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Human Response to Aviation Noise: Development of Dose-Response Relationships for Backcountry Visitors

Volume II: Results and Analyses

Prepared by:

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The Federal Aviation Administration and National Park Service conducted joint research to better understand the effects of noise due to commercial air tour operations over units of the National Park System. To evaluate the relationship between aircraft noise exposure and the quality of National Park visitor experience, research was conducted at backcountry sites providing day- and overnight-hiking and camping opportunities. Over 4600 visitor surveys and fifty days of acoustical measurements were collected and analyzed to develop dose-response relationships for backcountry visitors. This report, the second of two volumes, describes the the model-fitting approach used to identify the noise exposure metrics and mediator variables that best predict visitor responses to aircraft noise. The dose variables identified include sound exposure level, percent time audible, and energy percentages due to helicopters and fixed-wing propeller aircraft. Mediator variables identified include visitor ratings of the ‘importance of calmness, peace and tranquility’, attributes of adults-only in group, first visit to the site, having taken an air tour, and participation in activities of watching birds and listening to an interpretive talk. The models developed can be used as a tool for evaluating potential effects of air tours on visitors to National Parks.

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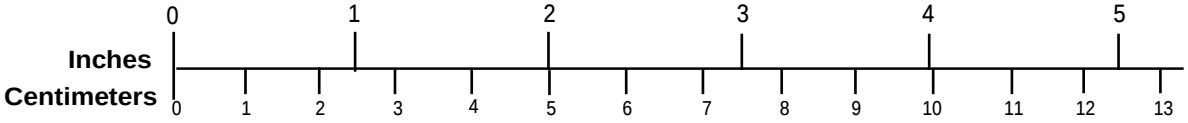

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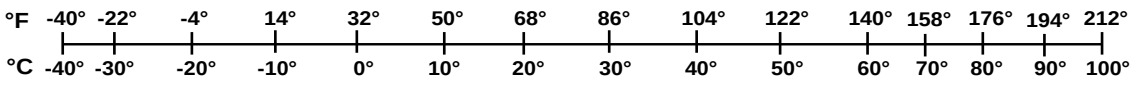

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1.0 INTRODUCTION

Spurred by the National Parks Overflight Act of 1987[1] and the National Parks Air Tour Management Act of 2000 (NPATMA),[2] the FAA Western Pacific Region, Office of Special Programs, the FAA Office of Environment and Energy, and the NPS Natural Sounds and Night Skies Division have embarked on a research program to further the understanding of human response to aviation noise* in protected natural areas. The foundation of the research program is the collection and analysis of aviation noise dose and corresponding visitor response data in National Parks. This report is the second of two volumes describing this research.

This research builds upon a number of prior studies conducted at frontcountry short-hikes and overlooks in the 1990's.[3,4,5,6] The data from these studies ('the 1990s dataset') were combined and analyzed to develop a comprehensive set of dose-response relationships for frontcountry sites. This analysis is documented in Anderson, et.al, "Aircraft noise dose-response relationships for National Parks",[7] and was used to inform the research methods and analyses presented herein. The current study also builds upon results of a number of other studies[8,9,10,11,12] that examined the effects of different types of sounds, including aircraft noise, on park visitors' experiences.

For the current study, data were collected at seven backcountry day- and overnight-hike sites and one cultural/historic site in four National Parks; Grand Canyon (GRCA), Bryce Canyon (BRCA), Zion, and Glacier (GLAC) during the period April through August 2011. The Volume One report summarizes the study methods, including visitor survey data and acoustic data collection, site selection methods and the study site characteristics, and concludes with data reduction and noise exposure dose computation methods. This effort resulted in the accumulation of a large dataset (survey responses and noise exposure doses) for backcountry day-hike and overnight visitors. The backcountry data collected in 2011 ('the 2011 dataset') are used to examine the correlation between noise exposure and visitor responses. The current volume, Volume Two, contains detail on the analysis and development of dose-response relationships.

* Aviation noise in the context of this study includes contributions from both tour aircraft and high-altitude commercial jets, as they often are concurrent and their effects on park visitors cannot effectively be separated.

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2.0 SUMMARY OF SURVEY AND VISIT DATA COLLECTED

The research conducted in 2011 resulted in a database consisting of over 4,600 completed visitor experience surveys; 70 percent are from visitors on backcountry day-hikes and 15 percent are from visitors on backcountry overnights. Table 1 summarizes the data collection locations, site-type classifications (e.g., day-hike, short-hike, etc.)*, and the number of completed surveys at each site-type and location. Section 2.1 presents summary results for the survey collection and comparisons among sites of select survey questions. Section 2.2 summarizes the visit information obtained from survey logs and global positioning system (GPS) based devices carried by visitors. Statistical summaries for all survey items by study site are presented in Appendix A.

Table 1. Summary of 2011 survey data collected

Park	Site	Day-Hike	Overnight Hike	Short-Hike	Cultural-Historic	Total
Grand Canyon	**Hermit Trail**	449	135			**584**
Grand Canyon	**Grandview Trail**	291	126			**417**
Grand Canyon	**Tusayan Ruins**				374	**374**
Zion	**Taylor Creek**	453				**453**
Zion	**West Rim Trail**	182	127			**309**
Bryce Canyon	**Fairyland Trail**	1102				**1102**
Glacier	**Hidden Lake Trail**	181		335		**516**
Glacier	**Sperry Trail**	540	345			**885**
	Total	**3198**	**733**	**335**	**374**	**4640**

Not all the collected survey data were used in the final analyses; the final dose-response data pool included only those respondents for whom good-quality visit location records and noise exposure dose data were available. Reasons for exclusion from the final pool include: inadequate records of the visit (e.g., lacking start time or destination), leaving the study area during the visit, and high wind conditions (see Volume 1, Section 5). Overall, 80 percent of the

* Site type is used in this research to refer to the context in which the noise exposure is presented. It encompasses both physical location and likely visitor activities at that location.

day-visit (including day-hikes, short-hikes, and cultural/historic sites) and 50 percent of the overnight visit survey data were matched with good acoustic dose data.*

2.1 Survey Response Data Summary

Each survey contained a number of key questions which have previously been shown to be important predictors within the dose-response relationships of visitors to overlook and short-hike site types.[7] Summaries of responses to these questions can provide understanding of the variation in visitor population among sites and between site types. The responses to the key questions that may influence the dose-response relationships are summarized below.

Personal expectations, motivations and past experiences regarding noise, sounds and the soundscape can affect visitor response to noise.[13,14] In relationships developed from the frontcountry dose-response data, these values were at least partially captured in ratings of the *importance of natural quiet.*† These ratings proved to be a key factor in predicting visitor response to noise exposure, as visitors reporting that natural quiet is very or extremely important also reported greater annoyance and/or interference with natural quiet due to aircraft noise than those who placed less value on this factor.

Importance of natural quiet may not adequately capture motivations and expectations at every location, as reasons for visitation vary by site and site-type. Therefore, several additional questions regarding visitor values were included in the 2011 data collection. One asked about the *importance of calmness, peace or tranquility*. In wilderness areas, this dimension has been shown to be greatly degraded by aircraft overflights.[11,13] A second question, intended to capture the values that drive interest in cultural and historic sites, asked about the 'importance of history and cultural significance of the site'.

Figure 1 summarizes responses to these questions. At the backcountry sites, 80 to 85 percent of respondents reported that experiencing *natural quiet* and the sound of nature was a very or extremely important reason for visiting, 75 to 85 percent reported that *calmness, peace and tranquility* was very or extremely important, and 30 to 55 percent reported that *history and cultural significance* was very or extremely important. At all sites, a greater number of people rated *natural quiet* very or extremely important than *calmness, peace and tranquility.* Further

* By their nature, overnight visitors are more likely to either leave the study area or have inadequate visit records. This occurred most often at Hermit and Grandview trails, where many branch-trails offered opportunities for visitors to hike off the main study trail.

† Shortened references to survey questions (response and mediator variables) are noted in italics throughout this report.

evaluation of these responses and their ability to help understand non-acoustic influences on visitor annoyance and perceptions of interference with natural quiet is conducted within the regression model framework presented in Section 5.0. (*Note: In the graphics shown in Figure 1 and throughout much of this document, sites and site-types are color-coded according to the following scheme: blue designates sites with day-and overnight hike options, green for sites with day- and short-hike options, red for sites with only short-hike options, and purple for cultural/historic sites.)*

At the frontcountry cultural/historic site, 61 percent of respondents reported *natural quiet* was very or extremely important, 56 percent reported that *calmness, peace and tranquility* was very or extremely important, and 82 percent reported that *history and cultural significance* was very or extremely important. The predictive power of visitor expectations regarding cultural and historic appreciation could be further explored with additional data collection at a range of cultural and historic sites.

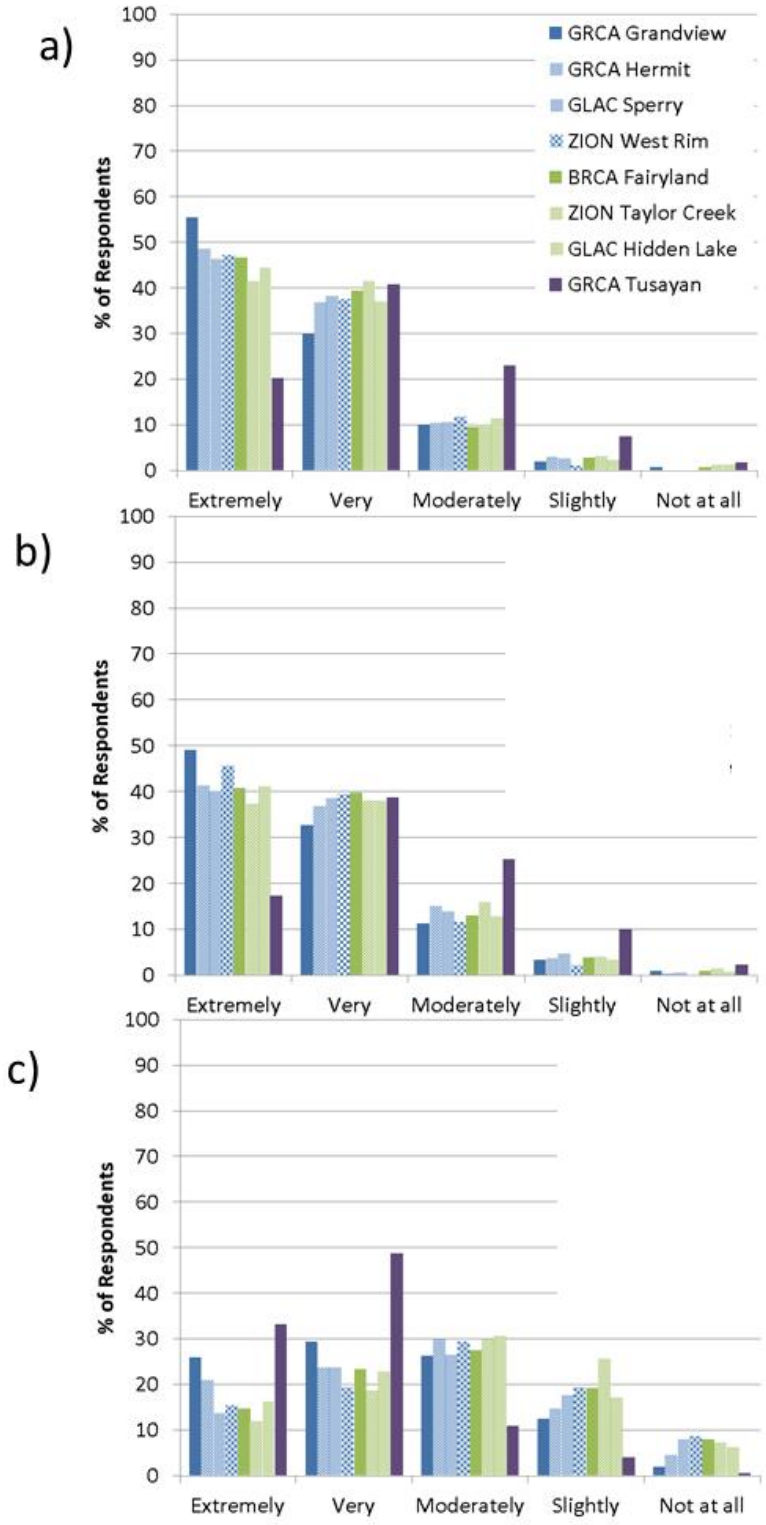

Figure 1. Percentage of respondents providing a given answer to: How important was it that this visit to <site> provide you with the opportunity to a) enjoy the natural quiet and sounds of nature? b) experience a feeling of calmness, peace, or tranquility? and c) to appreciate the history and cultural significance of the site?'

Visitor response to noise exposure has been shown to be influenced by the visitor's familiarity with the site.[7] Relationships developed from the 1990s dataset show that those who had previously visited the study location were more sensitive to aircraft noise. Within the 2011 dataset, Figure 2 a shows 10 to 30 percent of visitors had previously visited the site at which they were surveyed.

Lastly, visitor response to noise exposure may be influenced by the presence of children in the visitor's group. Relationships developed from the frontcountry dataset showed that visitors without children reported greater annoyance and/or interference due to aircraft noise than those with children.[7] Within the 2011 dataset, Figure 2 b shows that 10 to 20 percent of visitor groups contained children under the age of 16. As expected, shorter and less strenuous trails attracted a larger percentage of groups with children.

These results show that there are some subtle differences in visitor characteristics and expectations between sites and site-types. Relationships developed from the frontcountry dataset show that these characteristics play a key role in explaining the variability among individual visitors' responses to noise exposure.

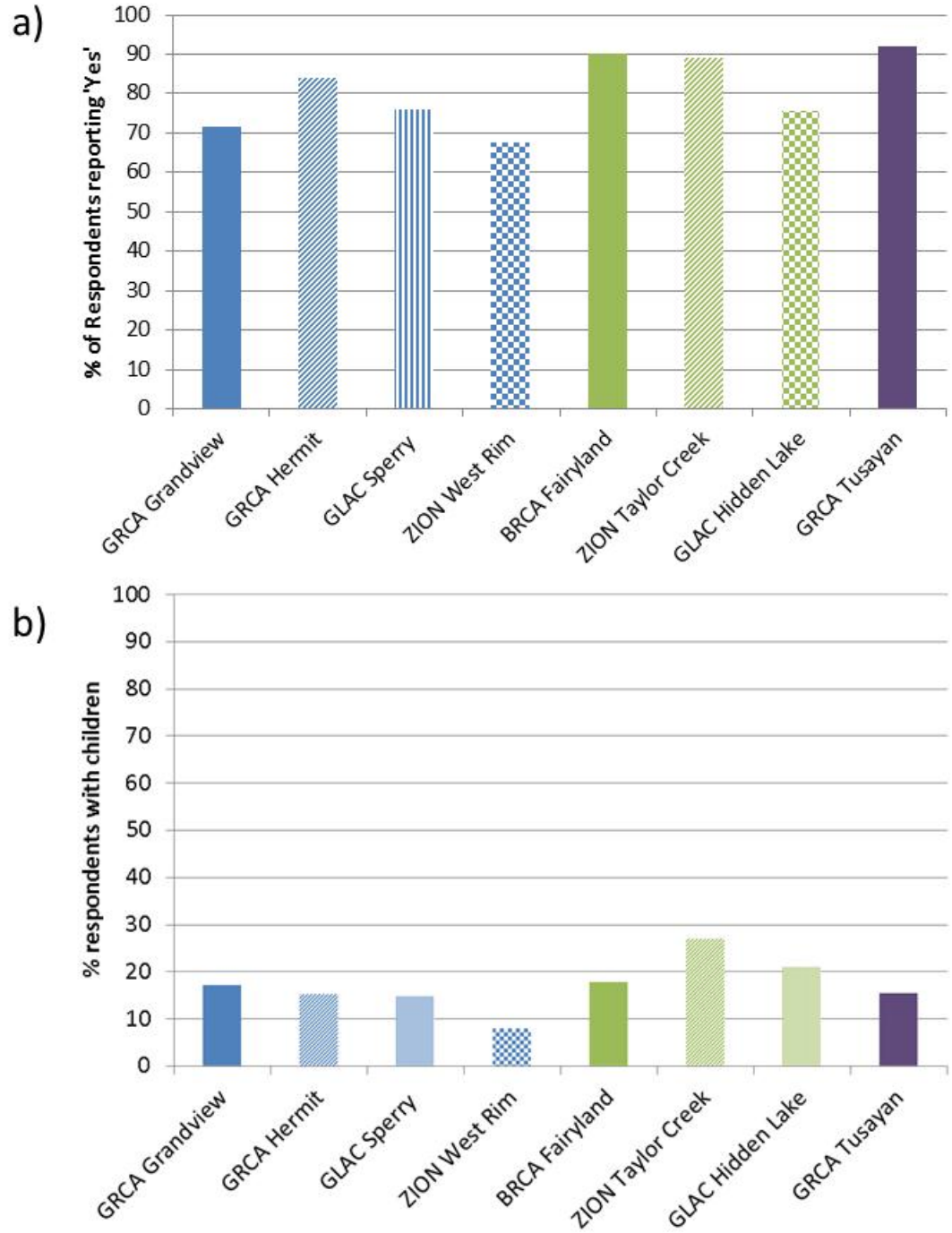

Figure 2. Percentage of respondents providing a positive response to: a) Is this your first visit to <site>? and b) How many children are in your personal group (spouse, family, friends) on this visit to <site>?

2.2 Visit Data Summaries

Calculation of an accurate noise exposure dose for each visitor requires knowledge of the temporal (visit start and end times) and spatial characteristics of each visit. As summarized in Volume 1, Section 5.2, these data were culled from survey logs and the GPS-based devices carried by visitors. The duration of each visit is very closely related to, and helps to define, site-type. In general, short-hikes have been defined as having visit durations less than one hour, while overlooks average visit durations of fewer than 15 minutes. In selecting sites for the 2011 study, researchers targeted backcountry sites where hikes along the full length of the trail would range from two to six hours in duration. However, many visitors chose not to hike the full length of the trails, resulting in shorter than expected visit durations. Table 2 shows the average visit duration at each trail. Trails where overnight hikes were available had average visits of 15 to18 hours, while trails where only day-hikes were available had average visits of two to four hours. Hikes less than one hour in length were excluded from the backcountry dose-response pool. These hikes are most consistent with short hikes, and the associated data may be used to test for effects of visit duration and potentially merged with the frontcountry dataset. Visit duration did not exhibit a significant effect within the dose-response relationships developed from the frontcountry dataset. It is further explored as a continuous explanatory variable within the backcountry regression analyses in Section 5.

Table 2. Visit duration statistics

Site	Average Duration	Minimum Duration	Maximum Duration	Standard Deviation
Hermit	15 hours	1 hour	104.9 hours	25.2 hours
Grandview	14.8 hours	1 hour	100.7 hours	23.3 hours
Fairyland	2.5 hours	1 hour	9.2 hours	0.8 hours
West Rim	3.7 hours	1 hour	8.2 hours	1.8 hours
Taylor Creek	3.1 hours	1 hour	5.8 hours	0.9 hours
Sperry	18.1 hours	1 hour	101.5 hours	21.1 hours
Hidden Lake	2.5 hours	1 hour	11 hours	1.3 hours

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3.0 SUMMARY OF ACOUSTIC DATA COLLECTED

The noise exposure dose and ambient sound level information (derived from in-situ sound level measurements) for each survey respondent is summarized in this section. Summaries are presented by site to highlight differences in noise exposure and soundscape conditions between these locations. Computed noise exposure dose metrics include:

- L_{AE}: The sound exposure level due to aircraft ;
- $L_{Aeq,Tresp}$: The equivalent sound level due to aircraft, normalized to the respondent's visit duration;
- $L_{Aeq,TAC}$: The equivalent sound level due to aircraft, normalized to the duration during which aircraft were audible;
- L_{Asmx}: The maximum sound level due to aircraft;
- %TAud: Percent of the visit duration aircraft are audible;
- $D'L_E$: The detectability exposure level, analogous to L_{AE};
- $D'L_{eq,Tresp}$: The equivalent detectability level due to aircraft, normalized to the respondent's visit duration, analogous to $L_{Aeq,Tresp}$;
- %TN: The percent of the visit duration aircraft are 'noticeable' (D'L ≥ 17).

Metrics based on aircraft detectability levels (D'L) are calculated from the one-second one-third octave-band records. These levels account for the signal-to-noise ratio in each one-third octave-band and are adjusted for bandwidth and frequency-specific human hearing characteristics. The one-second D'L values were used to compute summary detectability metrics analogous to A-weighted metrics.

The following graphics depict aggregated, summary statistics for all surveyed visitors in the dose-response pool, rather than hourly or daily statistics. Summaries are presented for visitor-groups based on site. Presented first are summaries of the A-weighted noise-exposure dose metrics calculated for each visitor: Sound exposure level due to aircraft ($L_{AE,}$ Figure 3), equivalent sound level due to aircraft normalized to the visit duration ($L_{Aeq,Tresp,}$ Figure 4), and maximum sound level ($L_{Asmx,}$ Figure 5). The median natural ambient (L_{50}) is presented next (Figure 6), as it informs the set of graphics summarizing the D'L metrics: detectability exposure level ($D'L_{E,}$ Figure 7) and equivalent detectability level due to aircraft, normalized to the respondent's visit duration ($D'L_{eq,Tresp,}$ Figure 8). Presented last are the time-based metrics: percent time audible (%TAud, Figure 9) and percent time noticeable (%TN, Figure 10).

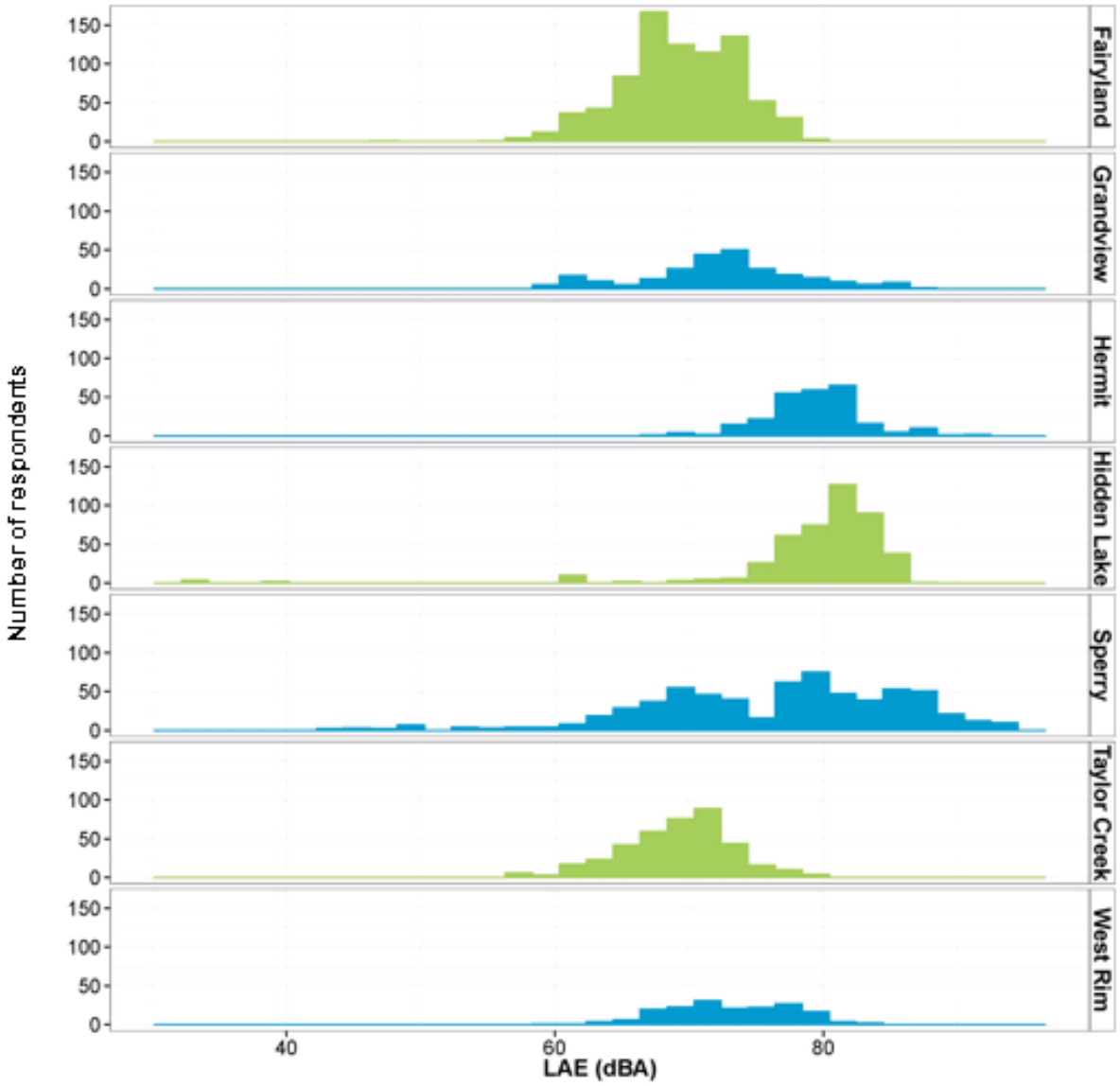

Figure 3. Sound exposure level due to aircraft (L_{AE}) over the visit duration

The largest variation and highest levels of sound exposure due to aircraft (L_{AE}) was observed at Sperry Trail, the site with the most overnight hikers. Visitors to Hermit Trail and Hidden Lake Trail also experienced high levels of aircraft sound exposure compared to other sites.

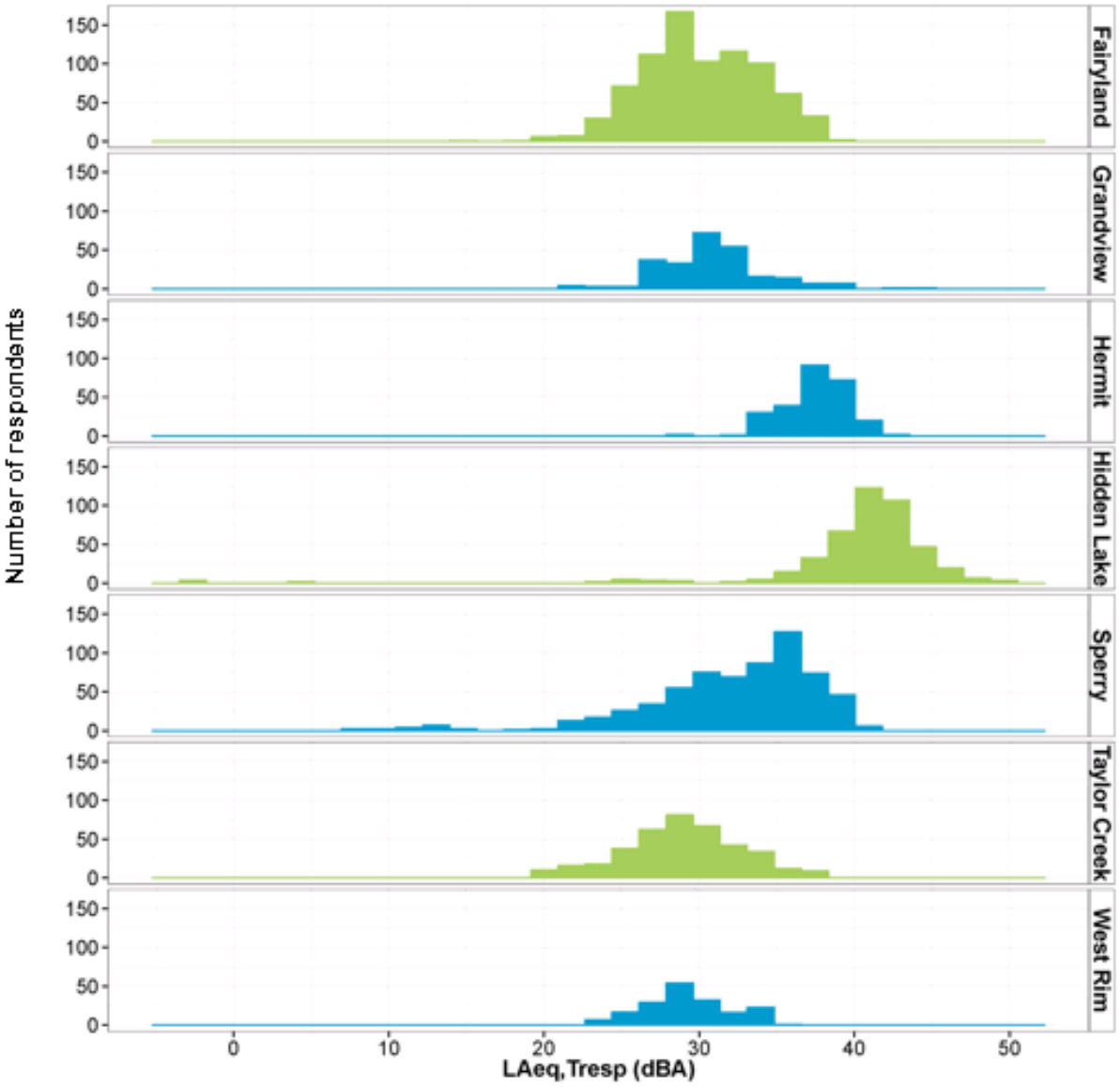

Figure 4. Equivalent sound level due to aircraft, normalized to the visit duration ($L_{Aeq,Tresp}$)

Similar patterns were observed for the equivalent sound level due to aircraft, normalized to the visit duration ($L_{Aeq,Tresp}$). The largest variation in equivalent sound level due to aircraft was observed at Sperry Trail. Visitors to Hermit Trail and Hidden Lake Trail also experienced higher normalized equivalent sound levels compared to other sites. Overall, there was a smaller range in the equivalent sound level metric across all sites due to the normalization to the visit duration.

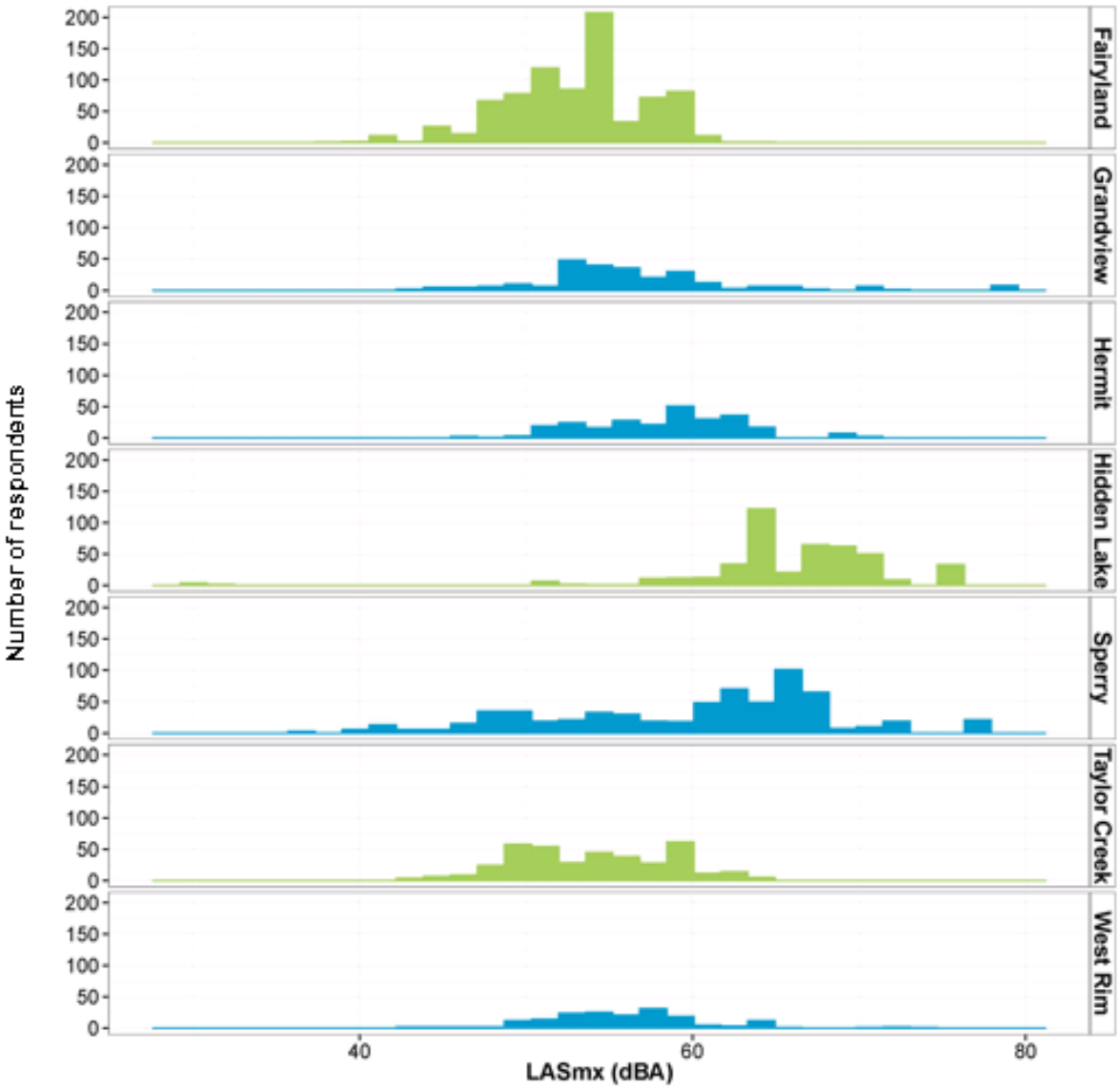

Figure 5. Maximum sound level (L_{Asmx}) over the visit duration

Compared to other dose-response measures, the maximum sound levels (L_{Asmx}) experienced by park visitors had the greatest variation within and among sites. The highest single event sound levels occurred at Hidden Lake Trail and Sperry Trail, with a few high values at Grandview Trail.

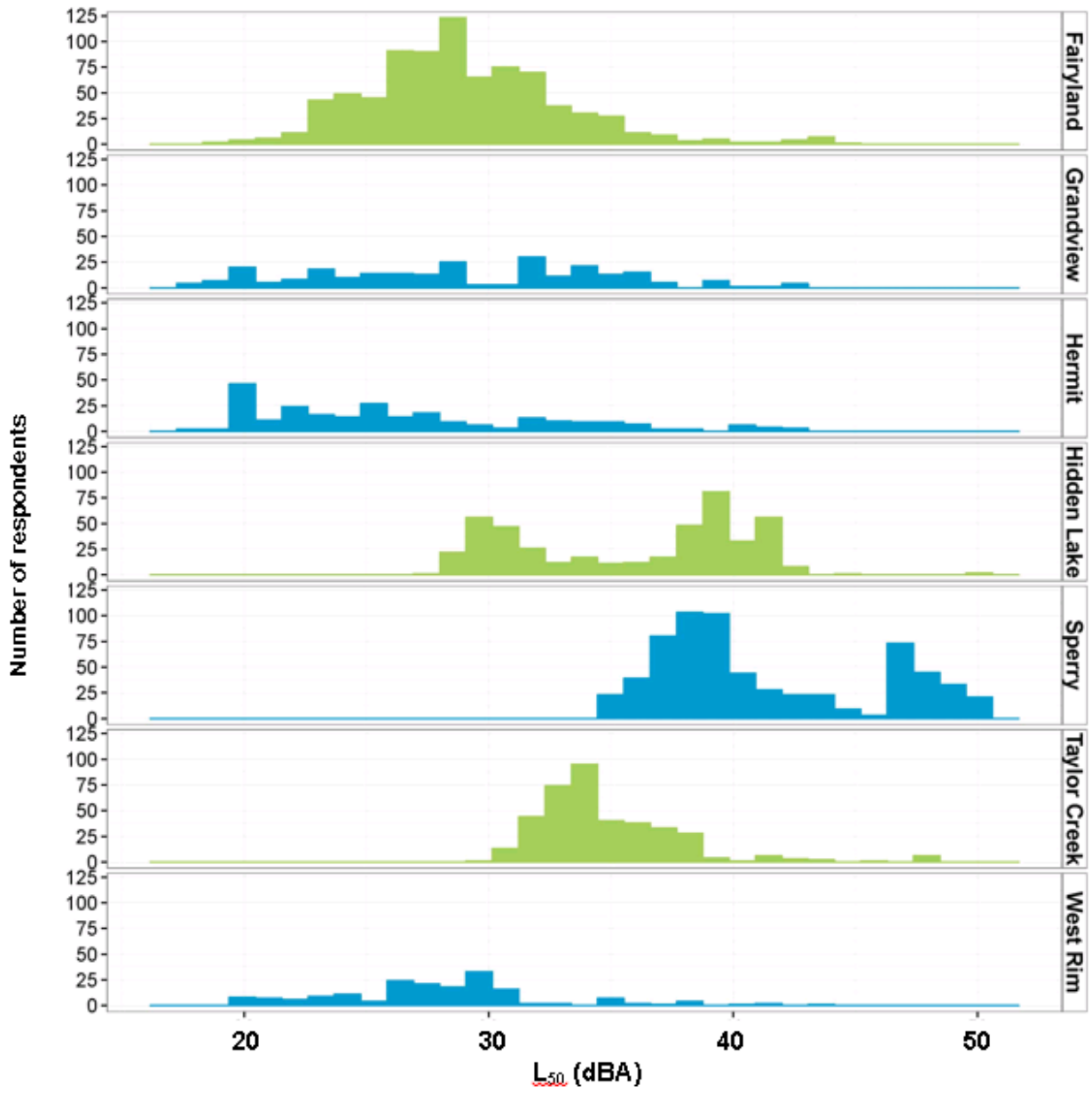

Figure 6. Histogram of Natural Ambient (L_{50}) over the visit duration

The A-weighted natural ambient sound sounds (L_{50}) show variation both within and between sites. Ambient sound levels vary significantly at the Grandview Trail, Hermit Trail, and Tusayan Ruins sites at Grand Canyon due to the variation in wind speed experienced at that park during the measurement period. The natural ambient at the Sperry Trail and Hidden Lake Trail sites in Glacier are both influenced by sounds from streams and waterfalls.

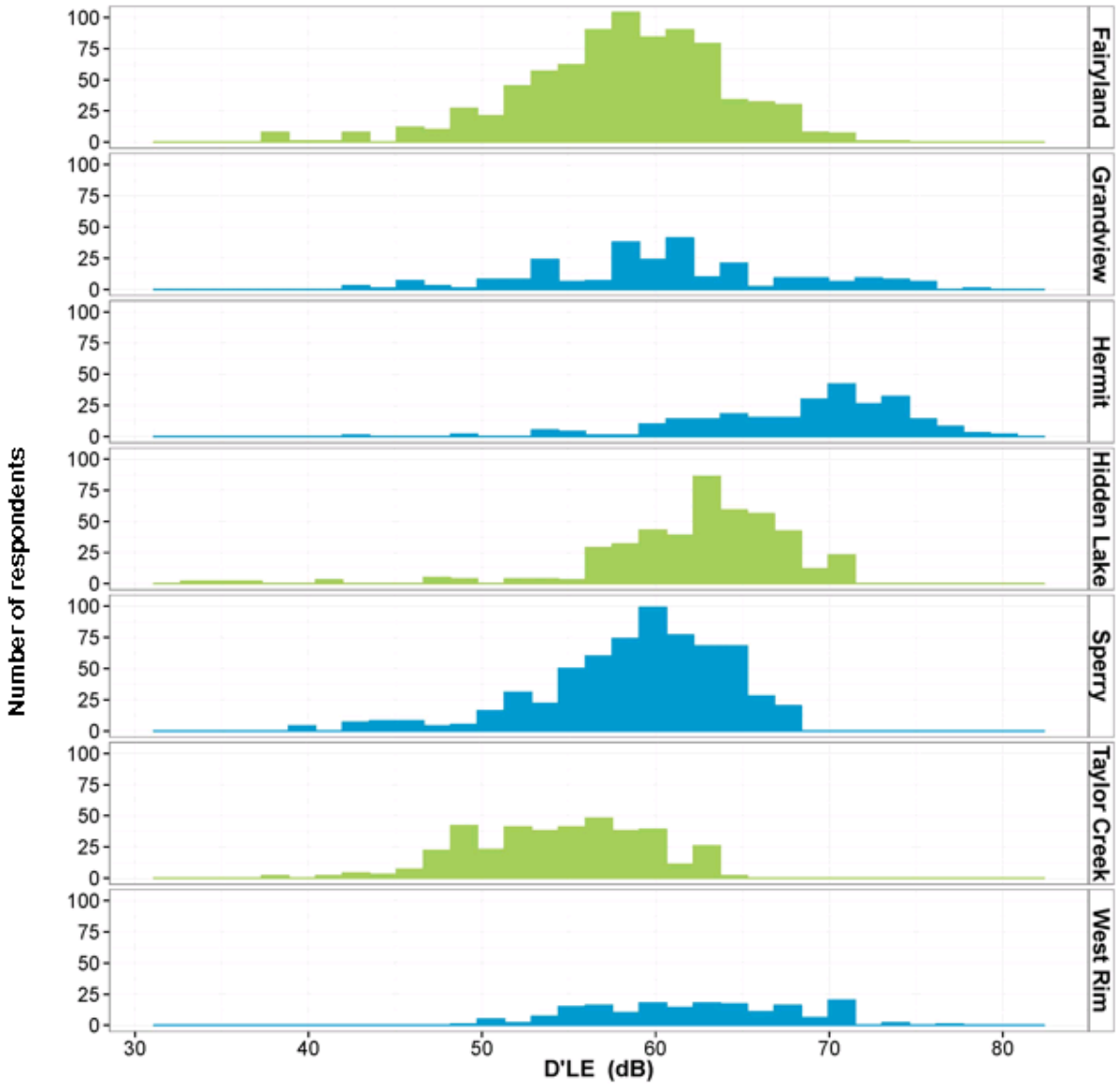

Figure 7. Detectability exposure level due to aircraft ($D'L_E$) over the visit duration

In contrast to the L_{AE}, $D'L_E$ has a larger variation in levels within each site. As this metric is based on the signal-to-noise ratio, the highest values now occur at the Grandview and Hermit sites, where the ambient levels are lowest. Values at the Sperry and Hidden Lake sites are now lower as the ambient sound levels at these sites are relatively high.

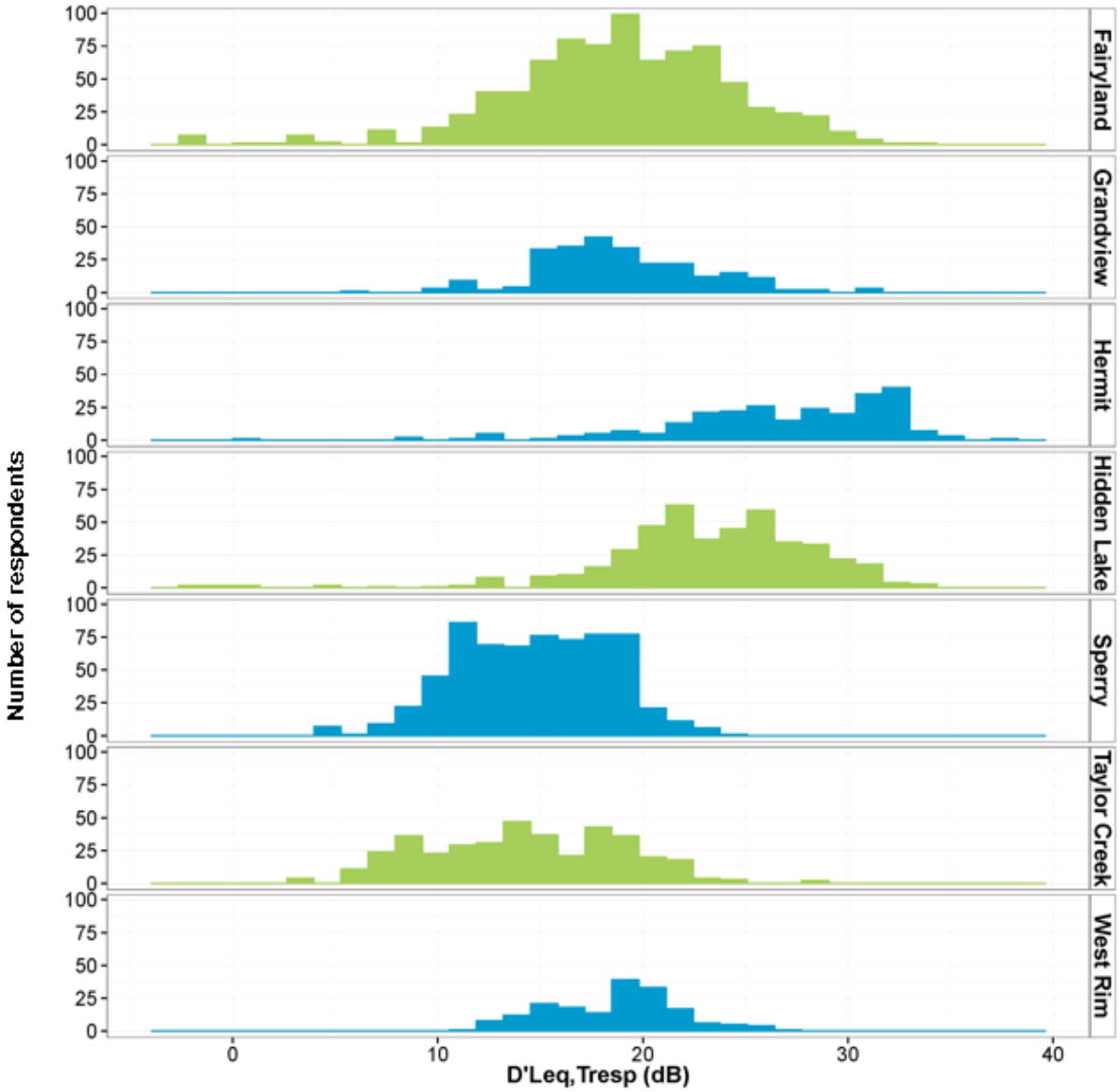

Figure 8. Equivalent detectability level due to aircraft, normalized to the visit duration ($L_{Aeq,Tresp}$)

Visitors to Hermit Trail experienced higher normalized equivalent sound levels compared to other sites. As with the D'L_E metric, D'$_{LeqTresp}$ values at the Sperry and Hidden Lake sites are lower as the ambient sound levels at these sites are relatively high.

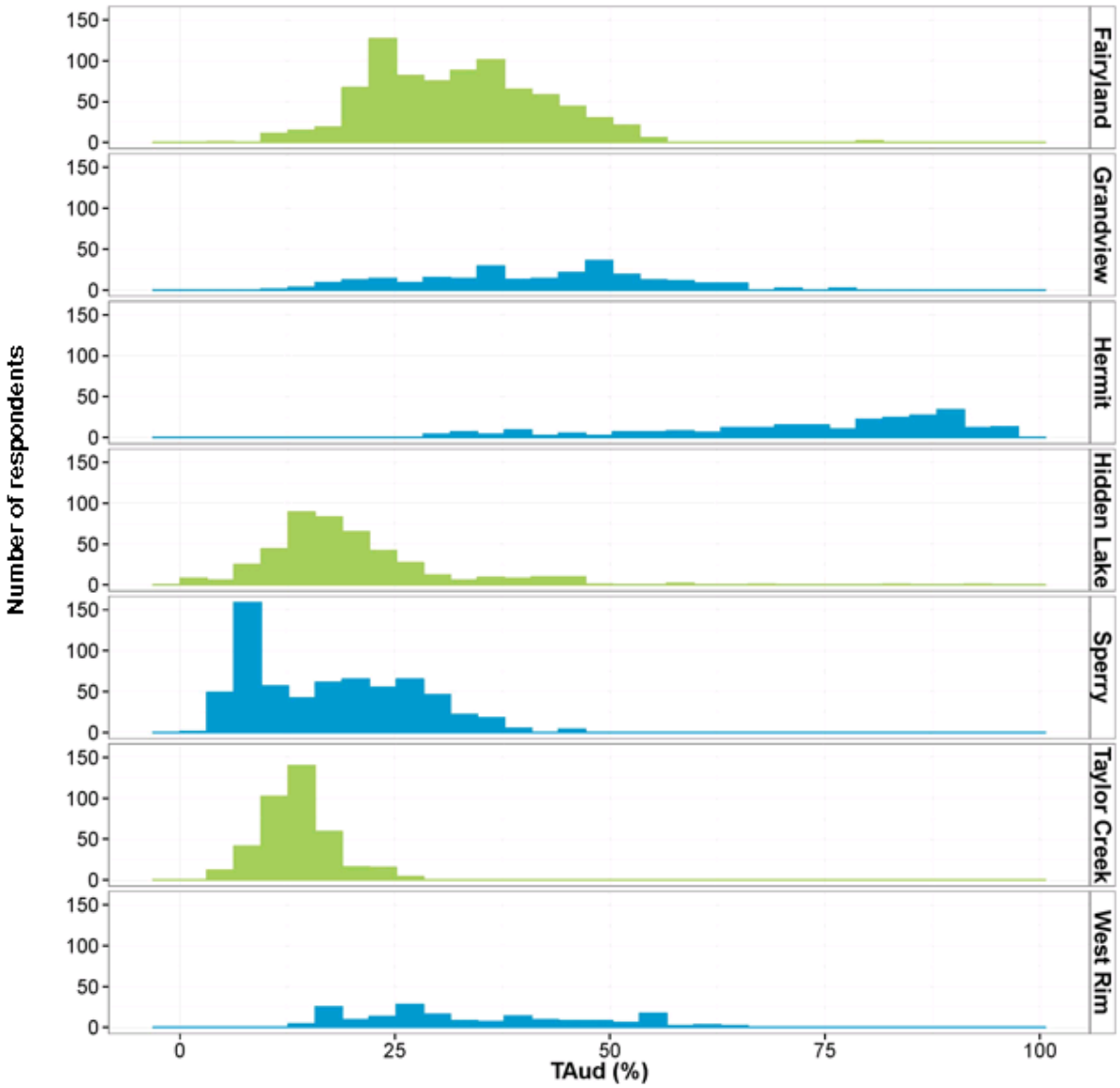

Figure 9. Percent time that aircraft are audible (%TAud) over the visit duration

The percent of time that aircraft were audible (%TAud) was highest at Hermit Trail and varied significantly among visitors at that site. While visitors to Hidden Lake Trail and Sperry Trail experienced high time-adjusted aircraft dose and high single event sound levels, their exposures were limited to an average of less than 50% of the visit duration.

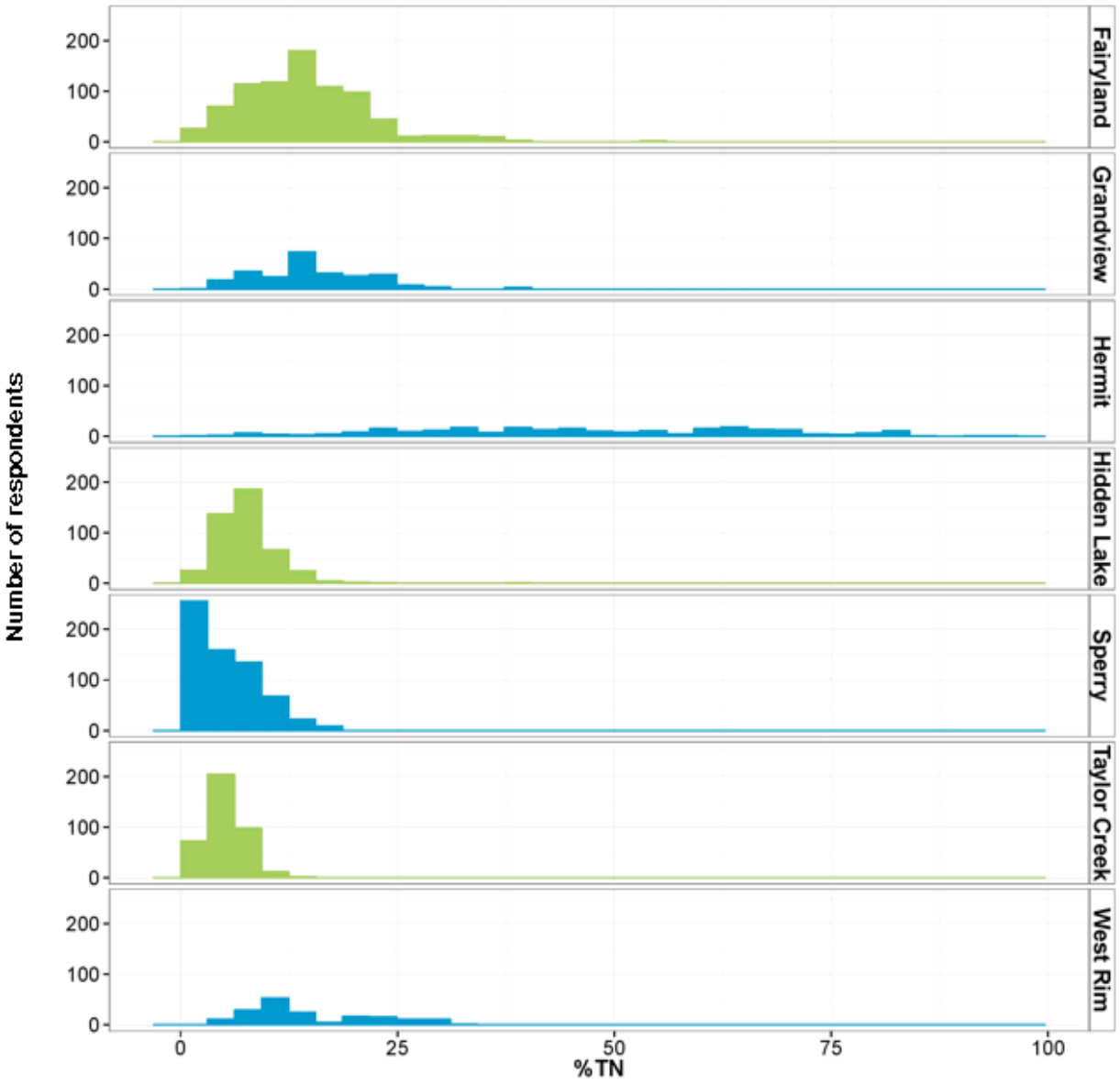

Figure 10. Percent time that aircraft are noticeable (%TN) over the visit duration

In contrast to %TAud, %TN values are lower, as the threshold for noticeability is higher than the threshold for audibility. Hermit Trail is the only site where visitors were exposed to noticeable aircraft for more than 50% of the visit.

Presented next are summaries of the aircraft-type-specific (helicopters (helos), propeller aircraft (props) and high-altitude jets (jets)) A-weighted noise exposure dose components calculated for each visitor, now with visitors grouped according to both site and site-type. Sound exposure level due to aircraft (L_{AE}) (Figure 11), equivalent sound level due to aircraft normalized to the visit duration ($L_{Aeq,Tresp}$) (Figure 12), percent time audible (%TAud) (Figure 13), and maximum sound level (L_{ASmx}) (Figure 14). These graphics show that the noise exposures at Hermit Trail, Sperry Trail, Hidden Lake Trail, Grandview Trail, and Tusayan Ruins all included significant contributions from helicopters, while the Fairyland Trail, Taylor Creek Trail, and West Rim Trail sites did not. In Figure 13 it is particularly noticeable that the high percentages of aircraft audibility at Hermit Trail were the result of helicopter overflights.

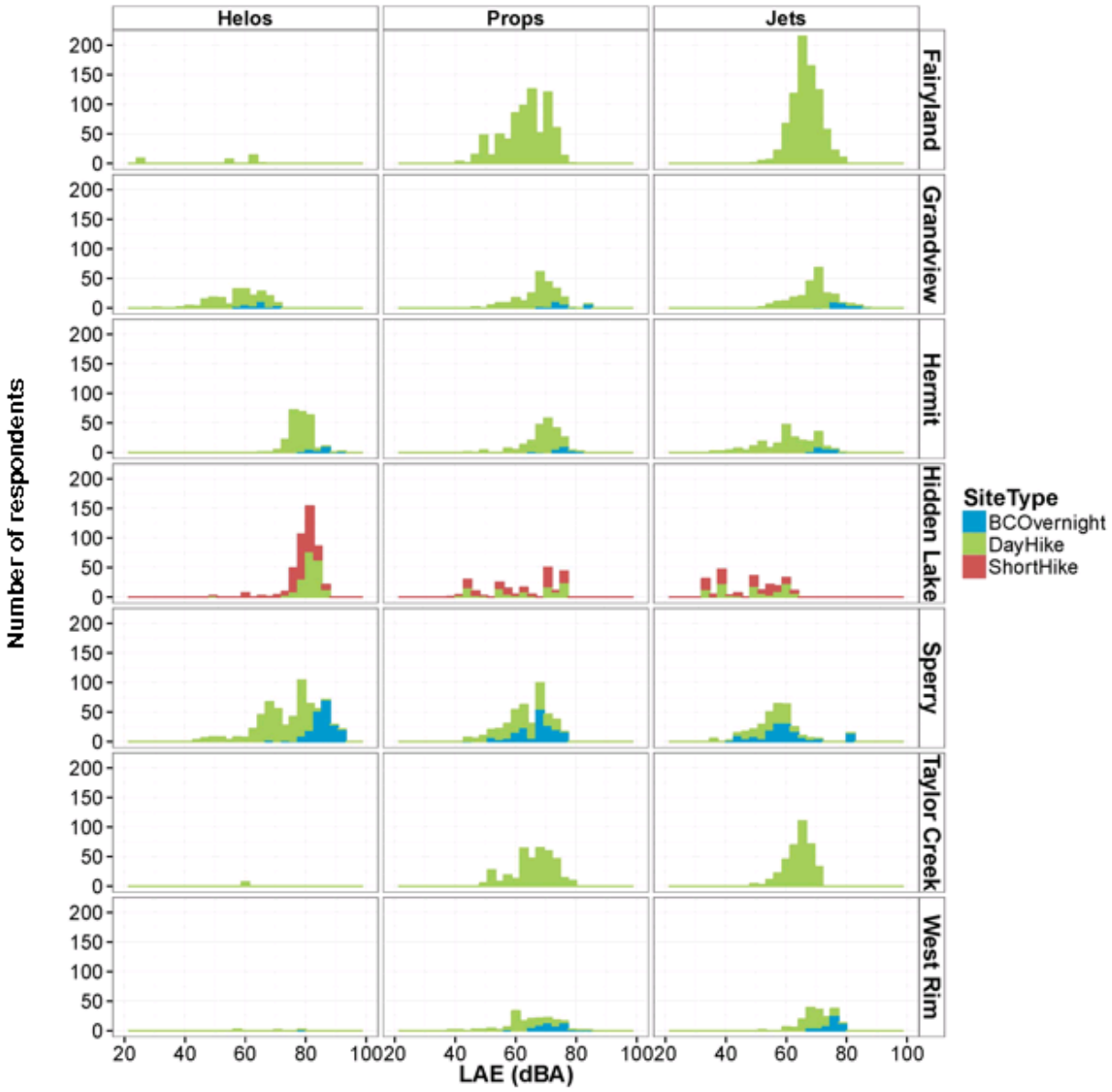

Figure 11. Histogram of sound exposure level (L_{AE}) over the visit duration, grouped by aircraft type

The largest variation and highest levels of sound exposure due to aircraft (L_{AE}) were observed at Sperry Trail, the site with the most overnight hikers. Visitors to Hermit Trail and Hidden Lake Trail also experienced high levels of aircraft sound exposure compared to the other sites.

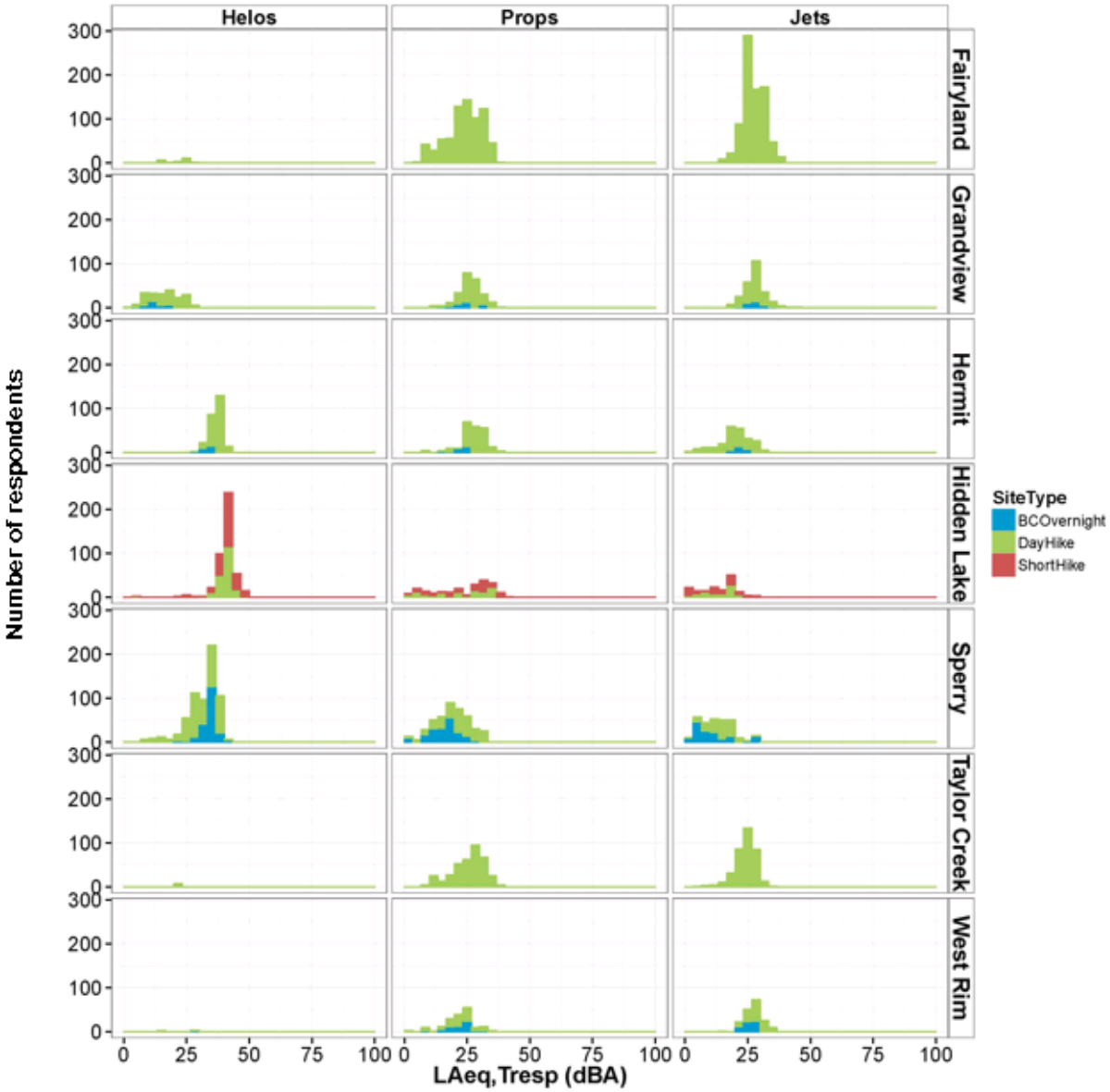

Figure 12. Histogram of equivalent sound level due to each aircraft type, normalized to the visit duration ($L_{Aeq,Tresp}$)

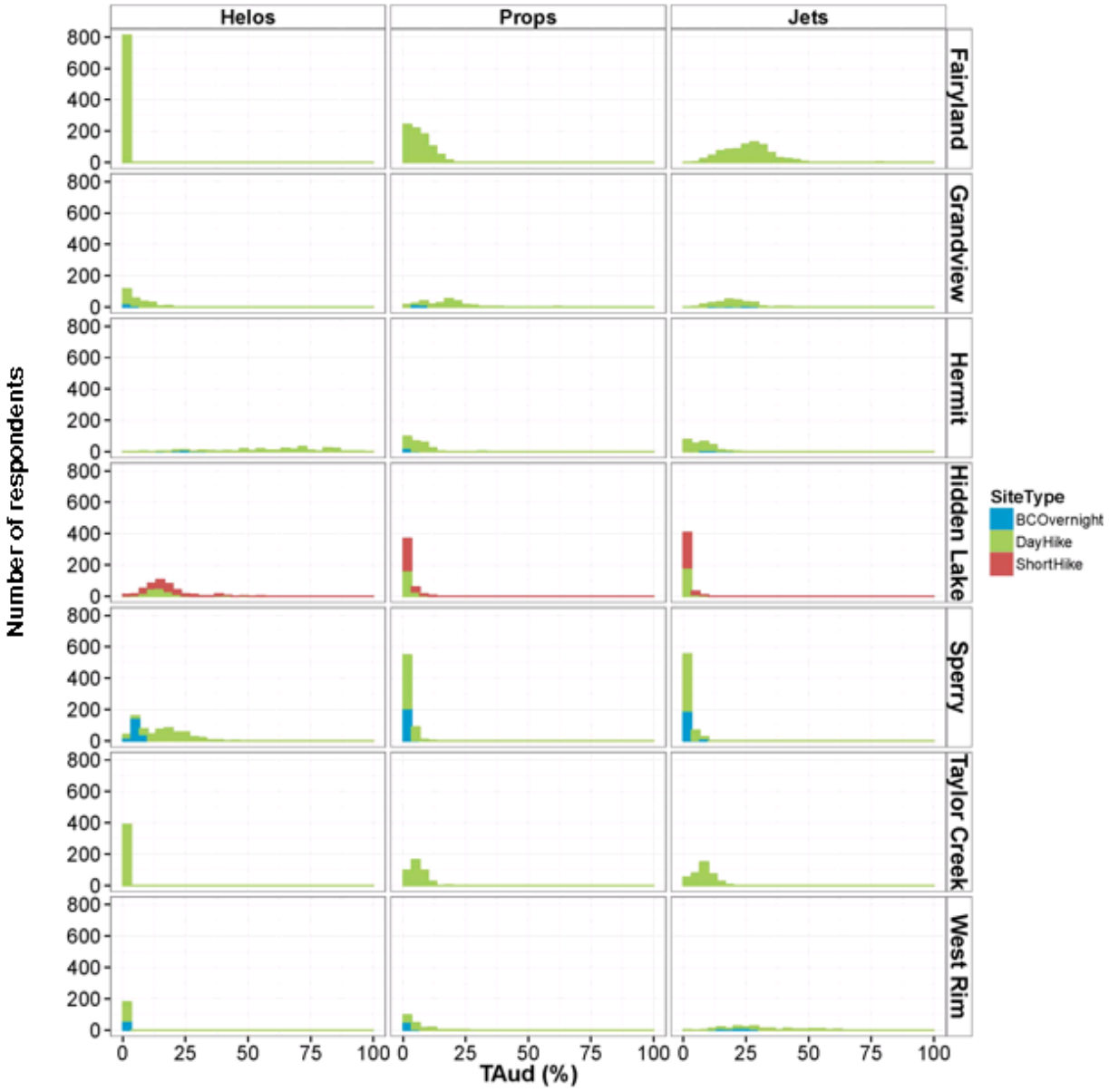

Figure 13. Histogram of percent time audible of each aircraft type (%TAud) over the visit duration

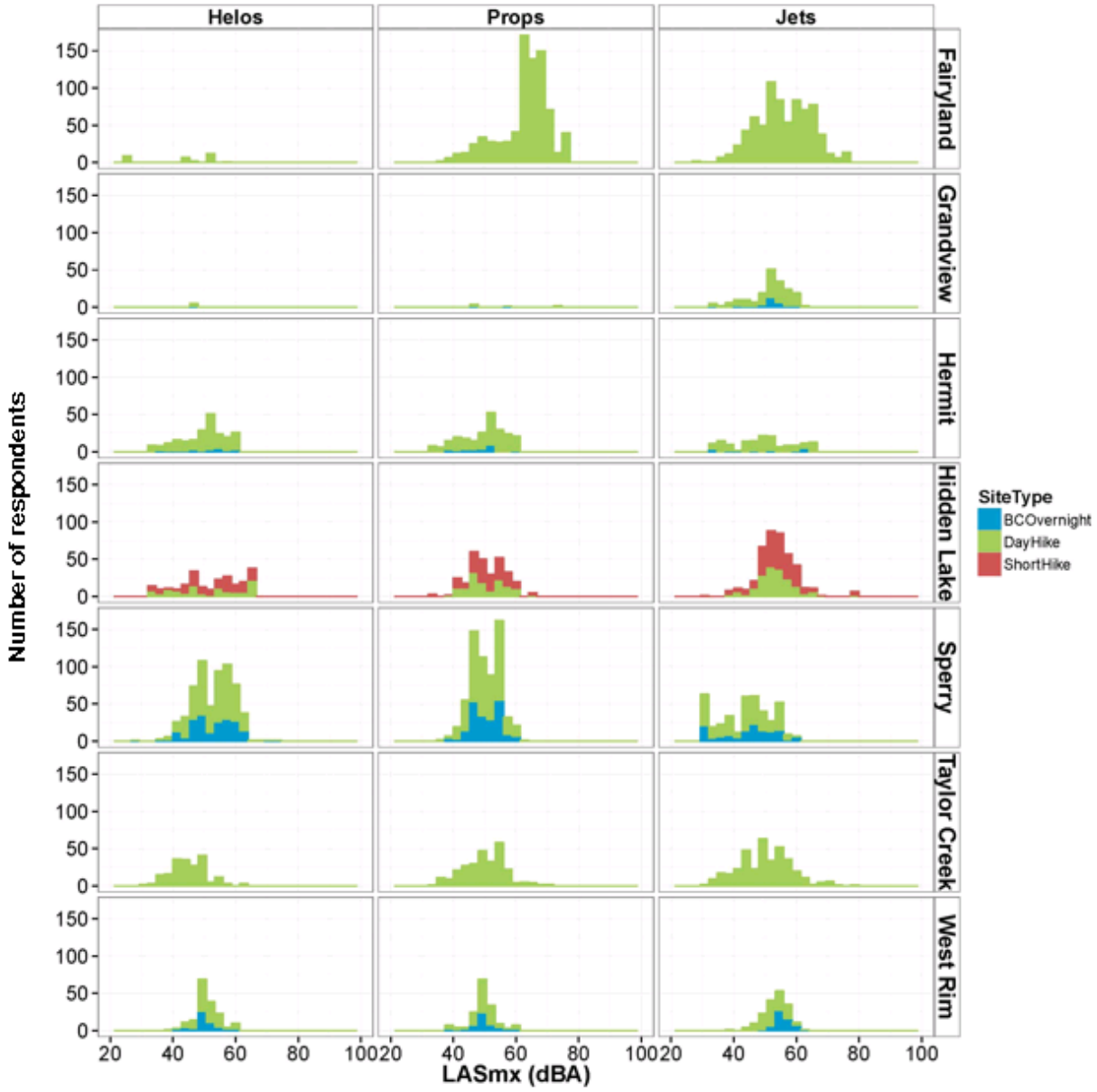

Figure 14. Histogram of maximum sound level of each aircraft type (L_{ASmx}) over the visit duration.

4.0 SURVEY COMPARISON

As discussed in Volume 1, Section 2, the current study incorporates three survey instruments for the purpose of evaluating key components of three research strategies. The survey instruments are:

- Human response to aviation noise survey 1 (HR1);
- Human response to aviation noise survey 2 (HR2); and
- Human response to aviation noise survey, audio recording version (audio clip).

The surveys each contain four parts, three of which are identical across instruments: the introduction, trip information and demographics. The sounds section of each survey contains questions on aircraft noise. These questions differ between the surveys in a number of key aspects, including format, phrasing, and the emphasis placed on aircraft noise.

Prior to formal analysis and development of dose-response relationships, comparisons were made to evaluate if responses from three questions on aircraft noise (reports of aircraft heard, annoyance, and interference with natural quiet) in separate survey instruments are statistically similar or if significant differences exist.

4.1 Comparing reports of aircraft heard

The initial screening question in the sounds section of each survey asks if aircraft (and, in HR2, other sounds) were heard during the visit (*hear aircraft)*. The placement of the question is identical in the HR1 and HR2 surveys. HR1 respondents are asked only if aircraft were heard; while HR2 respondents are presented with a list of ten sound sources, both natural and anthropogenic, that includes aircraft. In both surveys, this is the first mention of aircraft or aircraft noise/sounds. This question in the audio clip survey is identical in format to the HR1 survey, but is placed *after* respondents have completed the audio clip listening exercise. Table 3 shows the specific phrasing of each question.

Table 3. Summary of question formats: Did you hear aircraft?

Survey	Location	Question
HR1	Question 6	Did you HEAR airplanes, jets, helicopters, or any other aircraft during your time at [site]? *(yes or no)*
HR2	Question 6	Which of the following sounds did you hear during your time at [site]? (a) insect sounds (b) bird or animal sounds (c) waterfalls, running water, or waves (d) wind, rain, or thunder (e) group of people talking (f) someone's radio, TV, iPod, or other audio device (g) cars or trucks in a parking lot (h) cars or trucks on a road or highway (i) airplanes, jets, helicopters, or other aircraft (j) motorboats or motorized watercraft (k) none of the above
Audio Clip	Question 14	Did you HEAR airplanes, jets, helicopters, or any other aircraft during your time at [site]? *(yes or no)*

Figure 15 shows the percentage of respondents who reported hearing aircraft at each site. This figure shows that at five of seven backcountry sites (Grandview, Fairyland, Taylor Creek, Sperry and Hidden Lake), fewer HR2 survey respondents reported hearing aircraft than the HR1 or audio clip respondents. These differences are statistically significant only at the Sperry Trail site (p-value equal to 0.04). On average, 5% fewer visitors reported hearing aircraft using the indirect (HR2) format than the direct (HR1 / audio clip) format.

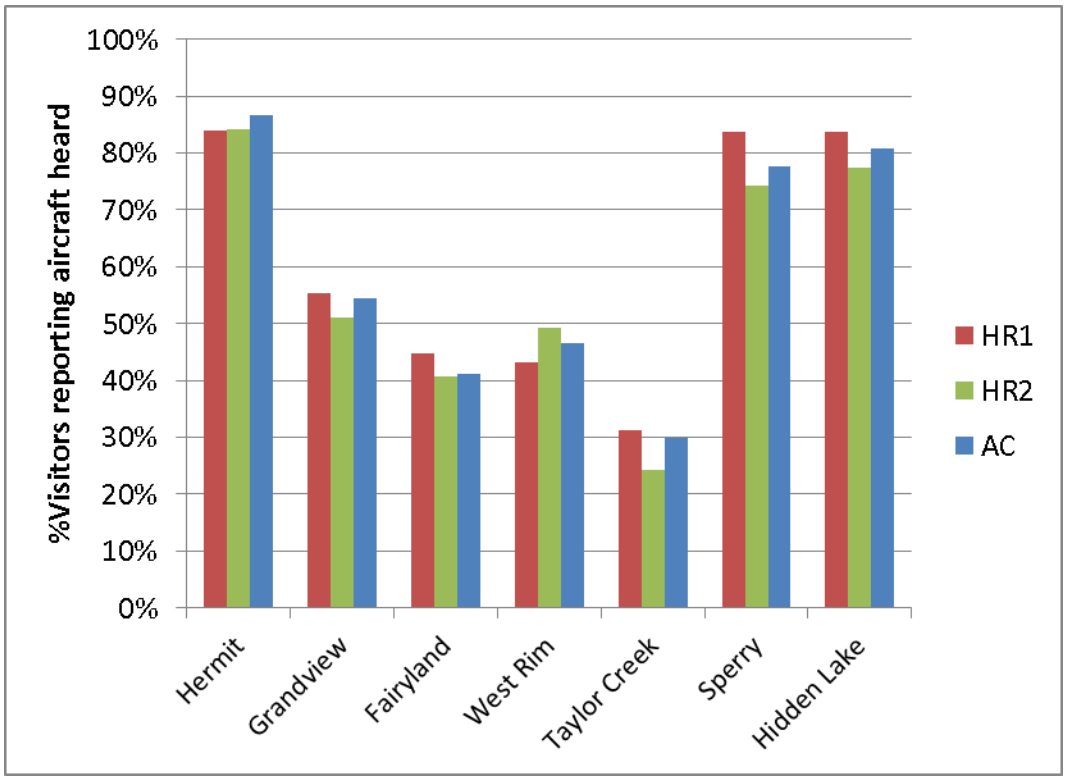

Figure 15. Histogram comparing percentage of visitors reporting of aircraft heard by survey and site

In a separate analysis, differences were examined as a function of the respondents' total aircraft sound exposure level in three bins (<65, 65-75, and >75 dBA), not stratified by site. In all cases, fewer respondents reported hearing aircraft using the direct format than the indirect format; 10% fewer at sound exposure levels less than 65 dBA, and 5% fewer at sound exposure levels between 65 and 75 dBA and above 75 dBA.[*] This indicates respondents of indirect questions are less likely to report hearing aircraft at lower sound exposure levels.

4.2 Comparing reported annoyance

Following the screening question, one or more questions are presented for the respondents to evaluate the *in situ* aircraft noise/sounds. The first of these questions in the HR1 and audio clip surveys concerns annoyance due to aircraft noise (*Annoy)*. The question is identical in the HR1 and audio clip surveys and allows only for negative or 'not at all' evaluations of aircraft noise on a 5-point scale. In contrast, the HR2 survey includes allowances for positive, neutral and

[*] The binned differences are not statistically significant (p-values of 0.08, 0.12, and 0.08, respectively).

negative ratings of each noise source on a nine-point scale. Table 4 shows the phrasing of these questions.

Table 4. Summary of question formats: Annoyance

Survey	Location	Question
HR1	Question 7	During your time at [site], how much did noise from airplanes, jets, helicopters, or other aircraft bother, disturb, or annoy you? *(extremely, very, moderately, slightly, not at all)*
HR2	Question 6b	How much did these sounds please or annoy you during your time at [site]? *(extremely annoy, very annoy, moderately annoy, slightly annoy, neutral, slightly please, moderately please, very please, extremely please)*
Audio Clip	Question 15	During your time at [site], how much did noise from airplanes, jets, helicopters, or other aircraft bother, disturb, or annoy you? *(extremely, very, moderately, slightly, not at all)*

Table 5 shows the distribution of survey responses, enabling comparison of differences due to the five- and nine-point ratings scales. Reported percentages are based on all respondents, including those who did not hear aircraft. As such, totals do not equate to 100%.

Table 5. Distribution of ratings of *Annoy* survey responses for the 5-point and 9-point scales.

Rating	HR1	HR2	Audio Clip
Extremely please	NA	1%	NA
Very please	NA	1%	NA
Moderately please	NA	3%	NA
Slightly please	NA	3%	NA
Not at all (HR1/audio clip) or Neutral (HR2)	18%	20%	15%
Slightly annoy	23%	13%	21%
Moderately annoy	12%	8%	17%
Very annoy	5%	4%	6%
Extremely annoy	4%	4%	3%
Total (those reporting aircraft heard)	62%	57%	62%

Differences in response distributions are observed between the nine-point bipolar survey and the five-point unipolar surveys in the moderately, slightly, and not at all / neutral annoy response categories. The most common response category on the five-point scale is ‘slightly’ (21-23% of respondents), while ‘neutral’ is the most common response on the nine-point scale (20% of

respondents). In addition, approximately 8% of respondents rated aircraft noise on the 'please' end of the nine-point scale. Notable also in Table 5 is the similarity in response distributions between the audio clip and HR1 surveys, suggesting that there is little bias introduced by the listening exercise.

The differences that are observed between surveys may be in part due to response bias, where a person responds to questionnaire items on some basis other than what the items were specifically designed to measure. Extreme and non-extreme response styles are commonly discussed response biases. Those with a non-extreme response style tend to favor the middle categories and avoid the extremes of a rating scale.[15] For these, the mid-scale 'neutral' point may be favored on the nine-point scale while the extreme-end 'not at all' may be less favorable on the five-point scale. In contrast, the very and extremely categories, at the extreme of both response scales, are viewed similarly and contain similar percentages of respondents (8-9%) across all three surveys. Another common phenomenon is the influence of the 'no-opinion' option. The 'neutral' choice on the nine-point scale may present a no-opinion option to respondents, while the five-point scale lacks a no-opinion option and can be viewed as a forced-choice scale. Some suggest presenting a no-opinion option is undesirable, as it allows respondents to skip the cognitive work necessary to form an opinion. Others counter that without a no-opinion option, those truly without an opinion will default to a rating from the middle of the scale, making results less accurate. Both of these biases would affect the neutral response category on the nine-point scale and the slightly and moderately response categories on the five-point scale. These biases are also confounded by the framing of the screening question (hear aircraft?) discussed in Section 4.1.

4.3 Comparing reported interference with natural quiet

The second question concerns interference with natural sounds and natural quiet due to aircraft noise (*Interfere)*. The question is identical in the HR1 and HR2 surveys and allows only for negative evaluations of aircraft noise on a 5-point scale. The question is not included in the audio clip survey. Table 6 shows the phrasing of this question.

Table 6. Summary of question formats: Interference with natural quiet

Survey	Location	Question
HR1	Question 8b	How much did the sounds from aircraft interfere with each of the following aspects of your visit at [site]? … Appreciation of the natural quiet and sounds of nature at the site *(extremely, very, moderately, slightly, not at all)*
HR2	Question 7	How much did the sounds from aircraft interfere with each of the following aspects of your visit at [site]? … Appreciation of the natural quiet and sounds of nature at the site *(extremely, very, moderately, slightly, not at all)*
Audio clip	NA	This question does not appear in the audio clip survey

Table 7 shows the proportion of visitor ratings in each category for each survey. The distribution of responses is nearly identical, differing only in the lower percentage of "not at all" ratings in the HR2 survey resulting from both fewer reports of aircraft heard and non-responses to this item.

Table 7. Distribution *Interfere* responses by survey, the identical 5-point scales.

Rating	HR1	HR2
Not at all	19%	8%
Slightly	14%	15%
Moderately	10%	11%
Very	6%	6%
Extremely	5%	5%
Total	54%	45%

4.4 Summary

As discussed in Volume 1, the current study incorporated three surveys for the purpose of evaluating key components of three research strategies. The HR1 survey and research methods were originally derived from those used in the residential dose-response framework for aircraft noise near airports. However, in the National Park context, the direct queries on aircraft sounds found in HR1 may alert the respondent to the target of the research during the survey. In the HR2 survey, aircraft sounds are one of a number of anthropogenic and natural sounds addressed in the survey. The results in this section comparing visitor evaluations of aircraft sounds in each survey instrument showed that HR2 respondents report hearing aircraft less often and report less annoyance from aircraft heard than HR1 or audio clip survey respondents at both the slightly or more and moderately or more levels. The difference may be attributed in

part to response biases from the point scales utilized in the surveys (five point neutral to negative for AC and HR1 vs. nine point positive to negative for HR2) and the avoidance of direct queries on aircraft sounds in the HR2 survey instrument. Based on these results, a survey-type coefficient was carried forward in regression models of *Annoy* to account for the differences between surveys. This method allows for the flexibility to assess response based on one or the other of the surveys, while maximizing the use of all the information collected.

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5.0 BACKCOUNTRY DAY-HIKE ANALYSIS RESULTS

The following section contains an analysis of the 2011 dataset to determine dose-response relationships for visitors on backcountry day-hikes. Measurement of backcountry visitor response was a key focus of this study, as these visitors may be more sensitive to aircraft noise than short-hike or overlook visitors. Sufficient responses were available to develop a robust model for the day-hike visitor. This analysis utilized a dataset pooled from surveys administered at day-hike sites at seven locations (Hermit Trail, Grandview Trail, Fairyland Trail, West Rim Trail, Taylor Creek Trail, Sperry Trail, and Hidden Lake Trail). On these trails, most visits (77%) were less than a half-day in duration (one to four hours). 22% of visits were four to seven hours, with 1% of visits greater than seven hours. Day-hike visits were *a priori* defined as greater than one hour and visits less than one hour were *a priori* defined as short hikes (Vol. 1, Section 4.1).

A regression model was used to explain visitor responses to aircraft noise based on each individual's aircraft noise dose. Section 5.1 discusses the model fitting and optimization approach used to identify the best dose predictors and mediator variables for the backcountry day-hike dataset. Section 5.2 summarizes the model considered to be the best fit for the day-hike data. Section 5.3 exercises this model to show the sensitivity to various mediating factors.

5.1 Model Fitting and Optimization

Consistent with the frontcountry analysis,[7] multilevel logistic regression was used to estimate parameters describing the functional form of the relationship between visitor responses and aircraft dose metrics, and how this relationship was modified by mediator variables. Logistic regression confines the resulting curves (and their 95% confidence regions) to lie between zero and unity (100%). The multilevel aspect avoids overestimates of prediction uncertainty and accounts for both variability among visitors (individual level variation) and among sites (group level variation), as described in detail in Anderson et.al, 2011.* Each model included "Site" as a random component, plus additional dose and mediator variables for each visitor:

* Ordinal logistic methods were also considered to model the survey data because they preserve each rating level of response (not at all, slightly, moderately, very, and extremely) without dichotomization. However these methods could not be used reliably within the current multi-level framework, which properly accounts for, and minimizes, the site-to-site differences that are inherent in the data sampling plan. The multi-level aspect was determined to be most important, as it is necessary to minimize the site-to-site uncertainty in order to develop a model that is generalized and can be applied to sites outside of those studied.

$$\Pr(y_i = 1) = logit^{-1}\left(\alpha_{j[i]} + \beta_0 + \sum_{d=1}^{M} \beta_d x_{id}\right), \text{ for } i = 1,\ldots,n. \quad (1)$$

where *j*[*i*] indexes the site (from 1 to 7) corresponding to visitor *i*, and x_{id} is the value of predictor *d* for visitor *i* in a model with M predictor variables. Site was analyzed as the "random" component of the multilevel regression:

$$\alpha_j^{site} \sim N\left(0, \sigma_{site}^2\right), \text{ for } j = 1,\ldots,7. \quad (2)$$

From the available visitor responses regarding aircraft noise exposure, two response variables, consistent with the frontcountry model, were selected for analysis:

1. Annoyance (*Annoy*) (HR1 and audio clip): During your time at [site], how much did noise from airplanes, jets, helicopters, or other aircraft bother, disturb, or annoy you? (5-point response scale of: *Not at all, slightly, moderately, very or extremely*)

   Annoyance (HR2): How much did these sounds please or annoy you during your time at [site]? *(*9-point response scale of: *extremely annoy, very annoy, moderately annoy, slightly annoy, neutral, slightly please, moderately please, very please, extremely please)*

2. Interference with natural quiet (*Interfere*): How much did the sound from aircraft interfere with your appreciation of the natural quiet and sounds of nature at [site]? (5-point response scale of: *Not at all, slightly, moderately, very, or extremely*)

The response data were converted to three dichotomized variables for analysis, representing visitors who did (1) or did not (0) experience "Slightly or more" (SorMore), "Moderately or more" (MorMore), or "Very or more" (VorMore) annoyance or interference with natural quiet from aircraft noise during their visit (Table 8). Responses for the nine-point scale survey (HR2) were converted with an additional step to convert categories indicating that aircraft noise was neutral or pleasing to visitors (*neutral, slightly please, moderately please, very please, extremely please*) to a "Not at all" response (see Section 4 for further discussion). The conversion to a "Not at all" response represented the lack of negative response from visitors due to aircraft noise. Three of the four possible dichotomizations were evaluated,* as each may provide useful information for evaluating noise exposure effects. For example, the 'very or more'

* The 'extremely or more' dichotomization was not evaluated as very few 'yes' responses exist in this category, and regressions utilizing this dichotomization do not have a significant correlation with sound level (i.e., the relationships are essentially horizontal).

dichotomization is similar to the FAA's threshold for determining significant aircraft noise impacts near civil airports.[16,17]

Table 8. Response dichotomizations

Level	'Yes' Responses	'No' Responses
Very or more (VorMore)	Extremely Very	Moderately Slightly Not at all Did not hear aircraft
Moderately or more (MorMore)	Extremely Very Moderately	Slightly Not at all Did not hear aircraft
Slightly or more (SorMore)	Extremely Very Moderately Slightly	Not at all Did not hear aircraft

Potential models for the backcountry day-hike dataset were evaluated by first selecting the combinations of dose variables, then the combinations of mediator variables, that result in the best models of visitor response to aircraft noise. The models of *Annoy* and *Interfere* responses were evaluated separately, as *Annoy* is included in all three surveys (HR1, HR2, and AC) while *Interfere* is included in only two surveys (HR1 and HR2). Models for the three different dichotomizations of the visitor responses (SorMore, MorMore, and VorMore) were fit for each combination of dose and response, for a total of six variations of each regression model. For this analysis, the best models were defined as those that minimized information loss based on the Akaike Information Criteria (AIC).[18] The AIC criterion identifies the model that minimizes information loss, utilizing the fewest parameters. Models with the lowest AIC values are preferred, but models with similar AIC values may not be significantly different. To identify the best combinations of dose variables for all three dichotomizations of the *Annoy* and *Interfere* responses, the relative probabilities of all models for a given response were calculated and compared with the model with the lowest AIC value (Equation 3).

$$Relative\ probability - e\exp((AICmin - AICi)/2) \qquad (3)$$

Models with a relative probability of greater than 0.05 compared to the model with the lowest AIC value were retained as candidate models for the mediator evaluation (Section 5.1.2). The relative probability criterion was utilized to identify the best combination of dose variables for all three dichotomizations of the *Annoy* and *Interfere* responses simultaneously, in order minimize the number of predictors and simplify practical implementation of the models.

5.1.1 Model testing: Alternate dose metrics

The dose metrics summarized in Vol. 1, Section 5, were evaluated singly and in combination based on their validity and goodness-of-fit in prior studies and current knowledge of auditory perception.[3,4,5,7,19] The alternate dose models evaluated included mediators of *Survey type* and visitor ratings of the *Importance of natural quiet* or the *Importance of calm/peace,* as these mediators were previously found to strongly influence visitor response to a given dose. Aircraft-type components ($P_{EnHelos,}$ $P_{en,Props}$) were included in the models where appropriate. As the component variables apportion the total aircraft sound exposure into individual aircraft-type components, they are only appropriate to include with cumulative A-weighted exposure doses (i.e., $L_{Aeq,Tac}$, L_{AE}).

The median ambient sound level excluding anthropogenic sounds (natural ambient L_{50}) was also included in the tests of alternative models. Ambient sound level is of particular interest, as the audibility of aircraft is logically dependent on the presence or absence of other natural and anthropogenic sounds in the listening environment. It is a characteristic which may help to distinguish between sites and site-types.

Table 9 summarizes the Pearson correlation coefficients between the noise exposure dose metrics. A value of +1 would indicate a perfect positive relationship (raising one value raises the other), -1 a perfect negative relationship (raising one value lowers the other), and zero indicates no relationship. These values can be compared to determine the relative relationships. The level-based dose descriptors (L_{ASmx}, $L_{AE,}$ $L_{Aeq,Tac,}$ $L_{Aeq,Tresp}$) are all highly correlated, and are expected to perform similarly in the regression models. The detectability-based descriptors ($D'L_E$, $D'L_{eq,Tac,}$ $D'L_{eq,Tresp}$) are also highly correlated within this group, and moderately correlated with their analogous level-based descriptors. The time-based descriptors (%TAud and %TN) do not show strong correlation with any of the level-based metrics.

Table 9. Noise exposure dose metric Pearson correlation coefficients

	L_{ASmx}	L_{AE}	%TAud	$L_{Aeq,Tresp}$	$L_{Aeq,Tac}$	$D'L_E$	$D'L_{eq,Tac}$	$D'L_{eq,Tresp}$	%TN
L_{ASmx}	1.00								
L_{AE}	0.89	1.00							
%TAud	-0.13	0.05	1.00						
$L_{Aeq,Tresp}$	0.80	0.84	0.20	1.00					
$L_{Aeq,Tac}$	0.86	0.83	-0.24	0.89	1.00				
$D'L_E$	0.58	0.72	0.42	0.60	0.40	1.00			
$D'L_{eqTac}$	0.51	0.49	0.22	0.67	0.55	0.77	1.00		
$D'L_{eqTresp}$	0.33	0.38	0.59	0.60	0.29	0.80	0.89	1.00	
%TN	0.19	0.34	0.34	0.10	-0.04	0.54	0.16	0.27	1.00

Table 10 summarizes the model-fitting statistics for models of the *Annoy* response with a relative probability of greater than 0.05 compared to the model with the lowest AIC value. From this group of candidate dose models, a single combination of dose variables which resulted in the best overall fit was identified. For this combination, the relative probability was greater than 0.05 for all three model dichotomizations. This combination included metrics of A-weighted sound exposure level (L_{AE}), percent time audible (%TAud), and percent aircraft energy ($P_{EnHelos}$, $P_{EnProps}$).

Further examination of Table 10 shows that the models with the lowest AIC values for each dichotomization of the *Annoy* response included the L_{AE} dose variable plus an additional dose variable. In addition, combinations of dose variables that included $D'L_E$ (in place of L_{AE}) resulted in lower AIC values for the *Annoy* SorMore response, however the AIC values for the MorMore and VorMore levels were much higher. The predictive power of $D'L_E$ at the slightly or more level suggests that detectability is a good predictor when 'slight' annoyance is of interest. This is consistent with earlier evidence that there is a strong relationship between annoyance and the detectability of low level aircraft sounds.[20]

Table 10. Results indicating the best dose metrics for use in *Annoy* dose-response model, based on AIC values. The relative probability (Rel Prob) represents the relative likelihood of the model compared to the model with the lowest AIC value. A value of 1.00 indicates the model with the lowest AIC value.

Dose Variables	Mediator	Slightly or More AIC	Slightly or moreRel Prob	Moder-ately or MoreAIC	Moder-ately or More Rel. Prob	Very or More AIC	Very or More Rel Prob
L_{AE} %TAud $P_{EnHelos}$ $P_{EnProps}$	Importance of calm/peace	2480.3	0.33	1646.8	1.00	894.1	1.00
L_{AE} %TAud $P_{EnHelos}$ $P_{EnProps}$	Importance of natural quiet	2480.2	0.35	1651.6	0.09	899.9	0.06
L_{AE} log10(%TAud) $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	2481.4	0.19	1653.9	0.03	900	0.05
L_{AE} log10(%TAud) $P_{EnHelos}$ $P_{en,Props}$	Importance of natural quiet	2481.3	0.20	1658.5	0.00	905.7	0.00
$D'L_E$ $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	2478.9	0.67	1675.3	0.00	915.3	0.00
$D'L_E$ $P_{EnHelos}$ $P_{en,Props}$	Importance of natural quiet	2478.1	1.00	1679.4	0.00	920.1	0.00

* Shading indicates the models for which the relative likelihood compared to the model with the lowest AIC values is >= 0.05 for all three modeled response dichotomizations (SorMore, MorMore, VorMore).

Table 11 summarizes the model-fitting statistics for the group of candidate best models for the *Interfere* response. The dose variables included in the best models for this response were less consistent; combinations of dose variables with low AIC values for the SorMore response resulted in higher AIC values for the MorMore and VorMore responses (and vise-versa). The best model for the *Interfere* response was the only model for which the relative likelihood was less than or equal to 0.05 compared to the model with the lowest AIC value for all three response dichotomizations. Identical to the *Annoy* response, it includes metrics of A-weighted sound exposure level (L_{AE}), percent time audible (%TAud), and percent aircraft energy ($P_{EnHelos}$, $P_{EnProps}$).

Consistent with the frontcountry model form, the percent aircraft-type energy variables ($P_{EnHelos,}$ $P_{enProps}$) were significant in all models. However, the interaction between $P_{EnHelos,}$ and $P_{EnProps}$ was not significant in any of the tested dose response models. The interaction was thus omitted from the models when testing additional mediator variables.

Table 11. Results indicating the best dose metrics for use in *Interfere* dose-response models, based on AIC values. The relative probability (Rel Prob) represents the relative likelihood of the model compared to the model with the lowest AIC value. A value of 1.00 indicates the model with the lowest AIC value.

Dose Variables	Mediator	Slightly or More AIC	Slightly or moreRel Prob	Moder-ately or MoreAIC	Moder-ately or More Rel. Prob	Very or More AIC	Very or More Rel Prob
L_{AE} %TAud $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	1757.4	0.05	1435.7	0.12	947.7	1.00
$L_{Aeq,Tresp}$ %TAud $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	1762.1	0.01	1435.7	0.12	949.1	0.50
$L_{Aeq,Tresp}$ $L_{50NatQuiet}$ $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	1760.4	0.01	1435.1	0.17	951.7	0.14
L_{AE} log10(%TAud) $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	1760.7	0.01	1441.2	0.01	951.8	0.13
L_{ASmx}	Importance of calm/peace	1782.4	0.00	1432.6	0.58	951.9	0.12
L_{ASmx} $L_{50,Nat}$	Importance of calm/peace	1779.9	0.00	1433.4	0.39	952.2	0.11
L_{AE} %TAud $P_{EnHelos}$ $P_{en,Props}$	Importance of natural quiet	1751.4	1.00	1440.9	0.01	952.4	0.10
$L_{Aeq,Tac}$ $P_{EnHelos}$ $P_{en,Props}$	Importance of calm/peace	1816.6	0.00	1431.5	1.00	953.3	0.06
$L_{Aeq,Tresp}$ %TAud $P_{EnHelos}$ $P_{en,Props}$	Importance of natural quiet	1754	0.27	1441	0.01	954	0.04
$L_{Aeq,Tresp}$ $L_{50,Nat}$ $P_{EnHelos}$ $P_{en,Props}$	Importance of natural quiet	1753.8	0.30	1439.4	0.02	955.4	0.02
L_{AE} log10(%TAud) $P_{EnHelos}$ $P_{en,Props}$	Importance of natural quiet	1754.8	0.18	1446.4	0.00	956.6	0.01

* Shading indicates the models for which the relative likelihood compared to the model with the lowest AIC values is >= 0.05 for all three modeled response dichotomizations (SorMore, MorMore, VorMore).

Again, there are additional trends noticeable in the above table. For the *Interfere* SorMore response, models that included $L_{Aeq,Tresp}$ (rather than L_{AE}), resulted in relatively low AIC values. For the *Interfere* MorMore and VorMore responses, models that included $L_{ASmx,}$ $L_{Aeq,Tresp}$ or $L_{Aeq,Tac}$ (rather than L_{AE}), and those that included L_{50Nat} (rather than %TAud) result in low AIC values. The appearance of the natural ambient sound level (L_{50Nat}) as a strong predictor of I*nterfere* ratings suggests that interference with natural quiet and the sounds of nature is, as expected, related to the level of natural sounds.

Also of note in both the *Annoy* and *Interfere* regression models is the relative strength of the models when either the *Importance of natural quiet* or *Importance of calm/peace* mediator is

included. Models including *Importance of natural quiet* have lower AIC values for the SorMore response, while models including *Importance of calm/peace* have lower AIC values for the MorMore and VorMore responses.

5.1.2 Model testing: Models including mediator variables

The 'best' dose-response model identified in step one was used to test whether the inclusion of additional survey and visit-based mediators (Table 12) resulted in models with lower AIC values. Mediator variables were added individually and in combination to the candidate *Annoy* and *Interfere* response models in an *a priori* order, beginning with variables included in the published analysis of frontcountry data[8]. The *Importance of natural quiet* variable was recognized as an important predictor of visitor response in the prior front-country analysis and was therefore the first mediator variable included in the models. Models with alternate *Importance* predictors were compared. Mediators were retained if they resulted in models with average AIC values (across all three dichotomizations) lower than AIC value of the original model from Section 5.1.1. In order to identify the most important mediators, in instances where average AIC values decreased only marginally (less than 1-2 units), mediators were not retained if the p-values of regression coefficients were not significant for at least one dichotomization. The process of adding these mediator variables to the candidate *Annoy* and *Interfere* response models is summarized in Table 13 and Table 14 below.

Table 12. Mediator variables

Variable Short Name	Definition / Survey Basis
Early start	Visitors who started hike/visit before 9 a.m.
Duration visit	Duration of Visit, described as continuous variable in minutes and log10(minutes)
Visited site before	"Is this your first visit to _____ trail?" (Yes, visited site before OR No, first visit)
Importance of…	"How important was it that your time on the _____ trail provide you with the opportunity to…. Choices: Not at all, slightly, moderately, very or extremely Response dichotomy: Very or extremely responses coded "yes"; not at all, slightly, moderately responses coded "no".
Importance of view scenery	a. View the natural scenery?"
Importance of natural quiet	b. Enjoy the natural quiet and sounds of nature
Importance of history	c. Appreciate the history and cultural significance of the site
Importance of calm/peace	d. experience a feeling of calmness, peace, or tranquility
Importance of adventure/challenge	e. Experience a sense of adventure or challenge
Activity	Which of the following activities did you take part in during your time <"on the" (day/multi-day hike trail) / "at" (Overlook/Cultural Resource Study Site)> <site>?
View scenery	a. Viewing the scenery
Picnic / meal	b. Picnicking or having a meal
Watch birds	c. Watching birds
View wildlife	d. Viewing wildlife (other than birds)
View a sunrise/ sunset	e. Viewing a sunrise or sunset
Talk	f. Attending a ranger-led talk, walk, or campfire program OR g. Attending some other demonstration, talk, or organized activity or performance
Adults only	Indicates the presence of children under the age of 16 in the visit group, based on interviewer observations. (Yes, only adults, OR No, group includes children)
Never air tour	Have you ever taken a scenic air tour over <park> or any other park? (Yes, Never taken air tour, OR No, Never taken air tour)
Residence	Where do you live? a. United States b. Another country
Group tour	Were you or your personal group part of some larger commercial, educational, or other organized group of visitors? (Yes /No)

The addition of a number of mediator variables to the original dose-response models identified in Section 5.1.1 resulted in models with lower AIC values. The mediator variables that reduced AIC values and had significant coefficient estimate for one or more dichotomizations of the *Annoy* response are: *Survey type, Importance of calm/peace, Site visit before, Adults only, Never air tour,* and *Watch birds*. Note that *Survey type* is a categorical variable with 3 values (AC, HR1, or HR2). In this analysis, the AC survey is the reference value and separate mediator coefficients are estimated for the HR1 and HR2 surveys. The remainder of the mediators are binary (yes/no) variables, where a 'no' response is the reference value, and the coefficient can be used to estimate the difference in annoyance or interference for visitors with a 'yes' response. The mediator variables accepted into the best model for the *Interfere* response include: *Importance of calm/peace, Adults only, Never air tour, and Talk*. Note in both models the *Importance of calm/peace* has lower AIC value for the MorMore and VorMore responses and a lower average AIC value across all three dichotomizations; it was therefore accepted in the final model. The *Importance of natural quiet* mediator has lower AIC values for the SorMore response but was not included together with *Importance of calm/peace* as these mediators are closely correlated, describing a similar visitor valuation.

Table 13. Stepwise testing of mediator variables for the *Annoy* responses. All models include the dose variables identified for the best dose model (L_{AE}, %TAud, $P_{EnHelos}$, $P_{EnProps}$) and *Survey Type* in addition to the mediator variables listed below.

Test variables	AIC SorMore	AIC MorMore	AIC VorMore	Result
Importance of natural quiet	2479.4	1648.5	897.8	Accept Importance of natural quiet
Importance of calm/peace	2479.7	1643.1	892.0	Accept Importance of calm/peace
Importance of view scenery	2482.5	1651.9	897.4	Reject Importance of view scenery
Importance of natural quiet, **Early start**	2479.5	1647.2	898.1	Reject Early start
Importance of calm/peace, **Early start**	2479.9	1642.1	892.6	Reject Early Start
Importance of natural quiet, **Visited site before**	2470	1644	894.5	Accept Visited site before
Importance of calm/peace, **Visited site before**	2470.5	1639	888.9	Accept Visited site before
Importance of calm/peace, Visited site before, **Adults only**	2461.6	1640.7	890.5	Accept Adults only
Importance of calm/peace, Visited site before, Adults only, **Never air tour**	2463.5	1631.2	886.4	Accept Never air tour
Importance of calm/peace, Visited site before, Adults only, Never air tour **Watch birds**	2458.5	1630.7	886.3	Accept Watch birds
Importance of calm/peace, Visited site before, Adults only, Never air tour, Watch birds, **Picnic/meal**	2458.9	1631.3	888.3	Reject Picnic/meal
Importance of calm/peace, Visited site before, Adults only, Never air tour, Watch birds, **Talk**	2460.4	1630.5	886.9	Reject Talk
Importance of calm/peace, Visited site before, Adults only, Never air tour, Watch birds, **View a sunrise/sunset**	2460.1	1632.6	888.3	Reject View a sunrise/sunset
Importance of calm/peace, Visited site before, Adults only, Never air tour, Watch birds**, View wildlife**	2459.6	1632.3	888.1	Reject View wildlife
Importance of calm/peace, Visited site before, Adults only, Never air tour, Watch birds, **log10.Duration visit**	2457.9	1632.2	887.4	Reject Log10 Duration visit

Table 14. Stepwise testing of mediator variables for the *Interfere* responses. All models include the dose variables identified for the best dose model (L_{AE}, %TAud, $P_{EnHelos}$, $P_{EnProps}$) in addition to the mediator variables listed below.

Test Variables	AIC SorMore	AIC MorMore	AIC VorMore	Result
Importance of natural quiet	1749.4	1431	948.4	Accept Importance of natural quiet
Importance of calm/peace	1755.2	1425.1	943.7	Accept Importance of calm/peace
Importance of view scenery	1753.9	1436.5	951.7	Reject Importance of view scenery
Importance of natural quiet **Early start**	1748.6	1432.2	950.2	Reject Early start
Importance of calm/peace **Early start**	1754.2	1426	945.6	Reject Early Start
Importance of natural quiet **Visited site before**	1748.4	1431.8	948.2	Reject Visited site before
Importance of calm/peace **Visited site before**	1754.3	1426	943.4	Reject Visited site before
Importance of natural quiet **Adults only**	1747.4	1432.1	949.5	Accept Adults only
Importance of calm/peace **Adults only**	1752.5	1426.1	944.8	Accept Adults only
Importance of natural quiet Adults only **Never air tour**	1745.8	1431.1	947.3	Accept Never air tour
Importance of calm/peace Adults only **Never air tour**	1751	1425.1	942.3	Accept Never air tour
Importance of natural quiet Adults only Never air tour **Watch birds**	1743.8	1433	947.3	Reject Watch birds
Importance of calm/peace Adults only Never air tour **Watch birds**	1748.5	1427	942.4	Reject Watch birds
Importance of natural quiet Adults only Never air tour **View a sunrise/sunset**	1746.7	1431.3	949.1	Reject View a sunrise/sunset
Importance of calm/peace Adults only Never air tour **View a sunrise/sunset**	1751.9	1425.4	944.1	Reject View a sunrise/sunset
Importance of natural quiet Adults only Never air tour **Picnic/meal**	1745.1	1432.2	949	Reject Picnic/meal
Importance of calm/peace Adults only Never air tour **Picnic/meal**	1750.2	1426.3	944.1	Reject Picnic/meal
Importance of natural quiet Adults only Never air tour **Talk**	1744.1	1430.6	942.8	Accept Talk
Importance of calm/peace Adults only NeverAir Tour **Talk**	1749.2	1424.5	937.7	Accept Talk
Importance of natural quiet Adults only Never air tour Talk **View wildlife**	1745.5	1430.9	944.4	Reject View wildlife

Test Variables	**AIC SorMore**	**AIC MorMore**	**AIC VorMore**	**Result**
Importance of calm/peace Adults only Never air tour Talk **View wildlife**	1750.6	1424.9	939.3	Reject View wildlife
Importance of natural quiet Adults only Never air tour Talk **lg10.Duration visit**	1746	1432.5	944.6	Reject lg10Duration visit
Importance of calm/peace Adults only NeverAir TourTalk **lg10.Duration visit**	1751.2	1426.4	939.6	Reject lg10Duration visit

5.2 Final Model Summary

Table 15 summarizes the dose and mediator variables included in the final (according to the criteria outlined above) dose-response models for the *Annoy* and *Interfere* responses. The regression model predicts the probability that a visitor experiences annoyance from given levels of aircraft noise according to the following equation:

$$\begin{aligned} z = {} & C_0 + C_1(L_{AE}) + C_2(\%TAud) + C_3(P_{EnHelos}) + C_4(P_{EnProps}) + C_5(S_{HR1}) \\ & + C_6(S_{HR2}) + C_7(M_{ImpCP}) + C_8(M_{SiteVisitBefore}) + C_9(M_{AdultsOnly}) \\ & + C_{10}(M_{AirTour}) + C_{11}(M_{WatchBirds}) \end{aligned}$$

$$R = \frac{1}{1+e^{-z}}$$

Where S_{HR1} or S_{HR2} are equal to 1 if the given survey instrument was received and equal to 0 if a different survey instrument was received. Survey-based mediator variables M_i are equal to 1 for Yes responses (as defined above) and equal to 0 for No responses. L_{AE}, %TAud, $P_{EnHelos}$, and $P_{EnProps}$ are calculated according to:

L_{AE} = 10 * log10 ($\Sigma 10^{(LAeq,1s/10)}$),

%TAud = 100 * (Duration of aircraft sounds (T_{AC}) / Duration of visit (T_{resp})),

$P_{EnHelos} = 100 * \left(10^{L_{AE}Helos/10}/10^{L_{AE}/10}\right)$,

$P_{en,Props} = 100 * \left(10^{L_{AE}Props/10}/10^{L_{AE}/10}\right)$.

The equation for the probability that a visitor experiences interference with natural quiet is similar, but includes a *Talk* mediator and does not include the *Survey* (S) variables, or the *SiteVisitBefore* and *WatchBirds* (M) mediators. Table 17 through Table 22 summarize the values of the regression coefficients, their standard uncertainties and p-values for each model.

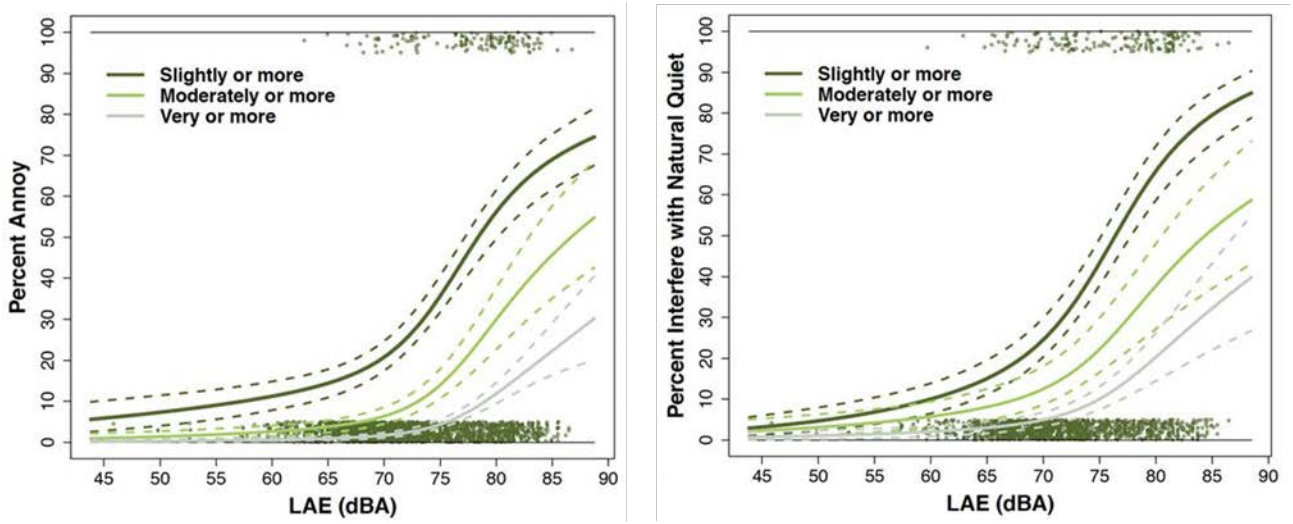


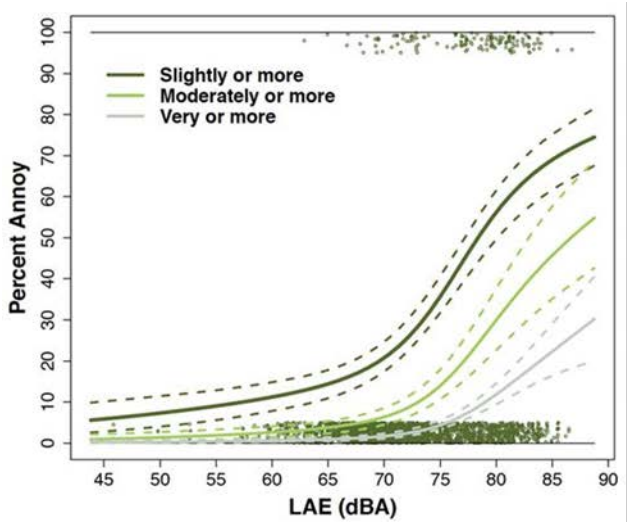
Figure 16 depicts a representative set of dose-response curves summarizing the relationships between increases in noise exposure and visitor response for the dose variable L_{AE} for both the *Annoy* and *Interfere* responses. In these plots, the L_{AE} dose variable is explicitly visualized, while the effects of the %TAud, $P_{EnHelos}$, and $P_{EnProps}$ doses on visitor response are represented using a function* relating each to $L_{AE.}$ Thus, the shapes of the does-response curves are adjusted to include the effects of additional dose variables on visitor response through their relationships with the primary dose variable. The three individual curves (solid lines) in the plots represent each of the three dichotomizations of visitor response (SorMore, MorMore, and VorMore); dashed lines represent the 95% confidence intervals. Values of the survey-based mediator variables were held constant at the average values for the 2011 day-hike survey data (Table 16). The data points (green dots) are jittered to aid in visualization and represent the SorMore dichotomization.

Table 15. Summary of dose and mediator variables included in the identified best-fit backcountry day-hike models of *Annoy* and *Interfere*

Variable	Notation	Definition	Annoy Model	Interfere Model
Visitor dose	L_{AE}	Aircraft sound exposure level	X	X
Percent time audible	%TAud	Percentage of time aircraft are audible during visit	X	X

* %TAud is represented with a linear function, while the percent aircraft energy variables (e.g., $P_{EnHelos}$, $P_{EnProps}$) are represented with a logistic function. The logistic function was chosen to constrain the percent aircraft energy to values between 0 and 100. These functions are only utilized for visualizing the dose-response relationships, and do not affect the regression coefficients of the models.

Variable	Notation	Definition	Annoy Model	Interfere Model
Percentage dose energy from helicopters	$P_{EnHelos}$	Percentage of the sound energy contributed by helicopters	X	X
Percentage dose energy from propeller aircraft	$P_{enProps}$	Percentage of the sound energy contributed by propeller aircraft	X	X
Survey	HR1, HR2	Survey instrument received	X	
Importance of calm / peace / tranquility	Importance of calm/peace	Respondent rated experience of calmness, peace or tranquility very or extremely important	X	X
Visited site before	Visited site before	Respondent visited the site before	X	
Adults only	Adults only	Respondent in adult-only group	X	X
Taken an air tour	Air Tour	Respondent has taken an air tour	X	X
Watch birds	Watch birds	Respondent has participated in bird watching during visit	X	
Talk / presentation	Talk	Respondent has participated in a talk or presentation during visit		X



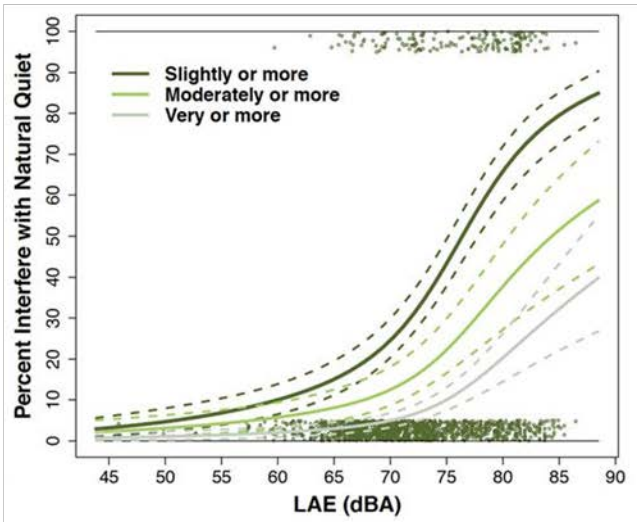


Figure 16. L_{AE} dose-response relationships for the *Annoy* and *Interfere* responses for levels of slightly or more, moderately or more and very or more ratings.

Table 16. Values of mediators for respondent population by site and overall.

	Fairyland (BRCA)	Taylor Creek (ZION)	West Rim (ZION)	Grand-view (GRCA)	Hermit (GRCA)	Sperry (GLAC)	Hidden Lake (GLAC)	Overall
Average % Time Audible	32	14	35	42	77	23	19	31
Average % Heli energy	0	0	0	6	80	86	96	31
Average % Prop energy	36	55	30	39	12	11	4	30
% Adults only	81	71	87	79	89	83	79	81
% Importance of calm, peace	86	84	89	86	87	83	84	79
% Visited site before	9	11	28	18	13	16	22	13
% Never taken air tour	88	86	87	90	89	90	91	11
%Watch birds	44	26	30	38	41	27	28	36
% Talk / presentation	3	1	2	5	6	6	6	3

Table 17. Coefficient estimates for each predictor, the associated standard uncertainty (SU) and significance (p-value) for the best model identified for the *Annoy* response, Slightly or More Dichotomization.

Predictor	Coefficient	SU	p-value
Intercept	-5.618	0.814	0.000
L_{AE}	0.043	0.012	0.000
%TAud	0.013	0.004	0.000
$P_{EnHelos}$	0.018	0.003	0.000
$P_{EnProps}$	0.006	0.002	0.009
Survey HR1	-0.067	0.121	0.579
Survey HR2	-0.851	0.129	0.000
Importance of calm/peace	0.311	0.129	0.016
Visited site before	0.485	0.144	0.001
Adults only	0.435	0.138	0.002
Never air tour	-0.070	0.163	0.667
Watch birds	0.280	0.106	0.008

Table 18. Coefficient estimates for each predictor, the associated standard uncertainty (SU) and significance (p-value) for the best model identified for the *Annoy* response, Moderately or More Dichotomization.

Predictor	Coefficient	SU	p-value
Intercept	-9.175	1.186	0.000
L_{AE}	0.077	0.017	0.000
%TAud	0.008	0.005	0.081
$P_{EnHelos}$	0.019	0.004	0.000
$P_{EnProps}$	0.013	0.004	0.000
Survey HR1	-0.230	0.153	0.133
Survey HR2	-0.713	0.163	0.000
Importance of calm/peace	0.502	0.177	0.004
Visited site before	0.450	0.173	0.009
Adults only	0.117	0.177	0.510
Never air tour	-0.820	0.258	0.002
Watch birds	0.213	0.134	0.113

Table 19. Coefficient estimates for each predictor, the associated standard uncertainty (SU) and significance (p-value) for the best model identified for the *Annoy* response, Very or More Dichotomization.

Predictor	Coefficient	SU	p-value
Intercept	-11.474	1.701	0.000
L_{AE}	0.076	0.023	0.001
%TAud	0.022	0.003	0.000
$P_{EnHelos}$	0.021	0.004	0.000
$P_{EnProps}$	0.017	0.006	0.003
Survey HR1	-0.123	0.222	0.580
Survey HR2	-0.309	0.230	0.180
Importance of calm/peace	0.688	0.284	0.015
Visited site before	0.572	0.237	0.016
Adults only	0.153	0.275	0.577
Never air tour	-0.920	0.412	0.026
Watch birds	0.279	0.191	0.143

Table 20. Coefficient estimates for each predictor, and the associated standard uncertainty (SU) and significance (p-value) for the best model that includes the *Importance of calm/peace* mediator variable for the *Interfere* response, Slightly or More Dichotomization.

Predictor	Coefficient	SU	p-value
Intercept	-7.282	0.952	0.000
L_{AE}	0.070	0.014	0.000
%TAud	0.015	0.004	0.001
$P_{EnHelos}$	0.017	0.003	0.000
$P_{EnProps}$	0.003	0.003	0.184
Importance of calm/peace	0.227	0.150	0.131
Adults only	0.358	0.157	0.023
Never air tour	-0.384	0.200	0.055
Talk	0.666	0.343	0.052

Table 21. Coefficient estimates for each predictor, and the associated standard uncertainty (SU) and significance (p-value) for the best model that includes the *Importance of calm/peace* mediator variable for the *Interfere* response, Moderately or More Dichotomization.

Predictor	Coefficient	SU	p-value
Intercept	-7.070	1.147	0.000
L_{AE}	0.057	0.016	0.000
%TAud	0.008	0.006	0.176
$P_{EnHelos}$	0.014	0.004	0.001
$P_{EnProps}$	0.002	0.003	0.549
Importance of calm/peace	0.608	0.186	0.001
Adults only	0.201	0.184	0.273
Never air tour	-0.422	0.240	0.078
Talk	0.588	0.355	0.098

Table 22. Coefficient estimates for each predictor, and the associated standard uncertainty (SU) and significance (p-value) for the best model that includes the *Importance of calm/peace* mediator variable for the *Interfere* response, Very or More Dichotomization.

Predictor	Coefficient	SU	p-value
Intercept	-8.618	1.546	0.000
L_{AE}	0.060	0.022	0.006
%TAud	0.019	0.005	0.001
$P_{EnHelos}$	0.016	0.004	0.000
$P_{EnProps}$	0.009	0.005	0.059
Importance of calm/peace	0.759	0.257	0.003
Adults only	-0.187	0.230	0.417
Never air tour	-0.755	0.353	0.032
Talk	1.091	0.396	0.006

5.3 Effect of changes in values of dose and mediator variable values

While

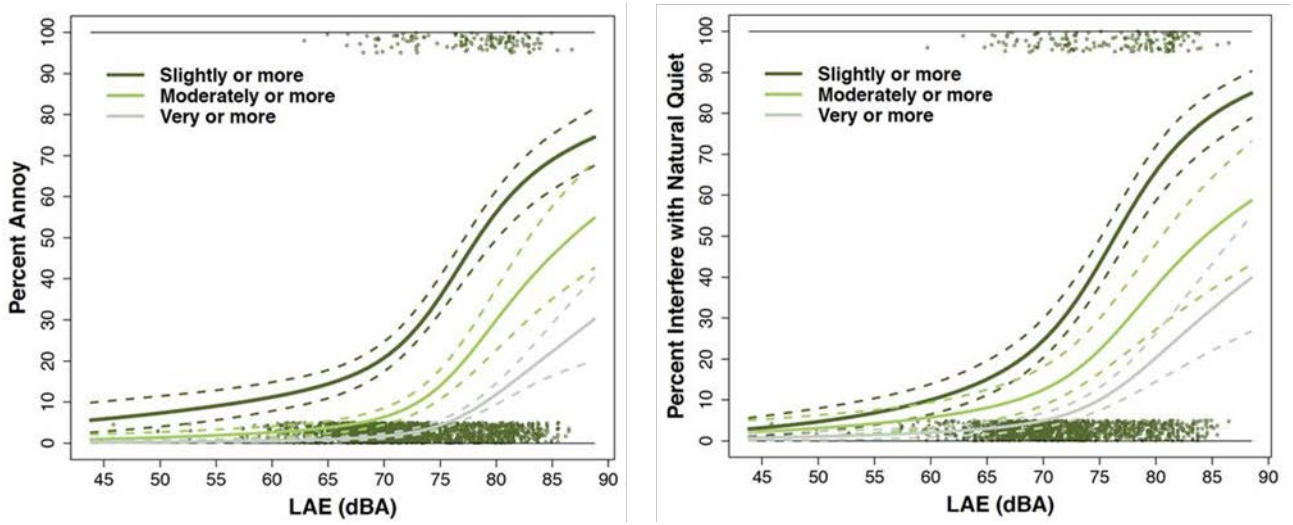


Figure 16 depicts how changes in the L_{AE} dose variable influence predicted visitor response, less obvious is how changes in the values of the additional doses and mediators influence predicted visitor response. To visualize these prediction sensitivities, the value of a single dose or mediator is varied while holding the others constant. For example, influences due to changes in the $P_{EnHelos}$ value can be quantified by varying this input value and holding the values of the remaining variables constant. This process can be repeated for any number of variations of input values. The following paragraphs provide two examples. In each example, variable values are held constant at their median values within the dataset.

Figure 17 and Figure 18 depict how a change in %TAud can influence the predicted visitor response. Figure 17 shows that an increase from 25 %TAud to 75 %TAud increases the predicted proportion of visitors at the MorMore level by 2% (i.e., the vertical offset) at an L_{AE} of 71 dB(A) (the median for the day-hike dataset). This change can alternately be expressed in terms of a horizontal (decibel-value) offset of -5 dB(A), or the decrease in L_{AE} that will result in equal proportions of visitors reporting annoyance at the MorMore level. Figure 18 shows that for the *Interfere* model at the MorMore level, an increase from 25 %TAud to 75 %TAud increases the predicted proportion of visitors experiencing interference with natural quiet by approximately 5%. Correspondingly, a decrease of 7 dB(A) L_{AE} would result in equal proportions of visitors reporting interference with natural quiet at the median values of the dataset.

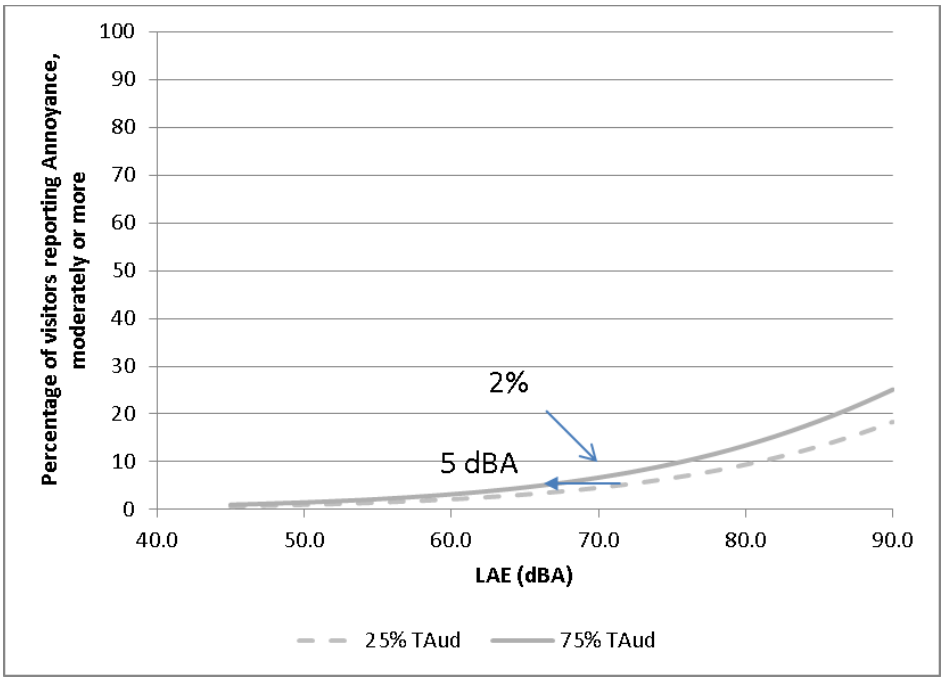


Figure 17. Variation in L_{AE} dose-response relationships caused by an increase in %TAud from 25% to 75%. Depicted for *Annoy* response at the moderately or more level.

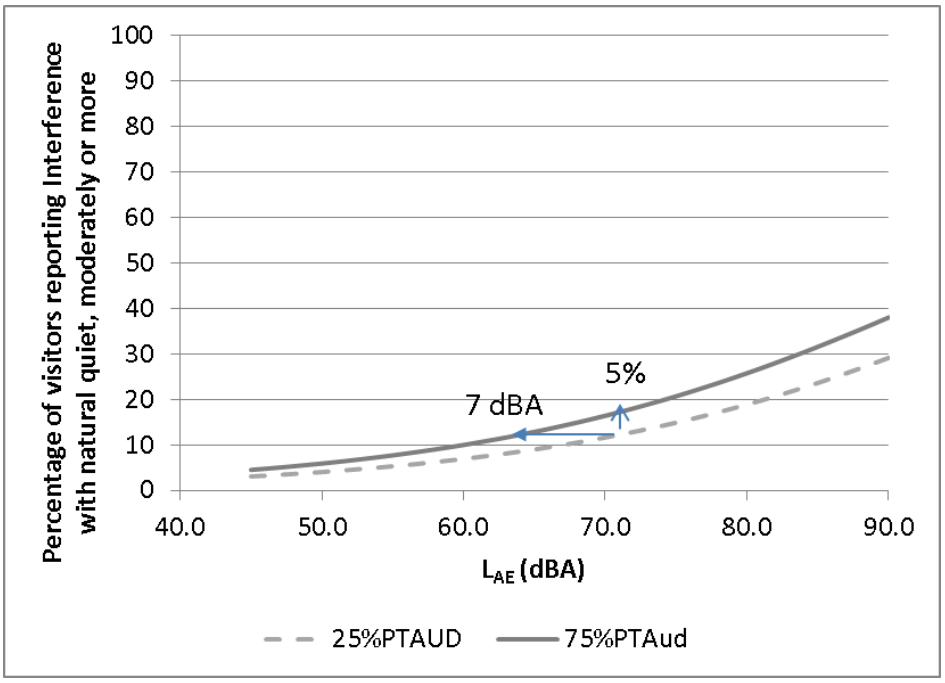


Figure 18. Variation in L_{AE} dose-response relationships caused by an increase in %TAud from 25% to 75%. Depicted for *Interfere* response at the moderately or more level.

Figure 19 and Figure 20 depict how a change in $P_{EnHelos}$ influences the predicted visitor response. In the example using the *Annoy* model at the MorMore level (Figure 19), an increase from 0% $P_{EnHelos}$ to 100% $P_{EnHelos}$ increases the predicted proportion of visitors experiencing *Annoyance* by 9% at an L_{AE} of 71 dB(A) (the median for the day-hike dataset). The horizontal offset for this increase in $P_{EnHelos}$ is an L_{AE} decrease of 19 dB(A). In the example using the *Interfere* model at the MorMore level (Figure 20), an increase from 0% $P_{EnHelos}$ to 100% $P_{EnHelos}$ increases the predicted proportion of visitors experiencing *Interference with natural quiet* by 18% at an L_{AE} of 71 dB(A). The horizontal offset for this increase in $P_{EnHelos}$ is an L_{AE} decrease of 24 dB(A).

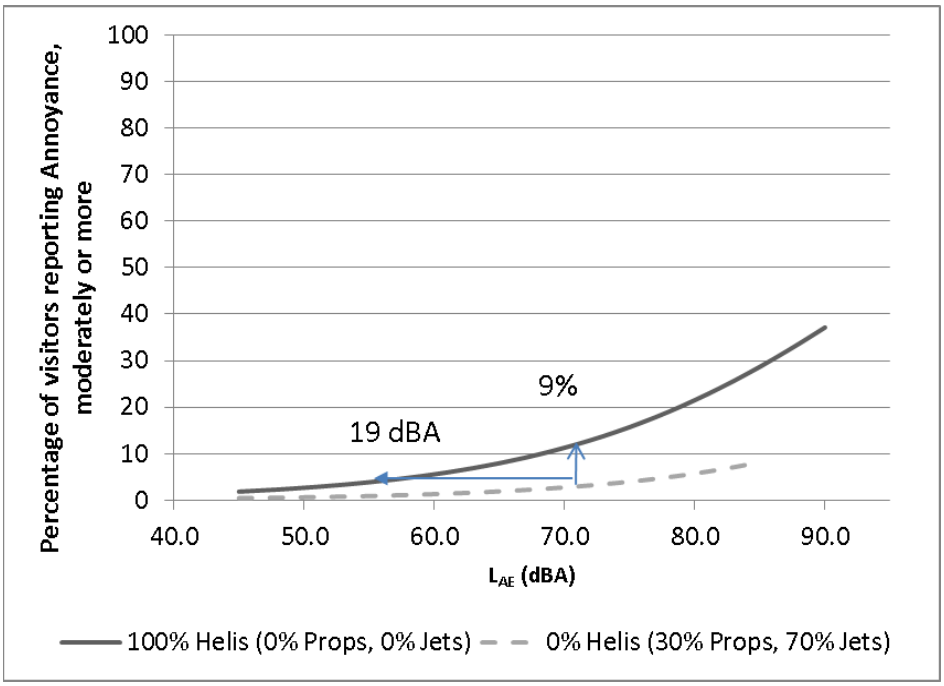


Figure 19. Variation in L_{AE} dose-response relationship caused by change in %Helicopter energy ($P_{EnHelos}$) from 0% to 100%. Depicted for *Annoy* response at the moderately or more level.

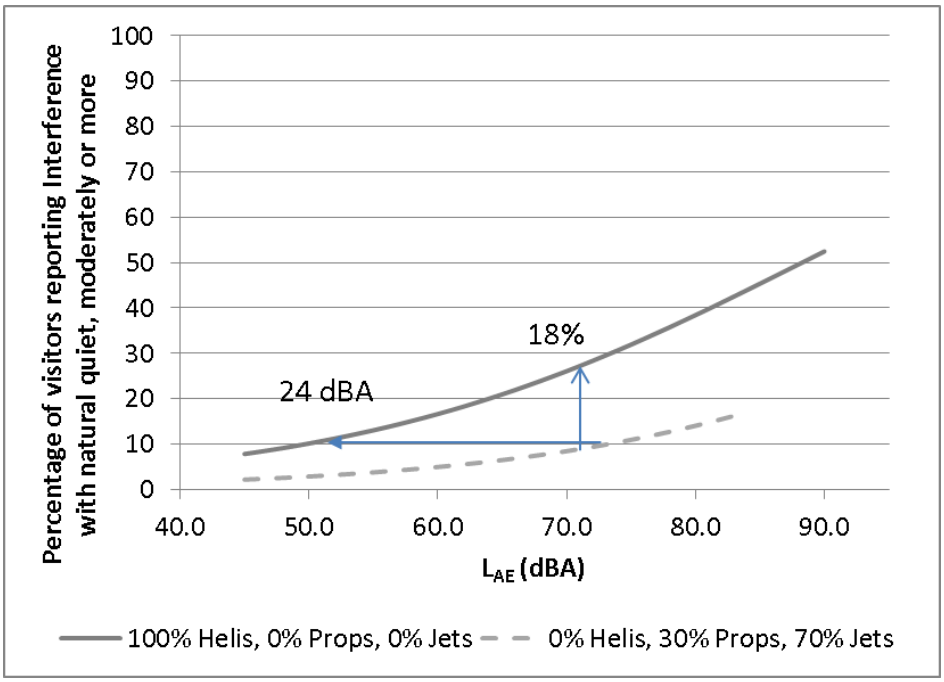


Figure 20. Variation in L_{AE} dose-response relationship caused by change in %Helicopter energy ($P_{EnHelos}$) from 0% to 100%. Depicted for *Interfere* response at the moderately or more level.

Table 23 and Table 24 summarize the sensitivities for the remaining mediator variables. Together with Table 16, these statistics help to inform which variables may be most important

for predictions of visitor response to aircraft noise. For example, knowledge of the proportion of noise exposure due to helicopters is important, as this variable can vary widely between sites and changes in this variable can significantly change the shape of the dose-response curve.

Table 23. *Annoy* model sensitivity in terms of vertical (%) and horizontal (dB) offset due to changes in mediator values

Predictor	% Change, Slightly or More	dB Change, Slightly or More	% Change, Moderately or More	dB Change, Moderately or More	% Change, Very or More	dB Change, Very or more
%TAud: 25% to 75%	15	-15	2	-5	2	-14
$P_{EnHelos}$: 0% to 100%	36	-41	9	-25	2	-28
$P_{EnProps}$: 0% to 100%	10	-14	5	-17	2	-22
Importance of calm/peace: No to Yes	5	-7	2	-7	1	-9
Visited site before: No to Yes	11	-11	2	-6	1	-8
Adults only: No to Yes	8	-10	1	-2	0	-2
Never air tour: No to Yes	-2	2	-6	11	-2	12
Watch Birds: No to Yes	7	-7	1	-3	0	-4

Table 24. *Interfere* model sensitivity in terms of vertical (%) and horizontal (dB) offset due to changes in mediator values

Predictor	% Change, Slightly or More	dB Change, Slightly or More	% Change, Moderately or More	dB Change, Moderately or More	% Change, Very or More	dB Change, Very or more
%TAud: 25% to 75%	15	-11	5	-7	6	-16
$P_{EnHelos}$: 0% to 100%	37	-24	23	-23	11	-22
$P_{EnProps}$: 0% to 100%	6	-5	2	4	5	-15
Importance of calm/peace: No to Yes	7	-7	5	-10	2	-13
Adults only: No to Yes	5	-5	2	-4	1	-3
Never air tour: No to Yes	-6	5	-4	7	-2	12
Talk: No to Yes	7	-10	8	-10	8	-18

6.0 COMPARISON BETWEEN SITE-TYPES

This section contains an analysis of the dose-response data to compare and contrast the relationships for visitors at multiple site-types. Specifically, data and relationships for visitors engaged in day-hikes were compared to both the 1990s frontcountry data and relationships and the backcountry overnight visitor data. In Section 0 the dose-response model form used for frontcountry sites was applied to the backcountry day-hike data for comparative purposes. In Section 6.2 the day-hike data are compared to the data from backcountry overnight visitors.
Frontcountry/Backcountry Comparison

To compare visitor populations between frontcountry and backcountry sites, Table 25 summarizes the average mediator values for backcountry day-hikes, and frontcountry short-hikes and overlooks. Visitors to day-hike sites were more likely to state that natural quiet was very or more important compared to visitors to short-hike/overlook sites. In addition, visitors to day-hike sites were most likely to be in adult-only groups. Similar percentages of visitors reported visiting the site previously for all site types.

Table 25. Frontcountry (overlook/short-hike) and backcountry (day-hike) visitor population characteristics

	Overlook	Short-hike	Day-hike
Natural quiet important (very or extremely)	65%	67%	87%
Previously Visited Site	13%	14%	14%
Adults Only in group	65%	75%	81%

For comparative purposes, a regression was fit to the frontcountry data using the dose combination of $L_{AE,}$ %TAud, $P_{EnHelos}$ and $P_{EnProps}$ as identified for the backcountry data. Figure 21 depicts the resulting backcountry and frontcountry dose-response relationships (solid lines) and 95% confidence intervals (dotted lines) for the A-weighted sound exposure level dose and A*nnoy* response, using the moderately or more dichotomization and HR1 survey-type (as this survey was used within the frontcountry research). The backcountry relationship has been extrapolated for this comparison; areas where no data are available are greyed-out. Intuitively, one might expect that a greater percentage of backcountry respondents would report annoyance due to lower ambient sound, levels, longer duration of exposure, and further immersion in the natural soundscape. Note however, that these differences have, to some extent, been incorporated in the dose-response relationships through the 'importance of natural quiet' mediator and percent time audible dose (exposure duration and ambient sound levels are both factors in this metric).

The models yield similar predictions in the region between 70 and 80 dBA, where the majority of day-hike data are centered and predictions most accurate. At sound exposures below 70 dBA, a greater percentage of *frontcountry* short-hike respondents are predicted to report annoyance. The confidence intervals surrounding the day-hike and short-hike relationships overlap through the majority of the data range, and neither relationship is based on significant amounts of data at sound exposures below 50 and above 85 dBA. Therefore, it is likely that these behaviors are an artifact of data limitations and predictions outside the available data range should be used with caution. Analysis of a combined frontcountry and backcountry dataset could produce a single model and yield further insights.

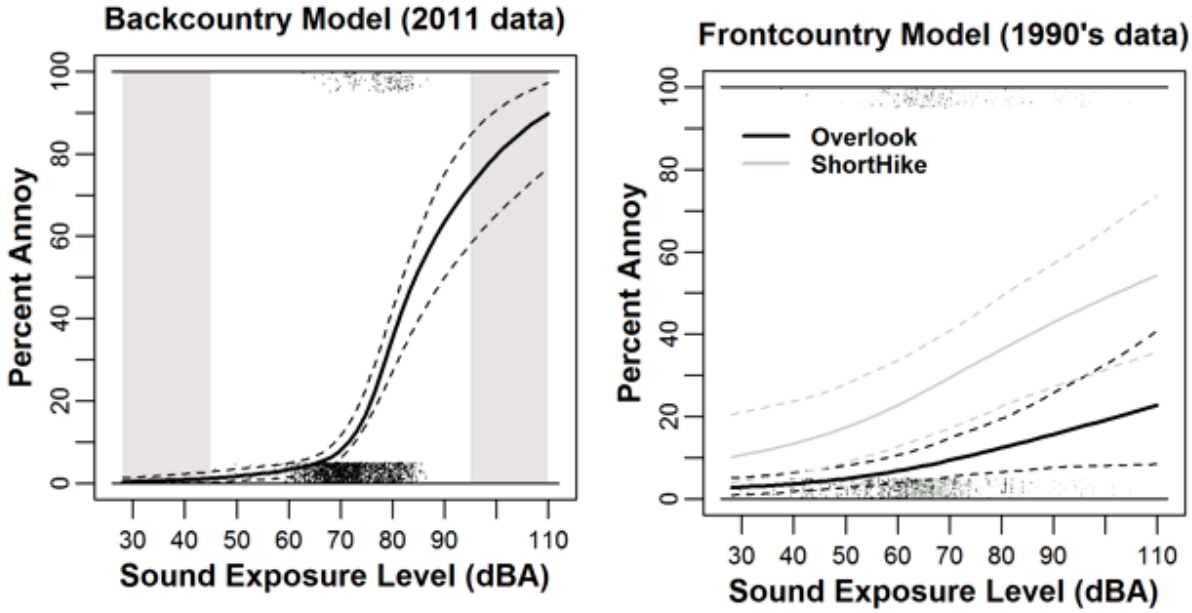


Figure 21. Day-hike, short-hike, and overlook dose-response curves for the *Annoy* at the Moderately or more level. For plotting purposes, the mediator variables were held constant.

6.1.1 Comparing frontcountry and backcountry model forms

The best-fit backcountry model differs from that identified for the frontcountry, most notably in the noise exposure metrics. There is, however, some similarity in the dose metrics included in these models. The dose combination of L_{AE} and %TAud (backcountry model) is derived from components of sound exposure level (L_{AE}), duration of aircraft sounds, and visit duration. The $L_{AeqTresp}$ dose (frontcountry model) is derived from components of sound exposure level ($L_{AE)}$ and visit duration; missing is the duration of aircraft sounds. This indicates that factors of the total noise exposure and the duration of the visit were important in both site types, while the

relative duration of the aircraft exposure exhibited more significance in the backcountry dataset than the frontcountry dataset, possibly due to the longer total visit durations.

6.2 Comparison of day-hike and overnight data

This section details an analysis conducted using the backcountry data collected in the 2011 research effort to determine if visitors on overnight (multi-day) hikes exhibited a different sensitivity to aircraft noise exposure than visitors on day-hikes. The overnight data consist of 287 respondents with complete dose and response data. Four sites at three National Parks are represented in this dataset: Hermit and Grandview Trails at Grand Canyon, West Rim Trail at Zion, and Sperry Trail at Glacier. Roughly half of the overnight surveys were collected at Sperry Trail. The analyses presented herein can provides an initial look at the differences between backcountry visit types (i.e., day-hike compared to overnight visits).

A number of the visitor population factors were examined to evaluate differences in expectations and visitor characteristics. Table 26 shows that a larger percentage of overnight visitors exhibit characteristics that have been shown in previous model-fitting exercises to increase sensitivity to aircraft noise. Approximately six percent more overnight visitors had previously visited the site and were in adult-only groups compared to day-hike visitors. Three percent more stated that natural quiet was very or more important and participated in either bird watching or interpretive talks. It is expected that these differences in visitor characteristics will contribute to an increase in the sensitivity of the overnight visitor population response to aircraft noise as compared to day-hike visitors.

Table 26. Day-hike and overnight-hike visitor characteristics

Factor	Day Hike	Overnight
Calmness, peace tranquility important (very or extremely)	86%	88%
Natural quiet important (very or extremely)	87%	90%
Previously Visited Site	14%	20%
Adults Only in group	81%	87%
Watch Birds	36%	39%
Talk	4%	7%
Never Air Tour	88%	88%

As expected, the amount of time spent in the backcountry environment is disparate between the two groups. Table 27 summarizes the distribution of visit duration at each trail for each visit-

type. Overnight hikes averaged one to two nights at West Rim and Sperry trail; three nights at Hermit and Grandview Trails, while day-hikes averaged three to four hours.

Table 27. Visit duration statistics for day- and overnight-hikes

Site	Site Type	Average Duration	Minimum Duration	Maximum Duration	Standard Deviation
Hermit	Overnight	60.0 hours	24.0 hours	105.0 hours	24.6 hours
Grandview	Overnight	56.0 hours	20.4 hours	100.7 hours	20.3 hours
West Rim	Overnight	29.1 hours	15.7 hours	75.0 hours	14.5 hours
Sperry	Overnight	41.7 hours	16.0 hours	101.5 hours	16.4 hours
Hermit	Day-Hike	3.8 hours	1 hour	9.2 hours	1.7 hours
Grandview	Day-Hike	4.3 hours	1 hour	8.8 hours	1.8 hours
Fairyland	Day-Hike	2.5 hours	1 hour	9.2 hours	0.8 hours
West Rim	Day-Hike	3.7 hours	1 hour	8.2 hours	1.8 hours
Taylor Creek	Day-Hike	3.1 hours	1 hour	5.8 hours	0.9 hours
Sperry	Day-Hike	3.8 hours	1 hour	8.4 hours	1.5 hours

Figure 22 presents histograms of the distribution of respondents' aircraft noise exposure for comparisons between day- and overnight-visitors. Compared to day-hike visitors, overnight visitors experienced a higher average total sound exposure level due to aircraft over the visit duration (Figure 22a), but a similar equivalent sound level normalized to the visit duration (**Error! Reference source not found.**b) or normalized to the aircraft overflight duration (Figure 22c). In addition, overnight visitors experienced a higher average maximum sound level (Figure 22d), but aircraft were audible a lower percentage of time over the visit duration (Figure 22e). The range of natural ambient L_{50} experienced by both visitor types was similar (Figure 22f). The range of nearly all the dose metrics (with the exception of natural ambient noise) was much narrower for overnight compared to day-hike visitors. This is expected, as variability in exposure is related to exposure duration: the longer the exposure, the less variation there will be between individuals. Daily patterns in aircraft activity tend to remain consistent, while temporal variations in daily activity will result in greater exposure variability for shorter visits; for example, more aircraft may fly during the morning than afternoon. The limited range of average dose and number of samples in the dataset requires caution when interpreting the dose-response relationships for overnight visitors.

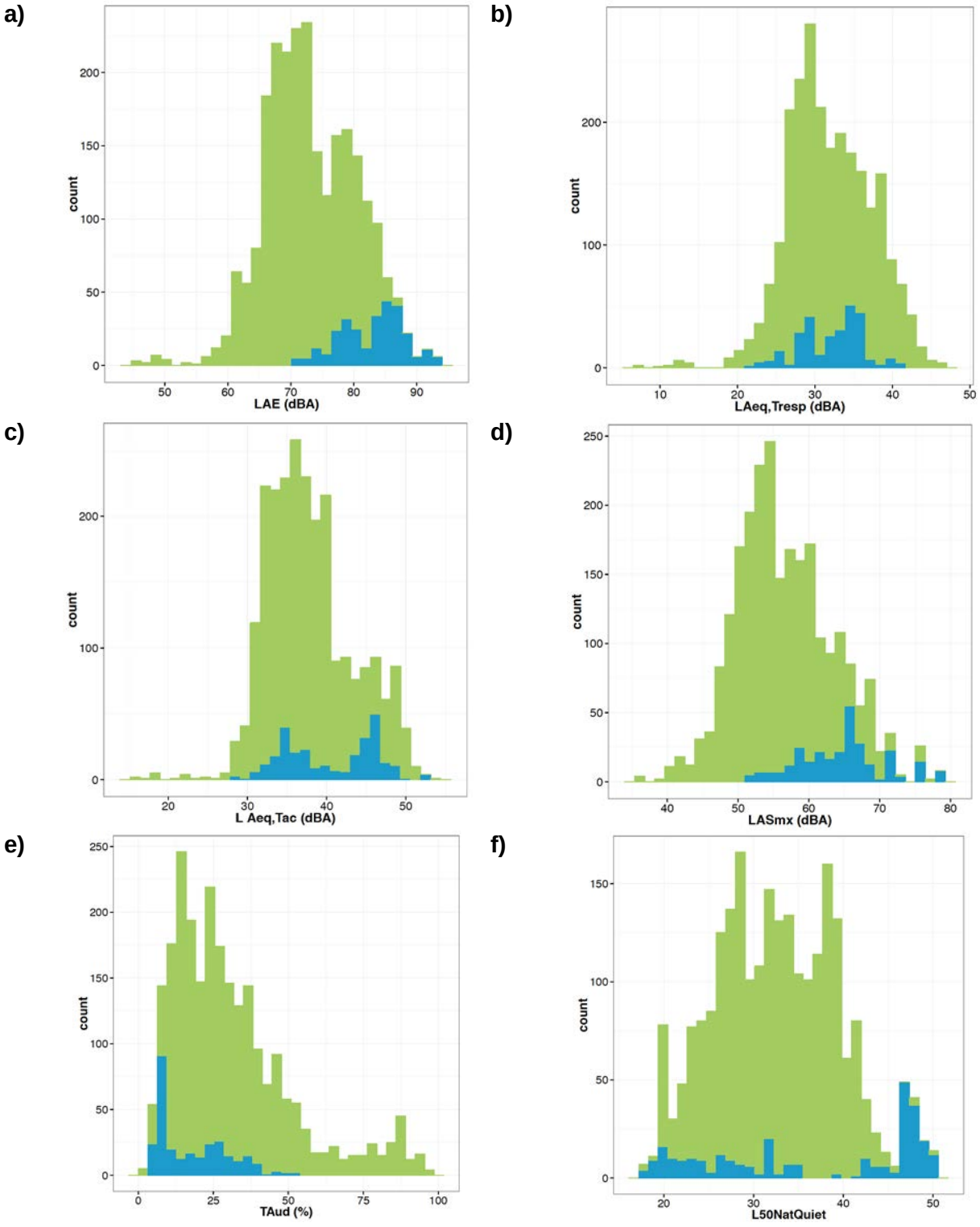


Figure 22. Histograms illustrating the distribution of aircraft dose experienced by day-hike (green) and overnight (blue) visitors over the visit duration: a) Sound exposure level (L_{AE}), b) Equivalent sound level, normalized to the visit duration ($L_{Aeq,Tresp}$), c) Equivalent sound level normalized to the aircraft overflight duration ($L_{Aeq,TAC}$) d) Maximum sound level (L_{Asmx}), e) Percent time aircraft are audible (%TAud), and f) Natural Ambient (L_{50}).

To explore differences in response between day and overnight visitors outside of a regression analysis, average visitor responses were binned and plotted against the L_{AE} and %TAud noise exposure doses. Figure 23 and Figure 24 present plots of the *Annoy* response at the moderately or more level, showing that overnight visitors surveyed responded similarly to day-hike visitors at equal values of L_{AE}, but were more sensitive at equal values of %TAud over the range measured. This trend is similar for the *Interfere* response and at the other response levels.

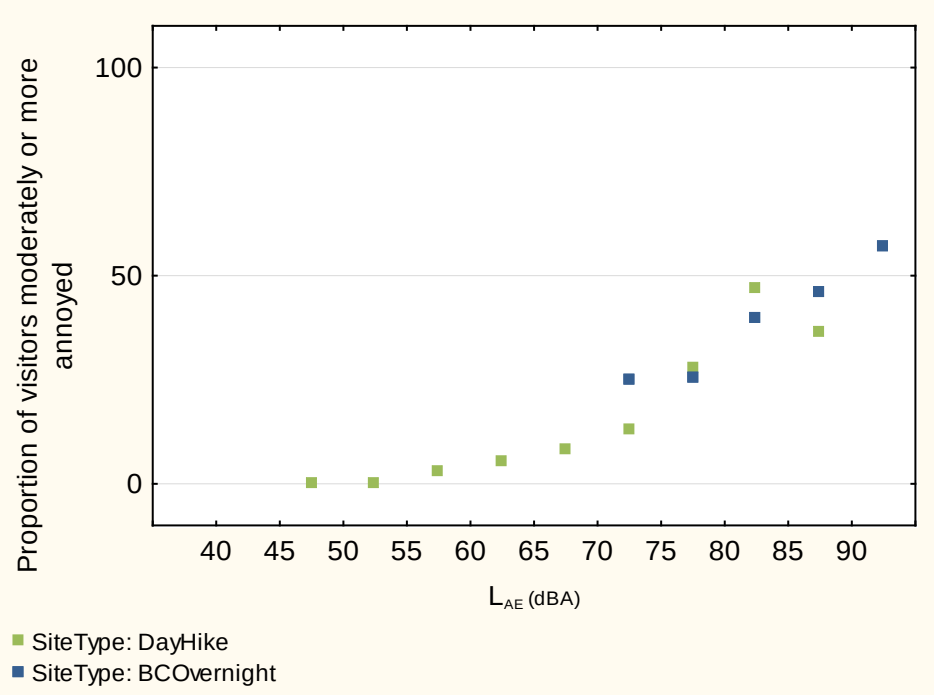


Figure 23. Proportion of visitors to day-hike (green) and overnight (blue) site types who were "moderately or more" annoyed as L_{AE} increases. The x-axis values represent the midpoints of five dBA bins.

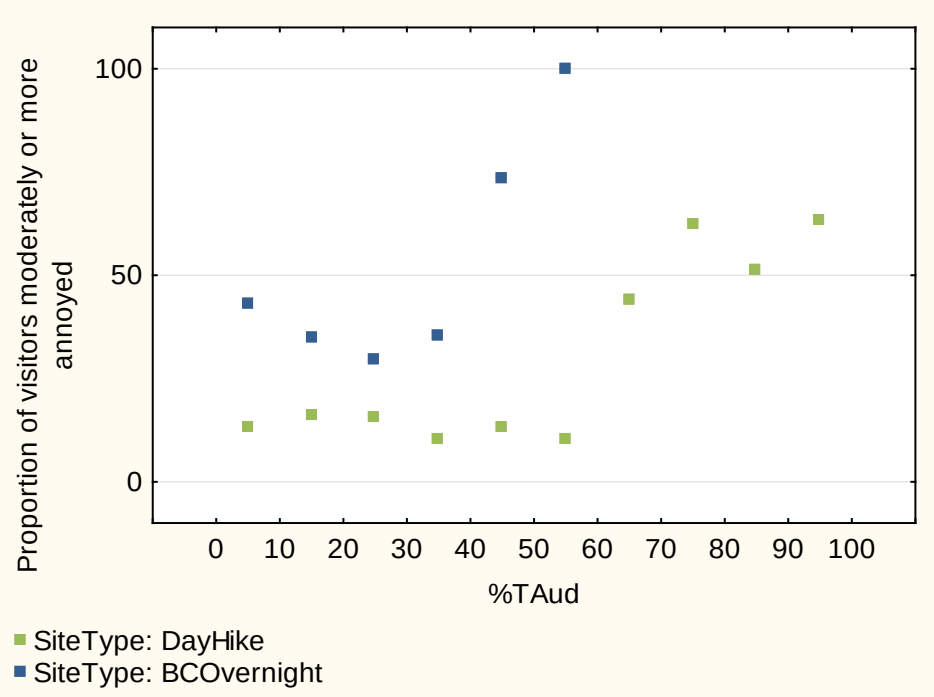


Figure 24. Proportion of visitors to day-hike (green) and overnight (blue) site types who were "moderately or more" annoyed as %TAud increases. The x-axis values represent the midpoints of 10-percent bins.

Due to the limited range of respondent noise exposure, a 'stand-alone' dose-response relationship for overnight visitors may not be viable for the available overnight dataset. However, a site-type 'offset' within the backcountry model may be included to account for the difference in sensitivity between overnight and day-hike visitors. The resulting dose-response relationship for overnight visitors would assume a slope and shape similar to the day-hike model.

To this end, the best-fit regression model form identified in Section 5 was fitted to the combined day-hike and overnight survey dataset with a 'site-type' predictor variable included in the model. The model including overnight visitors had a positive and significant site-type coefficient, indicating that overnight visitors were more sensitive. In other words, a larger percentage of overnight visitors were affected by aircraft noise than day-hike visitors at equal doses Overall, the resulting models were similar to models fitted to the day-hike only data. Due to the nature of hierarchical models, where coefficients are estimated through partial to complete pooling of data in different groups, the dose-response model for overnight visitors (287 surveys included) was influenced by the day-hike visitor data (1672 surveys included).

Figure 25 depicts a representative set of dose-response curves summarizing the relationships between increases in noise exposure and visitor response for the dose variable L_{AE} for both the day hike and overnight dataset for the *Annoy* response. In these plots, the L_{AE} dose variable is explicitly visualized, while the effects of the %TAud, $P_{EnHelos}$, and $P_{EnProps}$ doses on visitor response are represented using a function* relating each to $L_{AE.}$ Thus, the shapes of the does-response curves are adjusted to include the effects of additional dose variables on visitor response through their relationships with the primary dose variable. The individual curves (solid lines) in the plots represent the site type (day hike or overnight); dashed lines represent the 95% confidence intervals. Values of the survey-based mediator variables were held constant at the average values for the 2011 day-hike survey data (Table 16). The data points (green and gray dots) are jittered to aid in visualization and represent the SorMore dichotomization.

* %TAud is represented with a linear function, while the percent aircraft energy variables (e.g., $P_{EnHelos}$, $P_{EnProps}$) are represented with a logistic function. The logistic function was chosen to constrain the percent aircraft energy to values between 0 and 100. These functions are only utilized for visualizing the dose-response relationships, and do not affect the regression coefficients of the models.

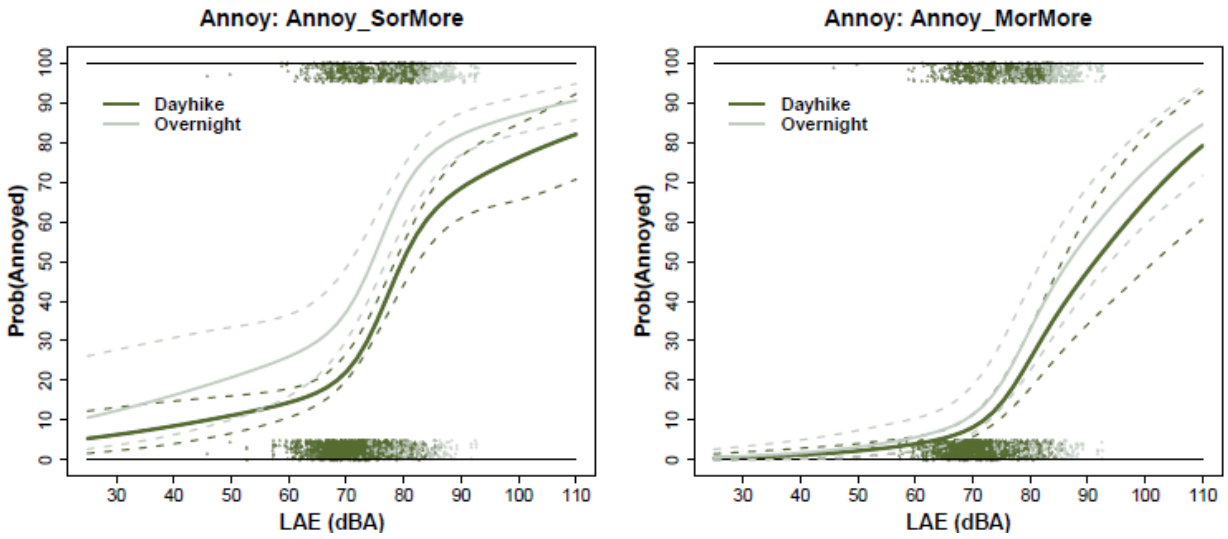


Figure 25. L_{AE} dose-response relationships for day hike (dark green) and overnight (light gray) visitors for the *Annoy* response for levels of slightly or more and moderately or more ratings.

In this figure, the site-type offset (difference between day-hike and overnight) is most pronounced for the slightly or more dichotomization, where the confidence intervals do not overlap throughout the range where the majority of the data points lie. The site-type offset is less pronounced for the moderately or more dichotomization, where the confidence intervals overlap throughout the range depicted.

Further analyses of the overnight dataset should include a model-fitting exercise to explore the full range of dose metrics (and potential mediating variables) evaluated during the day-hike analysis, reassessed with the combined dataset. It is plausible that there is an alternate dose or combination of dose descriptors that is most appropriate for this combined dataset with overnight visitors. This analysis should have a particular emphasis on validity and use of the site type coefficient (or offset) as described above. As a last step, the need for additional surveys and data collection for overnight visitors should be reassessed. A larger data set will reduce uncertainty, leading to a more precise estimate of the site-type offset, but may not ultimately be required. In addition, obtaining data to widen the range of available doses may present challenges, due to the tendency for respondent exposures at a single site to have limited variability.

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7.0 AUDIO CLIP SURVEY ANALYSIS

As part of the overall design of the dose-response research program, audio clips were used to collect information on park visitor response to aircraft overflights. This research method could be advantageous, as audio clips can provide a wider range of controlled sounds and sound levels than may be experienced in a typical visit or at a particular location. The goal of this analysis is to determine whether the audio clip evaluations are comparable to *in situ* evaluations of aircraft overflights. There are characteristics of an audio clip study that might result in differences in ratings as compared with ratings based on *in situ* aircraft noise exposure. These differences, and the challenges they present to data comparison, are discussed in Section 7.3.

The impact of various types of intrusions (such as aircraft overflights) on visitor experiences in outdoor areas have been studied using similar methods, both *in situ* and in laboratory-type settings. In these studies, subjects have been asked to evaluate 1) crowding, by means of pictures of sites that vary in the extent of visitor density[xxi,xxii] 2) landscape quality, by means of pictures and sounds with and without the presence of helicopter overflights,[11] and 3) noise, by means of audio clips that overlay natural sounds with various degrees of audio intrusions. Types of audio intrusions studied include aircraft [8,9xxiii] and visitor caused noise (voices).[10]

7.1 Study Design

As discussed in Vol. 1 Section 2.2, each respondent was asked to evaluate five of 49 available aircraft overflight clips. Clips were chosen by computer software using a partially randomized design that minimized any bias due to aircraft, aircraft type, selection of clips, or order in which the clips were played. The clips for each respondent were drawn from the pool which was divided into three sound level bins: Low ($L_{AE} \leq 50$ dBA), medium ($50 < L_{AE} \leq 65$ dBA), and high ($L_{AE} > 65$ dBA. A sampling algorithm in the survey instrument software ensured that each respondent heard a low, a medium, and a high audio clip, in random order, for the first three clips, each clip randomly selected from the pool within each bin. For clips four and five, two of the three bins of sounds clips (i.e., low, medium, and high) were first randomly selected, and then one clip was randomly drawn from each of the two pools. This logic was implemented to minimize respondent frustration. Pretests of this survey found that respondents receiving only low-level clips to evaluate became frustrated, as the aircraft sounds can be barely perceptible and did not provide a strong basis for ratings.

Respondents were asked to rate each of the five audio clips on two dimensions, annoyance and acceptability, using nine-point response scales identical to those in the HR2 survey instrument:

How acceptable or unacceptable would the aircraft sounds in Recording #<recording number> have been if you had heard them during your visit to <site>?

How pleased or annoyed would you have been by the aircraft sounds in Recording #<recording number> if you had heard them during this visit to <site>?

7.2 Exploratory Analyses

Initial analyses examined a number of factors that may have influenced visitor ratings. These factors include:

- Clip order
- Heard aircraft during visit
- Site and site-type
- Aircraft type
- Importance of natural quiet
- Site first visit
- Presence of children in the individual's group

Many of these factors had significant effect on responses within the *in situ* dose-response framework. Clip order and if the visitor heard aircraft during their visit (other than those presented in the audio clips) are important factors to explore within the audio clips research.

For these analyses, responses were coded numerically on a scale from one to nine, where one was "extremely acceptable / pleasing," five was "neutral," and nine was "extremely unacceptable / annoying." Responses were then averaged and plotted as a function of the sound level for each clip. In each case, a polynomial trend line was fitted to each factor category to assist with visual evaluation. The analyses were performed for each of the two response variables: annoyance and acceptability. Within the current dataset, each clip was rated by an average of 143 respondents.

Clip order: The audio clip survey design randomized playback order; which sought to minimize influences on visitor ratings due to selection of clips or playback order. To investigate any effect due to clip order, ratings of pleasing / annoying and acceptability were averaged by clip number, where clip 1 is the first clip heard by the respondent, clip 2 is the second clip heard, etc. The average ratings were plotted as a function of the aircraft sound exposure level (L_{AE})* during the clip (see Figure 26). This visualization shows if ratings become more/less severe

* The sound exposure level axis is not precisely to scale.

progressing from clip 1 to clip 5. The graphics illustrate that there was little change in the average rating between subsequent clips in the pleasing/annoying dimension. There is, however, a visible trend towards more unacceptable average ratings in the acceptability evaluations. One trend visible in most of the graphics in this section is a 'grouping' of responses corresponding to the sound level bins described in Section 8.1. This effect is shown more clearly in Figure 27, where separate graphics depict the average annoyance rating by clip number. The groupings become most pronounced in clips 4 and 5. These graphics also include a linear trend line fit to the average clip ratings. The slope of this trend line increases progressively from clip 1 through clip 4. The groupings may be indicative of a precedence effect, where clip ratings are influenced by the sound level(s) and rating chosen for previous clips. Further analysis could investigate this effect in more detail.

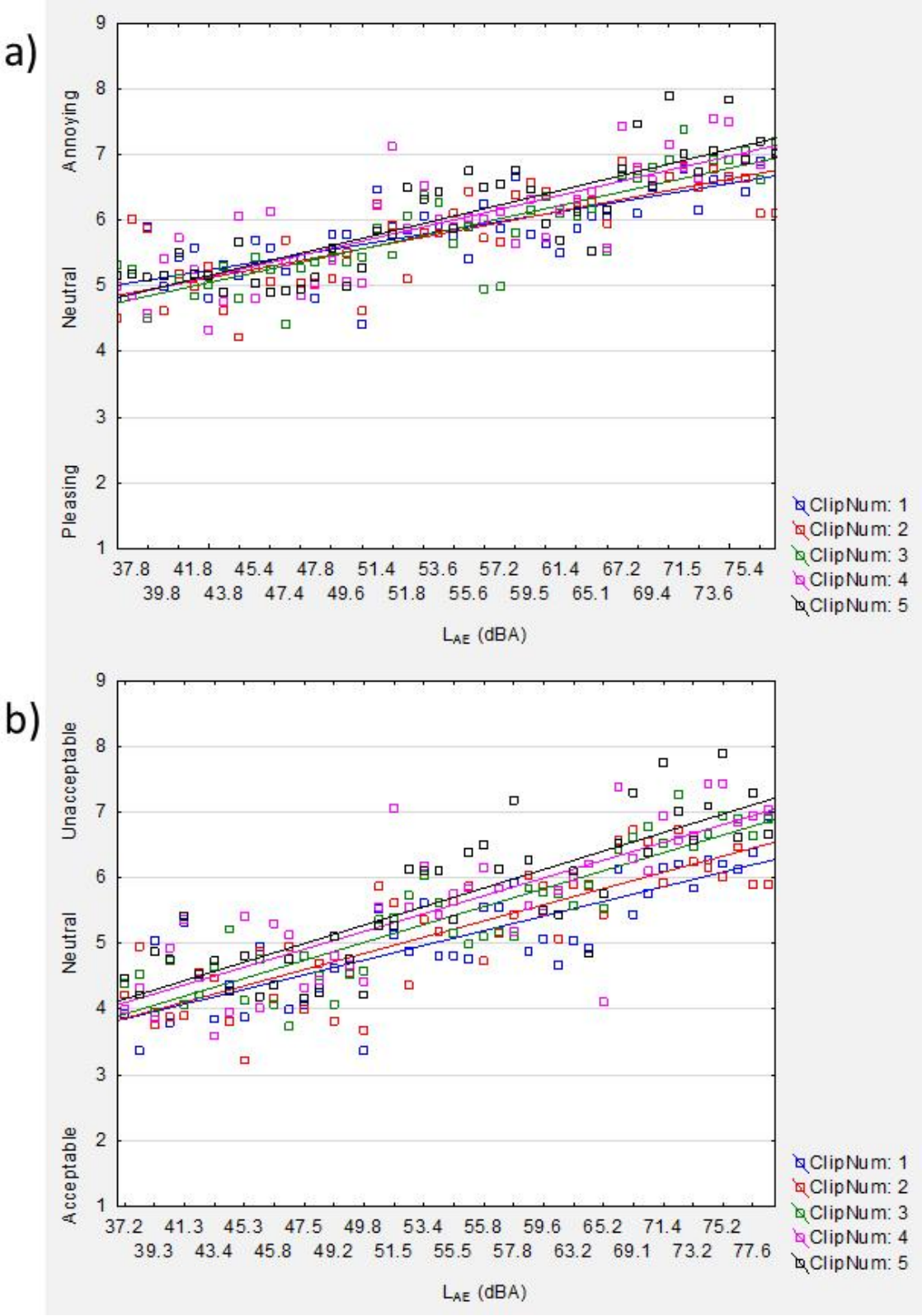


Figure 26. Average audio clip ratings by clip number for two evaluative dimensions: a) pleasing/annoying, and b) acceptable/unacceptable

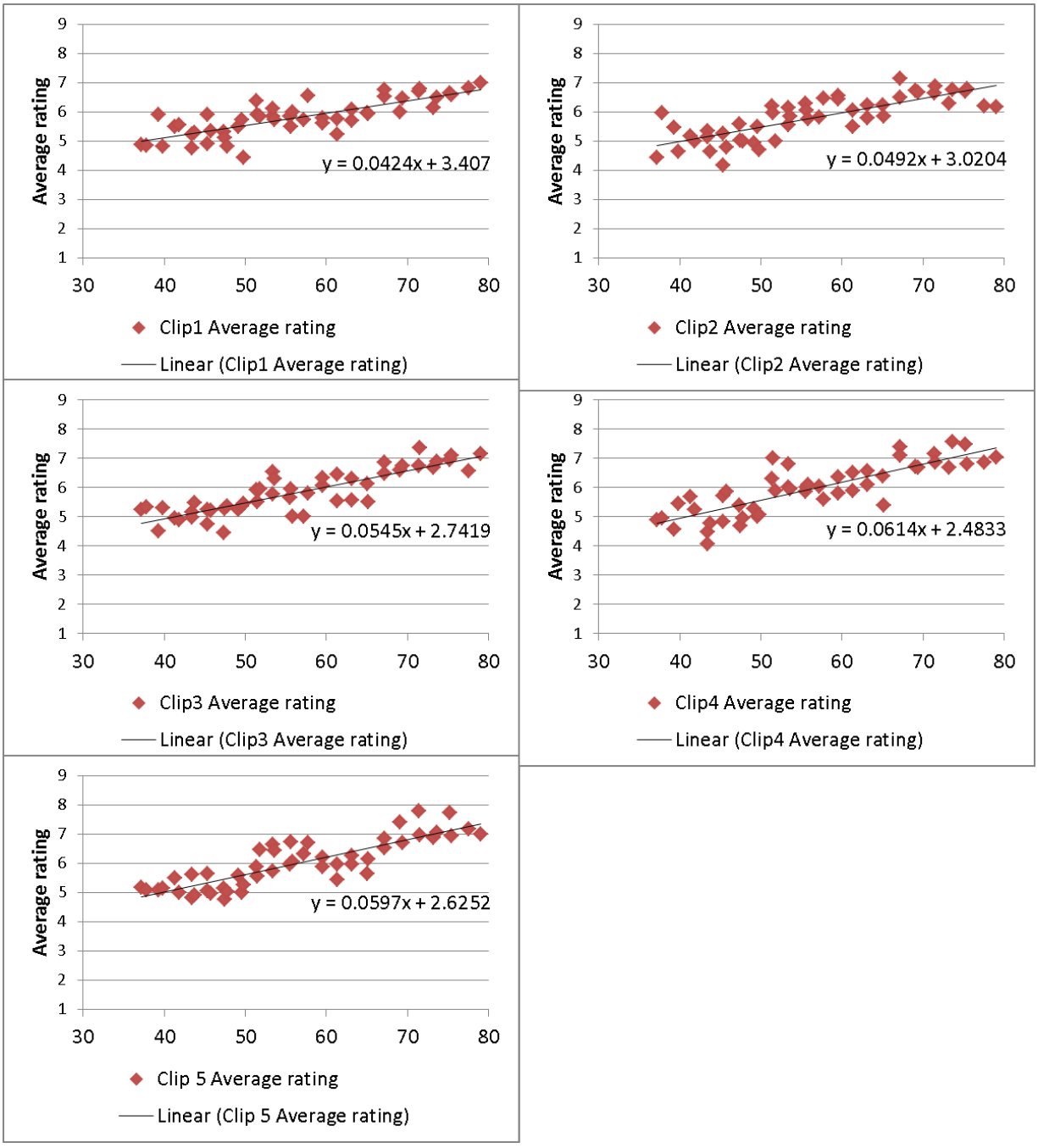


Figure 27. Average audio clip ratings separately by clip for the pleasing/annoying evaluation. The x-axis indicates the clip sound exposure level in dB(A).

Hear aircraft during visit: One of the objectives of this study was to determine if hearing aircraft during the site visit influences evaluations of audio clips, and vice versa. Figure 28 shows the average responses for each clip as a function of sound exposure level (L_{AE}), categorized by visitor reports of hearing aircraft during the site visit (yes/no). The graphics illustrate that there was little difference in visitor response to the clips between visitors who heard aircraft during the visit and those who did not.

Site and site-type: Analysis of *in situ* dose-response data has shown that visitors respond similarly at sites of the same type (such as two overlook sites), but differently based on site-type (overlook vs short hike). Figure 29 and Figure 30 show the average ratings categorized by site and site-type, respectively. The site-to-site responses show some variability (Figure 29); there is a slight tendency for respondents at sites with higher in situ exposures (Hermit and Grandview at Grand Canyon and Hidden Lake at Glacier) to rate the clips more annoying or unacceptable. Although hearing or not hearing aircraft did not influence audio clip evaluations, this suggests that the overall in situ sound exposure due to aircraft may have some influence on the evaluations.

When grouped by site-type (Figure 30) there is little difference in visitor response at similar sound levels. This is in contrast to in situ data, which show distinctions between site-types (day-hike vs overnight, short-hike vs overlook, and backcountry vs. frontcountry) that reflect visitor expectations and experiences. However, these results only represent visitor evaluations in two different backcountry settings. Further information is required to understand if the site-type differences found in the frontcountry dataset (between overlook and short hike visitors) would exist in corresponding audio clip survey data.

Aircraft type: Analysis of *in situ* data shows that visitors respond differently to the unique acoustic signatures of the different aircraft types (helicopters, propeller aircraft, and jet aircraft). Figure 31 shows the average ratings for each clip categorized by aircraft type. The graphics illustrate that, unlike *in situ* data, visitor responses differed very little by aircraft type. This may be due to the short duration of the clips (36 seconds), which does not allow for the inclusion of some of the unique characteristics of each aircraft type, such as intermittent blade slap of helicopters, nor does it convey the length (2-3 minutes) of some single overflights or time between exposure to multiple overflights

Presented next are the visitor-specific mediating factors: Importance of natural quiet, first visit to site, and presence of children in the personal group. These factors were all important within the dose-response regression framework to help explain the variability in ratings between

visitors. Figure 32 and Figure 33 presents graphics showing the average influence of these factors. These show that only the relative importance of natural quiet influenced individual responses to the audio clips. As one might expect, the external factors of the presence of children and 'first visit to site' did not influence responses to audio clips.

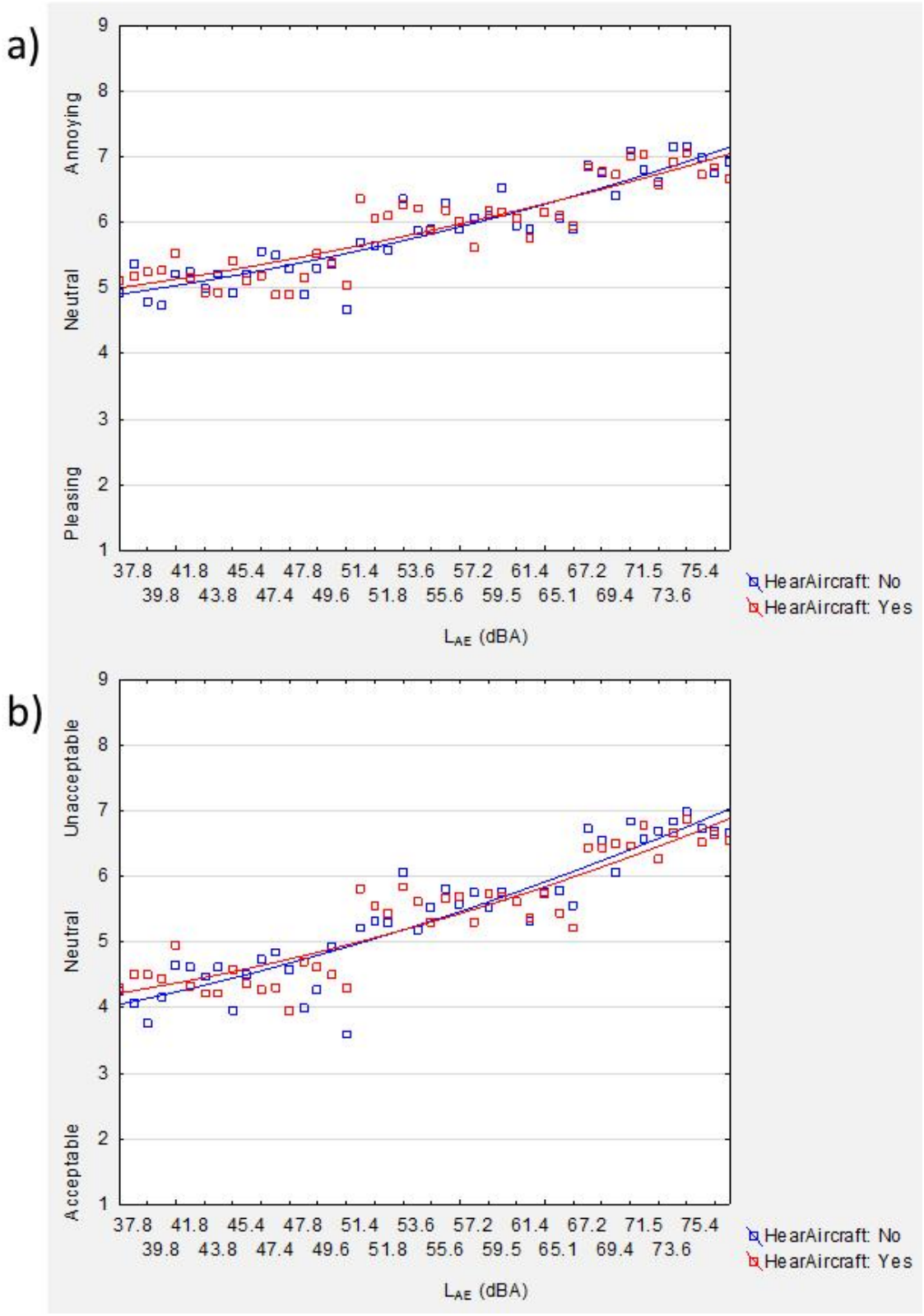


Figure 28. Average audio clip ratings grouped by whether aircraft were heard *in situ* for two evaluative dimensions: a) pleasing/annoying, and b) acceptable/unacceptable

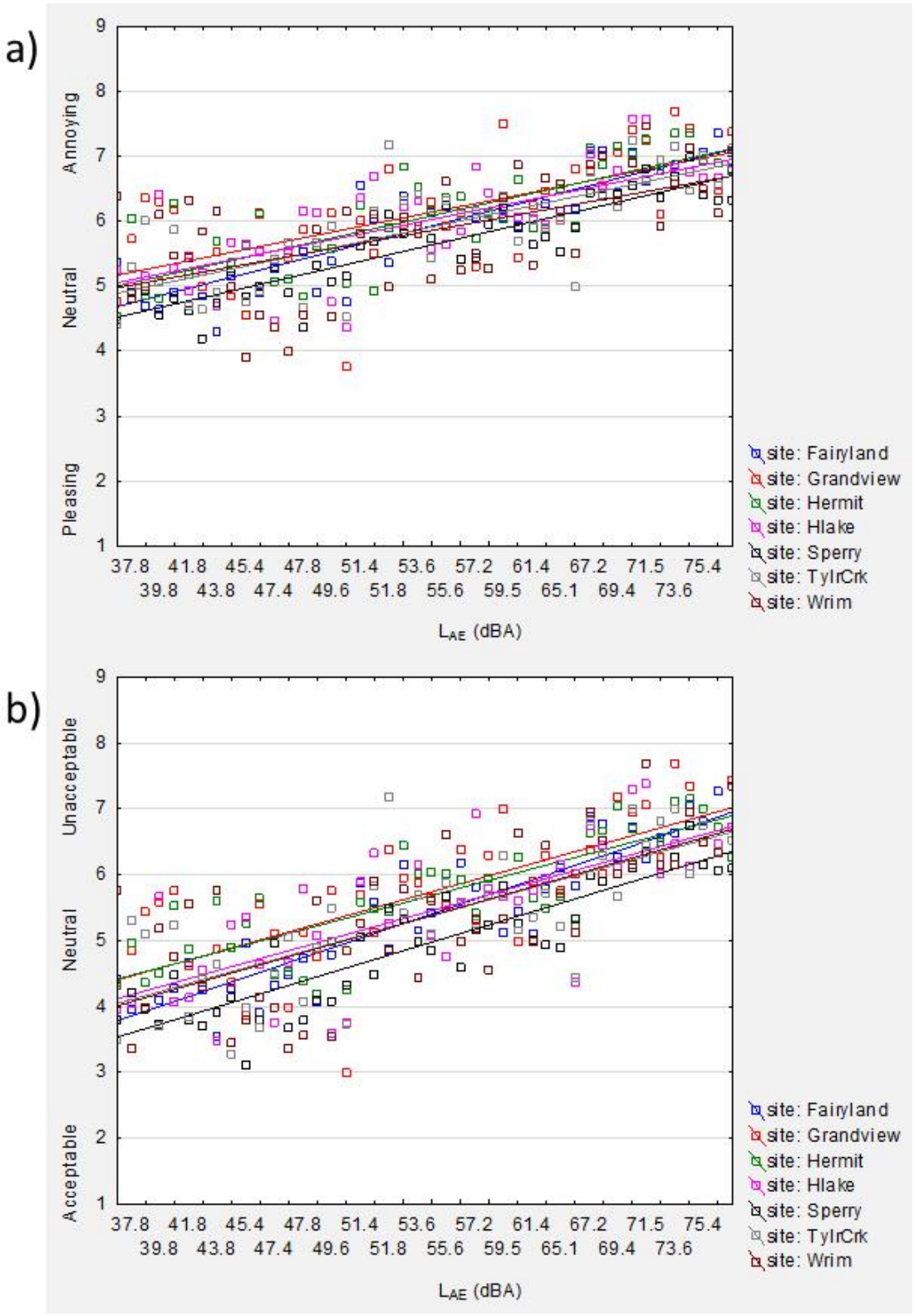


Figure 29. Average audio clip ratings grouped by measurement site for two evaluative dimensions: a) pleasing/annoying, and b) acceptable/unacceptable

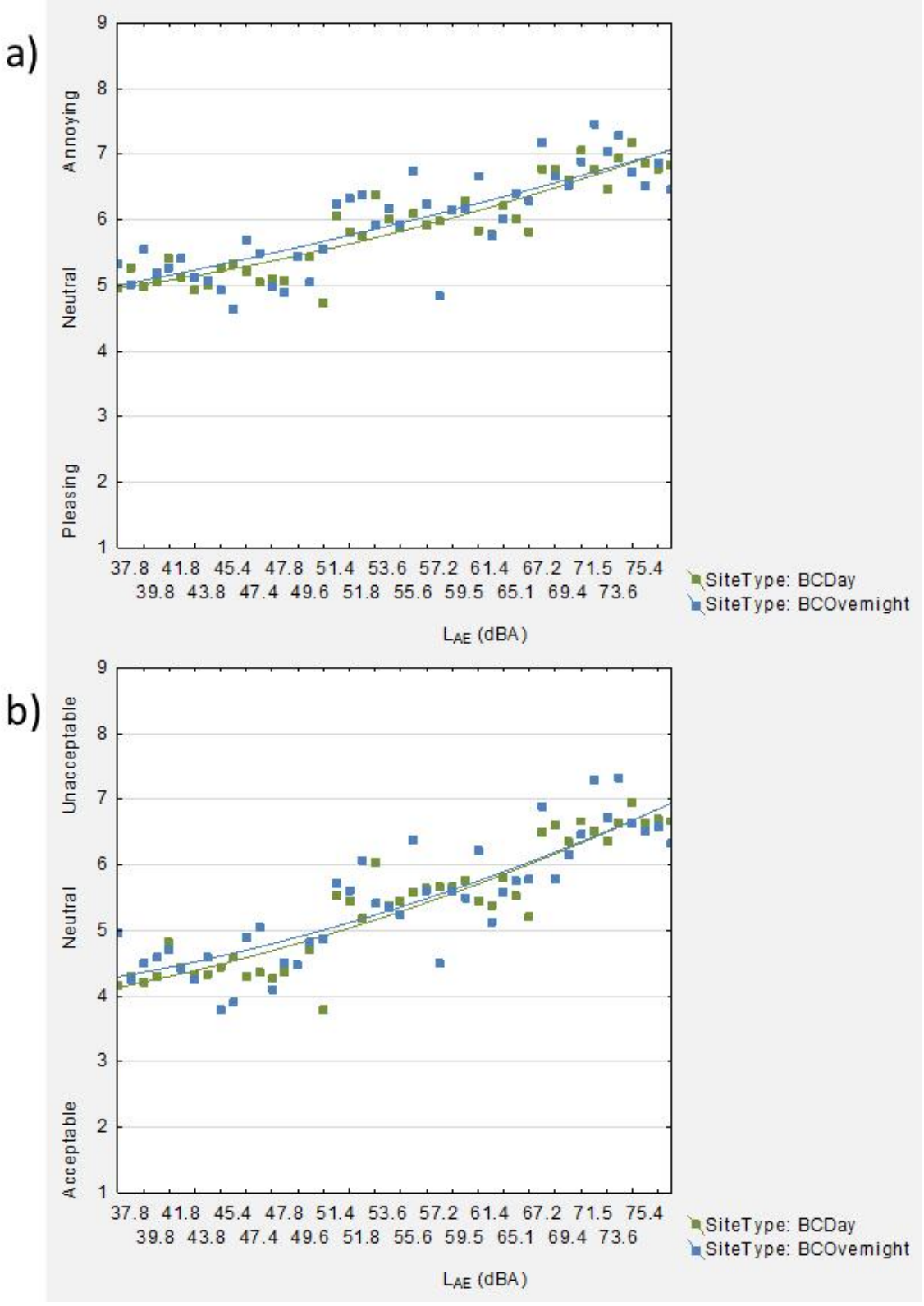


Figure 30. Average audio clip ratings grouped by site type for two evaluative dimensions: a) pleasing/annoying, and b) acceptable/unacceptable

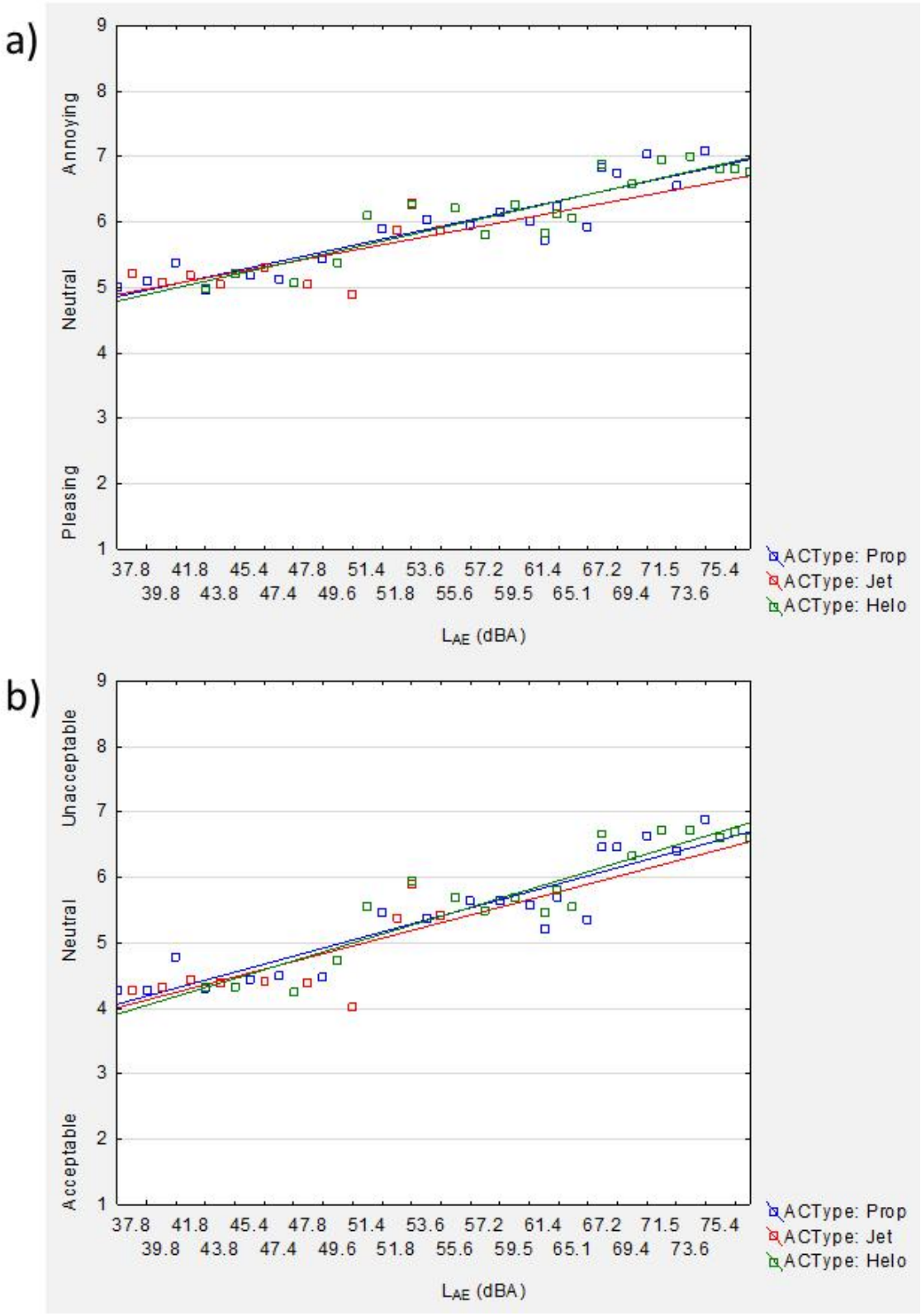


Figure 31. Average audio clip ratings grouped by aircraft type for two evaluative dimensions: a) pleasing/annoying, and b) acceptable/unacceptable

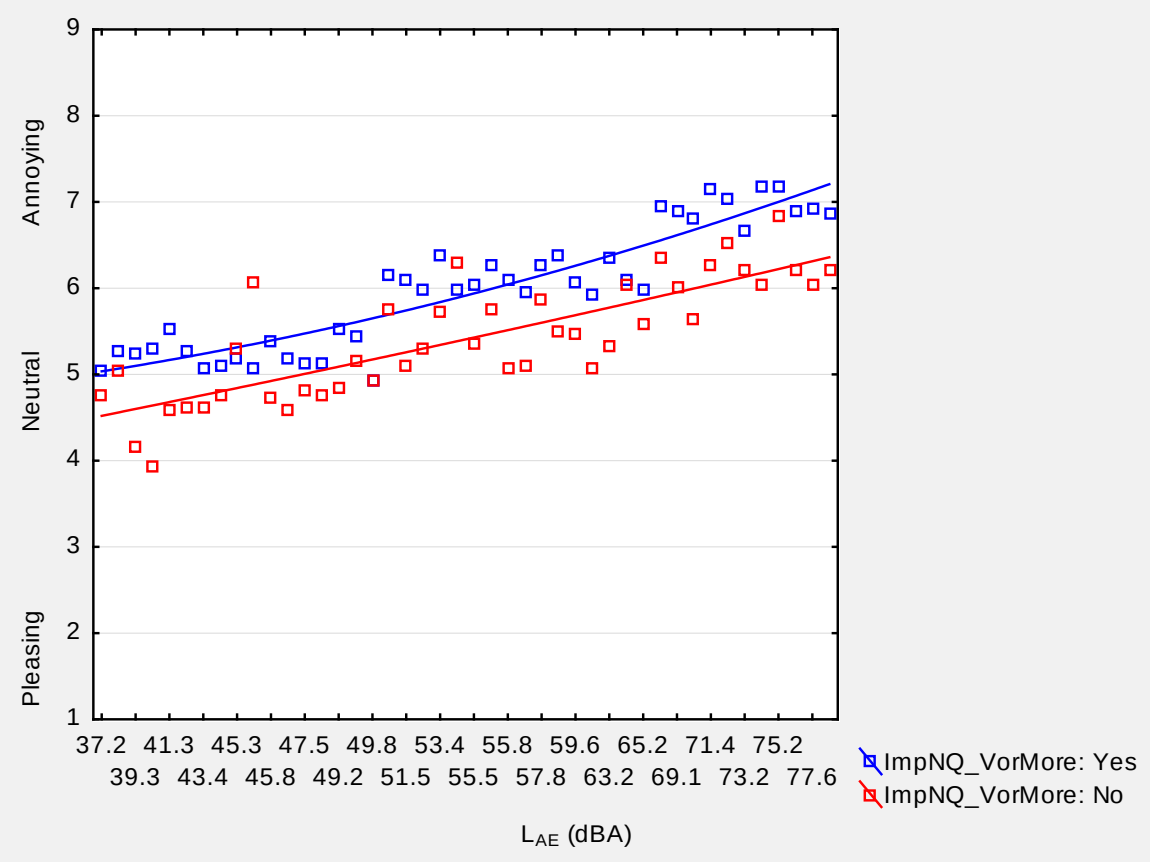


Figure 32. Average audio clip ratings (pleasing/annoying) categorized by ratings of the 'importance of natural quiet'

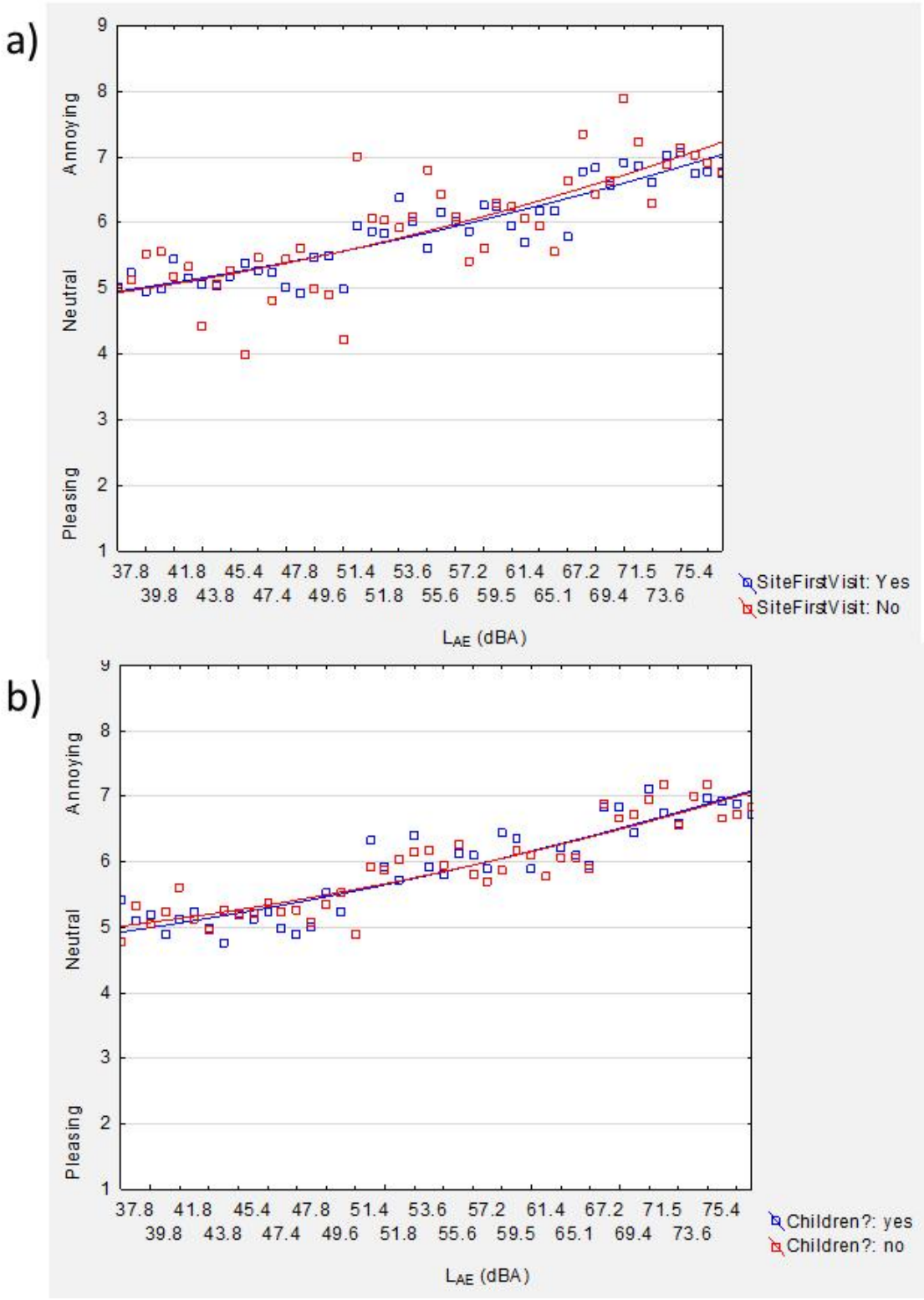


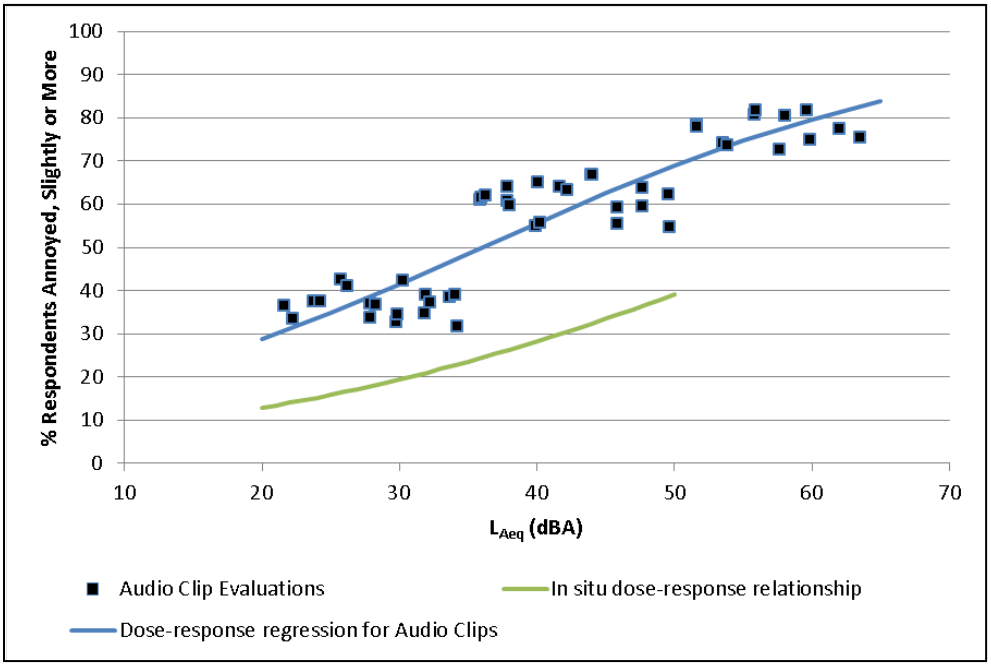
Figure 33. Average audio clip ratings (pleasing/annoying) based on a) whether this is the respondent's first visit to the site, and b) whether the respondent's group includes children

7.3 Comparison to *in situ* dose-response

To provide an alternate means to collect data and evaluate dose-response relationships, it is necessary to determine whether the audio clip evaluations provide estimates of the effect of aircraft noise that are comparable to those based on overflights occurring within an actual park visit experience. There are characteristics of an audio clip study which might result in differences in ratings as compared with ratings based on *in situ* aircraft noise exposure: (1) visitors are focused on the listening/rating activity, rather than normal activities (e.g., hiking), (2) visual stimuli associated with an actual overflight are not replicated in an audio clip, and (3) ratings of single overflight events (as represented in a short clip) may not be similar to ratings of the cumulative effect of multiple, intermittent, overflights such as often occur *in situ*.

Comparisons of *in situ* and audio clip dose-response relationships are presented (Figure 34) based on the equivalent sound level metric (L_{Aeq}), as this metric is a basis for the frontcountry *in situ* dose-response relationships and is commonly used to assess exposures with varying level and duration. In the following comparisons, ratings for the audio clip annoyance evaluations were dichotomized and fitted with a logistic function similar to both the frontcountry and backcountry model forms. To avoid any precedence effect as described earlier, only clip number 1 ratings were used. The audio clip relationship is compared to an alternate set of *in situ* day-hike dose-response regressions, developed using the $L_{AeqTresp}$ predictor and reflective of *in situ* response ratings on a 9-point scale (equivalent to the scale used for audio clip ratings). In addition, values of mediator variables (including percent energy helicopters and props) were set to the study averages summarized in Table 16. Figure 34 shows the average audio clip evaluation responses, the corresponding regression, and the *in situ* dose-response regression for the slightly-or-more and the moderately-or-more dichotomizations.

a)



b)

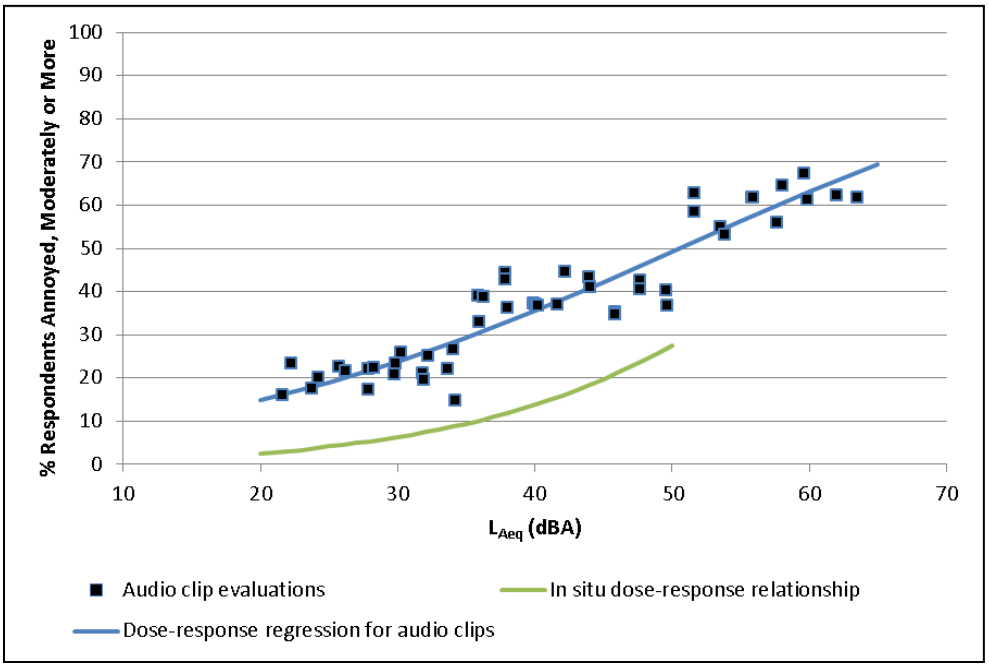


Figure 34. Audio clip dose-response relationships (clip 1 only) compared to *in situ* dose-response relationships for the equivalent sound level descriptor and 9-point rating scale: a) slightly-or-more dichotomization, and b) moderately-or-more dichotomization

This comparison shows that respondents rated the audio clip exposure (comprised of a single, shortened overflight) more strongly than an equivalent exposure from *in situ* aircraft noise (comprised of one or more overflights). This may be due to the focused nature and immediacy of response within the audio clip rating task; respondents have focused their attention on the sounds in the clip, and are asked to rate these sounds at the conclusion of the clip. In contrast, respondents *in situ* may be less focused on listening, and are asked to rate the aircraft sounds heard minutes to hours afterward.

7.4 Summary

An audio clip survey and research method was evaluated in this study as audio clips offer a controlled and cost-effective method for evaluating human response to aircraft noise and changes in aircraft noise in National Park settings. In this study, it was found that there are many key factors that influence visitor responses *in situ* that do not affect visitor response to the audio clip dose. Information on the variable nature of visitor responses due to visit-specific factors (familiarity with site, children in personal group, single-day vs overnight visits) are lost due to the nature of the rating activity during the audio clip survey. The audio clips present a novel experience isolated from the visit circumstances and other visitors, both of which might distract from the direct experience of the aircraft sound. Key information on the variation in response due to aircraft type is also lost. This may be attributable to the constraints of the audio clip formation and/or length, as information on tonal/impulsive aircraft overflight characteristics may be lost due to the short duration of the clip.

Comparison of dose-response relationships based on the equivalent sound level descriptor show that respondent ratings are stronger when based on a clip than *in situ.* This may be due in part to the focused nature and immediacy of response within the audio clip rating task. Respondents are instructed to focus their attention on the aircraft sounds and to rate these sounds immediately at the conclusion of each clip. In contrast, *in situ* surveys ask respondents to recall their visit and to rate aircraft sounds minutes or hours after hearing them. This result corroborates previous laboratory and field comparison of residential noise exposure[xxiv,xxv] which showed greater annoyance in the laboratory than *in situ* in the residential setting.

The results presented pose a challenge for interpreting this audio-clip dataset, as they suggest that the controlled dose experiment as structured in this study cannot replace *in situ* measurements. However, the audio clip study method may continue to warrant further investigation, as it remains a cost effective alternative to *in situ* data collection, offering the advantage of a controlled sound and sound level dose. With improvements, audio clips may

offer a reasonable means to determine the magnitude or potential for a change in response due to new or novel sources, or a change in source characteristics. Improvements in clip design (such as a longer length) may allow respondents to better judge differences between different sources or different aircraft types. In addition, laboratory-based paired comparison testing to highlight differences between stimuli could be used to augment a more traditional survey method; however, the limited number of stimuli that can be tested would not allow it to be used as a sole source of response data. Other alternative survey designs may also offer additional benefits.

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8.0 SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH AND ANALYSES

The goal for this dose-response data collection and analysis was to gain an understanding of backcountry visitor response to aircraft overflights. This research effort resulted in the accumulation of a dose-response dataset for backcountry visitors. Over 4,600 visitor surveys were collected at seven backcountry day- and overnight-hike sites and one cultural/historic site in four National Parks; Grand Canyon (GRCA), Bryce Canyon (BRCA), Zion, and Glacier (GLAC) during the period April through August 2011. Of the 4,600 total surveys, approximately 80% of single-day visit surveys (day-hike, short-hike, and cultural-historic visits) were associated with acceptable acoustic dose data. For overnight hikers, about 50% could be associated with enough required information to compute their corresponding acoustic dose. The final sample sizes for dose-response analyses (i.e., those associated with acceptable acoustic data) were 2,054 day-hike and 287 overnight-hike visitors.

The data for backcountry day-hike visitors was used to develop a robust set of dose-response relationships. These relationships will inform evaluations of air tour noise effects on visitors to National Parks. The dose-response models presented herein are derived in large part from respondent evaluations of noise exposure from helicopter and fixed-wing air tours. Thus, the models may not accurately predict response to noise exposure at locations without air tours and noise sources inconsistent with air tour operations.

Three surveys were included in this research: Human response to aviation noise survey 1 (HR1); Human response to aviation noise survey 2 (HR2); and the human response to aviation noise survey, audio recording version (audio clip). Each survey was designed to assess visitor evaluations of aircraft sounds/noise by different methods, utilizing evaluative dimensions including annoyance, interference with particular visit aspects, and acceptability. All surveys shared a subset of standardized questions on visit aspects, motivations, and demographics. The HR1 survey replicates research methods used in the 1990's frontcountry studies; it asks respondents explicitly to evaluate aircraft. The HR2 survey is designed to minimize the potential for response cueing bias that may result from direct queries on aircraft noise by asking respondents to identify sounds they heard in the study area from a list that includes both anthropogenic and natural sources. The Audio Clip survey is designed address the sound level range limitations of studying human response to aviation noise using *in situ* overflights. It allows researchers to collect visitor ratings of a range of aircraft noise exposure doses by presented

overflights in a series of short audio simulations. Subsequent questions allow visitors to evaluate aircraft sounds heard during their site visit.

HR2 survey respondents were less likely to report hearing aircraft and were less annoyed by aircraft noise at a given aircraft dose, when compared to HR1 or audio clip survey respondents. The difference in the annoyance responses between the surveys may be attributed to both the point scales utilized in the surveys (five point neutral to negative for AC and HR1 versus nine point positive to negative for HR2) and the avoidance of direct queries on aircraft sounds in the HR2 survey instrument. The slightly or more and moderately or more relationships are most affected by these differences, while the very or more relationship is unaffected. Although unaffected, this relationship may have limited utility assessments as there are few reports of very or extreme annoyance at low noise exposures.

The analysis of day-hike dose-response data involved model fitting and dose-descriptor and mediator testing. The best models were defined as those which minimize information loss based on the Akaike Information Criteria (AIC). Dose-response models were identified which best fit the *Annoy* and *Interference with natural quiet* responses for all three visitor response dichotomizations (Slightly or More, Moderately or More, and Very or More). These models include dose variables of sound exposure level, percent time audible, and energy percentages due to helicopters and fixed-wing propeller aircraft. Mediator variables identified include visitor ratings of the importance of calmness, peace and tranquility, attributes of adults-only in group, first visit to the site, having taken an air tour, and participation in activities of watching birds and listening to an interpretive talk.

The regression model that predicts the probability that a visitor will experience annoyance by a given level of aircraft noise according to the following equation:

$$\begin{aligned} \mathrm{z} = {} & C_0 + C_1(L_{AE}) + C_2(\%TAud) + C_3(P_{EnHelos}) + C_4\left(P_{EnProps}\right) + C_5(S_{HR1}) \\ & + C_6(S_{HR2}) + C_7\left(M_{ImpCP}\right) + C_8\left(M_{SiteVisitBefore}\right) + C_9\left(M_{AdultsOnly}\right) \\ & + C_{10}(M_{AirTour}) + C_{11}(M_{WatchBirds}) \end{aligned}$$

$$\mathrm{R} = \frac{1}{1+e^{-z}}$$

Where S = 1 if the given survey instrument was received and S=0 if a different survey instrument was received.

Mediator (M) variables are defined as:

M_{ImpCP}: Respondent rated the 'calmness, peace and tranquility' as a very or extremely important aspect of the visit.

$M_{SiteVisitBefore}$: Respondent had visited the site before.

$M_{AdultsOnly}$: Respondent's personal group consisted of only adults (no children under the age of 16).

$M_{AirTour}$: Respondent had taken an air tour.

$M_{WatchBirds}$: Respondent had participated in bird watching during the visit.

Where M = 1 for Yes responses (as defined above) and M=0 for No responses.

Dose variables L_{AE}, %TAud, $P_{EnHelos}$, and $P_{EnProps}$ are calculated according to:

L_{AE} = 10 * log10 ($\Sigma 10^{(LAeq,1s/10)}$)

%TAud = 100 * (Duration of aircraft sounds (T_{AC}) / Duration of visit (T_{resp}))

$P_{EnHelos} = 100 * \left(10^{L_{AE}Helos/10}/10^{L_{AE}/10}\right)$

$P_{en,Props} = 100 * \left(10^{L_{AE}Props/10}/10^{L_{AE}/10}\right)$

The equation for the probability that a visitor will experience Interference with natural quiet is similar, but includes a *Talk* mediator (respondent had participated in an interpretive talk) and does not include the *Survey* (S) variables, or the *SiteVisitBefore* and *WatchBirds* mediators.

A representative set of dose-response curves based on the day-hike data analysis are presented below for both the annoyance and interference with natural quiet responses (Figure 35). In these plots, only the L_{AE} dose variable is explicitly visualized, while the effects of the %TAud, $P_{EnHelos}$, and $P_{EnProps}$ doses on visitor response are represented using a function relating to $L_{AE.}$ Thus, the shapes of the dose-response curves are adjusted to include to effects of additional dose variables on visitor response through their relationships with the L_{AE} dose variable. The three individual curves in the plots (solid lines) represent the three dichotomies of visitor response (Slightly or More, Moderately or More, and Very or More). Dashed lines represent the 95% confidence region around each curve. Values of the survey-based mediator variables were held constant at the average values for the 2011 day-hike survey data. The data points (black dots) are jittered to aid in visualization and represent the Slightly or More dichotomization.

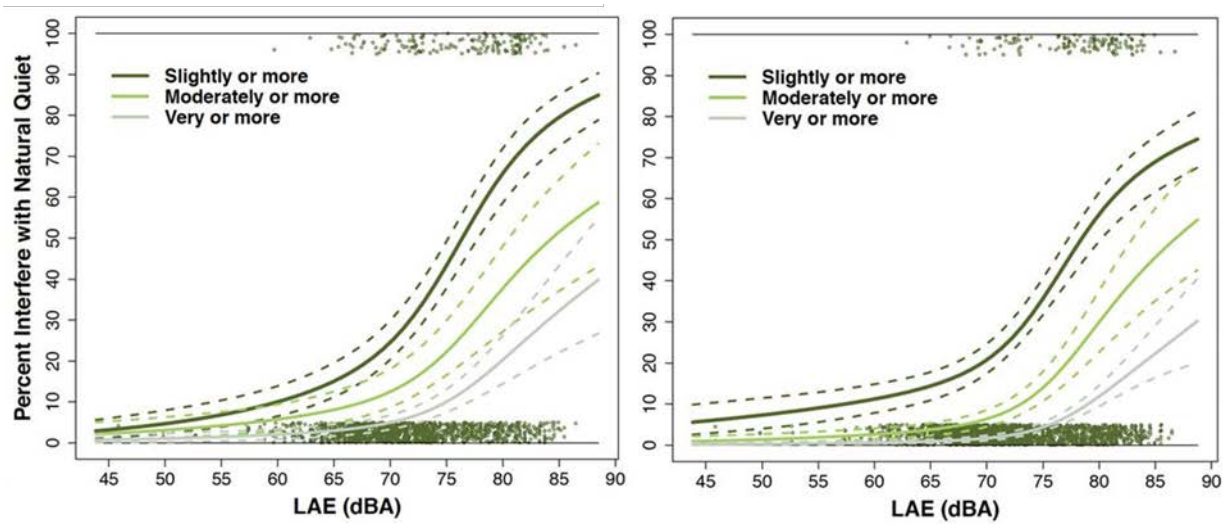

Figure 35. Representative set of day-hike dose-response curves

It should be noted that the relationships depicted in the previous graphic represent one dimension of a multi-factor, multi-dimensional model. As stated above, the values of the factors not depicted are set to the average or most likely value for the 2011 dataset. Changes in these values can influence the shape and location of these relationships, and care must be taken when utilizing these relationships. Change in the values of the dose descriptors %TAud, $P_{EnHelos}$, and $P_{EnProps}$ can greatly influence the predicted visitor response, and these variables can vary widely between sites. In contrast, the average values of the non-acoustic, visitor-based mediators do not vary as widely between sites, and do not strongly affect the shape of the dose-response curve. Spreadsheets or computer programs are suggested to properly exercise these relationships.

Many of the mediator variables that were important predictors of backcountry visitor responses to aviation noise were not included in the frontcountry survey instrument. This result confirms that many of the enhancements to the 2011 survey instrument provided important information that can be utilized to assess the responses of park visitors to aircraft. These mediators include *Importance of calm/peace*, *Never air tour*, *Talk*, and *Watch birds*). In particular, the significance of the *Importance of calm/peace* variable corroborates earlier research suggesting that this is an important value in National Park settings. The significance of the T*alk* and *Watch birds* 'activity' variables confirms that participation in specific activities can increase the severity of response to aircraft noise.

Detectability-based dose metrics (D'L) were calculated and tested within the model-fitting exercise. These metrics account for the signal-to-noise ratio of aircraft to ambient sounds in

each one-third octave band, and are generally used to predict when a person will detect a given sound within a background of noise. Although less powerful than the primary dose metrics, the detectability exposure level ($D'L_E$) for the annoyance response has useful predictive power at the 'slightly or more' level. This result may corroborate earlier evidence that there is a strong relationship between annoyance and the detectability of low level sounds.

This best-fit backcountry model differs from that identified for the frontcountry, most notably in the noise dose metrics. However, there is some similarity in these exposure metrics, as the $L_{AeqTresp}$ dose (frontcountry model) is derived from components of L_{AE} and visit duration; absent is the duration of aircraft sounds included within %TAud in the backcountry model. This indicates that the total noise exposure is important in both models, while the relative duration of the aircraft exposure exhibits more significance in the backcountry model, possibly due to longer visit durations.

For comparative purposes, a regression was fit to the frontcountry data using the dose combination of $L_{AE,}$ %TAud, $P_{EnHelos}$ and $P_{EnProps}$ as identified for the backcountry data. The confidence intervals surrounding the day-hike and short-hike relationships overlap through the majority of the data range; neither relationship is based on significant amounts of data at sound exposures below 50 and above 85 dBA. The models yield similar predictions in the region between 70 and 80 dBA, where the majority of day-hike data are centered and predictions most accurate. At sound exposures above approximately 75 dBA, where predictions are more uncertain, a greater percentage of backcountry respondents are predicted to report annoyance. While at sound exposures below 70 dBA, a greater percentage of frontcountry short-hike respondents are predicted to report annoyance. Due to the prediction uncertainties, model estimates outside the available data range should be used with caution. Analysis of a combined frontcountry and backcountry dataset could produce a single model and yield further insights.

The current research effort also collected dose-response data for overnight backcountry users. Due to the lower number of overnight users and increased variability in their visit patterns (i.e., hike routes and camp locations), fewer usable data points were acquired for overnight visitors (approximately 287 respondents, compared to 2054 day-hike respondents). The data show that overnight hikers were more likely to be repeat visitors to the location and less likely to have children with them, two important mediators of response to aircraft sound. When a multi-level regression model was fitted to day-hike and overnight hikers for comparison, results show that the overnight hikers were more sensitive to aircraft sound than day-hikers.

This research included an additional component based on visitor responses to audio clips of aircraft overflights. This method may be advantageous, as audio clips can provide a wide range of controlled sound level exposure. However, responses to overflights conveyed via audio clip did not replicate key information needed for use within a dose-response application framework. The data showed that visitors responded similarly regardless of the site-type or activity of the respondent (day-hike versus overnight hike), whether there were "children in group", if this was a "first time visit". This is in direct contrast to *in situ* dose response data, where it has been shown that these factors all play a key role in visitor evaluations. Site-to-site responses do, however, show some variability; there is a slight tendency for respondents at sites with higher *in situ* exposures (Hermit and Grandview at Grand Canyon and Hidden Lake at Glacier) to rate the clips more annoying or unacceptable. Although hearing or not hearing aircraft *in situ* did not influence audio clip evaluations, this suggests that the *in situ* sound exposure due to aircraft may have some influence on the evaluations. If audio clips are to be used within the dose-response framework, additional research would be necessary to determine if there are methods to better replicate the aircraft overflight and context within the visit experience.

Dose-response relationships developed for the *in situ* day-hikers were compared to similar dose-response relationships developed from the audio clip playback survey responses. Comparison of relationships developed using the equivalent sound level descriptor showed that audio clip noise exposure is rated stronger than similar noise exposures experienced *in situ*.

8.1 Additional Research and Analysis Needs

The dataset presented in this report is robust for day-hike visitors and provides a strong basis for dose-response analyses for air tour overflights for this category of visitors. The dataset also complements the prior dataset from the 1990s encompassing frontcountry overlook and short-hike visitors. There are opportunities to strengthen these results further through additional analyses of the current dataset, as well as collection of additional data from overnight visitors and other activity types such as visits focusing on cultural and historic sites. Analysis of a combined frontcountry / backcountry dataset could further elucidate similarities and differences between site-types.

The data presented herein on overnight visitors provides evidence that backcountry overnight visitors are more sensitive to noise exposure than are backcountry day-hike visitors. Although the limitations of this dataset do not allow us to determine stand-alone dose-response relationships, regression analyses using the combined day-hike/overnight dataset shows that there is a statistically significant site-type offset, or difference, between day-hike and overnight

visitors. Further analyses of the overnight dataset should include a model-fitting exercise to explore the full range of dose metrics (and potential mediating variables) evaluated during the day-hike analysis, reassessed with the combined dataset. It is plausible that there is an alternate dose or combination of dose descriptors that is most appropriate for this combined dataset with overnight visitors. This analysis should have a particular emphasis on validity and use of the site type coefficient (or offset) as described above. If overnight visitors are indeed more sensitive than day-hikers, this information could be essential if the NPS wishes to protect the experience of most sensitive visitors. If overnight visitors are actually no more sensitive than day-hike visitors, thresholds can be set based on a robust, combined day-hike/overnight hike dataset, providing a strong basis for setting regulatory requirements for air tours. As a last step, the need for additional surveys and data collection for overnight visitors should be reassessed. A larger data set will reduce uncertainty, leading to a more precise estimate of the site-type offset, but may not ultimately be required. In addition, obtaining data to widen the range of available doses may present challenges, due to the tendency for respondent exposures at a single site to have little variability.

The preliminary data on cultural and historic sites collected as part of this study provide only a glimpse of the differing priorities (i.e., greater importance of appreciation of culture and history of the site, lower emphasis on importance of natural quiet) of visitors to these sites. However, these data represent only a single site, and cultural and historic sites are diverse, ranging from ancient petroglyphs and remote ruins to battlefields to urban monuments. It may take a significant data collection effort to represent these parks effectively in a dose-response framework.

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APPENDIX A. SUMMARY OF SURVEY RESPONSES

This appendix reports descriptive statistics for responses to all questions contained in the survey questionnaires by sampling site within each park. Reported sample sizes reflect the number of respondents presented with each question. Response data for questions that appear in all three questionnaires are aggregated.

Table A-1. Was your hike a day-hike or a multi-day, overnight hike on this visit?

Location	Sample Size	Day-Hike	Multi-Day, Overnight Hike
GRCA Grandview	415	70.1%	29.9%
GRCA Hermit	583	77.0%	23.0%
GRCA Tusayan Ruins	400	100.0%	0.0%
BRCA Fairyland	1079	100.0%	0.0%
ZION West Rim	308	58.8%	41.2%
ZION Taylor Creek	453	100.0%	0.0%
GLAC Sperry	912	59.2%	40.8%
GLAC Hidden Lake	516	100.0%	0.0%

Table A-2. Is this your first visit to <site>?

Location	Sample Size	Yes	No	No Response
GRCA Grandview	415	71.6%	28.2%	0.2%
GRCA Hermit	583	83.7%	16.0%	0.3%
GRCA Tusayan Ruins	400	92.0%	7.0%	1.0%
BRCA Fairyland	1079	90.0%	9.9%	0.1%
ZION West Rim	308	67.5%	32.5%	0.0%
ZION Taylor Creek	453	89.0%	11.0%	0.0%
GLAC Sperry	912	75.8%	23.9%	0.3%
GLAC Hidden Lake	516	75.6%	24.0%	0.4%

Table A-3. Approximately how many times [before] have you visited <site>?

Location	Sample Size	1 Previous Visit	2 to 5 Previous Visits	6 or More Previous Visits	No Response
GRCA Grandview	415	7.0%	13.7%	7.5%	71.8%
GRCA Hermit	583	4.1%	6.5%	5.1%	84.2%
GRCA Tusayan Ruins	400	4.0%	3.0%	0.0%	93.0%
BRCA Fairyland	1079	4.5%	3.8%	1.3%	90.4%
ZION West Rim	308	5.2%	10.1%	1.6%	83.1%
ZION Taylor Creek	453	4.0%	4.2%	2.4%	89.4%
GLAC Sperry	912	7.7%	8.3%	2.9%	81.1%
GLAC Hidden Lake	516	7.4%	8.9%	6.8%	76.9%

Table A-4. Which of the following activities did you take part in during this visit to <site>?

Activity	Location	Sample Size	Yes	No
Viewing the scenery	GRCA Grandview	415	91.3%	8.7%
Viewing the scenery	GRCA Hermit	583	91.6%	8.4%
Viewing the scenery	GRCA Tusayan Ruins	400	85.8%	14.3%
Viewing the scenery	BRCA Fairyland	1079	94.9%	5.1%
Viewing the scenery	ZION West Rim	308	91.9%	8.1%
Viewing the scenery	ZION Taylor Creek	453	92.9%	7.1%
Viewing the scenery	GLAC Sperry	912	93.6%	6.4%
Viewing the scenery	GLAC Hidden Lake	516	95.5%	4.5%
Viewing a sunrise or sunset	GRCA Grandview	415	32.8%	67.2%
Viewing a sunrise or sunset	GRCA Hermit	583	21.6%	78.4%
Viewing a sunrise or sunset	GRCA Tusayan Ruins	400	8.8%	91.3%
Viewing a sunrise or sunset	BRCA Fairyland	1079	8.9%	91.1%
Viewing a sunrise or sunset	ZION West Rim	308	38.3%	61.7%
Viewing a sunrise or sunset	ZION Taylor Creek	453	1.5%	98.5%
Viewing a sunrise or sunset	GLAC Sperry	912	31.7%	68.3%
Viewing a sunrise or sunset	GLAC Hidden Lake	516	4.5%	95.5%
Viewing a sunrise or sunset	GRCA Grandview	415	63.4%	36.6%
Viewing a sunrise or sunset	GRCA Hermit	583	58.8%	41.2%
Viewing a sunrise or sunset	GRCA Tusayan Ruins	400	8.5%	91.5%
Viewing a sunrise or sunset	BRCA Fairyland	1079	43.4%	56.6%
Viewing a sunrise or sunset	ZION West Rim	308	63.6%	36.4%
Viewing a sunrise or sunset	ZION Taylor Creek	453	42.6%	57.4%
Viewing a sunrise or sunset	GLAC Sperry	912	60.7%	39.3%
Viewing a sunrise or sunset	GLAC Hidden Lake	516	53.3%	46.7%
Viewing a sunrise or sunset	GRCA Grandview	415	42.7%	57.3%
Viewing a sunrise or sunset	GRCA Hermit	583	43.2%	56.8%
Viewing a sunrise or sunset	GRCA Tusayan Ruins	400	18.0%	82.0%
Viewing a sunrise or sunset	BRCA Fairyland	1079	44.1%	55.9%
Viewing a sunrise or sunset	ZION West Rim	308	34.4%	65.6%
Viewing a sunrise or sunset	ZION Taylor Creek	453	26.3%	73.7%
Viewing a sunrise or sunset	GLAC Sperry	912	22.1%	77.9%
Viewing a sunrise or sunset	GLAC Hidden Lake	516	29.8%	70.2%
Viewing wildlife (other than birds)	GRCA Grandview	415	44.8%	55.2%
Viewing wildlife (other than birds)	GRCA Hermit	583	51.6%	48.4%
Viewing wildlife (other than birds)	GRCA Tusayan Ruins	400	22.0%	78.0%
Viewing wildlife (other than birds)	BRCA Fairyland	1079	47.7%	52.3%
Viewing wildlife (other than birds)	ZION West Rim	308	59.1%	40.9%
Viewing wildlife (other than birds)	ZION Taylor Creek	453	64.2%	35.8%
Viewing wildlife (other than birds)	GLAC Sperry	912	64.1%	35.9%
Viewing wildlife (other than birds)	GLAC Hidden Lake	516	94.6%	5.4%

Table A-4 (continued). Which of the following activities did you take part in during this visit to <site>?

Activity	Location	Sample Size	Yes	No
Hiking or walking	GRCA Grandview	415	97.6%	2.4%
Hiking or walking	GRCA Hermit	583	96.9%	3.1%
Hiking or walking	GRCA Tusayan Ruins	400	76.3%	23.8%
Hiking or walking	BRCA Fairyland	1079	98.4%	1.6%
Hiking or walking	ZION West Rim	308	98.1%	1.9%
Hiking or walking	ZION Taylor Creek	453	98.5%	1.5%
Hiking or walking	GLAC Sperry	912	97.9%	2.1%
Hiking or walking	GLAC Hidden Lake	516	96.7%	3.3%
Hiking or walking	GRCA Grandview	415	32.3%	67.7%
Hiking or walking	GRCA Hermit	583	25.4%	74.6%
Hiking or walking	GRCA Tusayan Ruins	400	3.3%	96.8%
Hiking or walking	BRCA Fairyland	1079	1.8%	98.2%
Hiking or walking	ZION West Rim	308	39.9%	60.1%
Hiking or walking	ZION Taylor Creek	453	0.0%	100.0%
Hiking or walking	GLAC Sperry	912	13.0%	87.0%
Hiking or walking	GLAC Hidden Lake	516	1.0%	99.0%
Entering a visitor center, lodge, store, or other building	GRCA Grandview	415	22.2%	77.8%
Entering a visitor center, lodge, store, or other building	GRCA Hermit	583	29.0%	71.0%
Entering a visitor center, lodge, store, or other building	GRCA Tusayan Ruins	400	76.3%	23.8%
Entering a visitor center, lodge, store, or other building	BRCA Fairyland	1079	25.8%	74.2%
Entering a visitor center, lodge, store, or other building	ZION West Rim	308	21.4%	78.6%
Entering a visitor center, lodge, store, or other building	ZION Taylor Creek	453	48.6%	51.4%
Entering a visitor center, lodge, store, or other building	GLAC Sperry	912	41.0%	59.0%
Entering a visitor center, lodge, store, or other building	GLAC Hidden Lake	516	53.5%	46.5%
Entering a visitor center, lodge, store, or other building	GRCA Grandview	415	2.9%	97.1%
Entering a visitor center, lodge, store, or other building	GRCA Hermit	583	4.1%	95.9%
Entering a visitor center, lodge, store, or other building	GRCA Tusayan Ruins	400	10.0%	90.0%
Entering a visitor center, lodge, store, or other building	BRCA Fairyland	1079	2.3%	97.7%
Entering a visitor center, lodge, store, or other building	ZION West Rim	308	1.3%	98.7%
Entering a visitor center, lodge, store, or other building	ZION Taylor Creek	453	0.7%	99.3%
Entering a visitor center, lodge, store, or other building	GLAC Sperry	912	2.1%	97.9%
Entering a visitor center, lodge, store, or other building	GLAC Hidden Lake	516	5.6%	94.4%

Table A-4 (continued). Which of the following activities did you take part in during this visit to <site>?

Activity	Location	Sample Size	Yes	No
Attending some other demonstration, talk, or organized activity	GRCA Grandview	415	1.7%	98.3%
Attending some other demonstration, talk, or organized activity	GRCA Hermit	583	1.7%	98.3%
Attending some other demonstration, talk, or organized activity	GRCA Tusayan Ruins	400	1.0%	99.0%
Attending some other demonstration, talk, or organized activity	BRCA Fairyland	1079	1.2%	98.8%
Attending some other demonstration, talk, or organized activity	ZION West Rim	308	0.6%	99.4%
Attending some other demonstration, talk, or organized activity	ZION Taylor Creek	453	0.9%	99.1%
Attending some other demonstration, talk, or organized activity	GLAC Sperry	912	3.1%	96.9%
Attending some other demonstration, talk, or organized activity	GLAC Hidden Lake	516	2.7%	97.3%
Other	GRCA Grandview	415	6.3%	93.7%
Other	GRCA Hermit	583	7.2%	92.8%
Other	GRCA Tusayan Ruins	400	3.3%	96.8%
Other	BRCA Fairyland	1079	0.0%	92.2%
Other	ZION West Rim	308	6.8%	93.2%
Other	ZION Taylor Creek	453	5.5%	94.5%
Other	GLAC Sperry	912	0.0%	91.7%
Other	GLAC Hidden Lake	516	0.0%	90.1%
None of the above	GRCA Grandview	415	0.0%	100.0%
None of the above	GRCA Hermit	583	0.5%	99.5%
None of the above	GRCA Tusayan Ruins	400	0.7%	99.3%
None of the above	BRCA Fairyland	1079	0.5%	99.5%
None of the above	ZION West Rim	308	0.0%	100.0%
None of the above	ZION Taylor Creek	453	0.4%	99.6%
None of the above	GLAC Sperry	912	0.3%	99.7%
None of the above	GLAC Hidden Lake	516	0.4%	99.6%

Table A-5. How important was it that this visit to <site> provide you with the opportunity to …

a. View the natural scenery?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.2%	0.0%	2.4%	21.2%	74.7%	0.2%	1.2%
GRCA Hermit	583	0.0%	0.5%	3.4%	28.3%	67.1%	0.2%	0.5%
GRCA Tusayan Ruins	400	0.0%	2.8%	23.5%	38.5%	31.3%	1.8%	2.3%
BRCA Fairyland	1079	0.1%	0.4%	2.8%	27.1%	68.6%	0.2%	0.9%
ZION West Rim	308	0.0%	0.3%	4.2%	26.9%	67.2%	0.0%	1.3%
ZION Taylor Creek	453	0.2%	0.7%	6.8%	25.2%	65.6%	0.4%	1.1%
GLAC Sperry	912	0.2%	0.5%	5.5%	34.4%	58.1%	0.2%	1.0%
GLAC Hidden Lake	516	0.0%	0.4%	1.9%	23.6%	72.9%	0.0%	1.2%

b. Enjoy the natural quiet and sounds of nature?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.7%	1.9%	10.1%	29.9%	55.4%	0.2%	1.7%
GRCA Hermit	583	0.2%	3.1%	10.6%	37.0%	48.7%	0.2%	0.2%
GRCA Tusayan Ruins	400	1.8%	7.5%	23.0%	40.8%	20.3%	3.8%	3.0%
BRCA Fairyland	1079	0.7%	2.9%	9.6%	39.1%	46.8%	0.3%	0.6%
ZION West Rim	308	0.6%	1.3%	12.0%	37.7%	47.4%	0.0%	1.0%
ZION Taylor Creek	453	1.3%	3.3%	10.2%	41.7%	41.7%	0.7%	1.1%
GLAC Sperry	912	0.3%	2.9%	10.7%	38.4%	46.5%	0.4%	0.8%
GLAC Hidden Lake	516	1.4%	2.5%	11.6%	37.2%	44.6%	1.2%	1.6%

c. Appreciate the history and cultural significance of the site?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	1.9%	12.5%	26.3%	29.4%	26.0%	2.7%	1.2%
GRCA Hermit	583	4.6%	14.9%	30.0%	23.8%	21.1%	3.6%	1.9%
GRCA Tusayan Ruins	400	0.5%	4.0%	11.0%	48.8%	33.3%	1.5%	1.0%
BRCA Fairyland	1079	8.0%	19.4%	27.2%	23.4%	14.8%	5.8%	1.4%
ZION West Rim	308	8.8%	19.5%	29.5%	19.5%	15.6%	5.8%	1.3%
ZION Taylor Creek	453	7.5%	25.8%	30.0%	18.8%	12.1%	4.6%	1.1%
GLAC Sperry	912	8.1%	17.9%	26.5%	23.9%	13.8%	8.4%	1.3%
GLAC Hidden Lake	516	6.4%	17.2%	30.8%	23.1%	16.5%	4.1%	1.9%

Table A-5 (continued). How important was it that this visit to <site> provide you with the opportunity to …

d. Experience a feeling of calmness, peace, or tranquility?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	1.0%	3.4%	11.3%	32.8%	49.2%	0.7%	1.7%
GRCA Hermit	583	0.5%	3.8%	15.3%	37.0%	41.5%	1.7%	0.2%
GRCA Tusayan Ruins	400	2.3%	10.0%	25.3%	38.8%	17.3%	3.8%	2.8%
BRCA Fairyland	1079	0.8%	3.7%	13.3%	39.7%	40.8%	0.7%	1.0%
ZION West Rim	308	0.0%	2.3%	11.7%	39.6%	45.8%	0.3%	0.3%
ZION Taylor Creek	453	1.5%	4.2%	16.1%	38.2%	37.5%	1.3%	1.1%
GLAC Sperry	912	0.7%	4.8%	13.9%	38.7%	40.2%	0.7%	1.0%
GLAC Hidden Lake	516	1.0%	3.5%	13.0%	38.2%	41.3%	1.2%	1.0%

e. Experience a sense of adventure or challenge

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.7%	2.9%	14.5%	32.3%	48.2%	0.5%	1.0%
GRCA Hermit	583	0.9%	5.3%	19.0%	35.0%	39.1%	0.3%	0.3%
GRCA Tusayan Ruins	400	14.0 %	19.3%	26.5%	17.8%	9.0%	9.3%	4.3%
BRCA Fairyland	1079	3.0%	9.5%	24.7%	34.0%	26.6%	1.4%	0.8%
ZION West Rim	308	1.3%	4.2%	17.9%	36.7%	39.0%	0.3%	0.6%
ZION Taylor Creek	453	3.3%	10.2%	32.2%	29.8%	22.5%	0.9%	1.1%
GLAC Sperry	912	1.9%	8.6%	21.8%	37.3%	28.7%	0.8%	1.0%
GLAC Hidden Lake	516	3.3%	8.1%	22.7%	33.3%	28.7%	1.7%	2.1%

Table A-6. During this visit to <site>, how much did you …

a. Appreciate the natural scenery?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.2%	0.2%	2.7%	24.1%	69.9%	0.2%	2.7%
GRCA Hermit	583	0.3%	0.3%	4.3%	27.8%	64.8%	0.2%	2.2%
GRCA Tusayan Ruins	400	0.0%	3.8%	20.0%	43.5%	24.0%	1.0%	7.8%
BRCA Fairyland	1079	0.1%	0.2%	3.0%	26.1%	69.0%	0.1%	1.5%
ZION West Rim	308	0.3%	0.6%	3.9%	25.3%	67.9%	0.0%	1.9%
ZION Taylor Creek	453	0.2%	0.0%	3.8%	34.4%	59.4%	0.0%	2.2%
GLAC Sperry	912	0.1%	0.9%	8.2%	34.0%	54.7%	0.2%	1.9%
GLAC Hidden Lake	516	0.0%	0.0%	1.4%	23.3%	72.9%	0.2%	2.3%

b. Enjoy the natural quiet and sounds of nature?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.5%	5.1%	12.0%	31.8%	47.7%	0.2%	2.7%
GRCA Hermit	583	0.9%	6.7%	19.4%	35.2%	35.5%	0.0%	2.4%
GRCA Tusayan Ruins	400	0.8%	9.5%	22.0%	39.3%	18.3%	2.3%	8.0%
BRCA Fairyland	1079	0.6%	1.2%	9.8%	42.4%	44.3%	0.3%	1.4%
ZION West Rim	308	0.0%	1.6%	10.7%	39.9%	45.5%	0.0%	2.3%
ZION Taylor Creek	453	0.2%	2.4%	13.0%	43.0%	39.1%	0.2%	2.0%
GLAC Sperry	912	0.4%	2.2%	13.4%	44.0%	37.7%	0.5%	1.8%
GLAC Hidden Lake	516	1.6%	5.2%	18.2%	35.5%	37.2%	0.4%	1.9%

c. Appreciate the history and cultural significance of the site?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	3.6%	13.3%	26.0%	25.1%	25.5%	2.7%	3.9%
GRCA Hermit	583	6.9%	16.8%	29.5%	21.8%	19.4%	2.9%	2.7%
GRCA Tusayan Ruins	400	0.8%	3.3%	13.8%	44.0%	29.8%	1.0%	7.5%
BRCA Fairyland	1079	10.7%	18.7%	27.5%	19.7%	12.8%	8.1%	2.5%
ZION West Rim	308	12.0%	17.5%	24.7%	21.4%	14.3%	7.8%	2.3%
ZION Taylor Creek	453	9.5%	24.3%	31.1%	18.8%	10.8%	3.1%	2.4%
GLAC Sperry	912	12.9%	19.8%	22.8%	19.3%	11.8%	11.5%	1.8%
GLAC Hidden Lake	516	10.7%	22.3%	26.6%	18.2%	13.8%	5.2%	3.3%

Table A-6 (continued). During this visit to <site>, how much did you …

d. Experience a feeling of calmness, peace, or tranquility?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.5%	4.6%	14.5%	32.8%	44.3%	0.2%	3.1%
GRCA Hermit	583	0.9%	5.5%	18.9%	36.7%	34.6%	0.9%	2.6%
GRCA Tusayan Ruins	400	1.5%	7.8%	24.3%	40.5%	15.0%	2.5%	8.5%
BRCA Fairyland	1079	0.5%	2.8%	13.1%	42.7%	38.6%	0.6%	1.8%
ZION West Rim	308	0.0%	1.0%	13.0%	41.2%	42.9%	0.0%	1.9%
ZION Taylor Creek	453	0.2%	5.5%	17.0%	38.9%	35.5%	0.7%	2.2%
GLAC Sperry	912	0.9%	3.7%	16.7%	41.3%	35.4%	0.2%	1.8%
GLAC Hidden Lake	516	1.4%	5.8%	18.0%	34.7%	36.8%	1.0%	2.3%

e. Experience a sense of adventure or challenge

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	415	0.5%	2.9%	16.4%	34.0%	43.4%	0.2%	2.7%
GRCA Hermit	583	1.2%	4.3%	18.5%	35.2%	38.3%	0.2%	2.4%
GRCA Tusayan Ruins	400	18.0%	16.5%	24.5%	15.8%	8.8%	8.3%	8.3%
BRCA Fairyland	1079	3.2%	10.8%	27.3%	33.2%	22.5%	1.3%	1.7%
ZION West Rim	308	1.0%	5.8%	19.8%	36.0%	34.7%	0.3%	2.3%
ZION Taylor Creek	453	2.9%	13.5%	35.3%	26.3%	19.2%	0.7%	2.2%
GLAC Sperry	912	2.0%	10.2%	23.7%	34.0%	27.4%	0.9%	1.9%
GLAC Hidden Lake	516	2.3%	9.9%	23.8%	34.3%	25.4%	2.1%	2.1%

Table A-7. Did you HEAR airplanes, jets, helicopters, or any other aircraft during this visit to <site>?

Location	Sample Size	Yes	No	No Response
GRCA Grandview	415	53.3%	46.3%	0.5%
GRCA Hermit	583	84.9%	14.9%	0.2%
GRCA Tusayan Ruins	400	38.8%	61.3%	0.0%
BRCA Fairyland	1079	42.2%	56.2%	1.4%
ZION West Rim	308	48.1%	51.0%	1.0%
ZION Taylor Creek	453	28.5%	71.3%	0.2%
GLAC Sperry	912	79.1%	19.8%	1.1%
GLAC Hidden Lake	516	80.6%	19.0%	0.4%

Table A-8. During this visit to <site>, how much did noise from airplanes, jets, helicopters, or other aircraft bother, disturb, or annoy you?*

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	No Response
GRCA Grandview	221	23.5%	29.9%	18.6%	8.6%	6.8%	12.7%
GRCA Hermit	495	14.5%	23.8%	25.1%	17.4%	13.1%	6.1%
GRCA Tusayan Ruins	155	41.3%	33.5%	18.1%	6.5%	0.6%	0.0%
BRCA Fairyland	455	43.5%	37.6%	11.9%	3.5%	1.5%	2.0%
ZION West Rim	148	45.3%	31.8%	16.2%	6.1%	0.7%	0.0%
ZION Taylor Creek	129	51.9%	27.9%	13.2%	3.9%	1.6%	1.6%
GLAC Sperry	193	37.8%	33.2%	15.0%	4.7%	9.3%	0.0%
GLAC Hidden Lake	113	43.4%	28.3%	18.6%	5.3%	4.4%	0.0%

* This question appeared only for those visitors who reported hearing aircraft.

Table A-9. How much did the sounds from aircraft interfere with each of the following aspects of this visit to <site>?[†]

a. Enjoyment of the site

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	153	26.1%	22.2%	11.8%	13.1%	6.5%	1.3%	19.0%
GRCA Hermit	332	18.4%	25.6%	22.3%	15.4%	8.1%	3.6%	6.6%
GRCA Tusayan Ruins	86	44.2%	22.1%	10.5%	5.8%	4.7%	11.6%	1.2%
BRCA Fairyland	310	37.4%	28.4%	14.8%	6.8%	3.9%	3.9%	4.8%
ZION West Rim	98	45.9%	26.5%	9.2%	3.1%	4.1%	11.2%	0.0%
ZION Taylor Creek	89	51.7%	25.8%	10.1%	3.4%	2.2%	3.4%	3.4%
GLAC Sperry	498	41.0%	26.1%	18.1%	5.4%	5.8%	3.6%	0.0%
GLAC Hidden Lake	273	34.4%	30.4%	19.4%	4.8%	5.1%	4.8%	1.1%

b. Appreciation of the natural quiet and sounds of nature at the site?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	153	16.3%	31.4%	14.4%	11.8%	13.7%	0.7%	11.8%
GRCA Hermit	332	9.0%	19.6%	19.6%	22.0%	23.2%	2.1%	4.5%
GRCA Tusayan Ruins	86	32.6%	25.6%	17.4%	11.6%	3.5%	9.3%	0.0%
BRCA Fairyland	310	26.1%	29.4%	19.7%	12.6%	5.2%	2.3%	4.8%
ZION West Rim	98	36.7%	26.5%	15.3%	6.1%	6.1%	9.2%	0.0%
ZION Taylor Creek	89	37.1%	31.5%	12.4%	7.9%	3.4%	4.5%	3.4%
GLAC Sperry	498	24.3%	27.1%	23.9%	10.8%	11.4%	2.4%	0.0%
GLAC Hidden Lake	273	20.5%	34.4%	19.8%	10.3%	10.3%	4.4%	0.4%

c. Appreciation of the historical and cultural significance of the site?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	153	28.8%	19.0%	11.8%	5.2%	3.9%	6.5%	24.8%
GRCA Hermit	332	28.3%	16.9%	16.9%	9.6%	6.0%	10.5%	11.7%
GRCA Tusayan Ruins	86	50.0%	17.4%	10.5%	5.8%	2.3%	14.0%	0.0%
BRCA Fairyland	310	45.2%	23.5%	8.7%	5.5%	2.3%	9.7%	5.2%
ZION West Rim	98	53.1%	13.3%	10.2%	3.1%	2.0%	18.4%	0.0%
ZION Taylor Creek	89	58.4%	18.0%	5.6%	4.5%	1.1%	9.0%	3.4%
GLAC Sperry	498	48.4%	16.9%	9.6%	3.8%	3.8%	16.9%	0.6%
GLAC Hidden Lake	273	49.1%	16.5%	9.5%	4.4%	4.0%	16.1%	0.4%

[†] This question was presented only to those visitors who reported hearing aircraft in the HR1 and HR2 surveys. Options d through l were presented only in the HR1 survey.

Table A-9 (continued). How much did the sounds from aircraft interfere with each of the following aspects of this visit to <site>?

d. Experiencing a sense of connection to the history, events, or people commemorated here?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	26.0%	23.4%	9.1%	3.9%	6.5%	11.7%	19.5%
GRCA Hermit	172	24.4%	18.0%	20.3%	8.7%	4.1%	12.2%	12.2%
GRCA Tusayan Ruins	42	50.0%	21.4%	9.5%	4.8%	2.4%	9.5%	2.4%
BRCA Fairyland	160	53.1%	15.6%	6.3%	3.1%	0.6%	21.3%	0.0%
ZION West Rim	47	63.8%	10.6%	8.5%	2.1%	0.0%	14.9%	0.0%
ZION Taylor Creek	51	54.9%	13.7%	9.8%	3.9%	0.0%	17.6%	0.0%
GLAC Sperry	282	47.5%	18.4%	9.2%	2.5%	3.5%	17.7%	1.1%
GLAC Hidden Lake	144	45.1%	18.1%	9.0%	2.8%	1.4%	21.5%	2.1%

e. Experiencing a sense of connection with nature?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	26.0%	28.6%	6.5%	9.1%	15.6%	1.3%	13.0%
GRCA Hermit	172	15.7%	18.6%	21.5%	17.4%	18.6%	4.1%	4.1%
GRCA Tusayan Ruins	42	38.1%	23.8%	14.3%	11.9%	2.4%	7.1%	2.4%
BRCA Fairyland	160	45.6%	23.8%	13.8%	7.5%	4.4%	5.0%	0.0%
ZION West Rim	47	51.1%	23.4%	10.6%	6.4%	2.1%	2.1%	4.3%
ZION Taylor Creek	51	45.1%	19.6%	19.6%	7.8%	2.0%	5.9%	0.0%
GLAC Sperry	282	29.8%	29.4%	18.8%	12.1%	7.8%	1.1%	1.1%
GLAC Hidden Lake	144	31.9%	22.2%	18.8%	15.3%	6.3%	3.5%	2.1%

f. Appreciating scenic beauty?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	32.5%	18.2%	9.1%	9.1%	11.7%	1.3%	18.2%
GRCA Hermit	172	24.4%	22.7%	18.6%	13.4%	8.7%	4.1%	8.1%
GRCA Tusayan Ruins	42	52.4%	11.9%	11.9%	11.9%	0.0%	9.5%	2.4%
BRCA Fairyland	160	62.5%	18.1%	8.1%	3.8%	3.1%	4.4%	0.0%
ZION West Rim	47	66.0%	10.6%	10.6%	4.3%	2.1%	6.4%	0.0%
ZION Taylor Creek	51	49.0%	23.5%	17.6%	2.0%	2.0%	3.9%	2.0%
GLAC Sperry	282	48.2%	22.7%	13.5%	6.7%	6.4%	1.4%	1.1%
GLAC Hidden Lake	144	44.4%	22.9%	13.9%	9.7%	4.2%	3.5%	1.4%

Table A-9 (continued). How much did the sounds from aircraft interfere with each of the following aspects of this visit to <site>?

g. Experiencing a feeling of calmness, peace, or tranquility?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	19.5%	26.0%	13.0%	9.1%	16.9%	1.3%	14.3%
GRCA Hermit	172	11.0%	18.6%	27.3%	16.9%	18.0%	4.1%	4.1%
GRCA Tusayan Ruins	42	35.7%	26.2%	7.1%	19.0%	0.0%	9.5%	2.4%
BRCA Fairyland	160	38.8%	33.1%	15.6%	5.6%	3.8%	3.1%	0.0%
ZION West Rim	47	51.1%	25.5%	12.8%	6.4%	0.0%	4.3%	0.0%
ZION Taylor Creek	51	41.2%	25.5%	15.7%	9.8%	2.0%	3.9%	2.0%
GLAC Sperry	282	31.2%	28.0%	16.7%	12.4%	8.5%	1.8%	1.4%
GLAC Hidden Lake	144	26.4%	27.8%	17.4%	16.0%	6.9%	3.5%	2.1%

h. Experiencing a sense of adventure or challenge?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	36.4%	18.2%	10.4%	6.5%	6.5%	1.3%	20.8%
GRCA Hermit	172	30.8%	19.2%	19.2%	11.0%	3.5%	6.4%	9.9%
GRCA Tusayan Ruins	42	47.6%	14.3%	16.7%	2.4%	0.0%	16.7%	2.4%
BRCA Fairyland	160	65.0%	11.9%	8.8%	3.1%	1.3%	9.4%	0.6%
ZION West Rim	47	66.0%	8.5%	12.8%	4.3%	0.0%	6.4%	2.1%
ZION Taylor Creek	51	56.9%	15.7%	11.8%	5.9%	0.0%	9.8%	0.0%
GLAC Sperry	282	60.3%	12.8%	12.1%	4.3%	4.3%	5.7%	0.7%
GLAC Hidden Lake	144	52.1%	18.1%	11.8%	6.3%	2.1%	8.3%	1.4%

i. Hearing something said during a ranger talk, campfire program, or other ranger-led activity?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	14.3%	5.2%	2.6%	0.0%	2.6%	37.7%	37.7%
GRCA Hermit	172	13.4%	2.9%	4.1%	1.2%	0.6%	55.2%	22.7%
GRCA Tusayan Ruins	42	42.9%	4.8%	4.8%	2.4%	0.0%	40.5%	4.8%
BRCA Fairyland	160	28.8%	1.3%	1.3%	0.6%	0.0%	68.1%	0.0%
ZION West Rim	47	34.0%	2.1%	4.3%	0.0%	0.0%	59.6%	0.0%
ZION Taylor Creek	51	21.6%	5.9%	0.0%	0.0%	0.0%	72.5%	0.0%
GLAC Sperry	282	26.6%	2.5%	2.5%	0.7%	2.5%	64.2%	1.1%
GLAC Hidden Lake	144	19.4%	4.2%	0.0%	1.4%	0.7%	70.1%	4.2%

Table A-9 (continued). How much did the sounds from aircraft interfere with each of the following aspects of this visit to <site>?

j. Hearing any other performance, talk, or group presentation?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	77	13.0%	5.2%	3.9%	0.0%	2.6%	36.4%	39.0%
GRCA Hermit	172	13.4%	3.5%	4.1%	2.3%	1.7%	52.9%	22.1%
GRCA Tusayan Ruins	42	35.7%	7.1%	4.8%	0.0%	0.0%	45.2%	7.1%
BRCA Fairyland	160	29.4%	3.1%	2.5%	0.6%	0.0%	64.4%	0.0%
ZION West Rim	47	36.2%	2.1%	2.1%	0.0%	0.0%	59.6%	0.0%
ZION Taylor Creek	51	29.4%	2.0%	0.0%	0.0%	0.0%	68.6%	0.0%
GLAC Sperry	282	28.0%	2.8%	2.5%	0.7%	1.8%	62.8%	1.4%
GLAC Hidden Lake	144	20.1%	2.8%	0.0%	1.4%	0.7%	70.8%	4.2%

k. Appreciating natural sounds at night?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	34	0.0%	20.6%	5.9%	5.9%	14.7%	0.0%	52.9%
GRCA Hermit	44	0.0%	9.1%	11.4%	6.8%	4.5%	0.0%	68.2%
GRCA Tusayan Ruins	NA							
BRCA Fairyland	NA							
ZION West Rim	27	55.6%	11.1%	11.1%	11.1%	0.0%	11.1%	0.0%
ZION Taylor Creek	NA							
GLAC Sperry	141	64.5%	11.3%	5.7%	4.3%	5.0%	9.2%	0.0%
GLAC Hidden Lake	NA							

l. Sleeping at night?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	Not Relevant	No Resp
GRCA Grandview	34	0.0%	5.9%	0.0%	0.0%	0.0%	0.0%	94.1%
GRCA Hermit	44	0.0%	11.4%	0.0%	0.0%	0.0%	0.0%	88.6%
GRCA Tusayan Ruins	NA							
BRCA Fairyland	NA							
ZION West Rim	27	74.1%	7.4%	0.0%	0.0%	0.0%	7.4%	11.1%
ZION Taylor Creek	NA							
GLAC Sperry	141	78.0%	5.0%	0.0%	0.0%	0.0%	8.5%	8.5%
GLAC Hidden Lake	NA							

Table A-10. How acceptable or unacceptable was the sound from aircraft that you heard during this visit to <site>?[*]

Location	Sample Size	Extremely unaccept-able	Very unaccept-able	Moderately unaccept-able	Slightly unaccept-able	Neutral	Slightly acceptable	Moderately acceptable	Very acceptable	Extremely acceptable	No resp
GRCA Grandview	153	11.8%	7.2%	11.8%	15.7%	20.3%	8.5%	15.0%	7.2%	2.0%	0.7%
GRCA Hermit	332	15.4%	16.0%	17.2%	12.7%	16.0%	7.2%	6.0%	7.2%	2.4%	0.0%
GRCA Tusayan Ruins	86	0.0%	5.8%	9.3%	17.4%	25.6%	9.3%	11.6%	14.0%	4.7%	2.3%
BRCA Fairyland	310	3.2%	2.9%	8.7%	12.3%	29.0%	9.7%	13.2%	15.5%	5.2%	0.3%
ZION West Rim	98	0.0%	5.1%	11.2%	13.3%	29.6%	4.1%	15.3%	17.3%	4.1%	0.0%
ZION Taylor Creek	89	3.4%	4.5%	7.9%	23.6%	29.2%	4.5%	7.9%	10.1%	7.9%	1.1%
GLAC Sperry	498	7.8%	7.6%	13.1%	17.7%	22.3%	7.2%	10.6%	8.4%	4.4%	0.8%
GLAC Hidden Lake	273	6.6%	7.0%	15.4%	17.6%	20.9%	8.1%	13.9%	6.2%	2.9%	1.5%

[*] This question was presented to only those visitors who reported hearing aircraft in the HR1 and HR2 surveys.

Table A-11. Did you SEE airplanes, jets, helicopters, or any other aircraft during this visit to <site>?

Location	Sample Size	Yes	No	No Response
GRCA Grandview	139	48.2%	50.4%	0.7%
GRCA Hermit	205	83.4%	16.1%	0.5%
GRCA Tusayan Ruins	129	12.4%	86.0%	1.6%
BRCA Fairyland	357	46.8%	51.8%	0.3%
ZION West Rim	103	47.6%	51.5%	2.9%
ZION Taylor Creek	163	23.9%	74.2%	1.8%
GLAC Sperry	336	57.4%	42.0%	0.6%
GLAC Hidden Lake	172	65.7%	33.1%	1.2%

Table A-12. During this visit to <site> did seeing aircraft bother, disturb or annoy you?

Location	Sample Size	Not At All	Slightly	Moderately	Very	Extremely	No Response
GRCA Grandview	67	25.4%	23.9%	9.0%	9.0%	10.4%	22.4%
GRCA Hermit	171	28.1%	21.6%	19.9%	12.3%	10.5%	7.6%
GRCA Tusayan Ruins	16	43.8%	31.3%	25.0%	0.0%	0.0%	0.0%
BRCA Fairyland	167	71.3%	18.0%	7.2%	3.0%	1.2%	0.0%
ZION West Rim	49	65.3%	28.6%	4.1%	0.0%	0.0%	2.0%
ZION Taylor Creek	39	79.5%	10.3%	7.7%	0.0%	2.6%	0.0%
GLAC Sperry	193	37.8%	33.2%	15.0%	4.7%	9.3%	0.0%
GLAC Hidden Lake	113	43.4%	28.3%	18.6%	5.3%	4.4%	0.0%

Table A-13. Which of the following sounds did you hear during this visit to <site>?

Sound	Location	Sample Size	Percent	No Response
Insect sounds	GRCA Grandview	150	74.0%	26.0%
Insect sounds	GRCA Hermit	182	56.6%	43.4%
Insect sounds	GRCA Tusayan Ruins	128	9.4%	90.6%
Insect sounds	BRCA Fairyland	374	63.4%	36.4%
Insect sounds	ZION West Rim	100	84.0%	16.0%
Insect sounds	ZION Taylor Creek	156	82.1%	17.9%
Insect sounds	GLAC Sperry	291	72.5%	27.5%
Insect sounds	GLAC Hidden Lake	166	54.2%	45.8%
Bird or animal sounds	GRCA Grandview	150	94.7%	5.3%
Bird or animal sounds	GRCA Hermit	182	90.7%	9.3%
Bird or animal sounds	GRCA Tusayan Ruins	128	62.5%	37.5%
Bird or animal sounds	BRCA Fairyland	374	90.9%	9.1%
Bird or animal sounds	ZION West Rim	100	92.0%	8.0%
Bird or animal sounds	ZION Taylor Creek	156	96.2%	3.8%
Bird or animal sounds	GLAC Sperry	291	85.9%	14.1%
Bird or animal sounds	GLAC Hidden Lake	166	80.7%	19.3%
Waterfalls, running water, or waves	GRCA Grandview	150	30.7%	69.3%
Waterfalls, running water, or waves	GRCA Hermit	182	44.5%	55.5%
Waterfalls, running water, or waves	GRCA Tusayan Ruins	128	5.5%	94.5%
Waterfalls, running water, or waves	BRCA Fairyland	374	19.0%	81.0%
Waterfalls, running water, or waves	ZION West Rim	100	77.0%	23.0%
Waterfalls, running water, or waves	ZION Taylor Creek	156	95.5%	4.5%
Waterfalls, running water, or waves	GLAC Sperry	291	97.9%	2.1%
Waterfalls, running water, or waves	GLAC Hidden Lake	166	94.0%	6.0%
Wind, rain, or thunder	GRCA Grandview	150	71.3%	28.7%
Wind, rain, or thunder	GRCA Hermit	182	74.7%	25.3%
Wind, rain, or thunder	GRCA Tusayan Ruins	128	55.5%	44.5%
Wind, rain, or thunder	BRCA Fairyland	374	72.7%	27.3%
Wind, rain, or thunder	ZION West Rim	100	71.0%	29.0%
Wind, rain, or thunder	ZION Taylor Creek	156	54.5%	45.5%
Wind, rain, or thunder	GLAC Sperry	291	52.6%	47.4%
Wind, rain, or thunder	GLAC Hidden Lake	166	56.6%	43.4%
Group of people talking	GRCA Grandview	150	86.7%	13.3%
Group of people talking	GRCA Hermit	182	78.6%	21.4%
Group of people talking	GRCA Tusayan Ruins	128	78.9%	21.1%
Group of people talking	BRCA Fairyland	374	74.3%	25.7%
Group of people talking	ZION West Rim	100	65.0%	35.0%
Group of people talking	ZION Taylor Creek	156	80.1%	19.9%
Group of people talking	GLAC Sperry	291	75.6%	24.4%
Group of people talking	GLAC Hidden Lake	166	83.1%	16.9%

Table A-13 (continued). Which of the following sounds did you hear during this visit to <site >?

Sound	Location	Sample Size	Percent	No Response
Someone's radio, TV, iPod, or other audio device	GRCA Grandview	150	3.3%	96.7%
Someone's radio, TV, iPod, or other audio device	GRCA Hermit	182	8.8%	91.2%
Someone's radio, TV, iPod, or other audio device	GRCA Tusayan Ruins	128	3.1%	96.9%
Someone's radio, TV, iPod, or other audio device	BRCA Fairyland	374	9.1%	90.9%
Someone's radio, TV, iPod, or other audio device	ZION West Rim	100	3.0%	97.0%
Someone's radio, TV, iPod, or other audio device	ZION Taylor Creek	156	3.8%	96.2%
Someone's radio, TV, iPod, or other audio device	GLAC Sperry	291	7.2%	92.8%
Someone's radio, TV, iPod, or other audio device	GLAC Hidden Lake	166	12.0%	88.0%
Cars or trucks in a parking lot	GRCA Grandview	150	11.3%	88.7%
Cars or trucks in a parking lot	GRCA Hermit	182	4.9%	95.1%
Cars or trucks in a parking lot	GRCA Tusayan Ruins	128	47.7%	52.3%
Cars or trucks in a parking lot	BRCA Fairyland	374	12.0%	88.0%
Cars or trucks in a parking lot	ZION West Rim	100	7.0%	93.0%
Cars or trucks in a parking lot	ZION Taylor Creek	156	3.2%	96.8%
Cars or trucks in a parking lot	GLAC Sperry	291	6.5%	93.5%
Cars or trucks in a parking lot	GLAC Hidden Lake	166	32.5%	67.5%
Cars or trucks on a road or highway	GRCA Grandview	150	4.7%	95.3%
Cars or trucks on a road or highway	GRCA Hermit	182	3.3%	96.7%
Cars or trucks on a road or highway	GRCA Tusayan Ruins	128	46.9%	53.1%
Cars or trucks on a road or highway	BRCA Fairyland	374	10.7%	89.3%
Cars or trucks on a road or highway	ZION West Rim	100	16.0%	84.0%
Cars or trucks on a road or highway	ZION Taylor Creek	156	5.8%	94.2%
Cars or trucks on a road or highway	GLAC Sperry	291	11.0%	89.0%
Cars or trucks on a road or highway	GLAC Hidden Lake	166	22.3%	77.7%
Airplanes, jets, helicopters, or other aircraft	GRCA Grandview	150	51.3%	48.7%
Airplanes, jets, helicopters, or other aircraft	GRCA Hermit	182	84.6%	15.4%
Airplanes, jets, helicopters, or other aircraft	GRCA Tusayan Ruins	128	34.4%	65.6%
Airplanes, jets, helicopters, or other aircraft	BRCA Fairyland	374	40.1%	59.4%
Airplanes, jets, helicopters, or other aircraft	ZION West Rim	100	51.0%	49.0%
Airplanes, jets, helicopters, or other aircraft	ZION Taylor Creek	156	24.4%	75.6%
Airplanes, jets, helicopters, or other aircraft	GLAC Sperry	291	74.2%	25.8%
Airplanes, jets, helicopters, or other aircraft	GLAC Hidden Lake	166	77.7%	22.3%

Table A-13 (continued). Which of the following sounds did you hear during this visit to <site>?

Sound	Location	Sample Size	Percent	No Response
Motorboats or motorized watercraft	GRCA Grandview	150	2.7%	97.3%
Motorboats or motorized watercraft	GRCA Hermit	182	2.7%	97.3%
Motorboats or motorized watercraft	GRCA Tusayan Ruins	128	0.8%	99.2%
Motorboats or motorized watercraft	BRCA Fairyland	374	5.3%	94.7%
Motorboats or motorized watercraft	ZION West Rim	100	1.0%	99.0%
Motorboats or motorized watercraft	ZION Taylor Creek	156	2.6%	97.4%
Motorboats or motorized watercraft	GLAC Sperry	291	3.1%	96.9%
Motorboats or motorized watercraft	GLAC Hidden Lake	166	1.2%	98.8%
None of the above	GRCA Grandview	150	0.7%	99.3%
None of the above	GRCA Hermit	182	0.0%	100.0%
None of the above	GRCA Tusayan Ruins	128	0.8%	99.2%
None of the above	BRCA Fairyland	374	0.8%	99.2%
None of the above	ZION West Rim	100	0.0%	100.0%
None of the above	ZION Taylor Creek	156	0.0%	100.0%
None of the above	GLAC Sperry	291	0.0%	100.0%
None of the above	GLAC Hidden Lake	166	0.0%	100.0%

Table A-14. How acceptable or unacceptable were these sounds during this visit to <site>?

a. Insect Sounds

Location	Sample Size	Extremely Unacceptable	Very Unacceptable	Moderately Unacceptable	Slightly Unacceptable	Neutral	Slightly Acceptable	Moderately acceptable	Very Acceptable	Extremely Acceptable	No Resp
GRCA Grandview	111	0.9%	0.0%	0.9%	2.7%	9.9%	7.2%	14.4%	29.7%	33.3%	0.9%
GRCA Hermit	108	0.0%	0.0%	0.0%	1.9%	11.1%	2.8%	13.9%	31.5%	38.9%	0.0%
GRCA Tusayan Ruins	12	0.0%	0.0%	0.0%	0.0%	8.3%	0.0%	25.0%	33.3%	33.3%	0.0%
BRCA Fairyland	237	0.0%	0.4%	0.8%	0.8%	12.7%	3.0%	19.8%	35.4%	25.3%	1.7%
ZION West Rim	84	0.0%	2.4%	3.6%	2.4%	16.7%	7.1%	6.0%	32.1%	25.0%	4.8%
ZION Taylor Creek	128	0.0%	3.1%	1.6%	2.3%	12.5%	2.3%	14.1%	33.6%	29.7%	0.8%
GLAC Sperry	211	1.9%	2.4%	4.3%	6.6%	13.3%	8.1%	13.3%	28.4%	19.9%	1.9%
GLAC Hidden Lake	90	1.1%	0.0%	1.1%	3.3%	23.3%	8.9%	18.9%	18.9%	22.2%	2.2%

b. Bird or animal sounds

Location	Sample Size	Extremely Unacceptable	Very Unacceptable	Moderately Unacceptable	Slightly Unacceptable	Neutral	Slightly Acceptable	Moderately acceptable	Very Acceptable	Extremely Acceptable	No Resp
GRCA Grandview	142	0.0%	0.0%	0.0%	0.7%	4.2%	2.1%	9.2%	27.5%	56.3%	0.0%
GRCA Hermit	173	0.0%	0.6%	0.0%	0.0%	2.9%	0.6%	8.1%	30.6%	57.2%	0.0%
GRCA Tusayan Ruins	81	1.2%	1.2%	0.0%	1.2%	2.5%	2.5%	8.6%	42.0%	39.5%	1.2%
BRCA Fairyland	340	0.9%	0.9%	0.0%	0.3%	1.5%	1.5%	7.9%	35.3%	47.1%	4.7%
ZION West Rim	92	0.0%	0.0%	0.0%	0.0%	2.2%	0.0%	8.7%	34.8%	53.3%	1.1%
ZION Taylor Creek	150	0.0%	0.0%	0.0%	0.0%	2.0%	0.7%	4.0%	34.7%	58.0%	0.7%
GLAC Sperry	250	0.4%	0.4%	0.4%	0.4%	2.0%	1.6%	7.6%	31.6%	52.4%	3.2%
GLAC Hidden Lake	134	0.7%	0.7%	0.0%	0.7%	6.7%	3.0%	8.2%	27.6%	49.3%	3.0%

Table A-14 (continued). How acceptable or unacceptable were these sounds during this visit to <site>?

c. Waterfalls, running water, or waves

Location	Sample Size	Extremely Unaccept-able	Very Unaccept-able	Moderately Unaccept-able	Slightly Unaccept-able	Neutral	Slightly Acceptable	Moderately acceptable	Very Accept-able	Extremely Acceptable	No Resp
GRCA Grandview	45	0.0%	2.2%	2.2%	0.0%	2.2%	0.0%	4.4%	22.2%	64.4%	2.2%
GRCA Hermit	87	1.1%	1.1%	0.0%	0.0%	1.1%	2.3%	8.0%	27.6%	58.6%	0.0%
GRCA Tusayan Ruins	7	0.0%	0.0%	0.0%	0.0%	28.6%	0.0%	28.6%	14.3%	28.6%	0.0%
BRCA Fairyland	71	1.4%	0.0%	0.0%	0.0%	11.3%	4.2%	9.9%	26.8%	40.8%	5.6%
ZION West Rim	77	0.0%	0.0%	0.0%	0.0%	2.6%	0.0%	5.2%	32.5%	55.8%	3.9%
ZION Taylor Creek	149	0.0%	0.0%	0.7%	0.0%	0.7%	0.0%	2.0%	22.1%	72.5%	2.0%
GLAC Sperry	285	0.7%	0.4%	0.0%	0.0%	0.4%	0.4%	3.2%	26.7%	67.7%	0.7%
GLAC Hidden Lake	156	1.9%	0.0%	0.6%	0.0%	1.3%	1.3%	4.5%	28.2%	60.3%	1.9%

d. Wind, rain, or thunder

Location	Sample Size	Extremely Unaccept-able	Very Unaccept-able	Moderately Unaccept-able	Slightly Unaccept-able	Neutral	Slightly Acceptable	Moderately acceptable	Very Accept-able	Extremely Acceptable	No Resp
GRCA Grandview	106	0.9%	0.0%	1.9%	0.0%	7.5%	2.8%	17.0%	42.5%	26.4%	0.9%
GRCA Hermit	140	0.7%	0.0%	0.7%	2.1%	5.0%	3.6%	11.4%	36.4%	39.3%	0.7%
GRCA Tusayan Ruins	71	1.4%	0.0%	1.4%	1.4%	11.3%	0.0%	11.3%	40.8%	32.4%	0.0%
BRCA Fairyland	272	0.4%	0.0%	0.0%	0.4%	5.1%	2.2%	11.0%	38.2%	37.9%	4.8%
ZION West Rim	71	0.0%	0.0%	0.0%	0.0%	5.6%	0.0%	9.9%	33.8%	47.9%	2.8%
ZION Taylor Creek	85	0.0%	0.0%	0.0%	0.0%	2.4%	3.5%	4.7%	34.1%	52.9%	2.4%
GLAC Sperry	153	0.7%	1.3%	0.7%	0.0%	7.8%	1.3%	9.2%	34.6%	43.8%	0.7%
GLAC Hidden Lake	94	1.1%	1.1%	0.0%	2.1%	6.4%	4.3%	16.0%	28.7%	35.1%	5.3%

Table A-14 (continued). How acceptable or unacceptable were these sounds during this visit to <site>?

e. Group of people talking

Location	Sample Size	Extremely Unacceptable	Very Unacceptable	Moderately Unacceptable	Slightly Unacceptable	Neutral	Slightly Acceptable	Moderately acceptable	Very Acceptable	Extremely Acceptable	No Resp
GRCA Grandview	129	0.8%	1.6%	2.3%	10.1%	27.1%	7.8%	17.8%	23.3%	9.3%	0.0%
GRCA Hermit	151	0.7%	0.0%	2.0%	6.0%	33.1%	6.6%	18.5%	24.5%	8.6%	0.0%
GRCA Tusayan Ruins	101	0.0%	1.0%	2.0%	6.9%	27.7%	9.9%	25.7%	21.8%	4.0%	1.0%
BRCA Fairyland	278	1.1%	1.4%	2.5%	7.9%	24.1%	10.4%	22.7%	23.7%	4.0%	2.2%
ZION West Rim	65	0.0%	0.0%	4.6%	7.7%	41.5%	6.2%	12.3%	16.9%	7.7%	3.1%
ZION Taylor Creek	125	0.8%	0.8%	1.6%	4.8%	27.2%	8.0%	24.0%	23.2%	6.4%	3.2%
GLAC Sperry	220	0.9%	0.9%	0.9%	1.4%	27.7%	8.2%	28.6%	25.9%	4.1%	1.4%
GLAC Hidden Lake	138	0.7%	3.6%	7.2%	10.9%	26.1%	8.0%	16.7%	18.8%	5.1%	2.9%

f. Someone's radio, TV, iPod, or other audio device

Location	Sample Size	Extremely Unacceptable	Very Unacceptable	Moderately Unacceptable	Slightly Unacceptable	Neutral	Slightly Acceptable	Moderately acceptable	Very Acceptable	Extremely Acceptable	No Resp
GRCA Grandview	5	0.0%	0.0%	0.0%	20.0%	20.0%	0.0%	20.0%	20.0%	0.0%	20.0%
GRCA Hermit	16	12.5%	12.5%	6.3%	12.5%	12.5%	6.3%	12.5%	6.3%	0.0%	18.8%
GRCA Tusayan Ruins	4	0.0%	0.0%	0.0%	0.0%	75.0%	0.0%	0.0%	25.0%	0.0%	0.0%
BRCA Fairyland	34	20.6%	8.8%	2.9%	0.0%	32.4%	2.9%	5.9%	2.9%	14.7%	8.8%
ZION West Rim	3	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	0.0%	0.0%	0.0%	33.3%
ZION Taylor Creek	6	16.7%	0.0%	16.7%	33.3%	16.7%	0.0%	0.0%	0.0%	16.7%	0.0%
GLAC Sperry	21	4.8%	9.5%	19.0%	33.3%	19.0%	0.0%	9.5%	0.0%	0.0%	4.8%
GLAC Hidden Lake	20	30.0%	10.0%	5.0%	15.0%	15.0%	10.0%	0.0%	0.0%	15.0%	0.0%

Table A-14 (continued). How acceptable or unacceptable were these sounds during this visit to <site>?

g. Cars or trucks in a parking lot

Location	Sample Size	Extremely Unaccept-able	Very Unaccept-able	Moderately Unaccept-able	Slightly Unaccept-able	Neutral	Slightly Acceptable	Moderately acceptable	Very Accept-able	Extremely Acceptable	No Resp
GRCA Grandview	17	5.9%	17.6%	17.6%	29.4%	5.9%	5.9%	17.6%	0.0%	0.0%	0.0%
GRCA Hermit	9	0.0%	0.0%	11.1%	22.2%	33.3%	22.2%	11.1%	0.0%	0.0%	0.0%
GRCA Tusayan Ruins	61	0.0%	3.3%	11.5%	16.4%	36.1%	11.5%	16.4%	3.3%	0.0%	1.6%
BRCA Fairyland	45	4.4%	2.2%	4.4%	13.3%	40.0%	4.4%	11.1%	8.9%	6.7%	4.4%
ZION West Rim	7	0.0%	0.0%	14.3%	14.3%	57.1%	14.3%	0.0%	0.0%	0.0%	0.0%
ZION Taylor Creek	5	0.0%	20.0%	0.0%	0.0%	40.0%	0.0%	0.0%	0.0%	20.0%	20.0 %
GLAC Sperry	19	0.0%	10.5%	10.5%	21.1%	42.1%	0.0%	5.3%	10.5%	0.0%	0.0%
GLAC Hidden Lake	54	7.4%	3.7%	7.4%	11.1%	42.6%	7.4%	13.0%	3.7%	3.7%	0.0%

h. Cars or trucks on a road or highway

Location	Sample Size	Extremely Unaccept-able	Very Unaccept-able	Moderately Unaccept-able	Slightly Unaccept-able	Neutral	Slightly Acceptable	Moderately acceptable	Very Accept-able	Extremely Acceptable	No Resp
GRCA Grandview	7	14.3%	0.0%	28.6%	14.3%	14.3%	0.0%	14.3%	0.0%	14.3%	0.0%
GRCA Hermit	6	0.0%	0.0%	16.7%	16.7%	33.3%	33.3%	0.0%	0.0%	0.0%	0.0%
GRCA Tusayan Ruins	59	1.7%	1.7%	8.5%	16.9%	37.3%	10.2%	15.3%	5.1%	0.0%	3.4%
BRCA Fairyland	40	7.5%	0.0%	10.0%	5.0%	35.0%	5.0%	20.0%	7.5%	5.0%	5.0%
ZION West Rim	16	6.3%	0.0%	12.5%	18.8%	18.8%	6.3%	31.3%	6.3%	0.0%	0.0%
ZION Taylor Creek	9	0.0%	0.0%	0.0%	33.3%	44.4%	11.1%	0.0%	0.0%	11.1%	0.0%
GLAC Sperry	32	0.0%	3.1%	25.0%	25.0%	31.3%	6.3%	3.1%	3.1%	0.0%	3.1%
GLAC Hidden Lake	37	2.7%	10.8%	16.2%	0.0%	43.2%	8.1%	10.8%	0.0%	8.1%	0.0%

Table A-14 (continued). How acceptable or unacceptable were these sounds during this visit to <site>?

i. Airplanes, jets, helicopters, or other aircraft

Location	Sample Size	Extremely Unaccept-able	Very Unaccept-able	Moderately Unaccept-able	Slightly Unaccept-able	Neutral	Slightly Acceptable	Moderately acceptable	Very Accept-able	Extremely Acceptable	No Resp
GRCA Grandview	76	9.2%	9.2%	18.4%	13.2%	21.1%	6.6%	14.5%	6.6%	0.0%	1.3%
GRCA Hermit	160	11.9%	20.6%	16.9%	14.4%	15.6%	9.4%	5.6%	3.8%	1.9%	0.0%
GRCA Tusayan Ruins	44	0.0%	6.8%	9.1%	18.2%	31.8%	13.6%	13.6%	4.5%	0.0%	2.3%
BRCA Fairyland	150	4.7%	2.7%	8.7%	11.3%	34.0%	10.0%	13.3%	9.3%	5.3%	0.7%
ZION West Rim	51	0.0%	5.9%	13.7%	9.8%	29.4%	3.9%	19.6%	17.6%	0.0%	0.0%
ZION Taylor Creek	38	5.3%	2.6%	7.9%	23.7%	36.8%	7.9%	7.9%	2.6%	2.6%	2.6%
GLAC Sperry	216	9.3%	7.4%	13.9%	19.0%	24.5%	6.9%	9.3%	6.5%	1.9%	1.4%
GLAC Hidden Lake	129	7.0%	7.8%	16.3%	17.1%	19.4%	8.5%	15.5%	4.7%	2.3%	1.6%

j. Motorboats or motorized watercraft

Location	Sample Size	Extremely Unaccept-able	Very Unaccept-able	Moderately Unaccept-able	Slightly Unaccept-able	Neutral	Slightly Acceptable	Moderately acceptable	Very Accept-able	Extremely Acceptable	No Resp
GRCA Grandview	4	0.0%	25.0%	0.0%	50.0%	0.0%	0.0%	25.0%	0.0%	0.0%	0.0%
GRCA Hermit	5	0.0%	0.0%	0.0%	0.0%	40.0%	40.0%	0.0%	0.0%	20.0%	0.0%
GRCA Tusayan Ruins	1	0.0%	0.0%	0.0%	0.0%	100.0 %	0.0%	0.0%	0.0%	0.0%	0.0%
BRCA Fairyland	20	20.0%	0.0%	0.0%	0.0%	50.0%	5.0%	0.0%	5.0%	15.0%	5.0%
ZION West Rim	1	0.0%	0.0%	0.0%	0.0%	100.0 %	0.0%	0.0%	0.0%	0.0%	0.0%
ZION Taylor Creek	4	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	25.0%	25.0%	0.0%
GLAC Sperry	9	0.0%	11.1%	11.1%	0.0%	44.4%	11.1%	0.0%	0.0%	0.0%	22.2%
GLAC Hidden Lake	2	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%

Table A-15. How much did these sounds please or annoy you during this visit to < site >?

a. Insect Sounds

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	111	1.8%	0.9%	2.7%	9.0%	23.4%	4.5%	19.8%	18.9%	18.0%	0.9%
GRCA Hermit	108	0.0%	0.0%	0.0%	7.4%	17.6%	8.3%	20.4%	21.3%	25.0%	0.0%
GRCA Tusayan Ruins	12	0.0%	0.0%	0.0%	0.0%	16.7%	0.0%	33.3%	16.7%	33.3%	0.0%
BRCA Fairyland	237	0.4%	1.3%	2.1%	3.4%	19.4%	5.9%	18.1%	30.0%	14.3%	5.1%
ZION West Rim	84	0.0%	7.1%	9.5%	6.0%	23.8%	4.8%	9.5%	20.2%	15.5%	3.6%
ZION Taylor Creek	128	3.1%	1.6%	3.9%	7.0%	23.4%	6.3%	10.2%	21.9%	19.5%	3.1%
GLAC Sperry	211	2.4%	4.7%	6.6%	17.1%	17.5%	6.6%	13.3%	16.1%	14.2%	1.4%
GLAC Hidden Lake	90	0.0%	0.0%	2.2%	10.0%	31.1%	8.9%	7.8%	17.8%	15.6%	6.7%

b. Bird or animal sounds

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	142	0.0%	0.0%	0.0%	0.0%	7.7%	2.1%	11.3%	29.6%	48.6%	0.7%
GRCA Hermit	173	0.0%	0.0%	0.0%	0.6%	6.4%	1.7%	11.0%	35.3%	45.1%	0.0%
GRCA Tusayan Ruins	81	1.2%	0.0%	0.0%	0.0%	9.9%	8.6%	9.9%	38.3%	30.9%	1.2%
BRCA Fairyland	340	0.0%	0.3%	0.0%	0.3%	3.2%	3.8%	11.2%	34.7%	39.7%	6.8%
ZION West Rim	92	0.0%	0.0%	0.0%	1.1%	6.5%	1.1%	12.0%	31.5%	46.7%	1.1%
ZION Taylor Creek	150	0.0%	0.0%	0.0%	0.0%	2.7%	2.7%	12.0%	37.3%	42.0%	3.3%
GLAC Sperry	250	0.0%	0.4%	0.4%	0.4%	4.0%	2.8%	9.6%	30.4%	48.8%	3.2%
GLAC Hidden Lake	134	0.0%	0.0%	0.0%	0.0%	6.7%	0.7%	13.4%	28.4%	44.0%	6.7%

Table A-15 (continued). How much did these sounds please or annoy you during this visit to < site >?

c. Waterfalls, running water, or waves

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	45	0.0%	2.2%	4.4%	0.0%	2.2%	0.0%	4.4%	24.4%	60.0%	2.2%
GRCA Hermit	87	0.0%	1.1%	0.0%	0.0%	3.4%	1.1%	6.9%	36.8%	50.6%	0.0%
GRCA Tusayan Ruins	7	0.0%	0.0%	0.0%	0.0%	28.6%	14.3%	0.0%	28.6%	28.6%	0.0%
BRCA Fairyland	71	0.0%	0.0%	0.0%	0.0%	15.5%	1.4%	12.7%	23.9%	35.2%	11.3%
ZION West Rim	77	0.0%	0.0%	0.0%	0.0%	3.9%	0.0%	9.1%	31.2%	53.2%	2.6%
ZION Taylor Creek	149	0.0%	0.7%	0.0%	0.0%	2.7%	1.3%	2.7%	22.8%	65.1%	4.7%
GLAC Sperry	285	0.4%	0.0%	0.0%	0.7%	2.5%	0.7%	3.5%	29.1%	60.4%	2.8%
GLAC Hidden Lake	156	0.0%	0.0%	0.6%	0.0%	3.8%	0.6%	3.2%	26.9%	59.0%	5.8%

d. Wind, rain, or thunder

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	106	0.9%	0.0%	3.8%	3.8%	17.0%	2.8%	14.2%	38.7%	17.0%	1.9%
GRCA Hermit	140	0.7%	1.4%	0.0%	5.0%	16.4%	7.1%	18.6%	20.0%	30.0%	0.7%
GRCA Tusayan Ruins	71	0.0%	1.4%	1.4%	2.8%	22.5%	8.5%	14.1%	23.9%	25.4%	0.0%
BRCA Fairyland	272	0.0%	0.0%	0.4%	1.5%	12.9%	2.2%	15.4%	30.5%	29.8%	7.4%
ZION West Rim	71	0.0%	0.0%	0.0%	0.0%	7.0%	8.5%	18.3%	26.8%	38.0%	1.4%
ZION Taylor Creek	85	0.0%	0.0%	0.0%	0.0%	9.4%	1.2%	12.9%	27.1%	45.9%	3.5%
GLAC Sperry	153	0.7%	0.0%	0.7%	0.7%	13.7%	3.3%	13.7%	28.8%	36.6%	2.0%
GLAC Hidden Lake	94	0.0%	1.1%	0.0%	1.1%	16.0%	3.2%	13.8%	27.7%	30.9%	6.4%

Table A-15 (continued). How much did these sounds please or annoy you during this visit to < site >?

e. Group of people talking

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	129	0.8%	0.8%	4.7%	14.7%	51.9%	7.8%	10.1%	4.7%	4.7%	0.0%
GRCA Hermit	151	1.3%	0.0%	2.0%	12.6%	55.6%	9.3%	9.9%	5.3%	4.0%	0.0%
GRCA Tusayan Ruins	101	0.0%	1.0%	5.0%	11.9%	51.5%	7.9%	18.8%	2.0%	2.0%	0.0%
BRCA Fairyland	278	0.7%	2.5%	2.5%	13.7%	50.0%	6.1%	12.2%	5.4%	0.4%	6.5%
ZION West Rim	65	0.0%	1.5%	3.1%	20.0%	56.9%	4.6%	6.2%	1.5%	4.6%	1.5%
ZION Taylor Creek	125	0.8%	0.0%	4.0%	12.8%	51.2%	4.0%	13.6%	6.4%	3.2%	4.0%
GLAC Sperry	220	0.9%	0.5%	1.4%	5.0%	56.4%	5.5%	17.7%	6.8%	2.3%	3.6%
GLAC Hidden Lake	138	3.6%	1.4%	5.1%	16.7%	52.2%	5.8%	4.3%	4.3%	1.4%	5.1%

f. Someone's radio, TV, iPod, or other audio device

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	5	0.0%	0.0%	0.0%	20.0%	40.0%	0.0%	40.0%	0.0%	0.0%	0.0%
GRCA Hermit	16	12.5%	18.8%	6.3%	18.8%	18.8%	6.3%	6.3%	6.3%	0.0%	6.3%
GRCA Tusayan Ruins	4	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BRCA Fairyland	34	11.8%	5.9%	2.9%	5.9%	44.1%	0.0%	5.9%	0.0%	2.9%	20.6 %
ZION West Rim	3	0.0%	0.0%	33.3%	0.0%	33.3%	0.0%	33.3%	0.0%	0.0%	0.0%
ZION Taylor Creek	6	0.0%	0.0%	0.0%	50.0%	33.3%	0.0%	0.0%	0.0%	0.0%	16.7 %
GLAC Sperry	21	4.8%	9.5%	14.3%	19.0%	42.9%	4.8%	0.0%	0.0%	0.0%	4.8%
GLAC Hidden Lake	20	15.0%	5.0%	0.0%	15.0%	40.0%	0.0%	0.0%	0.0%	5.0%	20.0 %

Table A-15 (continued). How much did these sounds please or annoy you during this visit to < site >?

g. Cars or trucks in a parking lot

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	17	0.0%	29.4%	5.9%	29.4%	17.6%	5.9%	5.9%	0.0%	0.0%	5.9%
GRCA Hermit	9	0.0%	0.0%	11.1%	44.4%	33.3%	0.0%	11.1%	0.0%	0.0%	0.0%
GRCA Tusayan Ruins	61	0.0%	4.9%	11.5%	21.3%	49.2%	1.6%	6.6%	3.3%	0.0%	1.6%
BRCA Fairyland	45	0.0%	4.4%	6.7%	15.6%	44.4%	2.2%	4.4%	2.2%	2.2%	17.8%
ZION West Rim	7	0.0%	0.0%	14.3%	14.3%	71.4%	0.0%	0.0%	0.0%	0.0%	0.0%
ZION Taylor Creek	5	20.0%	0.0%	0.0%	0.0%	40.0%	0.0%	0.0%	0.0%	0.0%	40.0%
GLAC Sperry	19	5.3%	5.3%	5.3%	15.8%	52.6%	5.3%	5.3%	0.0%	0.0%	5.3%
GLAC Hidden Lake	54	3.7%	1.9%	7.4%	13.0%	53.7%	1.9%	5.6%	0.0%	1.9%	11.1%

h. Cars or trucks on a road or highway

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	7	14.3%	28.6%	0.0%	14.3%	28.6%	0.0%	14.3%	0.0%	0.0%	0.0%
GRCA Hermit	6	0.0%	16.7%	16.7%	50.0%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%
GRCA Tusayan Ruins	59	0.0%	1.7%	6.8%	25.4%	52.5%	6.8%	3.4%	0.0%	0.0%	3.4%
BRCA Fairyland	40	0.0%	2.5%	10.0%	17.5%	42.5%	5.0%	5.0%	0.0%	2.5%	15.0%
ZION West Rim	16	6.3%	0.0%	12.5%	25.0%	43.8%	0.0%	6.3%	6.3%	0.0%	0.0%
ZION Taylor Creek	9	0.0%	0.0%	0.0%	22.2%	66.7%	0.0%	0.0%	0.0%	0.0%	11.1%
GLAC Sperry	32	0.0%	3.1%	25.0%	31.3%	28.1%	6.3%	0.0%	0.0%	0.0%	6.3%
GLAC Hidden Lake	37	2.7%	2.7%	18.9%	10.8%	48.6%	0.0%	5.4%	0.0%	0.0%	10.8%

Table A-15 (continued). How much did these sounds please or annoy you during this visit to < site >?

i. Airplanes, jets, helicopters, or other aircraft

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	76	7.9%	7.9%	22.4%	14.5%	38.2%	3.9%	5.3%	0.0%	0.0%	0.0%
GRCA Hermit	160	13.8%	16.3%	18.1%	20.6%	22.5%	2.5%	3.8%	1.9%	0.6%	0.0%
GRCA Tusayan Ruins	44	0.0%	6.8%	9.1%	20.5%	54.5%	2.3%	6.8%	0.0%	0.0%	0.0%
BRCA Fairyland	150	2.0%	5.3%	4.7%	24.0%	43.3%	6.7%	6.0%	2.0%	0.7%	5.3%
ZION West Rim	51	0.0%	9.8%	9.8%	17.6%	49.0%	2.0%	7.8%	2.0%	2.0%	0.0%
ZION Taylor Creek	38	2.6%	0.0%	5.3%	28.9%	50.0%	5.3%	2.6%	0.0%	0.0%	5.3%
GLAC Sperry	216	9.3%	6.5%	16.2%	23.6%	34.3%	3.2%	1.9%	1.4%	1.4%	2.3%
GLAC Hidden Lake	129	7.8%	3.1%	13.2%	28.7%	30.2%	3.1%	4.7%	2.3%	1.6%	5.4%

j. Motorboats or motorized watercraft

Location	Sample Size	Extremely Annoying	Very Annoying	Moderately Annoying	Slightly Annoying	Neutral	Slightly Pleasing	Moderately Pleasing	Very Pleasing	Extremely Pleasing	No Resp
GRCA Grandview	4	0.0%	25.0%	0.0%	50.0%	0.0%	25.0%	0.0%	0.0%	0.0%	0.0%
GRCA Hermit	5	0.0%	0.0%	0.0%	20.0%	40.0%	20.0%	0.0%	0.0%	20.0%	0.0%
GRCA Tusayan Ruins	1	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BRCA Fairyland	20	10.0%	0.0%	0.0%	5.0%	45.0%	0.0%	10.0%	0.0%	5.0%	25.0 %
ZION West Rim	1	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ZION Taylor Creek	4	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	25.0%	0.0%	25.0 %
GLAC Sperry	9	0.0%	11.1%	11.1%	11.1%	22.2%	11.1%	0.0%	0.0%	0.0%	33.3 %
GLAC Hidden Lake	2	50.0%	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table A-16. How much did these sounds positively add to or negatively detract from your experience during this visit to <site>?

a. Insect Sounds

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	111	0.9%	0.0%	1.8%	5.4%	27.9%	6.3%	27.0%	11.7%	18.9%	0.0%
GRCA Hermit	108	0.0%	0.0%	0.0%	1.9%	19.4%	11.1%	18.5%	22.2%	25.9%	0.9%
GRCA Tusayan Ruins	12	0.0%	0.0%	0.0%	0.0%	16.7%	8.3%	33.3%	8.3%	33.3%	0.0%
BRCA Fairyland	237	0.0%	0.0%	2.5%	0.8%	24.1%	8.0%	16.5%	28.3%	15.6%	4.2%
ZION West Rim	84	0.0%	1.2%	6.0%	15.5%	25.0%	7.1%	7.1%	20.2%	13.1%	4.8%
ZION Taylor Creek	128	0.8%	1.6%	3.9%	6.3%	28.9%	4.7%	11.7%	18.8%	21.9%	1.6%
GLAC Sperry	211	1.4%	2.8%	6.2%	12.3%	25.6%	7.6%	11.8%	16.6%	13.3%	2.4%
GLAC Hidden Lake	90	0.0%	0.0%	0.0%	7.8%	36.7%	11.1%	8.9%	10.0%	18.9%	6.7%

b. Bird or animal sounds

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	142	0.0%	0.0%	0.7%	0.0%	7.0%	2.8%	15.5%	28.9%	44.4%	0.7%
GRCA Hermit	173	0.0%	0.0%	0.6%	0.0%	5.8%	2.9%	13.9%	36.4%	39.3%	1.2%
GRCA Tusayan Ruins	81	0.0%	0.0%	0.0%	0.0%	9.9%	9.9%	16.0%	27.2%	35.8%	1.2%
BRCA Fairyland	340	0.0%	0.3%	0.3%	1.2%	4.1%	3.2%	13.2%	33.5%	37.4%	6.8%
ZION West Rim	92	0.0%	0.0%	1.1%	0.0%	2.2%	2.2%	13.0%	33.7%	45.7%	2.2%
ZION Taylor Creek	150	0.0%	0.0%	0.0%	0.0%	5.3%	0.0%	15.3%	38.0%	39.3%	2.0%
GLAC Sperry	250	0.0%	0.8%	0.4%	0.0%	4.0%	3.6%	9.2%	32.4%	46.4%	3.2%
GLAC Hidden Lake	134	0.0%	0.0%	0.0%	0.0%	5.2%	1.5%	10.4%	32.8%	42.5%	7.5%

Table A-16 (continued). How much did these sounds positively add to or negatively detract from your experience during this visit to <site>?

c. Waterfalls, running water, or waves

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	45	0.0%	0.0%	2.2%	0.0%	2.2%	4.4%	6.7%	26.7%	57.8%	0.0%
GRCA Hermit	87	0.0%	1.1%	0.0%	0.0%	1.1%	1.1%	12.6%	33.3%	50.6%	0.0%
GRCA Tusayan Ruins	7	0.0%	0.0%	0.0%	0.0%	28.6%	14.3%	14.3%	14.3%	28.6%	0.0%
BRCA Fairyland	71	0.0%	0.0%	0.0%	1.4%	15.5%	9.9%	9.9%	21.1%	32.4%	9.9%
ZION West Rim	77	0.0%	0.0%	0.0%	0.0%	5.2%	2.6%	9.1%	35.1%	45.5%	2.6%
ZION Taylor Creek	149	0.0%	0.7%	0.0%	0.0%	2.7%	0.0%	6.0%	24.8%	61.1%	4.7%
GLAC Sperry	285	0.7%	0.0%	0.4%	0.0%	1.8%	0.0%	6.3%	29.8%	59.3%	1.8%
GLAC Hidden Lake	156	0.0%	0.0%	0.0%	1.3%	2.6%	1.3%	4.5%	28.2%	56.4%	5.8%

d. Wind, rain, or thunder

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	106	0.0%	0.0%	4.7%	1.9%	17.9%	8.5%	13.2%	34.0%	17.9%	1.9%
GRCA Hermit	140	0.7%	0.0%	0.0%	5.0%	16.4%	9.3%	20.0%	20.7%	27.1%	0.7%
GRCA Tusayan Ruins	71	0.0%	0.0%	1.4%	5.6%	25.4%	7.0%	15.5%	21.1%	23.9%	0.0%
BRCA Fairyland	272	0.0%	0.0%	0.0%	2.6%	12.5%	1.8%	15.4%	32.7%	27.6%	7.4%
ZION West Rim	71	0.0%	0.0%	0.0%	0.0%	11.3%	5.6%	18.3%	25.4%	36.6%	2.8%
ZION Taylor Creek	85	0.0%	0.0%	0.0%	0.0%	8.2%	2.4%	12.9%	29.4%	44.7%	2.4%
GLAC Sperry	153	0.7%	0.0%	1.3%	0.7%	15.0%	3.3%	14.4%	27.5%	35.9%	1.3%
GLAC Hidden Lake	94	0.0%	0.0%	0.0%	1.1%	14.9%	6.4%	12.8%	25.5%	31.9%	7.4%

Table A-16 (continued). How much did these sounds positively add to or negatively detract from your experience during this visit to <site>?

e. Group of people talking

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	129	0.8%	0.8%	2.3%	22.5%	48.1%	7.0%	10.9%	3.1%	4.7%	0.0%
GRCA Hermit	151	0.7%	1.3%	0.7%	11.3%	62.3%	7.9%	4.6%	7.3%	4.0%	0.0%
GRCA Tusayan Ruins	101	0.0%	1.0%	5.0%	15.8%	52.5%	9.9%	12.9%	1.0%	2.0%	0.0%
BRCA Fairyland	278	0.7%	1.1%	4.0%	13.3%	49.3%	2.9%	11.2%	7.6%	1.4%	8.6%
ZION West Rim	65	0.0%	1.5%	3.1%	16.9%	60.0%	4.6%	6.2%	3.1%	3.1%	1.5%
ZION Taylor Creek	125	0.8%	0.8%	3.2%	16.0%	51.2%	4.0%	12.0%	4.8%	4.0%	3.2%
GLAC Sperry	220	0.5%	1.8%	0.5%	7.3%	61.4%	9.5%	8.2%	6.4%	2.3%	2.3%
GLAC Hidden Lake	138	2.9%	2.2%	8.7%	18.1%	47.8%	4.3%	3.6%	5.1%	1.4%	5.8%

f. Someone's radio, TV, iPod, or other audio device

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	5	0.0%	0.0%	0.0%	20.0%	40.0%	0.0%	40.0%	0.0%	0.0%	0.0%
GRCA Hermit	16	6.3%	6.3%	12.5%	25.0%	25.0%	6.3%	6.3%	6.3%	0.0%	6.3%
GRCA Tusayan Ruins	4	0.0%	0.0%	0.0%	0.0%	100.0 %	0.0%	0.0%	0.0%	0.0%	0.0%
BRCA Fairyland	34	11.8%	2.9%	2.9%	5.9%	47.1%	2.9%	5.9%	0.0%	2.9%	17.6 %
ZION West Rim	3	0.0%	0.0%	0.0%	0.0%	33.3%	0.0%	33.3%	33.3%	0.0%	0.0%
ZION Taylor Creek	6	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GLAC Sperry	21	0.0%	9.5%	19.0%	19.0%	47.6%	0.0%	0.0%	0.0%	0.0%	4.8%
GLAC Hidden Lake	20	10.0%	10.0%	5.0%	20.0%	35.0%	5.0%	0.0%	0.0%	0.0%	15.0 %

Table A-16 (continued). How much did these sounds positively add to or negatively detract from your experience during this visit to <site>?

g. Cars or trucks in a parking lot

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	17	0.0%	23.5%	17.6%	29.4%	23.5%	0.0%	5.9%	0.0%	0.0%	0.0%
GRCA Hermit	9	0.0%	0.0%	11.1%	33.3%	55.6%	0.0%	0.0%	0.0%	0.0%	0.0%
GRCA Tusayan Ruins	61	0.0%	3.3%	8.2%	23.0%	59.0%	1.6%	3.3%	0.0%	0.0%	1.6%
BRCA Fairyland	45	0.0%	4.4%	6.7%	17.8%	46.7%	2.2%	2.2%	0.0%	2.2%	17.8 %
ZION West Rim	7	0.0%	0.0%	14.3%	14.3%	71.4%	0.0%	0.0%	0.0%	0.0%	0.0%
ZION Taylor Creek	5	20.0%	0.0%	0.0%	0.0%	60.0%	0.0%	0.0%	0.0%	0.0%	20.0 %
GLAC Sperry	19	5.3%	5.3%	5.3%	10.5%	52.6%	5.3%	0.0%	5.3%	0.0%	10.5 %
GLAC Hidden Lake	54	3.7%	3.7%	5.6%	24.1%	50.0%	1.9%	1.9%	0.0%	1.9%	7.4%

h. Cars or trucks on a road or highway

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	7	14.3%	28.6%	0.0%	14.3%	28.6%	0.0%	14.3%	0.0%	0.0%	0.0%
GRCA Hermit	6	0.0%	0.0%	16.7%	33.3%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GRCA Tusayan Ruins	59	0.0%	3.4%	6.8%	25.4%	59.3%	0.0%	1.7%	0.0%	0.0%	3.4%
BRCA Fairyland	40	2.5%	2.5%	5.0%	17.5%	47.5%	5.0%	0.0%	0.0%	2.5%	17.5 %
ZION West Rim	16	6.3%	6.3%	6.3%	18.8%	43.8%	6.3%	6.3%	6.3%	0.0%	0.0%
ZION Taylor Creek	9	0.0%	0.0%	0.0%	33.3%	66.7%	0.0%	0.0%	0.0%	0.0%	0.0%
GLAC Sperry	32	0.0%	3.1%	18.8%	34.4%	28.1%	6.3%	0.0%	0.0%	0.0%	9.4%
GLAC Hidden Lake	37	2.7%	5.4%	13.5%	21.6%	43.2%	0.0%	2.7%	0.0%	0.0%	10.8 %

Table A-16 (continued). How much did these sounds positively add to or negatively detract from your experience during this visit to <site>?

i. Airplanes, jets, helicopters, or other aircraft

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	76	5.3%	10.5%	18.4%	18.4%	42.1%	2.6%	2.6%	0.0%	0.0%	0.0%
GRCA Hermit	160	13.1%	13.1%	18.1%	24.4%	24.4%	1.9%	1.9%	1.9%	0.6%	0.6%
GRCA Tusayan Ruins	44	0.0%	2.3%	13.6%	25.0%	45.5%	4.5%	9.1%	0.0%	0.0%	0.0%
BRCA Fairyland	150	2.0%	4.0%	8.0%	24.7%	48.7%	3.3%	3.3%	1.3%	0.7%	4.0%
ZION West Rim	51	0.0%	3.9%	11.8%	23.5%	47.1%	3.9%	5.9%	2.0%	2.0%	0.0%
ZION Taylor Creek	38	2.6%	5.3%	7.9%	21.1%	57.9%	0.0%	2.6%	0.0%	0.0%	2.6%
GLAC Sperry	216	8.3%	7.4%	13.0%	28.2%	33.3%	3.7%	1.4%	0.9%	1.4%	2.3%
GLAC Hidden Lake	129	5.4%	4.7%	14.0%	28.7%	32.6%	0.0%	2.3%	3.1%	2.3%	7.0%

j. Motorboats or motorized watercraft

Location	Sample Size	Extremely Negatively Detracts	Very Negatively Detracts	Moderately Negatively Detracts	Slightly Negatively Detracts	Neutral	Slightly positively Adds	Moderately positively Adds	Very positively Adds	Extremely positively Adds	No Resp
GRCA Grandview	4	0.0%	25.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%
GRCA Hermit	5	0.0%	0.0%	0.0%	0.5%	1.0%	0.5%	0.0%	0.0%	0.5%	97.4%
GRCA Tusayan Ruins	1	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	99.2%
BRCA Fairyland	20	10.0%	5.0%	5.0%	5.0%	45.0%	0.0%	5.0%	0.0%	5.0%	20.0%
ZION West Rim	1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ZION Taylor Creek	4	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%	0.0%	0.6%	0.0%	97.4%
GLAC Sperry	9	0.0%	11.1%	11.1%	0.0%	22.2%	22.2%	0.0%	0.0%	0.0%	33.3%
GLAC Hidden Lake	2	0.6%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	98.8%

Table A-17. To what extent would you support or oppose each of the following potential actions at <Park> National Park?

a. Reduce the number of sightseeing tour aircraft allowed to fly over the park

Location	Sample Size	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support	Don't Know/ Not Sure	No Response
GRCA Grandview	276	3.3%	3.6%	37.0%	21.7%	25.7%	6.9%	1.8%
GRCA Hermit	378	2.6%	6.3%	23.0%	32.3%	30.2%	5.3%	0.3%
GRCA Tusayan Ruins	271	3.7%	11.8%	39.9%	27.3%	10.3%	6.3%	0.7%
BRCA Fairyland	722	3.3%	5.8%	29.2%	26.6%	23.8%	9.0%	2.2%
ZION West Rim	205	4.9%	6.3%	30.7%	36.1%	18.5%	3.4%	0.0%
ZION Taylor Creek	290	2.4%	4.5%	37.6%	25.2%	19.0%	10.7%	0.7%
GLAC Sperry	576	4.5%	5.6%	30.6%	30.2%	22.6%	5.2%	1.4%
GLAC Hidden Lake	344	2.3%	7.0%	30.2%	31.4%	22.4%	4.1%	2.6%

b. Maintain the number of sightseeing tour aircraft allowed to fly over the park at the current level

Location	Sample Size	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support	Don't Know/ Not Sure	No Response
GRCA Grandview	276	8.3%	12.0%	34.8%	21.4%	9.1%	10.1%	4.3%
GRCA Hermit	378	9.3%	23.3%	26.5%	19.0%	5.8%	8.7%	7.4%
GRCA Tusayan Ruins	271	2.2%	11.1%	39.5%	28.4%	5.9%	11.1%	1.8%
BRCA Fairyland	722	3.5%	12.6%	36.3%	16.8%	8.7%	14.4%	7.8%
ZION West Rim	205	12.7%	10.2%	34.6%	25.9%	9.3%	7.3%	0.0%
ZION Taylor Creek	290	9.7%	9.7%	37.2%	19.3%	8.6%	14.8%	0.7%
GLAC Sperry	576	9.0%	20.1%	34.0%	17.9%	5.7%	9.2%	4.0%
GLAC Hidden Lake	344	10.2%	20.6%	36.6%	20.1%	3.5%	6.4%	2.6%

Table A-17 (continued). To what extent would you support or oppose each of the following potential actions at <Park> National Park?

c. Increase the number of sightseeing tour aircraft allowed to fly over the park

Location	Sample Size	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support	Don't Know/ Not Sure	No Response
GRCA Grandview	276	39.5%	33.7%	15.9%	2.2%	2.2%	5.4%	1.1%
GRCA Hermit	378	47.6%	29.4%	12.4%	2.1%	1.6%	4.0%	2.9%
GRCA Tusayan Ruins	271	18.5%	41.3%	24.7%	5.5%	3.3%	5.2%	1.5%
BRCA Fairyland	722	39.8%	28.0%	18.0%	3.2%	2.4%	6.9%	1.8%
ZION West Rim	205	36.1%	29.3%	22.0%	5.9%	4.4%	1.5%	1.0%
ZION Taylor Creek	290	32.4%	32.4%	23.1%	2.8%	2.4%	6.6%	0.3%
GLAC Sperry	576	39.4%	32.1%	20.0%	2.8%	1.4%	2.8%	1.6%
GLAC Hidden Lake	344	36.9%	36.9%	19.2%	1.7%	1.2%	2.6%	1.5%

d. Allow sightseeing tour aircraft to be flown over the park only during specially designated dates and times

Location	Sample Size	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support	Don't Know/ Not Sure	No Response
GRCA Grandview	276	12.7%	11.2%	25.4%	32.2%	12.7%	4.3%	1.4%
GRCA Hermit	378	5.6%	10.1%	22.5%	39.7%	15.9%	4.5%	1.9%
GRCA Tusayan Ruins	271	5.2%	9.6%	32.8%	37.3%	10.7%	4.1%	0.4%
BRCA Fairyland	722	15.1%	14.5%	25.9%	27.3%	9.6%	6.2%	1.4%
ZION West Rim	205	18.0%	12.2%	24.9%	36.1%	7.3%	1.5%	0.0%
ZION Taylor Creek	290	13.4%	13.1%	27.2%	31.7%	7.2%	6.9%	0.3%
GLAC Sperry	576	9.0%	12.3%	28.3%	33.2%	11.5%	4.0%	1.7%
GLAC Hidden Lake	344	8.7%	14.5%	28.8%	33.1%	9.3%	3.8%	1.7%

Table A-17 (continued). To what extent would you support or oppose each of the following potential actions at <Park> National Park?

e. Allow sightseeing tour aircraft to use designated flight paths over limited areas of the park

Location	Sample Size	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support	Don't Know/ Not Sure	No Response
GRCA Grandview	276	6.9%	8.3%	19.9%	39.5%	22.1%	2.9%	0.4%
GRCA Hermit	378	4.8%	6.6%	18.0%	40.5%	24.9%	4.0%	1.3%
GRCA Tusayan Ruins	271	4.1%	6.6%	22.9%	44.6%	17.3%	3.3%	1.1%
BRCA Fairyland	722	13.9%	15.1%	22.4%	31.4%	10.1%	6.1%	1.0%
ZION West Rim	205	16.6%	12.2%	23.4%	40.0%	7.3%	0.5%	0.0%
ZION Taylor Creek	290	12.4%	8.6%	23.1%	34.1%	13.8%	6.9%	1.0%
GLAC Sperry	576	8.2%	10.9%	22.9%	35.8%	17.2%	3.5%	1.6%
GLAC Hidden Lake	344	8.4%	13.4%	23.5%	39.5%	10.2%	3.5%	1.5%

f. Prohibit sightseeing tour aircraft from flying over the park

Location	Sample Size	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support	Don't Know/ Not Sure	No Response
GRCA Grandview	276	8.0%	22.1%	29.0%	17.8%	19.2%	3.6%	0.4%
GRCA Hermit	378	6.9%	27.0%	24.6%	20.1%	15.1%	4.8%	1.6%
GRCA Tusayan Ruins	271	10.0%	29.2%	37.3%	9.2%	7.0%	7.0%	0.4%
BRCA Fairyland	722	5.8%	16.9%	28.4%	18.4%	23.7%	6.0%	0.8%
ZION West Rim	205	8.3%	17.1%	29.8%	20.5%	22.9%	0.5%	1.0%
ZION Taylor Creek	290	7.9%	13.8%	39.3%	15.2%	16.6%	6.9%	0.3%
GLAC Sperry	576	10.2%	18.2%	32.1%	18.6%	15.1%	4.0%	1.7%
GLAC Hidden Lake	344	7.0%	21.8%	30.8%	18.3%	16.3%	4.4%	1.5%

Table A-18. Have you ever taken a scenic air tour over <Park> National Park or any other park?

Location	Sample Size	Yes, I have taken a scenic air tour over <Park> National Park	Yes, I have taken a scenic air tour over another park	No, I have never taken a scenic air tour over a park	No response
GRCA Grandview	415	6.3%	3.9%	89.9%	0.5%
GRCA Hermit	583	5.7%	6.2%	88.3%	0.3%
GRCA Tusayan Ruins	400	8.0%	6.0%	86.5%	0.8%
BRCA Fairyland	1079	0.7%	10.5%	87.4%	1.6%
ZION West Rim	308	1.3%	7.8%	90.3%	0.6%
ZION Taylor Creek	453	3.1%	10.6%	85.7%	1.3%
GLAC Sperry	912	2.9%	7.9%	88.2%	1.4%
GLAC Hidden Lake	516	1.2%	8.9%	89.0%	1.2%

Table A-19. Would you take a sightseeing air tour over <Park> National Park, even if visitors at <site> could hear the aircraft during their visit?

Location	Sample Size	Yes	No	Don't Know/ Not Sure	No response
GRCA Grandview	415	20.2%	52.8%	11.6%	15.4%
GRCA Hermit	583	21.6%	49.7%	14.8%	13.9%
GRCA Tusayan Ruins	400	29.5%	36.3%	32.3%	2.0%
BRCA Fairyland	1079	13.3%	63.5%	20.9%	1.9%
ZION West Rim	308	18.2%	54.5%	24.7%	2.6%
ZION Taylor Creek	453	17.9%	54.1%	25.6%	2.4%
GLAC Sperry	912	25.2%	49.2%	23.6%	2.0%
GLAC Hidden Lake	516	21.9%	49.8%	26.4%	1.9%

Table A-20. What is your gender?

Location	Sample Size	Female	Male	No response
GRCA Grandview	415	34.0%	66.0%	0.0%
GRCA Hermit	583	40.1%	59.3%	0.5%
GRCA Tusayan Ruins	400	47.3%	52.8%	0.0%
BRCA Fairyland	1079	44.8%	54.1%	0.8%
ZION West Rim	308	32.5%	67.2%	0.3%
ZION Taylor Creek	453	48.6%	50.1%	1.3%
GLAC Sperry	912	46.5%	52.5%	1.0%
GLAC Hidden Lake	516	42.2%	56.0%	1.7%

Table A-21. What is the highest level of formal education you have completed?

	Sample Size	Some high school	High school graduate or GED	Some college, business, or trade school	College, business, or trade school graduate	Some graduate school	Master's, doctoral, or professional degree	No resp
GRCA Grandview	415	4.6%	6.3%	8.9%	33.5%	9.9%	36.4%	0.5%
GRCA Hermit	583	5.8%	5.0%	11.5%	34.0%	7.4%	35.5%	0.9%
GRCA Tusayan Ruins	400	1.5%	5.5%	21.5%	36.0%	6.3%	28.3%	1.0%
BRCA Fairyland	1079	3.6%	5.2%	7.2%	19.9%	8.6%	41.8%	13.5%
ZION West Rim	308	4.5%	9.1%	12.0%	32.5%	8.4%	33.1%	0.3%
ZION Taylor Creek	453	5.5%	3.1%	15.2%	36.9%	6.0%	32.2%	1.1%
GLAC Sperry	912	4.1%	3.1%	10.6%	28.6%	7.0%	34.3%	12.3%
GLAC Hidden Lake	516	3.7%	3.1%	9.7%	35.1%	6.6%	40.7%	1.2%

Table A-22. Are you Hispanic or Latino?

Location	Sample Size	Yes	No	No Response
GRCA Grandview	415	6.5%	92.8%	0.7%
GRCA Hermit	583	2.9%	96.2%	0.9%
GRCA Tusayan Ruins	400	3.0%	96.5%	0.5%
BRCA Fairyland	1079	2.5%	96.3%	0.9%
ZION West Rim	308	2.9%	95.8%	1.3%
ZION Taylor Creek	453	4.0%	94.3%	1.8%
GLAC Sperry	912	2.1%	96.7%	1.2%
GLAC Hidden Lake	516	2.3%	96.3%	1.4%

Table A-23. What is your race? (Select all that apply)

Location	Sample Size	American Indian or Alaska Native	Asian	Black or African American	Native Hawaiian	Pacific Islander other than Native Hawaiian	White / Caucasian	No response
GRCA Grandview	415	2.2%	2.2%	3.1%	1.0%	1.4%	92.3%	2.7%
GRCA Hermit	583	2.9%	5.8%	2.1%	0.3%	0.9%	91.1%	1.9%
GRCA Tusayan Ruins	400	4.3%	3.0%	4.8%	0.0%	0.0%	92.5%	2.8%
BRCA Fairyland	1079	0.9%	2.9%	1.7%	0.0%	0.5%	92.6%	3.7%
ZION West Rim	308	3.2%	3.2%	2.3%	0.0%	0.0%	95.8%	1.0%
ZION Taylor Creek	453	0.9%	4.4%	2.9%	0.4%	0.2%	91.8%	3.1%
GLAC Sperry	912	2.1%	3.4%	2.2%	0.2%	0.3%	93.8%	2.4%
GLAC Hidden Lake	516	1.2%	5.0%	1.6%	0.0%	0.2%	91.5%	3.1%

NOTE: These do not add to 100%, as some respondents selected multiple choices

Table A-24. In what year were you born? (Converted to age in years)

Location	Sample Size	17 and Younger	18 to 24	25 to 34	35 to 44	45 to 54	55 to 64	65 and Older	No Resp
GRCA Grandview	415	2.7%	8.7%	28.7 %	13.0 %	19.3 %	20.0 %	7.2%	0.5%
GRCA Hermit	583	1.9%	11.3 %	20.4 %	14.9 %	17.5 %	17.0 %	5.1%	0.3%
GRCA Tusayan Ruins	400	2.8%	3.8%	29.8 %	11.3 %	18.8 %	25.3 %	7.5%	0.5%
BRCA Fairyland	1079	1.2%	9.1%	24.7 %	17.6 %	23.1 %	16.6 %	6.4%	1.1%
ZION West Rim	308	1.9%	19.5 %	29.5 %	17.2 %	14.9 %	14.3 %	2.3%	0.3%
ZION Taylor Creek	453	1.3%	11.9 %	20.1 %	11.5 %	24.9 %	20.3 %	1.5%	0.2%
GLAC Sperry	912	2.2%	11.0 %	18.2 %	12.0 %	17.8 %	25.4 %	12.2%	1.3%
GLAC Hidden Lake	516	3.9%	7.0%	32.2 %	19.0 %	21.3 %	18.2 %	21.5%	2.3%

Table A-25. Where do you live?

Location	Sample Size	United States	Other country	No Response
GRCA Grandview	415	83.9%	15.7%	0.5%
GRCA Hermit	583	85.8%	13.6%	0.7%
GRCA Tusayan Ruins	400	81.8%	18.0%	0.3%
BRCA Fairyland	1079	69.1%	29.6%	1.0%
ZION West Rim	308	88.0%	12.0%	0.0%
ZION Taylor Creek	453	92.3%	6.4%	1.3%
GLAC Sperry	912	90.4%	8.4%	1.2%
GLAC Hidden Lake	516	83.1%	15.7%	1.2%

Table A-26. Were you or your personal group part of some larger commercial, educational, or other organized group of visitors?

Location	Sample Size	Yes	No	No Response
GRCA Grandview	415	10.8%	88.4%	0.7%
GRCA Hermit	583	10.1%	89.5%	0.3%
GRCA Tusayan Ruins	400	3.5%	92.8%	3.8%
BRCA Fairyland	1079	6.4%	91.8%	1.6%
ZION West Rim	308	9.1%	89.9%	1.0%
ZION Taylor Creek	453	5.3%	92.3%	2.4%
GLAC Sperry	912	3.4%	94.8%	1.8%
GLAC Hidden Lake	516	2.5%	96.1%	1.4%

Table A-27. How many adults and children were in your personal group (spouse, family, friends) on this visit to <site>?

Location	Sample Size	1 person	2 people	3 or 4 people	5 or more people	No Response
GRCA Grandview	415	13.0%	30.4%	33.0%	22.9%	1.0%
GRCA Hermit	583	12.3%	39.6%	26.8%	20.4%	0.9%
GRCA Tusayan Ruins	400	10.3%	54.5%	26.3%	6.8%	2.5%
BRCA Fairyland	1079	13.4%	47.3%	19.7%	18.4%	1.2%
ZION West Rim	308	14.3%	41.9%	23.1%	18.8%	2.3%
ZION Taylor Creek	453	8.6%	37.7%	27.2%	25.4%	1.1%
GLAC Sperry	912	9.4%	37.5%	34.3%	17.9%	0.9%
GLAC Hidden Lake	516	9.9%	43.8%	28.1%	16.5%	1.6%

Table A-28. How many children were in your personal group (spouse, family, friends) on this visit to <site>?

Location	Sample Size	0 children	1 child	2 children	3 or 4 children	5 or more children	No Response
GRCA Grandview	415	75%	6.0%	5.5%	3.4%	2.2%	7.7%
GRCA Hermit	583	84.0%	7.5%	4.3%	1.9%	1.4%	0.9%
GRCA Tusayan Ruins	400	84.5%	6.0%	5.8%	3.5%	0.3%	0.0%
BRCA Fairyland	1079	81%	6.5%	6.0%	4.4%	1.4%	0.8%
ZION West Rim	308	92%	3.9%	1.9%	1.6%	0.3%	0.0%
ZION Taylor Creek	453	72.8%	12.4%	7.9%	5.7%	0.9%	0.2%
GLAC Sperry	912	85%	7.9%	4.6%	1.4%	0.8%	0.3%
GLAC Hidden Lake	516	77.7%	8.1%	8.1%	3.9%	0.8%	1.4%

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TERMINOLOGY

This section presents pertinent terminology used throughout the document. Note: Definitions are generally consistent with those of the American National Standards Institute (ANSI).

A-WEIGHTING – A frequency-based methodology used to account for changes in human hearing sensitivity as a function of frequency. The A-weighting network de-emphasizes the high (6.3 kHz and above) and low (below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of human hearing.

ACOUSTIC ENERGY – Commonly referred to as the mean-square sound-pressure ratio, sound energy, or just plain energy, acoustic energy is the squared sound pressure (often frequency weighted), divided by the squared reference sound pressure of 20 µPa, the threshold of human hearing. It is arithmetically equivalent to $10^{(LEV/10)}$, where LEV is the sound level, expressed in decibels.

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

AKAIKA INFORMATION CRITERION (AIC) – A statistical measure of the log of the likelihood of a regression model which incorporates a penalty for the number of parameters used to fit the model. The likelihood is a measure of the probability of the observed data, given the estimated parameter values. The AIC value is calculated as -2*log-likelihood+2*npar, where npar is the number of parameters included in the model.

AMBIENT – The composite, all-inclusive sound associated with a given environment, excluding the analysis system's electrical noise and the sound source of interest. Several definitions of ambient noise have been adopted by different organizations depending on their application.

- Existing Ambient: The composite, all-inclusive sound associated with a given environment, excluding only the analysis system's electrical noise (i.e., aircraft-related sounds are included);
- Existing Ambient Without Air Tours: The composite, all-inclusive sound associated with a given environment, excluding the analysis system's electrical noise and the sound source of interest, i.e., commercial air tour aircraft for ATMPs;
- Existing Ambient Without All Aircraft (for use in assessing cumulative impacts): The composite, all-inclusive sound associated with a given environment, excluding the analysis system's electrical noise and the sounds produced by the sound source of interest, in this

case, all types of aircraft (i.e., commercial air tours, commercial jets, general aviation aircraft, military aircraft, and agricultural operations); and

- Natural Ambient: The natural sound conditions found in a study area, including all sounds of nature (i.e., wind, streams, wildlife, etc.), and excluding all human and mechanical sounds.

ANNOYANCE – Any bothersome or irritating occurrence.

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.

AVIATION NOISE – Aviation noise in the context of this study includes contributions from both tour aircraft and high-altitude commercial jets, as they are concurrent and their effects on park visitors cannot effectively be separated.

BACKCOUNTRY – Any location in a study area subject to minimal human activity, such as designated wilderness areas or restricted, hiking and camping areas (destinations generally located 1 hour or more from frontcountry locations).

CULTURAL/HISTORIC SITE – A location with cultural or historic significance (or importance in American history) and historic integrity (or physical authenticity). Such locations are eligible for listing or are listed on the National Register of Historic Places, and the NPS has a Federal government leadership role in preserving them.

DAY HIKE – Backcountry study area or destination generally requiring a hike of more than one hour and subject to low to moderate human activity.

DAY-NIGHT AVERAGE SOUND LEVEL (DNL, denoted by the symbol Ldn) - A 24-hour time-averaged sound exposure level (see definition below), adjusted for average-day sound source operations. In the case of aircraft noise, a single operation is equivalent to a single aircraft operation. The adjustment includes a 10-dB penalty for operations occurring between 2200 and 0700 hours, local time.

DECIBEL - (symbol dB) A unit of measure for defining a noise level or a noise exposure level. The number of decibels is calculated as $10*(Log_{10}(\text{sound level/reference sound level}))$.

DICHOTOMIZATION – The separation into two parts, classifications, or groupings.

EQUIVALENT SOUND LEVEL (TEQ, denoted by the symbol LAeqT) - Ten times the base-10 logarithm of the time-mean-square, instantaneous A-weighted sound pressure, during a stated

time interval, T (where T=t2-t1, in seconds), divided by the squared reference sound pressure of 20 μPa, the threshold of human hearing. LAeqT is related to LAE by the following equation:

$$L_{AeqT} = L_{AE} - 10Log(t2-t1) \text{ (dB)}$$

Where L_{AE} = Sound exposure level (see definition below).

The L_{Aeq} for a specific time interval, T1 (expressed in seconds), can be normalized to a longer time interval, T2, via the following equation:

$$L_{AeqT2} = L_{AeqT1} - 10Log(T2/T1) \text{ (dB)}$$

FRONTCOUNTRY - Any location in a study area subject to substantial human activity, such as scenic overlooks, visitor centers, recreation areas, or destinations reached by short hikes (1 hour or less).

FREQUENCY – For a function periodic in time, the reciprocal of the period (the smallest increment of an independent variable for which a function repeats itself).

HERTZ - (abbreviation Hz) Unit of frequency, the number of times a phenomenon repeats itself in a unit of time.

L_{50} - A statistical descriptor describing the sound level exceeded 50 percent of a specific time period. For example, from a fifty-sample measurement period with the samples sorted from highest sound level to lowest sound level, the twenty-fifth sound level is the 50-percentile exceeded sound level.

L_{90} - A statistical descriptor describing the sound level exceeded 90 percent of a specific time period. For example, from a fifty-sample measurement period with the samples sorted from highest sound level to lowest sound level, the forty-fifth sound level is the 90-percentile exceeded sound level.

L_{AE} (see Sound Exposure Level)

L_{Aeq} (see Equivalent Sound Level)

$L_{Aeq,Tac}$ - Equivalent sound level using a time basis of a an aircraft overflight duration.

$L_{Aeq,Tresp}$ - Equivalent sound level using a time basis of a respondent's visit duration.

L_{ASmx} (see Maximum Sound Level)

L_{dn} (see Day-Night Average Sound Level)

LOW-LEVEL NOISE ENVIRONMENT - An outdoor sound environment typical of a remote suburban setting, or a rural or public lands setting. Characteristic day-night average sound levels (DNL, represented by the symbol, Ldn) would generally be less than 45 dB, and the everyday sounds of nature, e.g., wind blowing in trees and birds chirping would be a prominent contributor to the DNL.

MAXIMUM SOUND LEVEL - The maximum, A-weighted sound level associated with a given event (see figure with definition of sound exposure level). Fast exponential response (L_{AFmx}) and slow exponential response (L_{ASmx}) characteristics effectively damp a signal as if it were to pass through a low-pass filter with a time constant (τ) of 125 and 1000 milliseconds, respectively.

NATURAL AMBIENT (see Ambient)

NATURAL QUIET - The natural sound conditions found in a study area. Natural quiet is a subset of ambient noise. Traditionally, it is characterized by the total absence of human or mechanical sounds, but includes all sounds of nature, such as wind, streams, and wildlife.*

NATURAL SOUNDSCAPE - In accordance with National Park Service's Director's Order #47, the natural soundscape is the Natural Ambient sound level of a park. It is comprised of the natural sound conditions in a park, which exist in the absence of any human-produced noises.

NOISE - Any unwanted sound. "Noise" and "sound" are used interchangeably in this document.

NOISE DOSE - A measure of the noise exposure to which a person is subjected.

OVERLOOK - Any frontcountry location in a study area subject to substantial human activity, or destinations reached by automobile or bus, and generally traversable within thirty minutes.

OVERNIGHT HIKE – Backcountry study area or destination generally requiring a hike of more than one hour with an overnight stay (either in a camp or cabin setting) and subject to low to moderate human activity.

$P_{EnHelos}$ – The percentage of the sound energy forming the basis for $L_{Aeq,Tresp}$ (aircraft equivalent sound level using a time basis of a respondent's visit duration) contributed by helicopters.

* In a park environment, the National Park Service (NPS) defines natural quiet as the absence of mechanical noise, but containing the sounds of nature, such as wind, streams, and wildlife, as well as human-generated "self-noise" (e.g., talking, the tread of hiking boots on the trail, a creaking packframe, the rattle of pots or pans).

$P_{EnProps}$ - The percentage of the sound energy forming the basis for $L_{Aeq,Tresp}$ (aircraft equivalent sound level using a time basis of a respondent's visit duration) contributed by propeller aircraft.

SHORT HIKE - Any frontcountry location in a study area subject to moderate to substantial human activity, or destinations generally reached within one hour of hiking.

SITE TYPE - Site type is used in this research to refer to the context in which the noise exposure is presented. It encompasses both physical location and likely activities at that location.

SOUND – Auditory sensation evoked by the oscillation in pressure, stress, particle displacement, particle velocity, etc., in a medium with internal forces (e.g., elastic or viscous), or the superposition of such propagated oscillations.

SOUND EXPOSURE LEVEL (SEL, denoted by the symbol LAE) – Over a stated time interval, T (where T=t2-t1, in seconds), ten times the base-10 logarithm of a given time integral of squared instantaneous A-weighted sound pressure, divided by the product of the squared reference sound pressure of 20 μPa, the threshold of human hearing, and the reference duration of 1 sec.

$$L_{AE} = 10Lg\left[\sum_{k=t_1}^{t_s} 10^{L_{AK}/10}\right] \quad \text{(dB)}$$

In addition, L_{AE} is related to L_{AeqT} by the following equation:

$$L_{AE} = L_{AeqT} + 10Lg(t_2-t_1) \quad \text{(dB)}$$

Where L_{AeqT} = Equivalent sound level in dB (see definition above).

SOUND PRESSURE LEVEL (SPL) - Ten times the base-10 logarithm of the time-mean square sound pressure, in a stated frequency band (often frequency-weighted), divided by the squared reference sound pressure of 20 μPa, the threshold of human hearing.

$$SPL = 10Lg[p^2/ p_{ref}^2]$$

Where p^2 = time-mean-square sound pressure; and p_{ref}^2 = squared reference sound pressure of 20 μPa.

SOUNDSCAPE - In accordance with National Park Service's Director's Order #47 (http://www.nps.gov/policy/DOrders/DOrder47.html), soundscape is defined as "the total ambient acoustic environment associated with a given environment in an area such as a

national park. In a national park setting, this soundscape is usually composed of both Natural Ambient sounds and a variety of human-made sounds."

SPECTRUM – A set of sound pressure levels in component frequency bands, usually one-third octave-bands.

TIME-AUDIBLE – The percentage of time that a time-varying sound level can be heard by a receiver in a given area during a given time period.

REFERENCES

[1] *National Parks Overflights Act of 1987*. Public Law 100-91 (101 Stat. 674) (1987).

[2] National Parks Air Tour Management Act of 2000. Public Law 106-181, title VIII (114 Stat. 61) (2000).

[3] Anderson, G.S., Horonjeff, R.D., Menge, C.W., Miller, N.P., Robert, W.E., Rossano, D. Sanchez, G., Baumgartner R.M. and McDonald C. (1993) *Dose-Response Relationships Derived From Data Collected at Grand Canyon, Haleakala and Hawaii Volcanoes National Parks.* Denver CO, National Park Service, NPOA Report No. 93-6.

[4] Fleming, G.G., Roof, C.J., Rapoza, A.S., Read, D.R., Webster J.C. and Liebman P.C. (1998), *Development of Noise Dose / Visitor Response Relationships for the National Parks Overflight Rule: Bryce Canyon National Park Study.* Washington, D.C., U.S. Department of Transportation, Federal Aviation Administration, Report No. FAA-AEE-98-01.

[5] Rapoza, A.S., Fleming, G.G., Lee, C.S.Y. and Roof, C.J. (2005). *Study of Visitor Response to Air Tour and Other Aircraft Noise in National Parks.* Cambridge MA, U.S. Department of Transportation, Volpe National Transportation Systems Center, Report DTS-34-FA65-LR1.

[6] Miller, N.P., Anderson, G.S., Horonjeff, R.D., Thompson, R.H., Baumgartner, R.M. and Rathbun, P. (1999). *Mitigating the Effects of Military Aircraft Overflights on Recreational Users of Parks: Final Report*. Burlington, MA, Harris Miller Miller & Hanson.

[7] Anderson, G.S., Rapoza, A.S., Fleming, G.G. and Miller, N.P. (2011). Aircraft noise dose-response relationships for National Parks. *Noise Control Engineering Journal,* 59(5), 519-540.

[8] Lawson, S., Kiser, B., Hockett, K. and Ingram, A. (2008). *Research to support backcountry visitor use management and resource protection in Halekala National Park: Study Completion Report*. Blacksburg, VA, Virginia Polytechnic Institute and State University, College of Natural Resources.

[9] Lawson, S., Kiser, B., Hockett, K. and Ingram, A. (2008). *Research to support backcountry visitor use management and resource protection in Hawaii Volcanoes National Park: Study*

Completion Report. Blacksburg, VA: Virginia Polytechnic Institute and State University, College of Natural Resources.

[10] Pilcher, E., Newman, P. and Manning, R. (2009). Understanding and Managing Experiential Aspects of Soundscapes at Muir Woods National Monument. *Environmental Management* ,43, 425-435.

[11] Mace, B.L., Bell, P.A. and Loomis, R.J. (1999). Aesthetic, affective and cognitive effects of noise on natural landscape assessment. *Society & Natural Resources*, 12(3), 225-242.

[12] Mace, B.L., Bell, P.A., Loomis, R.J., and Haas, G.E. (2003). Source attribution of helicopter noise in pristine national park landscapes. *Journal of Park and Recreation Administration*, 21(3), 97-119.

[13] Tarrant, M.A., Haas, G.E., and Manfredo, M. J. (1995). Factors affecting visitor evaluations of aircraft overflights of wilderness areas. *Society and Natural Resources*, 8(4), 351-380.

[14] The National Academies Press (2010). *Technology for a Quieter America*, Washington D.C.

[15] Wetzel, E., Carstensen, C. H., and Bohnke, J. R. (2013). Consistency of extreme response style and non-extreme response style across traits. *Journal of Research in Personality*, 47(2), 178-189.

[16] Schultz, T.J. (1978) Synthesis of social surveys on noise annoyance. *Journal of the Acoustical Society of America,* 64(2), 377-405.

[17] Miedema, H, and Vos, H. (1998) Exposure-response relationships for transportation noise. *Journal of the Acoustical Sociaty of America,* 104(6), 3432-3445.

[18] Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19, 716-723.

[19] Harris Miller Miller and Hanson (2003). *Aircraft Noise Model Validation Study*. Burlington, MA, HMMH Report No. 295860.29.

[20] Fidell, S., Teffeteller, S., Horonjeff, R. and Green, D.M. (1979). Predicting Annoyance from Detectability of Low-Level Sounds. *Journal of the Acoustical Society of America*, 66(5), 1427–1434.

[xxi] Manning, R., Lime, D., Freimund W. and Pitt, D. (1996) Crowding norms at frontcountry sites: A visual approach to setting standards of quality. *Leisure Sciences*, 18, 39-59.

[xxii] Manning, R., Valliere, W., Wang, B., and Jacobi, C. (1999). Crowding norms: Alternative measurement approaches. *Leisure Sciences*, 21(2), 219-229.

[xxiii] Aasvang, G. M. and B. Engdahl (2004). Subjective responses to aircraft noise in an outdoor recreational setting: a combined field and laboratory study. *Journal of Sound and Vibration* 276(3-5), 981-996.