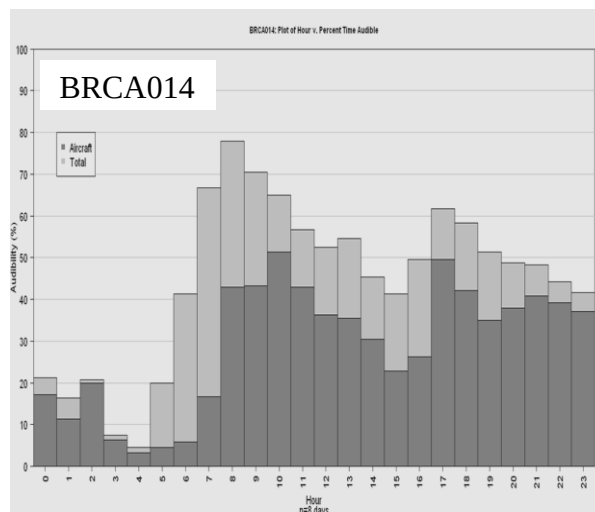
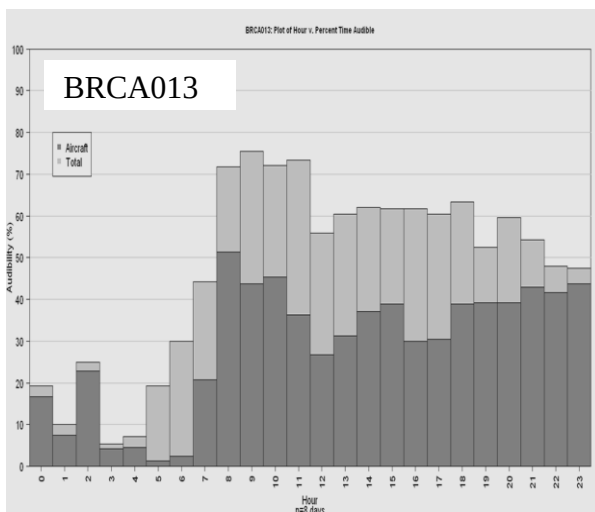
CD Track 9. Peregrine juvenile and thunder. Recorded at Farview Backcountry, July 20th 2010.

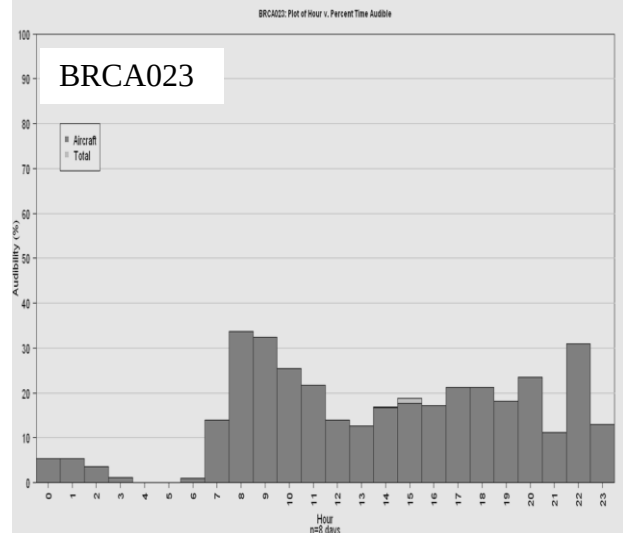
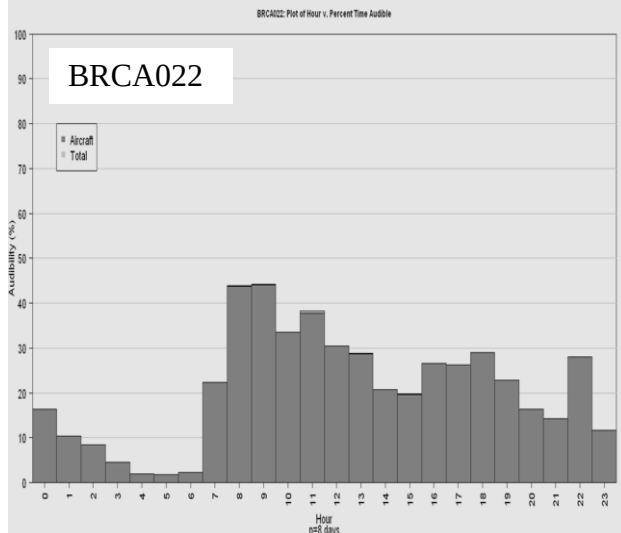
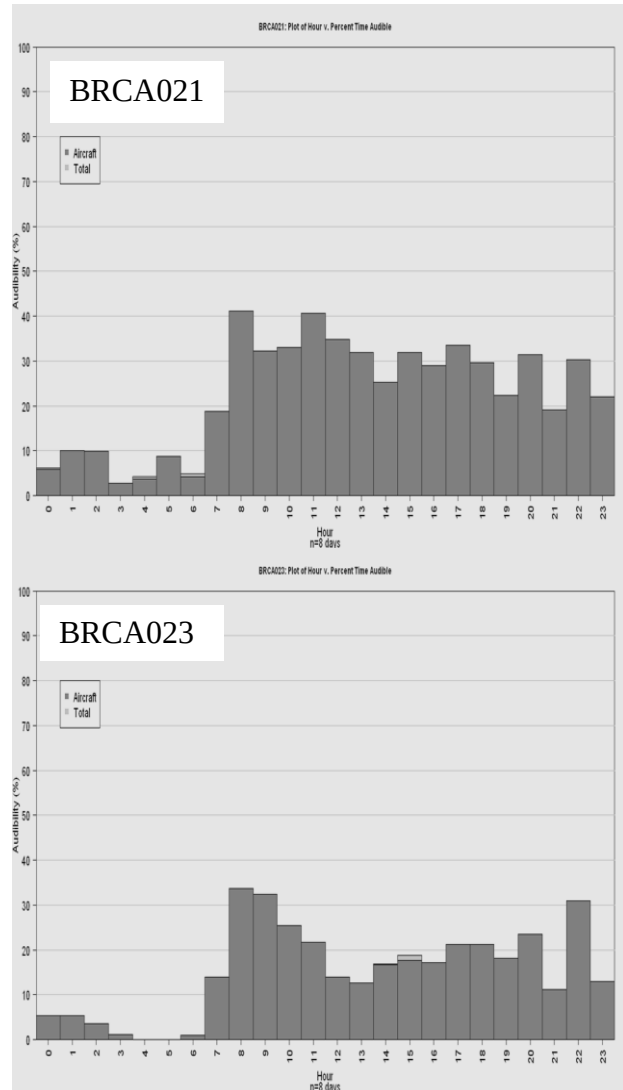
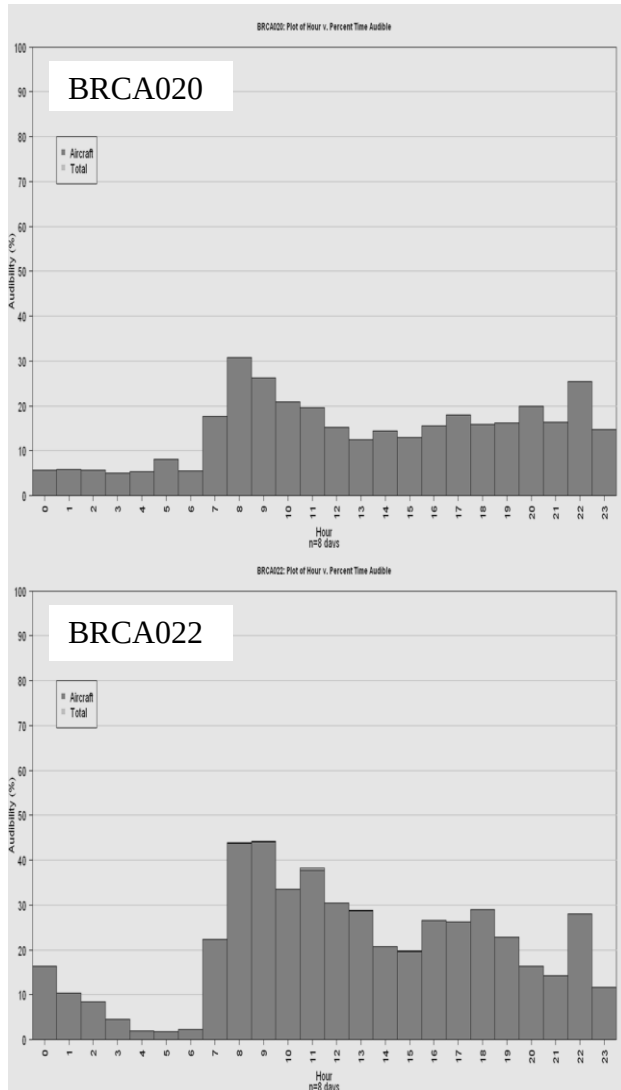


CD Track 10. Peregrine adult ee-chups with jet overlap. Yovimpa Backcountry, July 12th 2009.

Appendix G. Audibility of extrinsic and aircraft sounds by hour at all sites







The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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