Protecting Our Acoustic Heritage: An Analysis of a Survey of U.S. National Park Service Managers

A Report for the Natural Sounds and Night Skies Division, U.S. National Park Service

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Summary
NPS recognizes that park acoustical environments, or the combination of physical sound resources (i.e., natural, cultural, and historical sounds) within the park, are resources that require protection under NPS Management Policies. The Natural Sounds Program[1] of the NPS Natural Sounds and Night Skies Division was established to protect soundscape resources in units of the national park system. To better understand the acoustic resources and noise issues present throughout the National Park System, the Natural Sounds Program sent a survey to each of the park units (n=391) in 2008-2009[2]. Respondents from 141 park units provided information on park acoustic resources, noise sources and impacts, and mitigation measures. The survey question responses were analyzed by theme and the results are reported as number or percent of respondents. The acoustic resources reported most frequently were sounds from wildlife, sounds from bodies of water, and wind through vegetation. Nearly all respondents (98.7%) indicated that motorized vehicle noise, such as general traffic on roads, buses, motorcycles, and aircraft, was adversely affecting the acoustical environment and soundscape. Visitor impacts were reported most frequently (n=95) followed by impacts to the acoustical environment and wildlife impacts. Motorized noise sources were identified as the cause of most of the reported impacts and conflicts (n=97). Many types of noise mitigation measures were mentioned by respondents including different forms of park planning, communication with identified noise contributors, changing aspects of park operations, and aircraft regulations. Approximately one-third of the respondents indicated that no mitigation measures were being conducted at their park units. Exploratory correlation analyses were conducted to determine if there were any significant relationships between responding park characteristics and whether mitigation measures were being conducted or not. Significant relationships were found for many of the variables including park unit size, region, and park unit type. Additional research is needed to understand the barriers of soundscape management.

Introduction
The U.S. National Park Service (NPS) is charged with the management and protection of over 84 million acres of public lands. However, the sustainability of the natural, historical, and cultural resources on these lands are challenged by many complex landscape level issues such as climate change, loss of biodiversity, and overuse. An indicator of these issues is the continued loss of natural sounds. The National Park Service recognizes the acoustical environment of park units as a resource. According to the NPS Management Policies 2006, both natural sounds (section 4.9) and appropriate human generated sounds for cultural and historic settings (section 5.3.1.7) are to be protected from impacts.

The Natural Sounds Program of the NPS Natural Sounds and Night Skies Division was established to protect, maintain, or restore acoustical environments throughout the National Park System. The Program differentiates between the soundscape, the human perception of acoustic resources, and the acoustical environment, the combination of all the physical sound resources in

[1] Under Park Operations, the NPS Overflights Branch was created in 2000 to implement National Parks Air Tour Management Act. In 2002 it came under the Natural Resources Stewardship and Science directorate as the Natural Sounds Program.
[2] The total number of park units in 2009 at the time the last survey response was received was 391 according to the *National Parks Index 2009-2011* (www.nps.gov/history/history/online_books/nps/index2009_11.pdf).

a given area. This distinction is important for helping parks meet specific management objectives.

The objectives of this research were to determine the acoustic resources, the noise sources, the impacts, and the mitigation measures that are being implemented at national park units. This information will be used by the Natural Sounds Program to better assist parks in effectively managing park acoustical environments.

Methods

A survey instrument containing open ended questions was used to collect information on the acoustical environment, noise issues, and mitigation (see Appendix B for the survey instrument). The survey was distributed to every national park unit (n=391) [1]. The targeted respondent was a park unit manager, including park superintendents, chiefs of natural resources, park rangers, biologists, etc. The NPS Natural Sounds Program distributed the survey and introductory letter in an email memo to each of the Regional Environmental Coordinators and Regional Resource Chiefs in the seven regions. The regional staff then forwarded the email to each individual park unit to be completed by a park manager. The survey was also advertised through an article on the InsideNPS website.

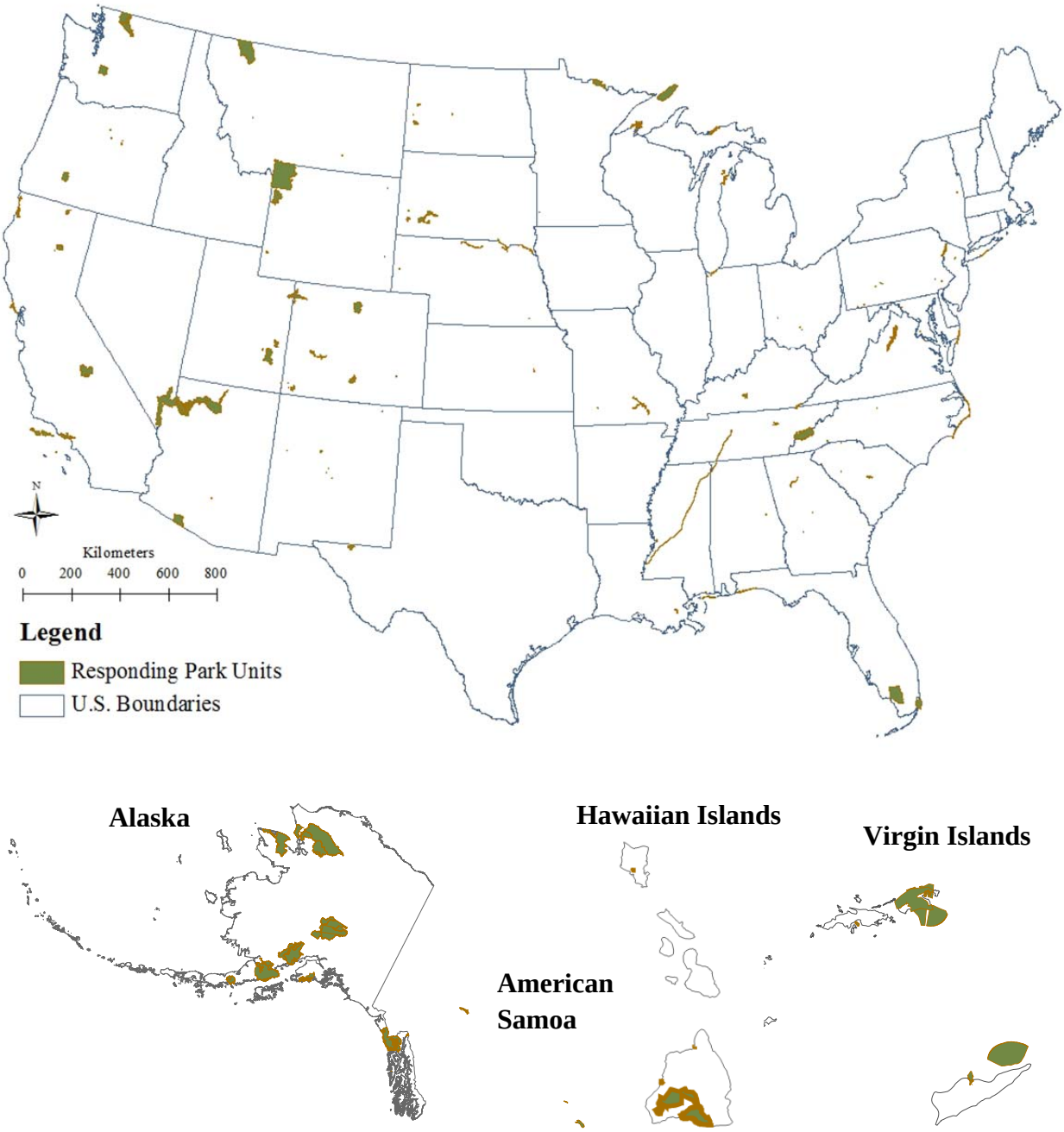
The first wave of the survey was distributed on November 3, 2008. A second wave reminder and survey was distributed through the regional offices on February 3, 2009. The last survey was received by the Natural Sounds Program on March 26, 2009. The survey could be filled out and resubmitted by email or the survey was available online at an internal NPS website, Natural Resource Program Center Sharepoint. The majority of respondents returned completed surveys by email. A total of 149 responses were received representing 141 different park units for a park unit response rate of 36%. All 149 responses were included in the analysis, unless indicated otherwise.

Key demographic variables were collected about the respondents and responding park units. The respondents provided the park unit name and type and their position at the park. Other independent variables about the responding park units were provided by the Natural Sounds Program including the region, if commercial air tours were present at the park, and if acoustical monitoring had been conducted at the park. Additional independent variables about the responding park units were collected by the researcher for analysis (i.e., park size, visitation in 2009, and if the park is part of the inventory and monitoring network) (NPS 2009a, NPS 2009b, and I&M 2009). Service-wide data was compared to responding parks to compare for representativeness (see Tables 10-14) in Appendix A at the end of the report). Table 15 provides a regional breakdown for some of the results of this survey. A map of the responding park units is provided demonstrating the diverse geographical representation (Figure 1).

Qualitative data analysis was conducted by identifying and classifying emerging themes from the question responses (Ryan and Bernard 2003). The qualitative data analysis software program, QSR NVivo 8, was used to organize survey responses into themes. A codebook was developed through peer debriefing that defines each of the themes, or codes, applied to the responses. Over 100 unique themes were defined and applied to the survey responses for analysis. Qualitative analysis results are summarized as the number of responses and percentages.

From the qualitative data analysis categorical themes emerged from the survey question on noise mitigation techniques. We performed multiple quantitative analyses to determine if independent variables mentioned above were associated with the categorical classifications of mitigation. All analyses were conducted using PASW Statistics 18 software (SPSS Inc. 2010). A chi-square test was used to determine if a significant relationship existed between the mitigation categories and the independent variables respondent position, park unit type, region, I&M park, commercial air tours present, and acoustical monitoring conducted. A difference of means test was used to determine if there was a significant difference between mitigating and non-mitigating parks and park unit size (acres) and visitation in 2009.

Figure 1. Map of the National Park Service units that responded to the Natural Sounds and Night Skies Division survey.



Results

From this survey, it is evident that parks have many unique acoustic resources, diverse impacts, and a range of mitigation techniques. The acoustic resource mentioned most frequently was sounds of wildlife. In terms of noise in parks, motorized noise from aircraft and road traffic were reported most often and associated with the most impacts to visitors and park resources. A wide variety of mitigation measures were described by respondents, such as park planning efforts, communication with noise contributors, and making changes to park operations. One third of the respondents indicated that no mitigation measures were being implemented at their park. The results for each of the questions are summarized below.

Question 1: What are the most significant acoustical resources present at your park?

There were 148 usable responses analyzed for this question. Categories of sounds that were coded for this question include: cultural, geophysical, historic, natural sounds in general, quiet, vegetation, sounds of visitors, water generated sounds and wildlife sounds. The frequencies of park references to different acoustic resources are displayed in Table 1.

Sounds generated by wildlife were the most often reported (n=133, 89.9%). Respondents mentioned sounds from birds (n=128), mammals (n=82), insects (n=66), and amphibians (n=64) as being significant resources.

Geophysical sounds were identified by survey respondents as significant acoustic resources. The sounds of water in the form of rivers, streams, waterfalls, and waves were reported by 105 respondents. Weather events, such as rain, thunder, or high winds were mentioned by 98 respondents. Other geophysical sounds comprised references to geologically generated sounds including rock slides, glacier movements, lava flows, wind through caves, or earthquakes (n=23).

Sounds generated by vegetation in the parks were identified as important acoustic resources by 94 respondents. Of these, 87 respondents indicated that the vegetation sounds were from wind moving through trees, grass, or other plant life. The other vegetation sounds identified by 15 respondents were due to other sounds from plants, such as “trees popping when it’s below zero” and “deer walking over vegetation, trees falling, rustling leaves on trees and ground, falling leaves and falling pinecones.”

Respondents often reported that the cultural (n=52) and historical (n=57) acoustic resources were important in that they reflect the resources parks were established to protect and manage. Historical acoustic resources included sounds that were recreated by parks (n=11) or soundscapes with minimal modern sounds. Example quotes included, “the sound of 18th century weapons firing during living history events brings to life the sound of battle” and “the most noticeable sound is the lack of modern acoustical intrusion.”

Natural quiet, quiet, and silence were also mentioned as important acoustic resources (n=48). The importance to park character were indicated by quotes, such as “to park management the most important acoustical resource is actually the overall lack of sound” and “during winter, the acoustical resource is the QUIET. It is generally silent, other than sounds of breeze, or occasional twittering songbird or croaking raven.”

Broadly referred to natural sounds or natural soundscapes were mentioned by 21 respondents. Some of the references indicated the connection of natural sounds to wilderness character (n=7). For example, one respondent stated, “about one-third of the park is legislated wilderness and the natural sounds of this environment are an important resource for wilderness character from the sound of running water, wind and weather to wildlife sounds.”

Visitor generated sounds were mentioned by 11 respondents. Visitor generated sounds were also referred to by 19 respondents as a cultural acoustic resource at the park. Sounds created by the visitor could come from visitor activities in the park, such as, “playing in creek, frolicking on dunes, visitors in campground, and musical concerts in campground.” Also, the sounds may be generated simply by the visitor’s presence in the park setting. For example one respondent identified “the rustle of fresh grass after a dew under foot in spring time, or the crunch of snow or the grinding of stone or oyster shell on the paths” as visitor generated sounds.

Table 1. Significant acoustic resources mentioned by survey respondents.

Significant Acoustical Resources	Number of Respondents	Percent
Wildlife	**133**	**89.9**
Birds	128	86.5
Mammals	82	55.4
Canids	61	41.2
Small mammals	29	19.6
Insects	66	44.6
Amphibians	64	43.2
Reptiles	16	10.8
Fish	13	8.8
Unknown wildlife sound	10	6.8
Underwater	5	3.4
Water	**105**	**70.9**
Weather	**98**	**66.2**
Vegetation	**94**	**63.5**
Wind through vegetation	87	58.8
Other vegetation sounds	15	10.1
Historic	**57**	**38.5**
Interpretation	11	7.4
Cultural	**52**	**35.1**
Visitor	19	12.8
Interpretation	7	4.7
Quiet	**48**	**32.4**
Other geophysical	**23**	**15.5**
Natural sounds	**21**	**14.2**
Visitor	**11**	**7.4**

Question 2: What sources of noise adversely affect the park's acoustical environment and soundscape?

The number of different noise sources reported ranged from zero at one unit to 16. The average number of noise sources for the responding park units was five. The vast majority (n=147, 98.7%) of respondents indicated that motorized noise in general or specific motorized sound sources were adversely affecting the parks' acoustical environment and soundscape (Table 2). For the two responding parks that did not include motorized noise impacts, one was a unique living community comprised of individual private residences, businesses, and town operations that did not recognize any noise sources and the other mentioned only rowdy visitor generated noise. The types of motorized noise identified included aircrafts, all-terrain vehicles (ATVs), boats, buses, engines idling, motorcycles, NPS vehicles, road or traffic noise, snowmobiles, trains, and trucks. The most frequently mentioned motorized noise sources were road and traffic noise (n=107). The second most frequently noted motorized noise source was aircraft (n=100). From these results it is evident that motorized travel is a major contributor to noise impacts in parks.

Park operations, including specific references to maintenance activities, park infrastructure and utilities, and construction projects, were also identified by many parks as a source of noise (n=73, 49.0%). Some park operations references specifically included sounds from motorized equipment, such as lawn mowers. If park vehicles or specific types of motorized vehicles were indicated as the source of noise from the park operation activities, then the references were also coded under those noise sources.

Noise sources that originated outside the park boundary were identified by 44 respondents as negatively impacting soundscapes. These references included urban development or urban setting, natural resource extraction activities, and adjacent facilities that create noise. References to road traffic outside of the park were not included in this category. Visitor generated sounds from talking, yelling, and personal electronics (i.e. cell phones and radios) were mentioned by 43 respondents as a noise source. More specific references to visitor created sounds in campgrounds, in particular sounds from visitors' generators in campgrounds, were categorized separately (n=21).

Table 2. Noise sources reported to adversely affect park acoustical environment and soundscape.

Noise Source	Number of Respondents	Percent
Motorized noise	**147**	**98.7**
Road traffic	107	71.8
Aircraft	100	67.1
Helicopter	37	24.8
Commercial	33	22.1
Military	29	19.5
Near airport	19	12.8
NPS	17	11.4
Private	15	10.1

Low flying	14	9.4
Air tours	7	4.7
Crop dusters	2	1.3
Boats	47	31.5
Motorcycles	27	18.1
Trains	24	16.1
ATV/ORV	19	12.8
Park vehicles	18	12.1
Buses	17	11.4
Trucks	17	11.4
Snow machines	10	6.7
Engine idling	5	3.4
Personal watercraft	4	2.7
Park operations	**73**	**49.0**
Maintenance	57	38.3
Infrastructure/utilities	21	14.1
Park construction	12	8.1
Outside park boundary	**44**	**29.5**
Visitors	**43**	**28.9**
Campground (generators)	**21**	**14.1**
Chainsaws	**20**	**13.4**
Hunting/firearms	**11**	**7.4**
Sirens	**8**	**5.4**
Military activity	**6**	**4.0**
Dogs	**5**	**3.4**
Modern sounds	**5**	**3.4**
Concessionaire	**4**	**2.7**

Question 3: What resource impacts or user conflicts, if any, are associated with the noise disturbances listed in #2?

For this question three primary components were analyzed: conflicts, impacts, and the specific noise sources cited as the cause of the conflicts or impacts. Few respondents indicated specific conflicts due to noise disturbances (n=27, Table 3). Motorized recreation and non-motorized recreation conflicts were the types of conflict most clearly indicated by respondents. The term "conflict", "controversy" or a similarly contentious term needed to be mentioned by the respondent in order for the statement to be coded as conflict. Of the 27 references to conflict, 19 indicated that motorized recreation was conflicting with another park use or recreation type. Non-motorized recreation, such as hiking, kayaking, horseback riding, or skiing, conflicted with motorized recreation in ten of the cases. Motorized recreation noise conflicted with backcountry or wilderness users in six cases. Loud campers, generator use in campgrounds, and motorized recreation created conflict for campers in three cases. Additionally, two respondents identified a

conflict between trying to maintain the cultural, spiritual setting of the park and recreation sounds or noise in general. Respondents also mentioned conflict with organizations or agencies (n=6), such as military overflight activities conflicting with the NPS mission, Federal Aviation Administration (FAA) not dealing with overflight violations, and park conflicts with concessionaires' activities.

Table 3. Conflicts and types due to noise reported by respondents.

Conflicts Due to Noise	Number of Respondents	Percent
Conflict reported	**27**	**18.1**
Motorized vs. non-motorized recreation	**19**	**12.8**
Non-motorized recreation	10	6.7
Backcountry/Wilderness users	6	4.0
Campers	3	2.0
Organization/Agency	**6**	**4.0**
Cultural/Traditional setting	**2**	**1.3**

More respondents indicated that noise sources caused impacts to visitors or park resources. Noise sources were identified as primarily impacting visitors (n=95), with 77 respondents specifically indicating that visitor experience is negatively affected. Other types of visitor impacts are listed in Table 4. Respondents listed several non-visitor related impacts, including the acoustical environment, wildlife, park interpretation activities, and parks' natural, historic, and cultural resources (Table 5). Some respondents indicated that impacts due to noise were unknown, in particular for wildlife (n=23). A few respondents indicated that there were no conflicts or impacts due to noise sources (n=12) or that they were minimal (n=16).

Table 4. Type of visitor impacts.

Visitor Impacts Due to Noise	Number of Respondents	Percent
Visitor Impacts	**95**	**63.8**
Experience	77	51.7
Noise complaints	21	14.1
Solitude	20	13.4
Wilderness	20	13.4
Campers	16	10.7
Contemplative	15	10.1
Backcountry	12	8.1
Wildlife viewing	4	2.7

Table 5. Other impacts reported by respondents due to noise.

Impacts Due to Noise	Number of Respondents	Percent
Soundscape	44	29.5
Wildlife	34	22.8
Interpretation	28	18.8
Historic resources	14	9.4
None	12	8.1
Cultural or traditional	11	7.4
Wilderness	7	4.7
Research	4	2.7
Park staff	3	2.0
Natural resources	2	1.3

Motorized noise sources were mentioned most frequently as the cause of impacts (n=97) (Table 6). Of the motorized noise, aircraft were mentioned by 45 respondents followed by road traffic with 36 respondents. Other noise sources causing impacts or conflicts included visitors (n=26), park operations, such as maintenance or infrastructure (n=21), and noise sources from outside the park boundary, such as urban development, aquaculture industry noise, music concerts and other entertainment events, oil and gas production, and prison operations (n=15).

Table 6. Noise sources reported to cause impacts or conflicts.

Noise Source	Number of Respondents	Percent
Motorized noise	**97**	**65.5**
Aircraft	45	30.4
Helicopter	13	8.8
Low flying	10	6.8
Commercial	6	4.1
NPS	6	4.1
Air tours	5	3.4
Military	2	1.4
Private	2	1.4
Crop dusters	1	0.7
Near airport	1	0.7
Road traffic	36	24.3
Boats	19	12.8
Motorcycles	18	12.2
Park vehicles	11	7.4
ATV	8	5.4
Trains	8	5.4

Trucks	8	5.4
Buses	7	4.7
Engine Idling	4	2.7
Snow machines	4	2.7
Personal watercraft	2	1.4
Visitors	**26**	**17.6**
Park operations	**21**	**14.2**
Maintenance	8	5.4
Infrastructure/utilities	5	3.4
Park construction	2	1.4
Outside park boundary	**15**	**10.1**
Campground (generators)	**14**	**9.5**
Modern sounds	**9**	**6.1**
Human generated	**5**	**3.4**
Chainsaws	**4**	**2.7**
Military activity	**4**	**2.7**
Hunting/Firearms	**3**	**2.0**
Concessionaires	**2**	**1.4**
Dogs	**2**	**1.4**
Bells	**1**	**0.7**

Question 4: Have any techniques been implemented to mitigate noise impacts in your park? If so, what were/are they? What other techniques could be implemented in the future?

There were 148 usable responses analyzed for this question. A total of 48 respondents (33.1%) indicated that no mitigation measures were being implemented at the park (Table 7). For the respondents reporting no mitigation measures, some indicated that there was no need (n=6) and/or mitigation was beyond park control (n=5). The other respondents reported the park unit was taking some action(s) to mitigate noise, such as park planning, communicating with identified noise contributors, or having some form of aircraft regulations (n=99) (Table 7).

Park planning efforts were mention by 35 respondents as a means to mitigate noise impacts. Park planning encompassed a range of planning efforts that affect park resources and visitors, including adjacent land use planning, wilderness minimum requirement analysis, winter use plans, soundscape management plans, and general management plans, and specific mention of National Environmental Policy Act compliance planning. Example quotes of some of these planning efforts are listed:

- "The park recently implemented the use of a Wilderness Minimum Requirement Analysis for all projects (research and in-house projects) which will evaluate and reduce, where possible, noise impacts from projects in wilderness and proposed wilderness."
- "The Winter Use Plans have made great strides in mitigating soundscape impacts of oversnow vehicles during the winter."

- "Each EIS/EA produced within the Park includes the required environmental consequence impact review of noise."

Mitigation measures that applied to park operations were described by 32 respondents. These measures included timing different park operations to minimize impacts, minimizing maintenance noise impacts, and linking acoustic protection with other park resource protection efforts. One respondent from a historic park indicated, "maintenance is encouraged to exit the historic core before 0900 – modern devices, machinery and equipment is expected to be removed from the colonial landscape before visitors arrive."

Communicating with identified noise source contributors was identified as a mitigation measure by 30 respondents. The strategies indicated under communication included a spectrum of methods from one-way communication to an open-dialogue between the park and noise contributor. For instance, one respondent stated, "some contacts have been made with the military regarding rerouting jet overflights." Another respondent demonstrated a more open dialogue form of communication dialogue stating, "the monument has been in talks with Nebraska Department of Roads to have the highway rerouted away from the monument." More intensive forms of communication and working with noise contributors were identified as collaboration (n=7). Collaboration included two-way communication and demonstrated intensive efforts to work with noise contributors. The following is an example quote of collaboration, "regular meetings are held with regional military commanders … regarding park overflights. There is an annual backcountry trip with military staff to emphasize wilderness values (this has been very successful)."

Aircraft regulations that were promulgated by the Federal Aviation Administration, jointly by NPS and the FAA, through U.S. Code, or by park management were indicated as being implemented or upheld by 30 respondents. Three specific subnodes were recorded within this category: minimum flight altitude restrictions (n=10), maintaining specific flight paths (n=7), and air tour management planning (n=2).

Respondents mentioned different elements of their parks' configuration, transportation system, or facilities that mitigated noise impacts. These references were coded as park design (n=24) and included measures such as installation of vegetative sound barriers, providing public transportation, thoughtful layout of campgrounds, and removing roads. One respondent described the use of vegetative buffers, "a buffer screen has been planted around the outer tour road boundary in order to mute some of the objectionable noise."

Acoustical research and monitoring was identified by 19 respondents as a means to mitigate noise impacts. The respondents indicated that acoustical monitoring was used to identify baseline information or used in conjunction with a specific park planning effort. As one respondent described, "sound monitoring has been collected to quantify the natural quiet and to establish a baseline for the natural quiet." Another respondent stated, "we are conducting acoustic inventories, which is the beginning to understand the issue and hopefully lead to solutions."

Another mitigation measure was the development of restriction zones that limit the type of activity allowed within an area. Respondents reported that certain activities in the park were not permitted in particular areas or during specified times, including limiting motorized vehicle access, implementing visitor quiet zones, and both voluntary and enforced bans for different visitor activities (n=24). Some restrictions were in place to protect sensitive wildlife areas and restricted the use of motorized vehicles in certain areas during particular seasons. Some comments for this measure were "suspension of certain activities or closure of areas to limit exposure to disturbance by endangered species during denning or nesting times" and "underwater sound monitoring has indicated that vessels are generally quieter at slower speeds, so vessel speed limits are imposed in whale aggregation areas to decrease disturbance and collision risk." Other parks had closed areas of the park to different forms of motorized recreation; for instance, respondents indicated that wilderness designations restricted the types of activities and mitigated noise impacts. One respondent indicated that "to enhance this wilderness setting, partially to reduce noise intrusion, multiple dirt roads were closed in accordance with a road closure plan in place even before wilderness was proposed."

Table 7. Mitigation measures being implemented at park units.

Noise Mitigation Measures	Number of Respondents	Percent
None	**48**	**32.4**
Park planning	**35**	**23.6**
General management plan	12	8.1
Wilderness minimum requirement	12	8.1
Adjacent land planning	10	6.8
Winter use plan	2	1.4
Soundscape management plan	1	0.7
Park operations	**32**	**21.6**
Timing operations	25	16.9
Maintenance activities	10	6.8
Resource protection	4	2.7
Aircraft regulations	**30**	**20.3**
Flight altitude restrictions	10	6.8
Flight paths	7	4.7
ATMP	2	1.4
Communication	**30**	**20.3**
Collaboration	7	4.7
Park design	**24**	**16.9**
Sound barriers	12	8.1
Transportation systems	7	4.7
Restriction zones	**24**	**16.2**
Wildlife	7	4.7
Wilderness	6	4.1

Quiet technology	**20**	**13.5**
Acoustical research or monitoring	**19**	**12.8**
NPS motorized vehicle use	**17**	**11.5**
Enforcement	**14**	**9.5**
Campground quiet hours	**13**	**8.8**
Education	**10**	**6.8**
Bans	**7**	**4.7**
Engine idling	**7**	**4.7**
Noise regulation	**6**	**4.1**
Concessionaire regulations	**5**	**3.4**
Interpretation modifications	**4**	**2.7**

Some respondents provided ideas for possible future mitigation measures that could be applied at their parks (Table 8). Ideas included park design (n=21), park planning (n=15), park operations (n=14), and implementing sound level regulations (n=14). Education and interpretation activities were listed by 15 respondents as future mitigation measures, almost double the number that reported currently using education and interpretation as a mitigation technique (n=8). Soundscape management planning was reported as a possible future measure by two respondents. As one stated, "a soundscape management plan would provide a more equitable and coherent soundscape policy."

Table 8. Ideas for possible future mitigation measures provided by respondents.

Ideas for Mitigation Measures	Number of Respondents	Percent
Park design	**21**	**14.2**
Transportation system	12	8.1
Sound barriers	9	6.1
Create soundscape	3	2.0
Interpretation and education	**15**	**10.1**
Park planning	**15**	**10.1**
Adjacent land planning	7	4.7
Soundscape management plan	2	1.4
Quiet technology	**15**	**9.5**
Park operations	**14**	**9.5**
Timing operations	5	3.4
Chainsaws	3	2.0
Project considerations	3	2.0
Noise regulation	**14**	**9.5**
Aircraft regulations	**13**	**8.8**
Flight paths	2	1.4
Air Tours	1	0.7
Flight altitude restrictions	1	0.7

NPS flights	1	0.7
Collaboration communication	**11**	**7.4**
Restriction zones	**8**	**5.4**
NPS vehicle use	**6**	**4.1**
Acoustical research and monitoring	**6**	**4.1**
Assistance request	**5**	**3.4**
Bans	**5**	**3.4**
Enforcement	**4**	**2.7**
Engine idling	**4**	**2.7**
Interpretation modification	**2**	**1.4**
Campgrounds	**1**	**0.7**
Concessionaires	**1**	**0.7**

Mitigation Analysis

Based on classifiable responses to question four (n=147), responding parks were grouped into two categories, mitigating (n=99) and non-mitigating (n=48), for additional exploratory analysis. The quantitative analyses were conducted to assess the relationship between these two categories and responding park independent variables including: region, park unit type, respondent's position, park size, visitation in 2009, presence of commercial air tours, whether acoustical monitoring has been conducted, and if the park is in the inventory and monitoring network.

For the categorical independent variables (respondent position, park unit type, region, inventory and monitoring, acoustical monitoring, and air tours), we calculated a chi-square statistic to determine if a significant relationship existed between these and the mitigation categories. Respondent position variable was categorized as natural resource positions and all other to improve the strength of the test, since natural resource type positions comprised 65% of the sample. Also, to improve the strength of the test park unit type was categorized as national park, historic site, monument, and all other designations. Of these, whether acoustical monitoring had been conducted and region were significant at $p<0.01$ (Table 9). All other independent variables, park unit type, respondent position, inventory and monitoring, and the presence of commercial air tours were significant at $p<0.05$. Responding park variables and the mitigation category comparisons are shown in Figures 2-7.

Table 9. Results of chi-square tests exploring relationships between mitigating and non-mitigating of noise in parks and independent variables.

Independent variable	X^2	Significance
Acoustical Monitoring	12.605	0.000**
Region	16.146	0.006**
Unit Type[a]	11.081[a]	0.011*
I & M Park	5.257	0.022*
Respondent Position[b]	4.821[b]	0.028*
Air Tours	4.001	0.045*

** $p < 0.01$; * $p < 0.05$

[a]Unit types were coded as (1) historic sites, (2) monuments, (3) national parks, (4) all other designations.

[b]Respondent positions were coded as (1) natural resource position and (2) other.

For the two continuous independent variables, park size and visitation in 2009, a difference of means t-test was conducted. The mean acreage of responding parks was 262,125.93 acres (standard deviation= 1,077,300). The mean acreage of park units mitigating noise was 380,619 (SD=1,307,100) and the mean acreage for non-mitigating parks was 24,551.06 (SD=58,768.85). The *t*-test results found the mean acreage to be significantly different between the two groups (*t*-statistic=2.705, degrees of freedom=98.815, *p*=0.008). For park visitation in 2009, not all units had available data (NPS 2009a) and, therefore, were not included in the analysis (n=7; 4 mitigating and 3 non-mitigating parks). The mean visitation for parks mitigating noise (n=95) was 807,509.34 (SD=1,433,690) visitors and the mean for non-mitigating parks (n=45) was 488,857.51 (SD=826,313) visitors. The two groups' means were not significantly different (*t*-statistic=1.384, degrees of freedom=138, p=0.168).

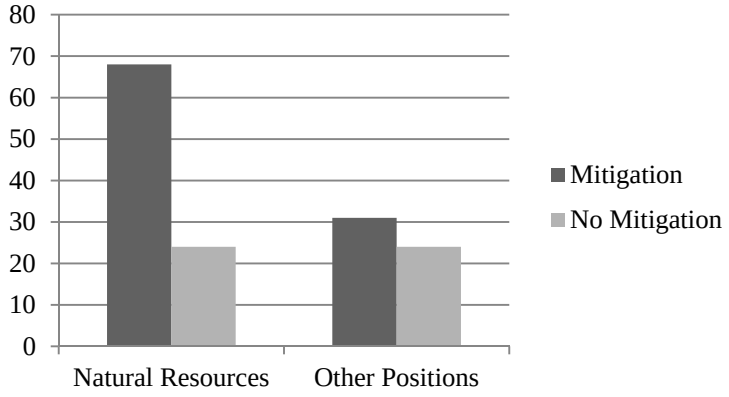


Figure 2. Respondents in a natural resource or other position and the number of parks reporting mitigation or no mitigation measures implemented.

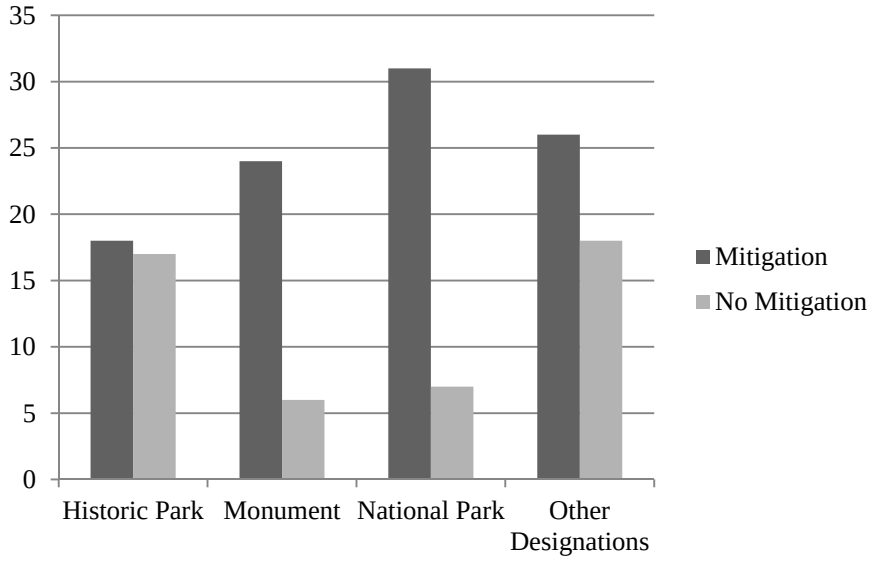


Figure 3. Responding park units and number reporting mitigation measures or no mitigation measures.

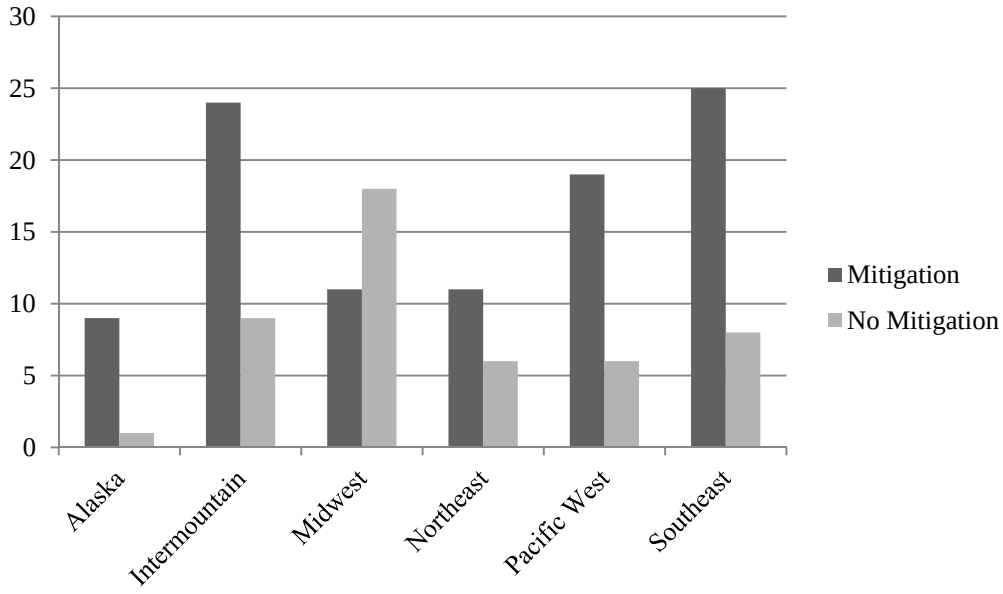


Figure 4. Responding park unit regions and number reporting mitigation measures or no mitigation measures.

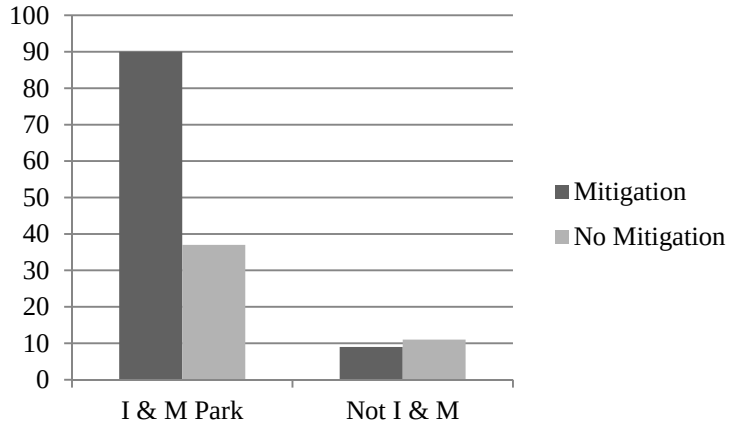


Figure 5. Park units that are or are not part of the inventory and monitoring network and number of respondents reporting mitigation measures or not.

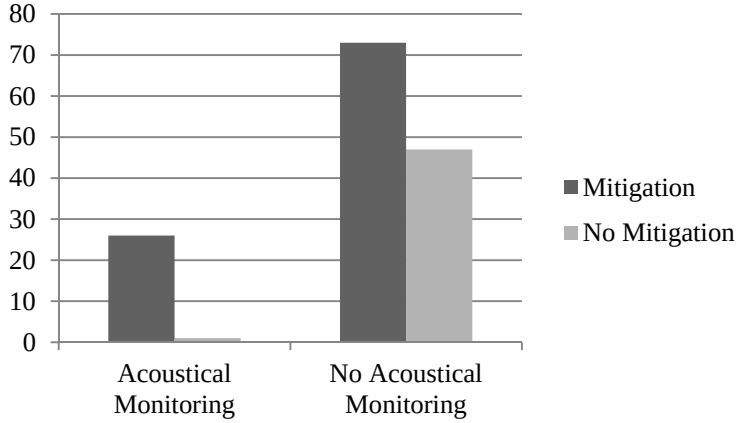


Figure 6. Park units that have conducted acoustical monitoring or not and the number of respondents reporting mitigation measures or not.

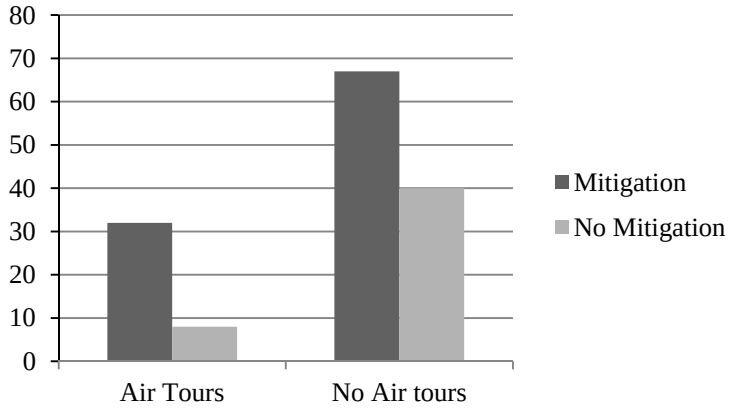


Figure 7. Park units with and without commercial air tours and the number of respondents reporting mitigation measures or not.

Discussion

The results of this survey highlight both the diversity of national park units within the National Park System and the shared impact of motorized noise. There was a variety of acoustic resources identified through this survey. Respondents emphasized wildlife, in particular birds, as important acoustic resources. The sounds of mammals, such as coyotes, wolves, bison, elk, and small mammals also were reported. These responses indicate that the park wildlife resources are recognized by managers as being substantial contributors to park acoustical environments. Additionally, the sounds of moving water in the form of rivers, waterfalls, and waves were identified frequently as an acoustic resource. Other responses mirrored the historic or cultural nature of the parks emphasizing respectful quiet, Native American ceremonies, or interpreted historic sounds. Other unique acoustic resources were described, such as the sounds of lava flows, glacier movements, cave acoustics, underwater reef sounds, and alligator bellows.

The pervasive nature of motorized noise is evidenced in the survey results. All but two parks responding to the survey reported noise from motor vehicles as negatively affecting park environments. Motorized noise sources were specifically linked to a park resource impact, visitor impact, or conflict by 97 (65.5%) respondents. The primary type of impact identified was to visitor experience. Impacts to park soundscapes or acoustical environments due to a noise were also identified. Some respondents indicated that there are impacts to other park resources including wildlife, cultural and historic resources, and wilderness. The number of parks reporting other resource impacts only exceeds visitor impacts by 17 responses. Additionally, impacts to park interpretation programs, research, and park staff were reported by 35 respondents. The results indicate that there may be a need for increased awareness and understanding about the impacts of noise on park resources other than visitor experience. As the Natural Sounds Program increases the amount of information available to parks on the importance of the acoustical environment through education efforts like The Power of Sound Interpretive Handbook, other resource impacts from noise may be recognized by parks, such as those to wildlife, historic, cultural, and wilderness (NSNSD 2011). This might be one technique to raise awareness and improve noise mitigation implementation.

Noise mitigation measures that the park units were implementing varied as well. Of note is that 32.4% of the respondents indicated that no noise mitigation was being implemented. Reasons provided by a few of the non-mitigating parks included that the park unit had no need to mitigate noise or that noise mitigation was beyond the control of the park managers. Other respondents that were not implementing mitigation measures indicated that there were future efforts the park could take or that they would be interested in pursuing noise mitigation in the future. Of note, only 12 respondents reported no impacts or conflicts at their parks due to noise. Only one of these park units reported no noise sources. While noise sources were reported for all other responding park units, the degree or significance of noise conditions at these parks needs further investigation. Additionally, further research is needed to determine if there is a need for soundscape management or noise mitigation at some of the non-mitigating park units.

Mitigation measures that were implemented by parks varied. Park planning was a frequently reported mitigation measure encompassing many different types of planning. The types of planning mentioned most often included park general management plans, wilderness minimum requirement analysis, and adjacent land use planning for projects originating outside of park

boundaries. Soundscape management planning was used by one park and proposed as future measures by two more. In terms of a mitigation strategy, most of these planning efforts seem to be a comprehensive approach in comparison to some of the other measures that parks implement.

Other mitigation measures that were implemented include adjusting park operations, park designs that minimize noise impacts, communicating with identified noise source contributors, working with appropriate agencies to enforce aircraft regulation over the parks, and acoustical monitoring. There are several other examples of mitigation measures that were implemented. These measures are not mutually exclusive; for instance, communicating with an adjacent military installation to limit flights over the park airspace. Other measures such as conducting acoustical monitoring may have been in conjunction with a park planning effort. The categorization of mitigation strategies provides some insight into the tools parks are using to address noise issues.

The exploratory correlation analyses found that many of the responding park attributes had a significant relationship with the mitigation variable (mitigating/non-mitigating). Respondents in a natural resource position were more likely to mention some type of mitigation measure being implemented by their parks than respondents in another position, such as superintendent, park ranger, or interpretation. Region and park unit type also were found to be significantly related to mitigation. The Midwest Region was the only region with more responding park units not mitigating noise. In terms of park unit type, national parks and national monuments identified noise mitigation measures more often than historic parks or other unit designations. Of note, though, some respondents from historic parks indicated the importance of respectful quiet, as well as providing interpretive activities that reflect the represented time period. Both of these require soundscapes that are not disrupted by motorized noise. Park unit mean size was found to be significantly different for parks mitigating noise compared to those not mitigating noise. The relationship indicates that larger parks are more likely to implement mitigation strategies than smaller parks. However, this finding is questionable due to the large variance in park unit acreage. At this point the meaning between attribute differences of mitigating and non-mitigating parks can only be speculated.

Park soundscapes and acoustical environments are recognized by NPS as a natural resource afforded the same protection as other park resources. The protection of soundscapes and the restoration of degraded soundscapes are called for in the NPS Management Policies (NPS 2006). While adopted by the agency, the extent of adoption and implementation in individual park units was largely unknown until this service-wide survey. The findings from this survey highlight the uniqueness of park acoustical environments and the growing intrusion and impact from motorized noise. While the majority of respondents articulated the aspects of this resource and the different impacts due to noise, over one-third reported no noise mitigation being implemented. Determining why some parks are implementing noise mitigation measures and others are not will be the next step in this research.

Future Research Directions

In order to better understand the noise mitigation and soundscape protection needs of park units, follow-up interviews will be conducted in 2011. The research will investigate what can be improved to address soundscape stewardship needs of parks by identifying different barriers.

Additionally, this research will explore the diversity of park needs and management responses to help the Natural Sounds Program in addressing park soundscape issues. A brief report on the results of this study will be provided to interested parties.

Acknowledgments
We thank the park respondents for participating in this study. We also thank the NPS Natural Sounds Program employees for their assistance with data entry. This research was funded in part by Purdue University's Department of Forestry and Natural Resources.

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Appendix A. Service-wide Comparison with Survey Respondent Data

Table 10. Acreage of responding parks and NPS total acreage.

	Responding		System-wide	
Measure	**Total**	**Mean**	**Total**	**Mean**
Acreage	38,800,676	275,182	84,378,873	215,803

Table 11. Region of responding parks with and without multiple respondents. Park system-wide percents are reported for comparison.

Region	Number	Number (without multiple respondents)	Regional Percent	System-wide Percent
Intermountain	35	31	22	20
Southeast	33	31	22	16
Midwest	29	27	19	15
Pacific West	25	25	18	14
Northeast	17	17	12	19
Alaska	9	9	6	4
National Capital	1	1	1	11
TOTAL	149	141		

Table 12. Respondent parks within Inventory and Monitoring networks, with air tour operations, and that have conducted acoustical monitoring.

	Responding		System-wide	
	Total	**Percent**	**Total**	**Percent**
I & M	121	86	293	75
Air Tours	37	27	106	27
Acoustical Monitoring	25	18	65	17

Note: The duplicate cases were removed (n=8). Park system-wide totals and percents are reported for comparison.

Table 13. Park unit types and number responding to the survey.

PARK UNIT TYPE	Number	Percent	System-wide Percent
National Park	**39**	**26.2**	**14.8**
National Park	34		
Park and Preserve	5		
Historic Site/Historical Park	**35**	**23.5**	**31.5**
Historic Site	21		
Historical Park	12		
Park and Preserve	2		
National Monument	**31**	**20.8**	**18.9**
National Monument	30		
Monument and Preserve	1		
National Battlefield and Military Park	**8**	**5.4**	**6.1**
National Recreation Area	**7**	**4.7**	**4.6**
National Seashore	**7**	**4.7**	**2.6**
National River Designation	**6**	**4.0**	**3.8**
National Scenic River	3		
Wild and Scenic River	1		
Wild River	1		
Recreational River	1		
National Memorial	**5**	**3.4**	**6.9**
National Lakeshore	**4**	**2.7**	**1.0**
National Trail Designation	**3**	**2.0**	**0.8**
Historic Trail	2		
Scenic Trail	1		
National Preserve	**2**	**1.3**	
Parkway	**1**	**0.7**	**1.0**
International Park	**1**	**0.7**	
TOTAL	**149**		

Table 14. Survey respondents' position at the park unit.

RESPONDENT POSITION	Number	Percent
Natural Resources	**94**	**63.1**
Chief of Resource Management	35	
Natural Resource Manager	29	
Biologist	7	
Biological Science Technician	7	
Integrated Resource Manager	4	
Other	12	
Interpretation	**19**	**12.8**
Park Ranger	9	
Chief of Interpretation	5	
Chief Park Ranger	4	
Interpretive Specialist	1	
Superintendent	**19**	**12.8**
Superintendent	18	
Site Supervisor	1	
Historical/Cultural	**6**	**4.0**
Archaeologist	1	
Chief of Cultural Resources	1	
Historian	1	
Museum Specialist	1	
Socio-cultural Group Lead	1	
Cultural Resource Specialist	1	
Law Enforcement	**4**	**2.7**
LE Park Ranger	3	
Chief of Protection	1	
Other	**7**	**4.7**
Chief of Planning	2	
Horticulturist	1	
Management Assistant	1	
Outdoor Recreation Specialist	1	
Superintendent Secretary	1	
Training Specialist	1	
TOTAL	**149**	

Table 15. Acoustic resources, noise sources, and percent of respondents mitigating for each region.

Region	Number of Respondents (percent)	Most Frequently Reported Acoustic Resources (percent)	Most Frequently Reported Noise Sources (percent)	Percent Mitigating in the Region
Alaska	10 (6.7)	Water (90.0) Wildlife (90.0) Weather (80.0)	Aircraft (100) Park operations (60.0)	90.0
Intermountain	34 (22.8)	Wildlife (85.2) Weather (70.6)	Road traffic (76.5) Aircraft (73.5)	72.7
Midwest	29 (19.5)	Wildlife (93.1) Water (72.4)	Road traffic (79.3) Aircraft (51.7)	37.9
Northeast	18 (12.1)	Wildlife (100) Water (88.9)	Road traffic (72.2) Park operations (72.2) Aircraft (66.7)	64.7
Pacific West	25 (16.8)	Wildlife (88.0) Water (80.0)	Aircraft (72.0) Road traffic (64.0)	76.0
Southeast	33 (22.1)	Wildlife (84.8) Water (66.7) Weather (66.7)	Road traffic (78.8) Aircraft (60.6)	75.8

Appendix B. Survey Instrument

National Park Service
U.S. Department of the Interior

Natural Sounds Program

Nationwide Survey of Acoustical Environments in Parks

The National Park Service Organic Act mandates the preservation and/or restoration of natural resources within parks, including the acoustical environment. In addition, NPS Management Policies 4.9 and 53.1.7 respectively require that we "restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts"; and that "the Service will preserve soundscape resources and values of the parks to the greatest extent possible to protect opportunities for appropriate transmission of cultural and historic sounds . . .".

Many people use "soundscape" to reference the entire acoustical environment. However, the Natural Sounds Program distinguishes between physical resources and phenomena (the "acoustical environment") and the human perception of that environment ("the soundscape"). This distinction is important for helping parks to meet their management objectives. Desirable and appropriate sounds depend on the purposes and values for which the park was established and current management objectives. For example, in sites where music, language, and history

Coyote

Granite Lake site at Yosemite National Park

help people understand our national heritage, the park's acoustical environment may include jazz music, battlefield sounds, or the songs of indigenous people. On the other hand, this type of acoustical environment would not be appropriate in

"The Natural Sounds Program works to protect, maintain, or restore acoustical environments throughout the National Park System. We fulfill this mission by working in partnership with parks and others to increase scientific and public understanding of the value and character of soundscapes and to eliminate or minimize noise intrusions."

the wilderness of Yellowstone. We also distinguish between managing noise versus enhancing opportunities to understand and enjoy the sounds of nature (or culture). Both are important aspects of our mission.

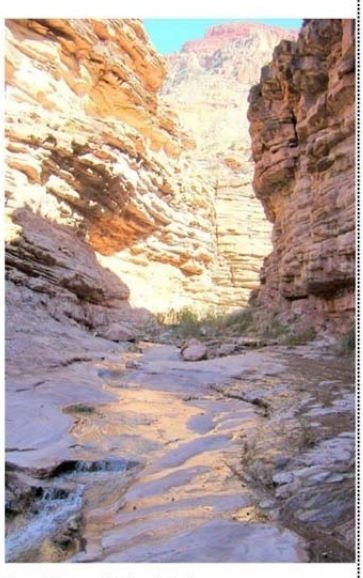
The purpose of this survey is to provide the Natural Sounds Program with more information about the total acoustical resources present at your park, sources of noise, major issues or conflicts associated with noise, and possible mitigation techniques that could be used to minimize noise impacts. This information will help us further NPS understanding of the management issues in parks, thereby strengthening the support our program can offer for assisting parks to effectively manage soundscapes.

In an effort to receive information from the most parks, we have developed a short survey made up of only four questions. The time it takes to the complete the survey will ultimately depend on the complexity of the park. Please complete each question as completely and with as much detail as possible. The information we obtain from the survey will improve our understanding of the role the acoustical environment plays in overall ecosystem health and visitor experience.

The results of the survey will be compiled and summarized in a brief report. Once completed, this report will be released to all park units and other interested parties.

Nationwide Survey of Acoustical Environments in Parks • Fall 2008

Survey Questions



Grand Canyon National Park

Please answer the following questions to the best of your ability. You can send your responses by regular mail, fax or email (see contact information below). You can either write directly on these sheets or send your responses in a separate word document. If you have any questions please contact Lelaina Marin, Outdoor Recreation Planner at 970-225-3552.

1. What are the most significant acoustical resources present at your park within the following categories: weather, water, vegetation, wildlife, cultural, and historic sounds? Be as specific as possible (e.g. coyotes, elk bugling, waterfalls, bird songs, insects, amphibians, battle re-enactments).

2. What sources of noise adversely affect the park's acoustical environment and soundscape (transportation, motorized recreation, infrastructure, resource extraction, maintenance, and visitors). Note that not all sounds produced by visitors should be considered noise.

National Park Service
U.S. Department of the Interior

The Natural Sounds Program Office, located in Fort Collins, Colorado, is part of the National Park Service's (NPS) Natural Resource Stewardship and Science. The program currently resides within the Air Resources Division. The NPS Natural Sounds Program Office was established in 2000 to help parks manage sounds in a way that balances the protection of park resources with the various expectations of park visitors.

Natural Sounds Program Office
Attn: Lelaina Marin
1201 Oakridge Drive, Suite 100
Fort Collins, CO 80525

Phone
970 225-3552
970 267-2109 (fax)

E-mail
Lelaina_Marin@nps.gov

The National Park Service cares for the special places saved by the American people so that all may experience our heritage.

Survey Questions

Please provide your contact information

Name: _____

Title: _____

Park Name:_____

Address: _____

_____

_____

Phone #:_____

Email Address: _____

3. What resource impacts or user conflicts, if any, are associated with the noise disturbances listed in #2?

4. Have any techniques been implemented to mitigate noise impacts in your park? If so, what were/are they? What other techniques could be implemented in the future?

Hawaii Volcanoes National Park

National Park Service
U.S. Department of the Interior

Natural Sounds Program Office
1201 Oakridge Drive, Suite 100
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The Natural Sounds Program Office, located in Fort Collins, Colorado, is a part of the National Park Service's (NPS) Natural Resource Stewardship and Science. The program currently resides within the Air Resources Division.

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