

Rocky Mountain National Park

Assessing Wilderness Soundscapes Using Observer Based Source Identification Logging

Investigator's annual report

May 2014

Background

In summer of 2013 in conjunction with an ongoing wilderness character assessment in Rocky Mountain National Park (RMNP), a pilot study was conducted in order to evaluate methods for assessing soundscapes in wilderness. Specifically, this study investigated the potential for Observer Based Source Identification Logging (OBSIL) as a rapid assessment method for measuring audibility of sound sources within wilderness. The National Park Service, Natural Sounds and Night Skies Division (NSNSD) has conducted acoustical monitoring in RMNP for a number of years, however monitoring has been primarily focused on establishing ambient (background) levels as well as monitoring noise from commercial aircraft. To conduct these measurements, NSNSD sites are generally located in remote areas to minimize interference of most sources other than aircraft. While these are useful measurements for understanding certain aspects of the acoustical environment, wilderness visitors are subjected to a diversity of sources including vehicles, other visitors, wind and running water to name a few. Therefore, this study focused on designing a sample method based on stratification of locations and sources most likely to influence wilderness visitors was of interest.

Methods

Sampling using the OBSIL method requires specifying a number of parameters up front including: specific sources and categories to record; how long to conduct each observation; when to sample; where to sample; and finally any additional environmental information such as weather conditions or GPS location. Recording these parameters can either be done manually using hardcopy (paper) logging sheets and a code list, or in the case of this study using an iOS application developed by NSNSD.

The NSNSD has developed 28 source categories of interest for outdoor acoustical environments (Table 1). Each of these categories can be further broken down into individual sources, such as individual aircraft type (Table 2). These categories do not represent a comprehensive list of all possible sources and additional sources can be added if necessary (note that some gaps exist in codes for future additional of sources).

Table 1 Source categories of interest for monitoring outdoor acoustic environments as compiled by NSNSD.

Code Primary	Natural	Description	Code Primary	Natural	Description
0	O	No Sound Audible	21	Y	Wind
1	N	Aircraft	22	Y	Water
2	N	Vehicle	23	Y	Thunder

3	N	Watercraft	24	Y	Mammal
4	N	Oversnow	25	Y	Bird
5	N	Train	26	Y	Reptile
6	N	Motor	27	Y	Amphibian
7	N	Grounds Care	28	Y	Insect
8	N	People	29	Y	Animal (Unknown non-human, any species)
9	N	Domestic animal	30	Y	Geothermal / Mass Movement
10	N	Building Sounds	39	Y	Natural Other
11	N	Construction	40	Y	Natural Unknown
19	N	Non-natural Other	41	O	Artifact
20	N	Non-natural Unknown	99	O	Unknown (cannot tell if natural or non-natural)

Table 2 Individual sources for the general aircraft source category.

Code - Primary	Code - Secondary	Natural	Description
1	1	N	Aircraft
1	1.1	N	Jet
1	1.11	N	Jet, Air Tour
1	1.12	N	Jet, Commercial
1	1.13	N	Jet, G/A
1	1.14	N	Jet, Military
1	1.2	N	Prop
1	1.21	N	Prop, Air Tour
1	1.22	N	Prop, Commercial
1	1.23	N	Prop, G/A
1	1.24	N	Prop, Military
1	1.25	N	Prop, Ultralight
1	1.3	N	Helicopter
1	1.31	N	Helicopter, Air Tour
1	1.32	N	Helicopter, Commercial
1	1.33	N	Helicopter, G/A
1	1.34	N	Helicopter, Military

Data from previous acoustical monitoring efforts in RMNP revealed the average daytime (7am to 7pm) audible length of detection for commercial aircraft (a primary source of interest) to be between 2 and 4 minutes with an average Noise Free Interval (NFI) of around 3 minutes. Using this as a starting point, an observation length of 30 minutes was selected. This length was determined to be provide a reasonable observation widow to calculate Percent Time Audible

(PTA) and NFI for sources of interest, while allowing for five to eight samples to be collected per day depending on distance and terrain between sample points. While sources such as jet aircraft can occur at any time of day, a daytime sample window between 7am and 7pm was selected as it offered the greatest potential for capturing the diversity of anthropogenic noise sources wilderness visitors might encounter.

Study Location

The trail system in the area known as Wild Basin in RMNP was selected for this study. This area of the park is popular for day use and overnight visitors but has a low amount of development and is generally considered a high quality wilderness area by RMNP staff. Using the Kernel Density function in ESRI's ArcGIS Spatial Analyst Toolbox, a density surface was calculated for all trails in the Wild Basin region using a grid size of 10 meters and a search radius of 100 meters. All trails were considered and no weighting was applied. The trail density surface was rescaled into 100 equal interval classes, which was then divided by 100 to create a probability surface with values between .01 and 1 (Figure 1).

Using the Create Spatially Balance Points in ESRI's ArcGIS Geostatistical Analyst toolbox, a sample of 100 points was generated. Unfortunately, unforeseen weather events cut the field survey short and only 28 of the original 100 points were surveyed before the area became inaccessible. Figure 1 below shows those sample points for which data were collected. While these points cover only a few of the trails in Wild Basin, they do provide a distribution from the primary trailhead to one of the furthest points accessible by trail in the region.

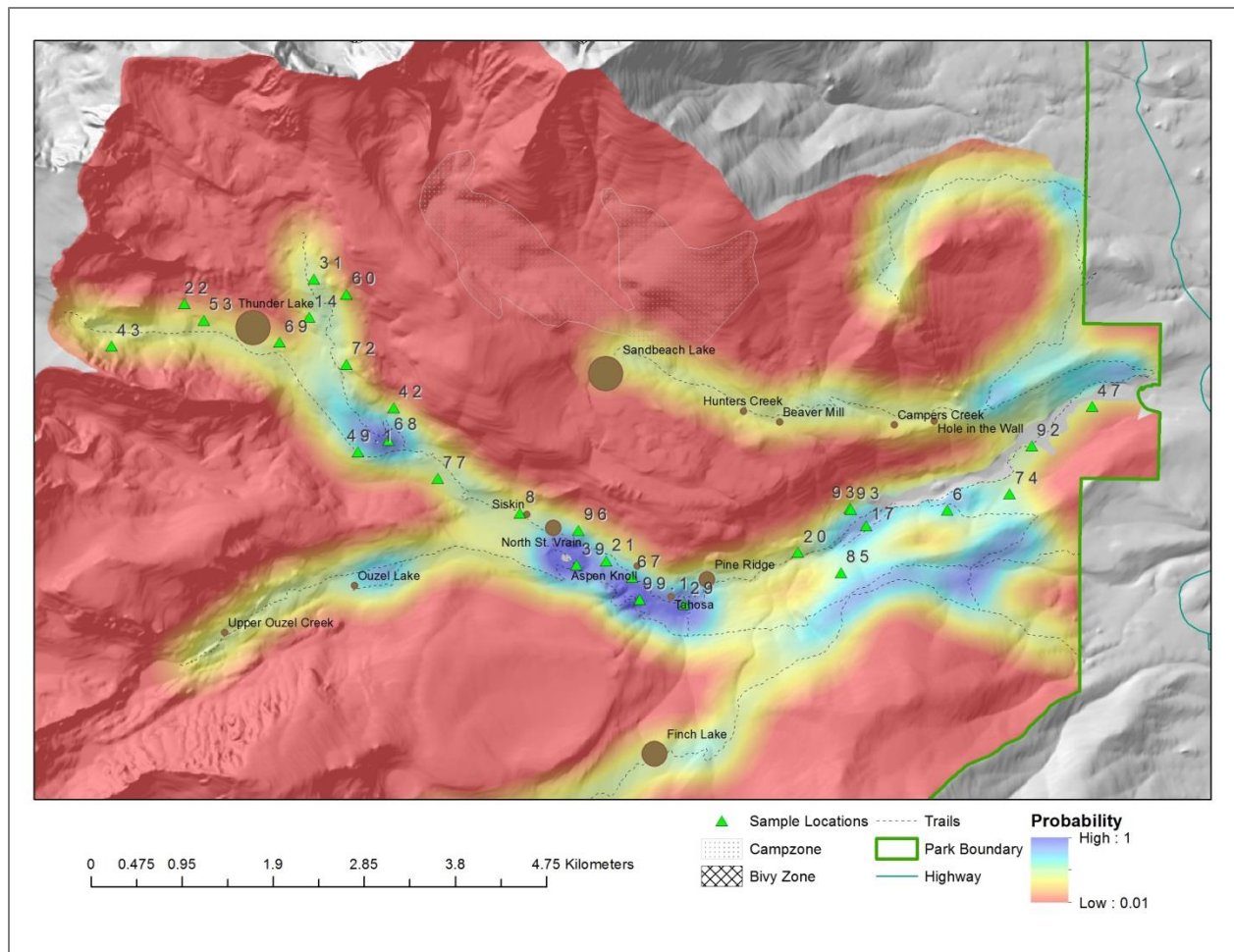


Figure 1 Sample locations and probability surface based on trail density in the Wild Basin area of RMNP.

Results

In total, 29 observation sessions were conducted for a total of 14.5 hours of source identification logging. Due to the lower than anticipated sample size, it was not felt enough data were collected to stratify sampling based day of week. Therefore, all samples were combined for analysis and descriptive statistics were run for all primary sources.

Table 3 shows descriptive results for the length of events across all samples, as well as PTA. For the length of individual events, the average, minimum, maximum and standard deviation have been reported. Lengths are in seconds, which is both the native output from the logging application and also simplifies calculations. For anthropogenic noise sources, the average length of an aircraft event was 134 seconds (2 minutes 14 seconds). The minimum length for an aircraft event was 7 seconds and the maximum length was 508 seconds (8 minutes 28 seconds). The extremely short minimum duration likely represents an event that either ended shortly after the logging session began, or was detected shortly before the logging session ended. The 508 second maximum duration is likely the result of concurrent events in which one or more new aircraft were detected before the previous detection event ended.

Table 3 Length and percent time audible (PTA) for all primary source categories detected. Length is reported in seconds and are represent all positive detections of that source.

Source	Number of Observations (n = 29)	Length of Individual Events (seconds)				Percent Time Audible (PTA)	
		Mean	Min	Max	Std. Dev.	Samples - Present	Samples - All
Aircraft	24	134	7	508	92	24%	20%
Amphibian	1	2	1	2	1	0%	0%
Bird	25	305	2	1800	509	57%	49%
Insect	20	212	2	1800	427	42%	29%
Mammal	15	252	3	1796	484	23%	12%
People	12	59	2	256	58	10%	4%
Thunder	3	14	2	60	14	12%	1%
Vehicle	2	29	1	105	30	32%	2%
Water	23	1207	6	1800	678	96%	76%
Wind	20	569	1	1800	622	63%	44%
Animal	1	26	6	46	28	3%	0%
(Unknown)							

Two additional analysis of interest were PTA by hour of the day and NFI by hour of the day. For PTA by hour, aircraft was used for the source of interest and is shown in Figure 2. It is important to note the low sample size for 9am and 6pm and therefore this graph should be interpreted as only a rough estimation of PTA for those hours. For visual comparison, data collected by NSNSD has been provided showing the distribution of PTA for aircraft throughout the day (Figure 3). Overall, PTA from this study is lower than that of the NSNSD data. There are a number of possibilities including the time of year when data were sampled, as well as potential masking effects from other sources such as water. These differences warrant further investigation.

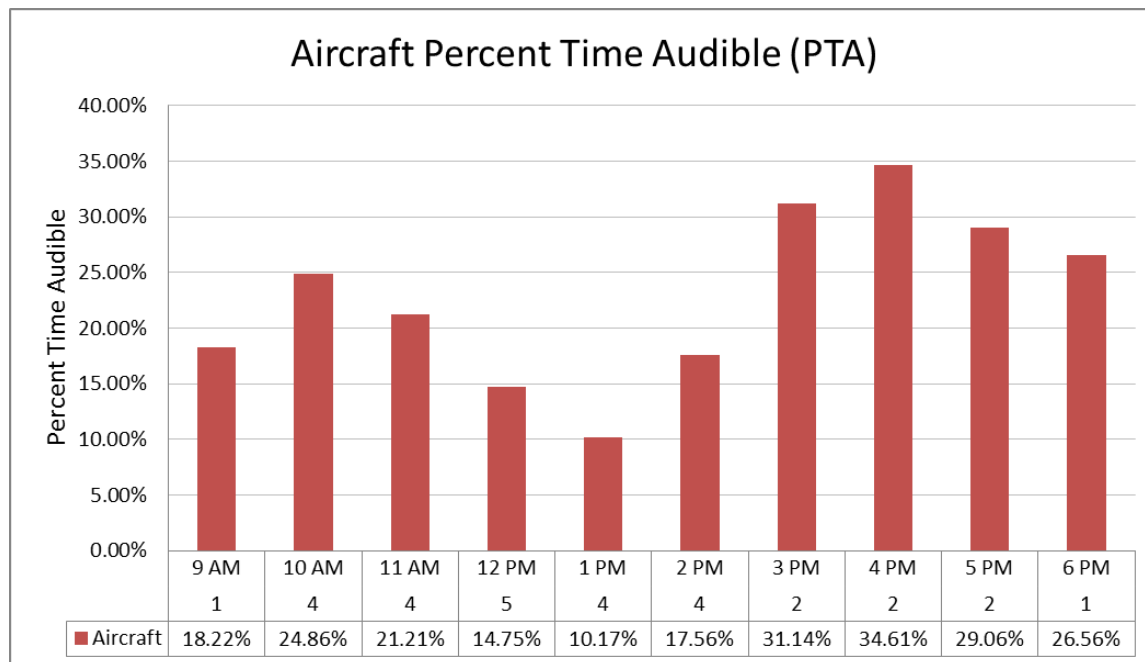


Figure 2 Percent time audible for aircraft between 9am and 6pm. The number between the hour and PTA denotes the sample size for that hour.

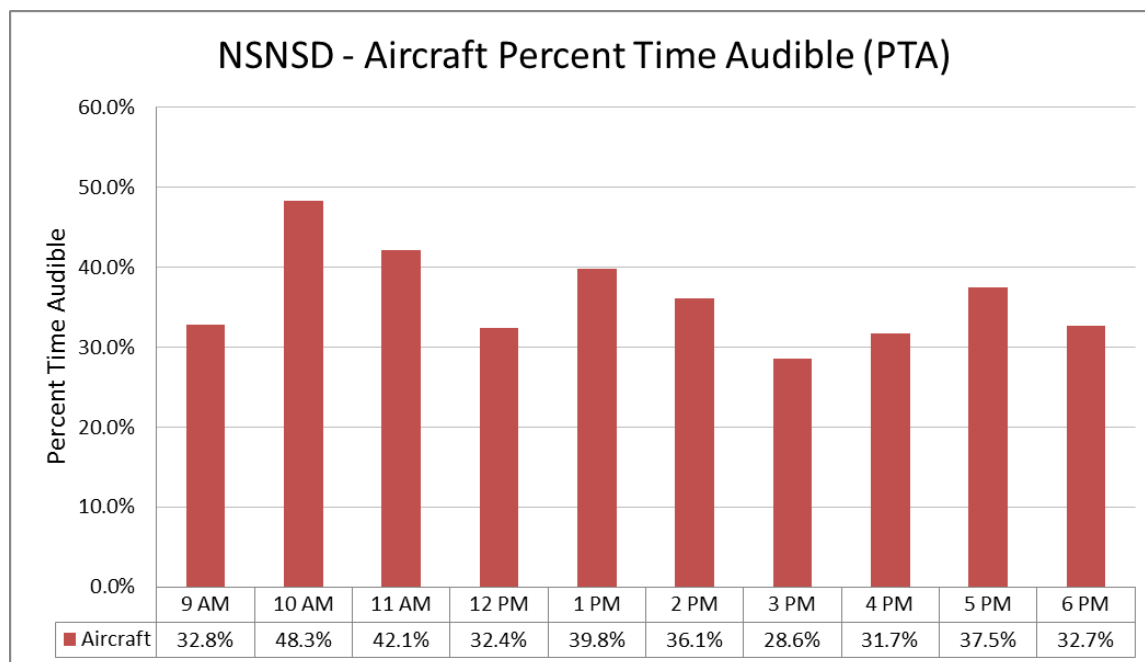


Figure 3 Percent time audible based on data from NSNSD site ROMO101. PTA has been calculated from a sample size of 3 days (3 hours total for each hour of the day).

In addition to PTA, NFI was calculated for each hour for which observations were collected. Figure 4 shows the average calculated NFI between the hours of 9am and 6pm. The maximum NFI for an observation is directly related to the total length of the observation period. Since the observation length for this study was 30 minutes, the maximum possible NFI is also 30 minutes.

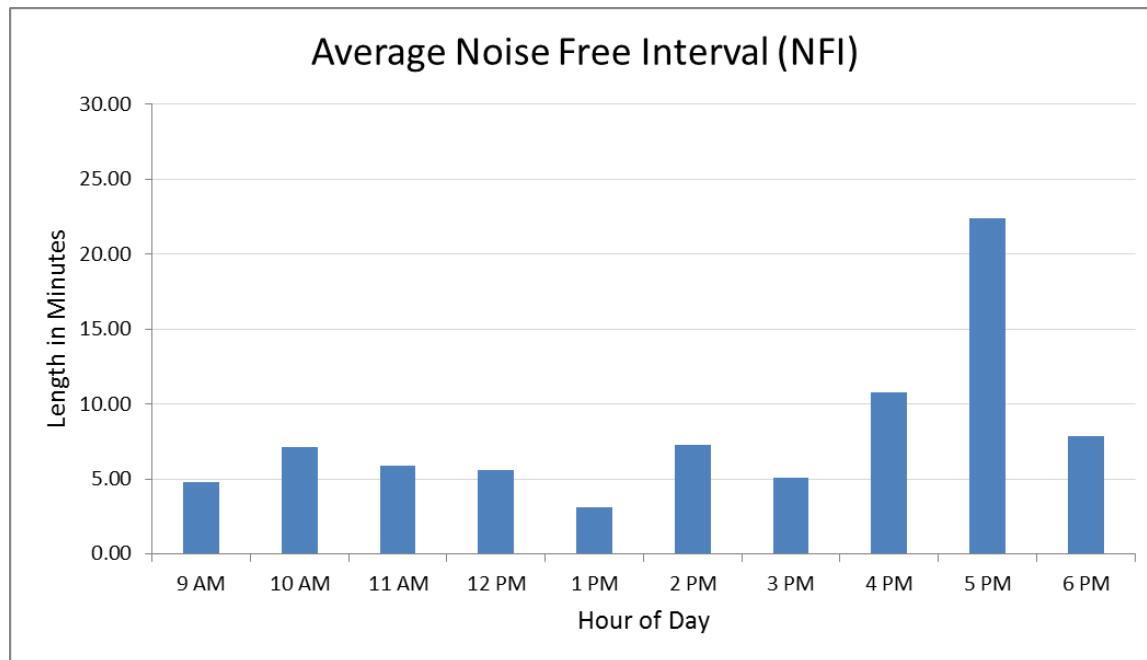


Figure 4 The average noise free interval (NFI) between 9am and 6pm.

Discussion

Results from this pilot study indicate OBSIL has potential as a viable method for assessing baseline soundscape conditions in wilderness or similar outdoor acoustic environments. This type of acoustical monitoring allows for the relatively rapid assessment of a broad geographic area using a minimum number of tools and no installation of equipment.

Of the 29 sites sampled, common sources included: aircraft $n=24$; birds, $n=25$; insects, $n=20$; water, $n=23$; and wind $n=20$. When these sources were present, the natural sources were on average audible 42% to 96% of the time Table 3. The most prevalent non-natural sound was aircraft, which was audible on average 24% of the time during observations were a detection occurred and 20% overall. While the percentage of time that aircraft was audible was substantially lower than other common natural sources, it was still detected during the majority of observations.

One important insight from this study is that when certain sources such as flowing water are present, they may be acting as a masking source. Since the OBSIL method only measures audibility based on detection, it is difficult to determine the full potential of flowing water as a masking source in this type of environment. The common occurrence of flowing water ($n=23$) and generally constant presence (mean length = 1207 seconds or 12:07 minutes) suggests that when present, water constitutes a significant portion of the auditory environment. If this is the case, anthropogenic sounds such as aircraft may be being mitigated at least in part by masking effects from sources such as water.

From a wilderness experience standpoint, this suggests that soundscapes at least in some areas of wilderness may provide better than expected visitor experiences when compared to current acoustical monitoring measures.

Finally, the intent of this study is not to suggest that OBSIL be considered a replacement for existing acoustical monitoring programs. Rather, OBSIL provides a complimentary method for expanding soundscape assessments across a greater percentage of management areas that would otherwise be too costly in time, money and other resources to measure. This method may also be of interest for wilderness managers due to its relatively low impact, requiring no installation of equipment and thus maintain the primitive and undeveloped values of wilderness.