National Park Service
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The Power of Sound

Natural Sounds and Night Skies Division
Interpretive Handbook






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Natural Sounds and Night Skies Division
Fort Collins, CO
Natural Resource Stewardship and Science Directorate

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Available online at: http://www1.nrintra.nps.gov/naturalsounds/outreach/

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Photo (left): The bells of Mission San Juan Church, San Antonio Missions National Historical Park – NPS Photo by Lelaina Marin
Photo (contents page): A wave crashes into the rocks at Ship Harbor, Acadia National Park – NPS Photo by Todd M. Edgar

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Goals of Handbook

Through this interpretive handbook, the Natural Sounds and Night Skies Division hopes to:

1. Increase understanding of the acoustical environment as a park resource.

2. Increase understanding of soundscapes as an important part of the visitor experience.

3. Promote interpretation of soundscapes and acoustic resources in NPS units.

4. Provide a reference for learning more about natural, cultural, and historic sounds in NPS units.

5. Provide interpreters with tools for developing programs that will connect visitors to park soundscapes and acoustic resources.

This handbook arose out of a growing interest from park interpreters to develop interpretive programs that connect visitors to park soundscapes and acoustic resources. Although its target audience is the park interpreter, sections of the handbook will be incorporated into our internal and public websites as references for park managers and the public. In addition to the printed version, the handbook, in its entirety, will be available on our internal website.

The online version of this handbook can be found at:
http://www1.nrintra.nps.gov/naturalsounds/outreach/

"Wilderness sounds would be here, bird songs in the morning and at dusk. The aspen leaves would whisper and the pines as well, and in the sound of water and wind I would hear all that is worth listening for."

~ Sigurd Olsen

Introduction: A Powerful World of Sound

Elk bugling in the cool autumn air of Rocky Mountain National Park, waterfalls thundering in Yosemite Valley, cannons firing at Fort McHenry National Monument, the quiet hush among giant redwoods—these are the sounds that make visiting our national parks a unique experience.

Natural and cultural sounds awaken the sense of awe that connects us to the splendor of national parks and have a powerful effect on our emotions, attitudes, and memories. Who can forget the flash of adrenaline from the sound of looming whitewater or the lightning bolt that cracked just a little too close? The National Park Service regards these sounds as part of a web of natural and cultural resources that must be protected.

Our ability to see is a powerful tool for experiencing our world, but sound adds a richness that sight alone cannot provide. In many cases, hearing is the only option for experiencing certain aspects of our environment. Natural sounds often present the best opportunities to find wildlife because animals can be heard at much greater distances than they can be seen. Cultural sounds are invaluable for recreating a historic scene or setting a mood. Noise, on the other hand, impacts the acoustical environment much like smog impacts the visual environment; it obscures the listening horizon for both visitors and wildlife. Places of deep quiet are most vulnerable to noise. Therefore, wildlife in remote wilderness areas and park visitors who journey to these quiet places are likely to be especially sensitive to noise.

Photo, both pages: The deafening roar of a waterfall, such as can be heard at Lower Yellowstone Falls, forms a memorable part of the experience for many visitors to Yellowstone National Park. NPS photo by A. Mebane.

Who we are

"Natural sounds are part of the special places we preserve. Rustling winds in the canyons and the rush of waters in the rivers are the heartbeat and breath of some of our most valuable resources." ~ *NPS Director Robert Stanton*

The National Park Service has determined that natural sounds are valuable resources worthy of protection. Out of this ideal the Natural Sounds and Night Skies Division (NSNSD) was born. The NSNSD works to protect, maintain, or restore acoustical environments throughout the National Park System. Its goal is to provide coordination, guidance, and a consistent approach to soundscape protection with respect to park resources and visitor use. The program helps provide national park managers with specialized resource management and policy expertise as well as technical assistance in the form of acoustical monitoring, data collection and analysis, and all aspects of park planning and compliance. Finally, NSNSD staff work in partnership with parks and other entities to further understanding of and inspire public appreciation for soundscapes throughout the national park system.

For Natural Sounds and Night Skies Division staff contact information, please see: http://www.nature.nps.gov/naturalsounds/organization/

On the ball with the Natural Sounds and Night Skies Division Staff.
Bottom row, left to right: Damon Joyce, Katy Warner and Cecilia Leumas; 2nd row: Randy Stanley, Jessica Briggs, Charlotte Formichella, and Karen Treviño; 3rd row: Daniel Mennitt, Frank Turina, Lelaina Marin, Vicki McCusker, Emma Lynch; 4th row: Deanna Ochs (on detail), Kurt Fristrup, and Chad Moore. NPS photo by Damon Joyce.

The crack of thunder can exceed 120 decibels, loud enough to cause pain to the human ear. NPS photo.

Because We Said So, That's Why - Soundscape Policy

Okay, so we know the Director said it's important and a team of specialists has been dedicated to help parks preserve their soundscapes, but just how far does this thing reach? One might say soundscape protection is written in the National Park Service DNA. Those planning documents that outline the guiding principles for park management reflect a growing concern about noise in national parks and direct parks to safeguard their soundscapes.

NPS Management Policy 4.9 states: "…the Service will monitor human activities that generate noise that adversely affects park soundscapes (and) will preserve, to the greatest extent possible, the natural soundscapes of parks."

To read the entire statement, see Appendix A under Soundscape Management.

Now, in case you're worried about the commotion generated in your occasionally overexuberant program, you can relax. Within the right context, there's a policy for that. In fact, management policies on visitor use specifically prohibit activities that generate noise that would interfere with, among other things, interpretive services. This applies not just to interpretive talks, but to those human-caused sounds deemed appropriate to the park's established purpose, such as cultural rites or celebrations, historic activities, and battlefield reenactments. Section 5.3.1.7 of the NPS Management Policies (2006), Cultural Soundscape Management, states:

"The Service will … protect opportunities for appropriate transmission of cultural and historic sounds that are fundamental components of the purposes and values for which the parks were established."

(The mention of the word "appropriate" in the policy will be examined more closely under Defining Key Terms.)

But just because it's on paper, doesn't make it so. Protecting acoustical environments is a multi-layered process involving soundscape monitoring and analysis, setting standards in planning documents, and integrating information from a variety of sources into effective park policy.

The Natural Sounds and Night Skies Division has developed protocols for collecting and analyzing soundscape data and assists parks in interpreting and applying the information. More significantly, it is developing guidance and strategies for soundscape management planning to ensure that natural and culturally appropriate sounds are left unimpaired for the enjoyment of future generations.

Understanding Sound and Noise

Cultural sounds, being among a park's acoustic resources, form a significant part of the visitor experience and are among the sounds the NSNSD is helping to protect. NPS photo.

Soundscapes 101 - Defining Key Terms

We've been throwing around some terms up to now that may be unfamiliar, and that are important to understand before reading on. Below are the Natural Sounds and Night Skies Division's definitions of some of these terms as well as few you might have thought you already knew.

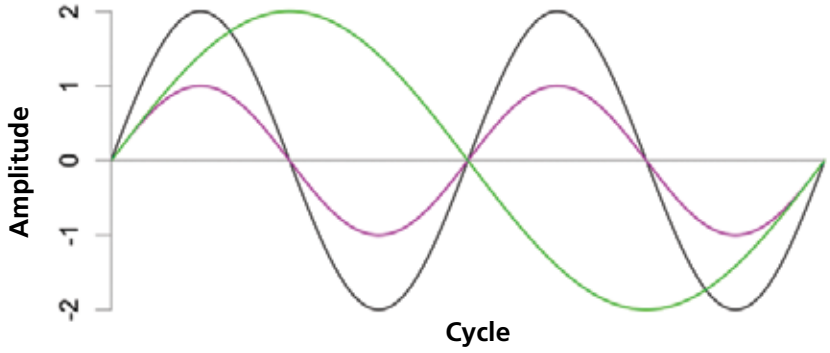
Physical sound sources, or *acoustic resources*, include both natural sounds (wind, water, wildlife, vegetation) and cultural and historic sounds (battle reenactments, tribal ceremonies, etc.), and a *soundscape* can be defined as the human, or animal, perception of those acoustic resources. Like beauty, soundscapes are in the mind of the beholder. The rhetorical question about the tree that falls in the forest may help illustrate this. Because no human is there to hear it, the resulting crash is not a part of the human soundscape. It is however, a pretty significant part of the soundscape of the squirrel standing in the tree's path.

The *acoustical environment* is the combination of all the physical sound resources in a given area. This includes natural sounds and cultural sounds, as mentioned before, and non-natural human-caused sounds. The sound vibrations made by our imaginary falling tree, then, are a part of the acoustical environment. Bat echolocation calls, likewise, while outside of the realm of the human soundscape, are a part of the acoustical environment. One can perhaps understand, then, why it is critical to take the entire acoustical environment into account when working to protect natural sounds.

Still with us? Good! Now hang on for the fun part. Sounds that characterize the acoustical environment of a park can be divided into two main categories: intrinsic and extrinsic. *Intrinsic* sounds belong to a park by its very nature, based on its purposes, values, and establishing legislation. In addition to natural sounds, intrinsic sounds can include cultural and historic sounds that contribute to the acoustical environment of a park. *Extrinsic* sound refers to any sound not forming an essential part of the park unit, or a sound originating from outside the park boundary. These could include the voices of school children visiting the park, or jets flying thousands of feet above the park unit.

Speaking of school children, now seems a good time to tackle the conundrum of appropriate versus inappropriate sounds. *Inappropriate* sounds are those that do not help meet the mission of a given park or of an area within the park. So, whereas children's laughter during an interactive game outside of an environmental education center would likely be deemed appropriate, the same boisterous interaction may be inappropriate in endangered piping plover habitat. A radio playing at a moderate level could be appropriate in a campground but inappropriate in the backcountry where visitors anticipate natural quiet. Crank that radio volume up several notches at the campground and you are staring squarely into the face of appropriate sound at an unacceptable level (in most situations, in most parks…now you see why it's a conundrum?) What's important to understand is that characterization of a sound as appropriate or inappropriate is heavily dependent on location of the sound and the enabling legislation of the park. It is often referred to (in circles where they talk about this kind of stuff, which admittedly are small) as extraneous. Whether a sound is acceptable or unacceptable will depend on how long, how loud, or how often it occurs.

Now you might be asking yourself, "isn't that



The image to the right illustrates the concepts of frequency and amplitude. The magenta wave has one half the amplitude of the black wave, and produces a quieter sound. The green wave completes half as many cycles as the black wave, meaning its frequency is one half the black wave, and has a lower pitch.

Sound behaves differently in heavily vegetated areas, such as this forest in Mount Rainier National Park, than in a relatively barren landscape, such as that of Dinosaur National Monument. Top image: NPS photo, lower image: NPS photo by Deanna Ochs.

just a high-priced term for 'noise'?" To which we would have to answer, "almost…." (Did you really expect this to be *that* easy?) *Noise* is a general term for either unwanted or extraneous sound. Noise, being unwanted, is subjective. The rumbling of a motorcycle going over the Blue Ridge Parkway may be considered noise to someone enjoying the views from a pull off, but not to the person riding the motorcycle.

Don't Tell Me 'Cause it Hertz

So, now that you're feeling pretty good about your understanding of acoustics in the national parks, we might as well go ahead and tackle *sound*. In a nutshell, okay, a coconut shell, it goes something like this: Humans perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air. It is measured in terms of amplitude and frequency. *Amplitude* is the relative strength of sound waves (transmitted vibrations) and can be detected by hearing organs, which we perceive as loudness or volume. Amplitude is measured in decibels (dB), which refer to the sound pressure level or intensity. The lower threshold of human hearing is 0 dB; moderate levels of sound (a normal speaking voice, for example) are under 60 dB; relatively loud sounds, like that of a vacuum cleaner, measure around 70 dB. Rock concerts, at around 125 dB, (in case you needed science to confirm this) are pushing the human pain threshold.

Decibels work on a logarithmic scale; an increase of 10 dB causes a doubling of perceived loudness [1] and represents a ten-fold increase in sound level. In other words, if the sound of one vacuum cleaner measures 70 dB, 80 dB would be the equivalent of 10 vacuum cleaners. (Nice for cleaning house, perhaps, but a bit hard on the ears.) Sound levels are often adjusted, or "weighted," to match human hearing, and are expressed as dBA, as opposed to just dB.

Sound levels in national parks can vary greatly, ranging from among the quietest ever monitored, to extremely loud. Where, for example, the din of a typical suburban area fluctuates between 50 and 60 dBA, the crater of Haleakala National Park is intensely quiet, with levels hovering around 10 dBA. Along some remote trails in Grand Canyon National Park, sound levels, at 20 decibels(A), are softer than a whisper [2]. The noise levels standing near a snowcoach in Yellowstone National Park, however, can be compared to standing three feet from a churning garbage disposal [3]. In "Understanding the Impacts," next page, we address the significance of these sounds levels.

Sometimes referred to as pitch, *frequency* is defined as the number of times per second that a sound pressure wave repeats itself and is expressed in terms of hertz (Hz). A drum beat has a much lower frequency than a whistle, and a bullfrog call has a lower frequency than a cricket. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz. Frequencies above 20,000 Hz are known as ultrasound. When your dog cocks his head to listen to some seemingly imaginary sound, he is tuning into ultrasound frequencies, as high as 45,000 Hz. Bats can hear at among the highest frequencies of any mammal, up to 120,000 Hz. This enables them to pursue minute insects without the benefit of light and simultaneously avoid smacking into immovable objects.

Because the acoustical environment is made up of many sounds, the way people experience it depends on interactions between the frequencies and amplitudes of all the sounds. For example, the sound of a piece of music at any given moment is a result of the interplay between the amplitudes and frequencies of all the instruments. Try to imagine Beethoven's' 5th Symphony with all instruments playing at the same pitch and volume (rather dull, no?), and one begins to appreciate the richness of the acoustical environment. To take it outside, the low rumble of distant thunder, the rustle of leaves in the trees, the sound of one's foot snapping a twig, and the robin singing overhead are sounds that may all occur simultaneously, but the way we hear them depends on the interactions between their frequencies and amplitudes (as well as how we feel about that approaching storm). Some frequencies may block out or "mask" other frequencies (the low-pitched sound of thunder may temporarily mask the relatively high-pitched robin song). Therefore, when the Natural Sounds and Night Skies Division studies park acoustical environments and soundscapes, they are not only interested in individual sounds but also the relationships and interactions among them.

Other factors such as vegetation, topography, atmospheric conditions, and our individual hearing sensitivity also contribute to the

The great egret emits a harsh squawk to defend its territory, while the bull elk (below right) communicates his dominance during mating season with a high-pitched "bugle."
Photo credits: Great egret–John J. Mosesso/NBII; Bull elk–Donald Metzner.

soundscape experience. A heavily vegetated area, for example, will absorb more sounds than a barren landscape, thereby decreasing the distance from which a sound may be heard. Think of the noise difference when standing next to a busy road versus a few hundred feet into the woods near that same road. It can be astonishing. This is particularly apparent in the Cathedral Grove at Muir Woods National Monument. The grove's remarkably peaceful character is due in part to the thick, porous bark of the redwood trees, which inhibits sound transmission. Thus, understanding these relationships is vital to protecting acoustical environments and soundscapes.

Understanding the Impacts

"Noise knows no boundaries." [4]

It is impossible to see, difficult to define, and even harder to regulate. But for all of its esoteric qualities, recent studies are revealing surprising impacts of noise on park resources and visitor experiences. The following summaries on the effects of increasing noise levels in our national parks will provide interpreters a brief summary on current research results. This is, however, an emerging field of study. Future findings may well influence the way parks are managed in the decades to come. Interpreters wishing to stay informed can read up on new findings on the Natural Sounds and Night Skies Division websites listed at the end of each summary.

Effects of Sound and Noise on Wildlife

That old expression, "The early bird gets the worm," turns out to be truer than ever in urban settings today. In fact, recent studies are finding that some birds in noisy environments have taken to singing at night in order to be heard over the din of the city. And if the current trend of increasing human-generated noise levels continues, more and more birds may resort to such nocturnal habits.

Sound, just like the availability of nesting materials or food sources, plays an important role in the ecosystem. Activities such as finding desirable habitat and mates, avoiding predators, protecting young, and establishing territories are all somewhat dependent on the acoustical environment. So, what does that mean for humans? Beyond needing to have a good pair of earplugs handy for those predawn bursts of birdsong, it is a strong indication that animals are being forced to adapt to increasing noise levels. To illustrate further, imagine that you

Schematic representation of how masking reduces an animal's listening area. As background sound levels increase, the area in which the perched bird can hear biologically significant sounds, represented by the domes, is reduced. The intensity of masking, as measured by listening area reduction, depends upon the characteristics of the biological signal, the noise, and the animal's auditory system. Image by Ted E. Dunn

are at a cocktail party. The room is filled with animated people, all talking loudly. Your mission: to find a mate that will ensure healthy progeny. Your criteria? The male with the deepest voice. There is one problem, however. The party is near a busy highway, and the males are speaking in a higher pitch than normal in order to be heard.

Preposterous? A similar scenario (without, as far as we know, the cocktails) is actually occurring among certain amphibian populations. Research shows that males of at least one frog species is adapting to traffic noise by calling at a higher pitch [5]. This could be problematic for the females, because they prefer lower-pitched calls, which indicate larger and more experienced males. Human-caused noise has produced similar results in multiple bird species [4].

In general, a growing number of studies indicate that wildlife, like humans, is stressed by a noisy environment. The endangered Sonoran pronghorn avoids noisy areas created by military jets, female frogs exposed to traffic noise have more difficulty locating the male's signal, and gleaning bats avoid hunting in areas with road noise [4]. When these effects are combined with other stressors such as winter weather, disease, and food shortages, sound impacts can have important implications for the health and vitality of wildlife populations within a park.

These findings are especially significant because national parks are under increasing noise pressure. Noise levels in park transportation corridors today are at 1000 times the natural level. Additionally, the sounds of vehicular traffic have a much larger "footprint" than the concrete surface. Road noise impacts on wildlife have been shown to extend over a mile into the forest [4]. Air transportation, as well, can affect life on the ground. Sound levels during peak periods in a high air traffic corridor in the Yellowstone backcountry, for example, were elevated by up to 5 decibels. The result is as much as a 70% reduction in the size of area in which predators can hear their prey[4]. Thus, if a predator can typically hear its prey 100 feet away in any direction, the noise from air transportation shrinks that range to 30 feet. Increasingly, careful consideration of the impacts of human-generated noise on wildlife is a critical component of management for healthy ecosystems in our parks.

To view an Annotated Bibliography on Impacts of Noise on Wildlife, please visit: http://www.nature.nps.gov/naturalsounds/PDF_docs/wildlifebiblio_Aug08.pdf

NPS photo

Effects of Sound and Noise on Visitors

Our world is getting noisier. With dramatic increases in traffic, the explosion of digital gadgets (think of your buddy's constantly chirping Smartphone) and our increasing capacity to reach once-remote areas, quiet solitude is a diminishing commodity. Not surprisingly then, the American public comes to parks with natural quiet in mind. They come for the soothing effect of a gurgling stream, a delicate bird song, or the rustle of leaves on a fall day. From the awe-inspiring thunder of a waterfall to the gentle rustle of leaves in the breeze, natural sounds have a subtle but profound impact on visitors. In fact, 95% of Americans say one of the most important reasons for preserving national parks is to provide opportunities to experience natural peace and the sounds of nature [6].

However, natural quiet in parks is increasingly at risk. To study the effects of human-caused noise on visitors, volunteers at Muir Woods National Monument cataloged all sounds they heard, day and night, for a year. What they found was surprising. It was rarely quiet [7]. Parks are experiencing an on-going acoustic assault by everything from air tours to maintenance equipment. Such noise affects visitors' perceptions of solitude and tranquility. In a related study at Muir Woods, visitors found increasing levels of human-caused sounds to be unacceptable and even annoying [7]. Noisy visitors, loud talking, and other related sounds were found to substantially detract from the quality of the visitor experience. In other studies, noise has been shown to be more disturbing to visitors if it is loud, occurs in bursts, is unpredictable, or if it interferes with quiet activities such as bird watching.

Isolated areas are not exempt. In Grand Canyon, no single location is totally free of aircraft noise, and in some areas it can be heard up to 43 times in a 20-minute period. Backcountry hikers, after September 11, 2001 reported

knowing that something was very wrong because there were no sounds from commercial aircraft [2]. Tranquility, it turns out, even in the most remote areas of our national parks, is at stake.

"As the din of modern society continues to grow, the need for refuge from noise and clamor are becoming increasingly important." National parks must strive to "help meet that need by providing places of calm and quiet where people can still hear the wind in the trees, the rhythm of nature, and the beat of their own heart…"[7, p. 25]

To view an Annotated Bibliography of Visitor Experience and Soundscapes, please visit: http://www.nature.nps.gov/naturalsounds/PDF_docs/VisitorExperience_Soundscapes_AnnotatedBiblio_17Aug10.pdf

Effects of Sound and Noise on Cultural and Historic Resources

"And the rockets' red glare, the bombs bursting in air…" These words tell a story about our country's fight for freedom and have a powerful effect on millions of Americans. The specific sounds associated with our history or cultural heritage not only teach us about the past, they connect us to distant times and places in a way that few other things can.

The acoustical environment of national park cultural and historic sites, therefore, is an important part of the ambiance and helps create meaningful connections. The silence of an empty cell on Alcatraz Island hints at the sense of isolation of a former inmate. Cannon fire or Taps at a Civil War battlefield conjures images of both pride and sadness. Every unit within the national park system has its own cultural soundscape that is both unique and appropriate to that particular place. From the brassy horns of New Orleans Jazz to hypnotic native drumming, no two are the same. Unwanted or inappropriate sounds, such as aircraft, vehicles, and construction equipment, can detract from the experience. With this in mind, the National Park Service manages park units to protect those cultural and historic sounds considered fundamental to the park's purposes and mitigate extraneous noise.

To listen to some cultural and historic sounds recorded in parks, please visit: http://www.nature.nps.gov/naturalsounds/cultural/.

"There is no quiet place in white man's cities. No place to hear the unfurling of leaves in the spring or the rustle of an insect's wings."

~ Chief Seattle

NPS photo

Where is All That Noise Coming From?

Let's face it, people can be noisy. This fact is no different when we visit parks. And, since parks were created in part for people's enjoyment, a certain degree of noise is appropriate. Some means of exploring our protected areas, however, are noisier than others. When visitors view the park via an air or bus tour, for example, intrusive sounds are created that can impact wildlife and other visitor experiences. The increasing popularity of such activities demands that managers understand and work to mitigate their effects on park resources.

Noise sources come from outside park boundaries as well. The distant hum of overhead air traffic or whirring of wind turbines can take a toll on park resources. Determining the levels and types of sound that are appropriate for different areas within a park is key to effective management. The Natural Sounds and Night Skies Division can provide data that are critical for making the complex decisions that will preserve vulnerable soundscapes.

Despite their importance, soundscapes are often overlooked or impacts to this resource are understated in NPS planning and decision-making processes. Rationalizations include that the developed area already has noise impacts, so adding more will not make much difference or that this is an urban area so soundscapes are not an issue. Another factor influencing management and policy decisions is that the soundscape as a resource is a relatively new issue for most land managers. Proper management of soundscapes is becoming more complex and challenging as threats to acoustic resources, from inside and outside of park boundaries, increase. Planning is an essential step in addressing these threats.

The following is an overview of the most prevalent extrinsic sound sources and the strategies and decisions for managing the issues. Park interpreters are encouraged to further study the issues affecting their park units. Information gained can then be passed on to the park visitor, who remains a key player in the policies that shape the future of public lands. Specific laws and policies governing park actions can be found in Appendix A.

"Take Anything But My Car!"

It is no secret; Americans love their cars. Even in national parks our automobile-dependent habits are difficult to shake. Who can't recall sitting in long traffic lines at popular park destinations, consumed by gas fumes, and wondering why they bothered?

Not only are our cars clogging the air we breathe; the noise they and other motorized vehicles generate is one of the most dominant and pervasive sound sources in national parks. A 1997 Memorandum of Understanding between the Secretary of Transportation and the Secretary of the Interior noted that "Congestion in many National Parks is causing lengthy traffic delays and backups that substantially detract from the visitor experience. Visitors find that many of the National Parks contain significant levels of sound and air pollution and traffic congestion similar to that found on the city streets they left behind."

In many National Park units, the existing infrastructure and transportation systems are at, or beyond, the capacity for which they were designed during high visitation periods. Recently, parks have started to address the issue of vehicle congestion and noise by offering alternatives to driving. In conjunction with these measures, the Natural Sounds and Night Skies Division is working with parks and motorized recreational industries to educate their user groups on the importance of respectful and responsible use.

At Zion National Park between 1982 and 1997, as many as 5,000 cars a day were lining up on holiday weekends to enter the canyon. To mitigate the congestion and noise park managers banned the use of private vehicles during peak visitation times and created a mandatory shuttle system through the most popular portions of the park. Though the change was initially highly controversial, today park staff members report an overwhelmingly positive public response. Visitors frequently comment that the park is much more serene without the presence of cars.

Wildlife health and behavior were also affected by the restored tranquility. In the years preceding the decision, several animal species had moved far from the main roads to avoid vehicular sounds. Today visitors report seeing increasing numbers of wildlife in the valley.

"Eighty-three percent of the land area of the continental US is within 1061 meters of a road [8, p. 182]." Images in background and right: NPS photos.

"Walking along the Lake Michigan Shoreline at Indiana Dunes National Lakeshore on September 12, 2001, I was struck by an uncanny sense of solitude. While I had walked that stretch of beach dozens of times before, this time was different. And then it occurred to me; there were no planes flying overhead."

~ Visitor, Indiana Dunes National Lakeshore

Look…it's a Plane!

"185,000 air tours fly over parks every year." ~ Garret Keizer, writer [9]. (These are addition to the commercial aviation, military, private and general aviation flights that traverse over our national parks daily).

For some visitors few experiences can compare to the dizzying sensation of soaring over dramatic hanging valleys or of being dwarfed by the looming walls of Mount McKinley as seen from the windows of a tiny aircraft. The popularity of such activities is evidenced in the increasing numbers of recreational overflights in national parks. In Grand Canyon alone, the number of tour overflights grew by 37% between 1987 and 2005 [2]. These figures do not include the huge numbers of commercial and general aviation flights occurring over national parks. In fact, all forms of aviation activities over parks, including commercial passenger flights, park maintenance, scientific research, and fire and emergency operations, have increased dramatically in recent years.

The impact of such activities to the rafter drifting through the silent backcountry or the pika listening for warning calls, for example, is one question policy makers must grapple with when drafting management plans. While providing for the public enjoyment of national parks is mandated in the Organic Act, protection of park resources takes precedence. Due to the intense controversy surrounding the issue, Congress mandated the Federal Aviation Administration (FAA) and the National Park Service to work together to mitigate or prevent adverse impacts to park resources and values from air tours. The resulting National Parks Air Tour Management Act of 2000 requires the cooperative development of commercial Air Tour Management Plans (ATMPs) for each of the over 106 parks where such tours operate.

In 2004 the FAA and the National Park Service signed a Memorandum of Understanding for the ATMP Program and completed a detailed plan for implementation. As of 2010, ATMPs are being developed for multiple parks including Hawaii Volcanoes, Mount Rushmore, and the Statue of Liberty National Monument. For more information on the National Parks Air Tour Management Program, visit the FAA website: http://www.faa.gov/about/office_org/headquarters_offices/arc/programs/air_tour_management_plan/

Images top and right: Aircraft activity over parks has increased dramatically in recent years. NPS photos.

Yellowstone National Park is using acoustical data to help create winter use policies that protect the resource while allowing for a variety of winter activities. NPS photo.

Snowmobiles and OHV's

"What is noise to one park visitor may be music to another [2, p. 66]."

To some Yellowstone National Park visitors, that music is the sound of a snowmobile coursing over snow-covered meadows. To the restaurant owner in town, the din of the snowmobile brings another kind of music – the ring of the cash register. The cross-country skier, seeking the quiet wonder of Yellowstone's wilderness, however, may perceive it as a nuisance. And to the park manager, the snowmobile's hum sounds like the roar of controversy.

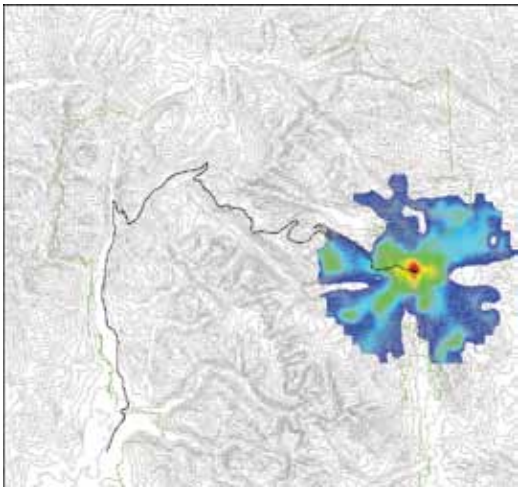
Regardless of what one hears in the sound of oversnow vehicles, the issue is inescapable. Before their numbers were limited, one could count as many as 1,500 snowmobiles a day in Yellowstone. In a 2000 National Parks Conservation Association study, the machines could be heard 90 percent of the time at eight popular sites [10]. In addition to the pervasive noise are concerns about impacts on wildlife, air and water quality, and the threat to one of the park's most alluring values – its wildness.

The issue extends far beyond the boundaries of Yellowstone and the clamor of the snowmobile. Public lands throughout the country are feeling the pressure of increasing numbers and types of off-highway vehicles (OHVs). Public opinion on both sides of the argument is vehement. While many view mounting regulations as infringing on the right to enjoy their public lands, others see a problem that is already out of control. In the words of Bethany Walder, 1999 Executive Director of Wildlands CPR, "(The giant) is wide awake, and it's roaring and stomping all over public lands…[11]"

After years of public debate and research, Yellowstone has set some limits on that "giant." While awaiting the conclusion of another Environmental Impact Statement, the park has restricted snowmobile use to 318 a day. All must be led by commercial guides and use new cleaner and quieter machines. According to Al Nash, Yellowstone National Park's Chief of Public Affairs, "the shift from historical unmanaged winter use to limited and managed use and sounds and emissions requirements has resulted in quieter conditions in Yellowstone in winter." In fact, in the years following the new regulations, Yellowstone staff have measured some of the quietest conditions they have ever recorded in the natural environment.

To learn more about the Yellowstone and Grand Teton NP's Winter Use Plan, please visit: http://www.nps.gov/yell/planyourvisit/winteruse.htm.

Acoustical data may also play a role in creating policies regarding OHVs in national parks. Using noise mapping models, the Natural Sounds and Night Skies Division is helping Big Cypress National Preserve, Cape Hatteras National Seashore, and Grand Canyon-Parashant National Monument to better understand and manage OHV use. By superimposing the noise footprint and intensity of selected activities over area maps, these models reveal significant and sometimes startling information about how and where noise travels.



This mapping model shows the noise footprint of a motorcycle traveling in Rocky Mountain National Park. Red indicates greatest noise intensity and deep blue, the lowest. The heavier black line represents Trail Ridge Road. Note that the sound footprint does not form a complete circle, as various objects (a rock wall for example) block the noise and force it into other areas. This image indicates that at this point noise can be heard for 4.6 miles from the source, for a total area of 75 square miles. At the highest point on Trail Ridge Road, the motorcycle's area of audibility will encompass 240 square miles. Image provided by the Natural Sounds and Night Skies Division.

Policies, however, like park resources, are vulnerable. Public opinion can and does influence how parks deal with controversial issues. Understanding the effects of such activities on park resources, integrating soundscapes into park planning efforts, establishing effective public policy, and helping visitors make informed decisions are tasks for all levels of park personnel.

Park Operations

"In the silence I listen, I watch, I reuse, I attend. I observe. I require this silence. I search it out. The finely drawn treble song of a white-throated sparrow is part of it. Invasions of it by the noise of engines torment me. This is my solitude." ~ Alice Koller

Park operations, including construction, mowing, and aircraft use, as well as park infrastructure, such as heating and ventilation units, can also affect acoustic resources and soundscapes. Management policies, however, (ah yes, good ol' Policy 4.9) stipulate that superintendents are to "monitor mechanical noise that adversely affects opportunities to enjoy park soundscapes." So, while sounds from such operations are inevitable, parks are working to find "quieter" ways of performing necessary tasks. Such measures might include scheduling noisy activities around noise-

NPS photo

Visitors to Great Sand Dunes National Park and Preserve can enjoy some of the most profound silence yet discovered by the Natural Sounds and Night Skies Division acoustical monitoring team. Image both pages: NPS Photo.

sensitive times of day (i.e., when interpretive programs are conducted, sensitive times for wildlife), using quieter tools when feasible, and locating noisy equipment as far from sensitive areas as possible.

Denali National Park and Preserve serves as an example. Though the park contains some of the most remote places in the national park system, there was a time when a visit to the Wonder Lake Ranger Station was less than peaceful. A noisy 30-kilowatt diesel generator that powered the station ran 24 hours a day. As part of its planning process, park personnel set out to mitigate the generator noise by installing a bank of batteries that greatly limited its run time. The result was a quieter acoustical environment and a restored sense of the solitude that is Denali's heritage.

Watercraft

"A day at the beach is no picnic with the whine of engines on the water."~ Les Blomberg, Executive Director of the Noise Pollution Clearinghouse [12]

The National Park Service walks a tightrope when balancing public use issues and preservation policies. However, when the two ideas conflict, as is often the case with personal watercraft (PWCs, commonly known as jet skis), the Organic Act stipulates that protection must take priority over public use. The constant challenge for managers and other park personnel is to be aware of the complex and sometimes unexpected impacts of such activities on park resources, and balance those with the resources and values for which the unit was set aside.

As with snowmobiles and OHVs, assessing the noise levels of PWCs has helped to illuminate their true impacts and enables managers to make more informed decisions. The National Park Service has determined that PWC use can "have a direct and adverse effect on park values such as peace and quiet." In April 2000, PWC use was banned in national park areas unless it is consistent with the unit's enabling legislation or overall management objectives.

Today the Natural Sounds and Night Skies Division provides valuable data and guidance for this on-going issue. After collecting noise source measurements of airboats and motorboats in Everglades National Park, the Natural Sounds and Night Skies Division is working to model their potential noise impacts. The results from such modeling will help to inform future park planning efforts.

Military Overflights

A variety of efforts between the National Park Service and the U.S. Air Force (USAF) have resulted in greater mutual cooperation over the past decade. Attendance by both parties at Airspace and Range Council meetings, for example, and NPS-sponsored backcountry trips for military officers and park managers have helped build relationships and resulted in more collaborative problem solving.

One result of the cooperative relationship between the NPS and USAF is a sourcebook addressing military overflights in the Pacific Northwest National Parks found at: http://www.nature.nps.gov/naturalsounds/PDF_docs/USAFNPSWesternPacificRegionalSourcebook.htm. Versions covering other regions are planned.

Airports and Development

A visitor pauses reflectively at the site of the opening battle of the American Revolution, in Minute Man National Historical Park. Her mind naturally conjures the crack of a rifle, and the sounds of chaos that mark a defining moment in the nation's history. Through her mental window she begins to imagine herself as a young mother, desperate to gather her children, when the puttering of a small commuter plane jolts her back to the present. Another zooms by, destined for the airfield adjacent to the park. Her reverie disintegrates, along with a profound interpretive opportunity.

This scenario could play out for thousands of park visitors as Americans increasingly rely on small, regional airports. As demand for their services increase, these facilities seek to enhance their capacity to handle more traffic. A host of other sites, including Death Valley, Yosemite, and Grand Teton, face potential soundscape impacts from regional airport expansion. Careful examination of soundscapes should be addressed at all levels of planning to protect natural soundscapes now and well into the future.

Energy Development

While the roar of a waterfall or the unnerving shrill of an elk's bugle can be stirring experiences, the earth often speaks in whispers. John Muir once wrote, "The faint lisp of snowflakes as they alight is one of the smallest sounds a mortal can hear. The sound of falling sequoia seeds, even when they happen to strike on flat leaves or flakes of bark, is about as faint." The sound of silence offers tremendous opportunities to discover earth's secrets.

Great Sand Dunes National Park and Preserve enjoys some of the most profound silence yet discovered by the Natural Sounds and Night Skies Division's acoustical monitoring team. Yet this silence, as with national park soundscapes nationwide, is under threat due to the burgeoning demand for energy development. While Great Sand Dunes is confronted with potential oil and gas drilling near its border, threats to national park soundscapes come from all types of energy development, including geothermal, hydropower, wind, and even solar. The threat of loss of natural quiet, however, moves beyond the human experience. Wildlife habitat, reproduction, and migration routes could suffer as well, as the noise from such development encroaches on wild areas.

Energy development is important, but it creates impacts that must be managed and mitigated. Given the potential consequences of such development, the value of reliable acoustical data cannot be overstated. The Natural Sounds and Night Skies Division has begun developing new protocols for assessing impacts from nearby industrial noise sources. Close coordination between park management, cooperating agencies, and commercial interests will be required in order to ensure that unacceptable noise impacts to national park lands do not occur.

"One of my most powerful memories on a ranger-led program occurred deep inside Mammoth Cave. The ranger instructed everyone to cut our flashlights and sit without making a sound. We must have sat for 5 minutes in the most intense dark and silence I have ever experienced. The silence was so heavy I could almost feel it. I suddenly sensed earth's power in a whole new way."

~ Visitor, Mammoth Cave National Park

A visitor contemplates a 500-year-old Sitka spruce in Olympic National Park. NPS photo by Charlotte Formichella.

Interpretation and Education

Why Interpret Soundscapes?

Some of our most profound experiences in life are not seen. They are heard (or in the case of the Mammoth Cave visitor, unheard). Sounds embed themselves deep into the human psyche and often illicit a visceral response. The jangling of the ice cream truck transports us to hot, carefree summer day in our youth. A siren screeches in the middle of a dark night and we are jolted awake with an eerie sense of foreboding.

Intrinsic sounds in national parks, then, are sources for powerful connections to the resource. However, every day that goes by, with every new beeping, chirping, or squawking gadget we create, our experience of those sounds is more at risk. Cell phones, for example, while valuable and potentially life-saving tools, now intrude upon nature's chatter in all but the most remote places. Chip Dennerlein, of the National Parks Overflights Advisory Group states, "There are many places in the National Park System which look very much like they did two hundred years ago, but very few places sound like they did even twenty years ago."

The National Park Service works to protect soundscapes, just as they do views of the Grand Canyon or the wildlife of Isle Royale. Interpretation is critical in encouraging visitors to tune out or turn off extraneous noise and refocus on the park's intrinsic sounds. Through attentive listening techniques, the visitor gains access to an unexpected meaning in the resource: the power of natural sounds.

Following are tips, ideas and resources to guide interpreters in creating soundscape-based programs. Entire soundscape programs have also been developed and will soon be available on the NSNSD website at: http://nature.nps.gov/naturalsounds/outreach/. Specific, detailed activities are found in Appendix B.

Interpretive Themes and Subthemes

Adapted from a submission by Lindsay Utley

1. Soundscapes offer a window into the natural world.
   a. One can identify his or her location by the soundscape.
   b. Tuning in to the sounds birds and other animals offers insights into their lives and behaviors.
   c. Sounds can be heard in unsuspected situations, such as the changing of the seasons.
2. Soundscapes are like symphonies.
   a. Nature is music's oldest influence.
   b. Our emotions are influenced by what we hear.
   c. Each element adds a new dimension, whether positive or negative.
3. Humans and animal species all have unique "soundprints."
   a. Soundscapes can work like a landscape – people can deduce where they are from their surroundings.
   b. Many animals use species-specific sounds to communicate.
   c. Learning the language of one's species is critical to survival.
   d. Culture impacts the soundscape.
4. Natural sound is an endangered resource.
   a. Human noise masks natural sound.
   b. Natural sounds are increasingly threatened by human-generated noise.
   c. Hearing is the "forgotten sense."
   d. Quiet is key to unlocking the heartbeat of nature.
5. In the wild, sound is a matter of life or death.
   a. Many animals have a heightened sense of hearing for hunting and protection.
   b. The ability to hear natural sounds is vital for mate selection, communication such as alarm calls, effective use of habitat, and other aspects of survival.
   c. Increasing human-generated sounds in natural areas have negative impacts on wildlife.

The bullfrog call has been said to imitate the words "jug-o-rum." John J. Mosesso/NBII.

The Amazing Universe of Sounds

The following is a list of potential sound sources along with technical information to guide the interpreter. It is by no means a complete list of the amazing universe of sounds in our national parks. It is meant merely to stimulate ideas for programs or outreach materials that promote respect for park acoustical environments and soundscapes. Actual soundclips are available on the NSNSD website and sources for on-line sound libraries are listed in the back of this handbook.

Interpreters also have access to soundscape recordings from specific national parks. To ask about these recordings, contact Natural Sounds and Night Skies Division acoustical technicians at: http://www.nature.nps.gov/naturalsounds/organization/.

Bugles, Peeps and Chirps

The visitor who experiences the reverberating thud of male bighorn sheep butting heads, the eerie bugle of a bull elk in "rut," and the slap of a beaver tale on the water's surface often cherishes these memories for a lifetime. They are potent reminders of the ancient rituals preserved in our natural spaces and serve as key examples of the richness of park soundscapes.

Most national park visits, however, are dominated by the more mundane songs of birds, frogs, and insects going about their daily activities. Such sounds, while less dramatic than a bugling elk, can be a captivating and memorable part of a park experience.

Standing in the midst of the deafening trill of spring peepers, for example, is a riveting reminder that "worthless swamplands" are critical habitat to thousands of amphibian species. While most amphibians are almost impossible to spot, their calls travel for miles.

With a little instruction, their intriguing sounds are easy to identify and fun to imitate. Wood frogs sound off with a raucous duck-like quack during breeding season. The green frog sounds like the plucking of a banjo and the western chorus frog call can be likened to the sound of running a finger over a fine-toothed comb. The Alaskan red-legged frog produces a weak stuttering "uhuh- uh-uh-uh-rowr" as a mating call, giving one the impression of a bachelor, nervous around females.

Other calls, while not seen in a playful light, can promote understanding of the role of natural sounds in the ecosystem. A rattlesnake, for example, will shake its tail to warn of an imminent strike. Killdeer use a distinct, high-pitched trill, while faking a broken limb, to distract predators from their ground nests. The song of the cactus wren characterizes the desert landscape. When building nests these wrens will call out with a rapid buzz at any threat to their progress. Such examples help convey the significance of preserving the integrity of the acoustical environment.

Bird songs, in general, are ideal tools for introducing young visitors to natural sounds. They are often beautiful, or even humorous, and can be heard almost anywhere. Because they can be likened to human phrases, people easily relate to them and even children can be encouraged to tune in. For example, the American goldfinch call is thought to sound like the words "potato chip!" Children easily relate to the call of the ovenbird, heard in deciduous woodlands in spring, which sounds like "teacher! teacher! teacher!"

Other calls accompany dramatic courtship displays. Lark buntings and American woodcocks, for example, perform distinct mating calls during an elaborate aerial show. A visitor who is attuned to such ethereal sounds will have a greater chance of glimpsing elusive animal behavior.

Insects, like birds, have an endless repertoire of sounds. And though their buzzing, humming and droning are typically unwelcomed to human ears, interpreters can use these calls as a conduit to the complex world of insect communication.

Hearing the piercing whine of cicadas brings to mind hot, lazy summer days for most park visitors. Many would not be surprised to learn that male cicadas produce the loudest sounds in the insect world (actually approaching the pain threshold of the human ear). But how many know that the loud noise repels birds? Entomologists believe that the sound hurts the predators' ears.

On the opposite end of the sound spectrum, ants use subtle cues to communicate. By clicking mandibles or knocking their heads against solid objects, ants create sound vibrations that send messages of alarm. Such examples can help visitors appreciate that the acoustical environment operates on many levels and that even "quiet activities," such as hiking and cross-country skiing, may be disruptive.

"When I stepped out of my car I heard the sounds of tribal drumming reverberating off the sandstone cliffs. It sent chills up the back of my neck and I suddenly understood what it must have sounded like here a thousand years ago."

~ Angie Richman, Chaco Culture National Historical Park

In short, wildlife calls and songs are present in almost every environment. They are so ubiquitous, in fact, that we often tune them out. In learning to hear them again, one suddenly feels linked to a secret world, privy to the intimate workings of animal life and social connections. One realizes that what might appear a drab, uninspired patch of forest floor harbors rich and diverse animal life.

Wildlife sounds are, of course, just one component of the natural acoustical environment that impacts a visitor's experience. The sound of wind moving across a barren landscape, water trickling into a hollow between rocks or the thunder of a calving glacier all offer opportunities for connections to some of the more intangible, yet essential, values of national parks.

And Now a Word from Our Culture…

Culturally-based sounds can be priceless interpretive tools. They help reinforce a sense of pride in place, a connection to heritage and the awareness that humans, too, are integral to soundscapes. In a time when people are demonstrably less willing to read interpretive text in parks and museums, sounds offer another avenue for reaching them. For the visually impaired, they add a critical element of richness to the park experience that would otherwise be lost. And for those who do not speak English, sound provides a universal language for experiencing and understanding the parks.

Many anthropogenic (man-made) sounds have embedded themselves in the American psyche and echo significant movements in the country's development. The chant "No taxation without representation!" needs no explanation to the American adult. The whistle of a train, the heavy rattle of a slave's chains and the crack of musket fire are all imbued with meaning about the American experience. The interpreter who skillfully weaves such sounds into a program will create lasting connections to the meanings in the resource.

Providing the audience with an opportunity to listen to the sounds of covered wagons rolling across the prairie, for example, may help visitors imagine the feeling of jostled bones and grit between the teeth experienced by early travelers. Encouraging participants to listen for the "ping" of sap dripping into a bucket during a tour about making maple syrup will help them connect to the sense of anticipation of those who toiled through cold and snow to make the coveted treat.

Many culturally-based sounds are tangible symbols of a park's relevance. The deafening roar of the fabric looms in the factories at Lowell National Historical Park, for example, conveys the loss of autonomy experienced by factory workers who left the farm. The resonant clang of an iron spike being driven into a rail at Golden Spike National Historic Site can depict a nation linked for the first time by the railroad, while the piercing screech of sirens at Oklahoma City National Memorial evoke the sense of a country torn apart by terror. The sounds of gunshots and human cries contrasted with the silence of an empty prairie at Bear Paw Battlefield are haunting reminders of the anguish of the Nez Perce as they ceased their struggle against the white man.

Music has an undisputed ability to transport people through time and space and recreate a mood. Additionally, many pivotal moments in U.S. history are defined by a musical style. An interpretive tour of the Vietnam War Memorial might be enhanced with a recording of the angry, conflict-driven songs of the 1960s. Recordings of Native American tribal music help set a jubilant or reverent atmosphere, and the lighthearted sounds of ragtime piano can conjure the robust spirit of the gold rush days.

These are just a few examples of the sounds that are intrinsic to our national parks which can be incorporated into programs. Interpreters are encouraged to consider other options that embody the spirit of a place, people, or time period. Such creative use of sounds in programs offers a potent, often-overlooked means of connecting the visitor to the resource and a better understanding of the role of soundscapes in national parks.

Above: Ancient flutist petroglyph at Dinosaur National Monument. NPS photo by Deanna Ochs. Right: Pounding a spike into the railroad that joined East with West at Golden Spike National Historical Site. NPS photo.

Climber in Denali National Park (both pages). NPS photo.

Now, Dazzle 'em With These

Still want more? A lot of people have very eloquently and concisely said what has taken us, well, *several* pages to convey. Here is a small sampling of inspiring quotations about the benefits of solitude and natural sounds. Feel free to sprinkle them liberally throughout your programs, brochures and activities. Or stand at the visitor center front desk and spout them. We don't care (although your supervisor might). Just spread the word about the wonder of natural sounds and the importance of protecting them.

"People talk about the silence of nature, but of course there is no such thing. What they mean is that our voices are still, our noises are absent." —Sue Halpern

"This is the hardest of all sounds in nature to hear: the silent assertion of a landscape itself. It requires a rare confluence of moods—clarity on nature's part, receptiveness on our own—a suspension of normal expectations and a relaxed extension of our senses, to feel such deep vibrations." —Robert Finch

"If you have ever sat on a mountain top and surveyed the country below, you must realize that what you saw was even more beautiful because of the awesome silence which surrounded you. Art galleries maintain quiet because curators realize that a painting viewed in the midst of noise is less beautiful than when it is contemplated in the midst of silence." —Karl Pruter

"In the attitude of silence the soul finds the path in a clearer light, and what is elusive and deceptive resolves itself into crystal clearness. Our life is a long and arduous quest after Truth and the soul requires inward restfulness to attain its full height." —Mahatma Gandhi

"How often we speak of the great silences of the wilderness and of the importance of preserving them and the wonder and peace to be found there. When I think of them, I see the lakes and rivers of the North, the muskegs and expanses of tundra, the barren lands beyond all roads. I see the mountain ranges of the West and the high, rolling ridges of the Appalachians. I picture the deserts of the Southwest and their brilliant panoramas of color, the impenetrable swamplands of the South. They will always be there and their beauty may not change, but should their silences be broken, they will never be the same." —Sigurd F. Olsen

"Only in the oasis of silence can we drink deeply from our inner cup of wisdom." —Sue Patton Thoele

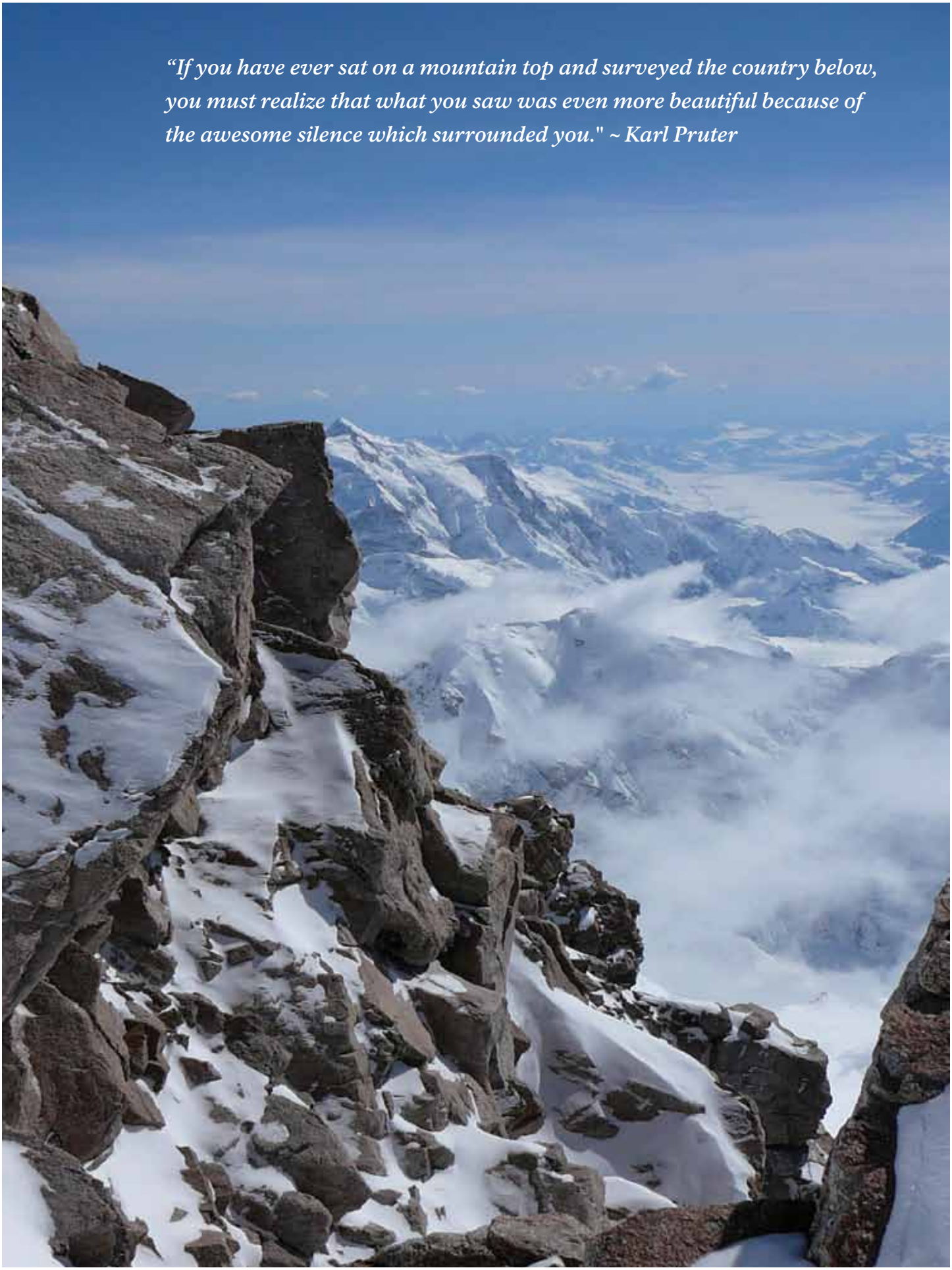
"By such a river it is impossible to believe that one will ever be tired or old. Every sense applauds it. Taste it, feel its chill on the teeth: it is purity absolute. Watch its racing current, its steady renewal of force: it is transient and eternal. And listen again to its sounds get far enough away so that noise of falling tons of water does not stun the ears, and hear how much is going on underneath—a whole symphony of smaller sounds, hiss and splash and gurgle, the small talk of side channels, the whisper of blown and scattered spray gathering itself and beginning to flow again, secret and irresistible, among the wet rocks." —Wallace Stegner

"If you love it enough, anything will talk with you."—George Washington Carver

Before the Inspiration Fades

Once program participants are inspired about the wonderful world of natural sounds, what's next? Interpreters can offer the following suggestions, or encourage visitors to come up with their own ideas to help protect park soundscapes:

- Find a place to appreciate the sound of nature during their park visit. Ask them to contemplate how their presence affects the natural sound environment.
- Remember that people come to national parks to escape clamor of everyday life. Be aware of the noise they might be making and consider their impact on the people around them.
- Speak quietly and turn off engines instead of idling whenever possible, especially in campgrounds and when observing wildlife.
- Mute electronics such as cell phones, watches, and cameras.
- Help make campgrounds quiet by observing quiet hours, keeping radios and voices low, using quiet-technology generators, and turning off vehicle engines whenever possible.
- Use alternative and/or quieter transportation when available.
- Participate in non-motorized recreational activities, such as hiking, snowshoeing, and canoeing.
- Use boats with electric motors and limit engine size.
- Invite others to explore and appreciate the inspiring, thrilling, relaxing, thought-provoking sounds of our national parks.
- Learn more about the Natural Sounds and Night Skies Division by visiting the website at http://www.nature.nps.gov/naturalsounds.


"If you have ever sat on a mountain top and surveyed the country below, you must realize that what you saw was even more beautiful because of the awesome silence which surrounded you." ~ Karl Pruter

Sound monitoring equipment at Mount Rainier National Park collects data for approximately 25 days. NPS photo.

Spying on Nature—Acoustical Monitoring

As discussed earlier, efforts to protect the acoustical environment in our national parks are driven by NPS management policies. Before any action can be taken, however, park planners must have reliable data about a park's existing acoustical environment. Through sound monitoring efforts parks can learn about the acoustical environment as a whole, and identify desirable and appropriate sound sources, as well as those that are undesirable in the park setting. Information gathered can then be used to identify the potential impacts of non-natural sounds and proposed developments or actions that may affect the acoustical environment.

Ready, Set, Collect: Planning and Preparation

Preparation for data collection includes identifying primary sampling areas, and defining the season and period of time for taking measurements. Each monitoring effort considers soundscape management objectives, as well as acoustically sensitive areas, such as endangered species habitat or cultural areas. In general, 25 days is the minimum recommended collection period to ensure statistical confidence.

Identifying Sampling Areas

Before acoustical monitoring can begin, sampling areas must be identified within the park. These are locations of comparable vegetation, topography and climate that contain similar wildlife and other sources of natural sound. Selections are based on a variety of factors including:

- Soundscape management objectives of those zones;
- Noise-sensitive areas; and
- Proximity to natural and human-caused sounds.

Acoustical technicians (since they're the ones lugging the heavy equipment) also consider site access, and availability of equipment and personnel.

Summer Better than Others: When to Measure

Whenever possible, acoustical data is collected in all seasons. When not possible, technicians collect data during the season in which the activity of interest occurs, and again during the season when the activity occurs least often or not at all. This method helps to account for

A pika, from his exposed perch, relies, in part, on warning calls from others to alert him to danger. John J. Mosesso/NBII

variables, such as weather and biological activity that differ among seasons. For example, air tour companies typically operate more or only during the summer months. Thus, measurements are taken during both the summer and winter seasons.

Data Collection Types

What's In *Your* Backpack? (Measuring a Park's Acoustics)

A hiker preparing for his trip stands in the midst of a mountain of equipment. Somehow it all has to fit into his modest-sized pack. He takes inventory. Raingear…check! Water bottle…check! Anemometer…check! Calibrator…check! Sound level meter…check!

As you might have guessed, this is not your typical hiker (or if it is, he's heading for trouble). He is a member of the Natural Sounds and Night Skies Division acoustical monitoring team, preparing to set up sound equipment in a remote backcountry area. Once at the site, he and a fellow team member will set up what might seem to the average person, or occasional cow, to be a bizarre arrangement of questionable gadgets. These "questionable gadgets" are highly sophisticated monitoring devices that, over the next month (provided the cows don't take a notion to trample them) will take frequency (hertz) and sound pressure level readings (decibels) of the area. This information is displayed on a "spectrogram," a visual analysis tool which uses color bands to represent a sound's frequency and amplitude. Spectrograms provide data on how sound levels vary throughout the day and a rough idea of what made the sound.

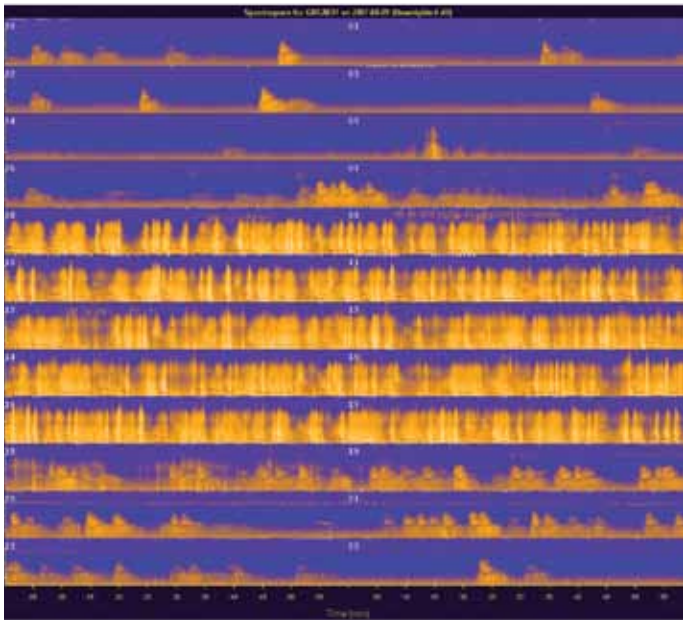
Like Spitting into the Wind

Acoustical technicians also collect data about a variety of meteorological factors. Anyone who has stood outside during a heavy snow and wondered about the stillness in the air can understand why. Weather affects ambient sound levels. Powdery snow has impressive sound-absorbing qualities. Air temperature affects sound as well. Those campers may not necessarily be making more noise at night (just as they claimed); they may just seem louder because sound often travels farther in cold temperatures. Wind speeds substantially influence noise levels. (It is no more effective shouting into the wind than spitting into it!) Strong winds can literally knock high frequency sounds off target and even raise their pitch.

Not For Human Ears—Digital Audio Recordings

Whereas the acoustical data tell us the "how"—how loud, or how high-pitched a sound is, for example, audio recordings tell us the "what"; what species made the sound, what the animal was doing (was the cow licking the device or chewing on it?), etc. Technicians at the Natural Sounds and Night Skies Division then listen carefully to samples from these recordings and catalog each sound they hear. Such recordings can reveal sounds of activities that animals are reticent to perform in the presence of humans, like the forceful thud of bighorn sheep rams butting horns. Because animals sometimes get very close to the recording devices, intimate details of their vocalizations or movements are picked up that humans are rarely close enough to hear. In one such recording, for example, the listener was privy to the grunting, bugling, and breathing of a bull elk in rut (mating season). Another had recorded the beating of hummingbird wings at close range (a treat previously enjoyed only by those sporting bright pink shirts in summertime).

Beyond providing the listener some "up close and personal" details of animal behavior, au-



The spectrogram (right) displays sounds recorded at Grand Canyon National Park over a 24-hour period. Each band displays two hours of acoustical data, beginning at midnight. The solid lines of orange represent a continuous sound, such as cicadas calling, where spikes of color represent sudden bursts of sound. Brighter colors indicate louder sounds. A quick glance reveals that sound levels in the Grand Canyon peak between 8:00 am and 6:00 pm. With practice, one can discern aircraft, vehicles, voices, animal calls and natural occurrences like thunder. Image provided by the Natural Sounds and Night Skies Division.

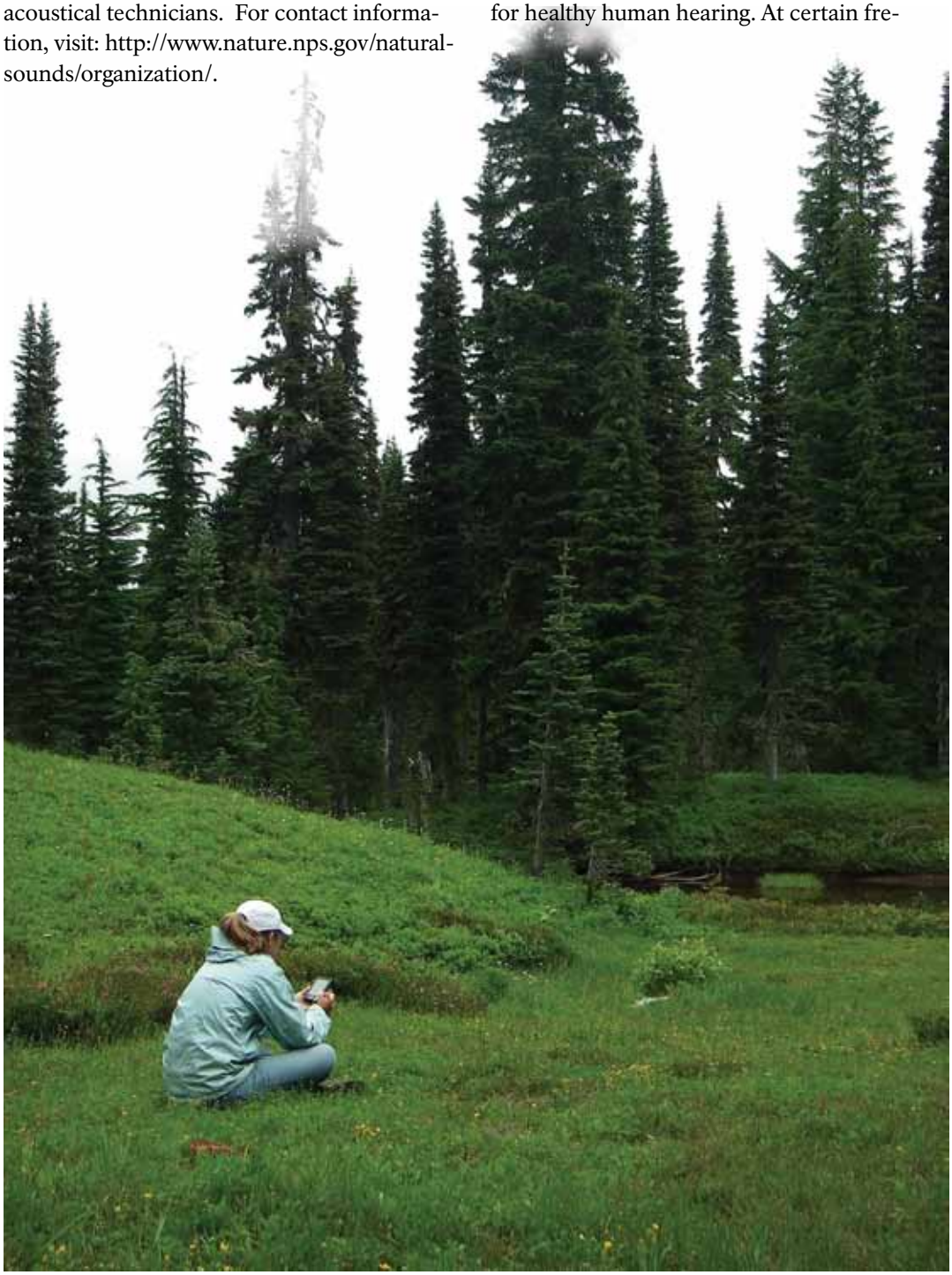
dio recordings can help parks track the numbers, presence and locations of endangered or shy animal species. These "footprints" of animal behavior can chronicle changes in wildlife activity in response to human presence or management practices. In short, "they offer a wealth of ecological information that can advance scientific understanding of park ecosystems and inform park management plans [12]."

Looking to add some "pow" to your programs or some "ahhh" to activities? Interpreters can have access to these recordings by contacting the Natural Sounds and Night Skies Division-acoustical technicians. For contact information, visit: http://www.nature.nps.gov/naturalsounds/organization/.

Giving "PDA" a Whole New Meaning

A lone woman sits quietly on a hillside in a remote area of Dinosaur National Monument. There is no movement but the breeze; no sound but her light breathing. Or so it would seem. On closer inspection one sees that she is listening intently and sporadically tapping on a small mechanical device. The woman is a member of the Natural Sounds and Night Skies Division monitoring team, logging sounds.

While sound-recording equipment is constantly improving, there is just no substitute for healthy human hearing. At certain fre-



"It will talk as long as it wants, this rain. As long as it talks I am going to listen." ~Thomas Merton

Gleaning bats can identify an insect by the sound of its footsteps. NPS photo.

quencies, human ears are more sensitive than sound equipment. Additionally, our "binaural" hearing (ears on both sides of the head) allows us to listen intently to a sound on our left, even while a different sound event is occurring to our right. In light of this, Natural Sounds and Night Skies Division monitoring teams conduct "observer logging sessions" in monitoring sites.

During the logging sessions, monitors note the sounds they hear over a one-hour period using a palm Personal Digital Assistant (PDA). The listener taps buttons on the PDA screen to indicate the start and end of a sound. With practice many overlapping sound events can be monitored. From these data many details can be derived, such as how much time lapses between human-caused sounds, and the percentage and length of time a sound is audible. The data are then easily downloaded into a database that analyzes the information and generates summary reports.

Logging sessions are a fast, easy way to collect acoustic information, and can even be used as an interpretive activity with visitors. Several parks have already involved volunteers and visitors in helping collect valuable data this way. Individuals that learn such attentive listening techniques can become valuable advocates for the protection of natural sounds. Interpreters interested in learning how to acquire PDAs for educational purposes should contact the Natural Sounds and Night Skies Division acoustical technicians at the website listed above.

How Can Acoustical Monitoring Help Your Park?

"Many park managers have inklings of how soundscapes are changing, but don't exactly know how to quantify it." - Emma Lynch, Natural Sounds and Night Skies Division Acoustical Resources Specialist

A cluster of field staff, testing equipment, slowly lowers a microphone into a pond at the Fort Collins Natural Sounds and Night Skies Division office. A curious onlooker dons headphones that are attached to the underwater microphone. "Water gathers sounds from underground that are barely perceptible in the air," one of the researchers explains. A pebble is dropped into the water, and the subject jumps with the sheer power of the corresponding "kerplunk!" Another staff member taps lightly on a nearby metal handrail. Without headphones the sound is barely perceptible, while the headphone wearer nods to a reverberating "ping! ping! ping!"

The acoustical environment, like an ecosystem itself, involves complex and interrelated components. While many of these components take place beyond the realm of human awareness, they nonetheless play a role in the functioning of the ecosystem. Certain bats, for example, known as "gleaning bats" detect sounds as delicate as that of an insect walking on the ground. Just as we might know who is approaching us from behind by the rhythm of their gait, such bats can distinguish an insect's species merely by the sound of its walk.

Park operations, equally, can have a significant impact on a site's acoustical environment. The redwood grove in Muir Woods National Monument, for example, harbors a nesting pair of spotted owls. The Natural Sounds and Night Skies Division monitoring team was brought in to assess the acoustical environment of the site. Their efforts tipped off park management that a generator was kicking in during the night, potentially disturbing the endangered pair.

Acoustical monitoring provides a baseline for understanding all components of the acoustical environment in a park, including sounds undetectable to the human ear and park-generated sounds. The highly sensitive equipment and expertise of the Natural Sounds and Night Skies Division acoustical monitoring team can provide park managers a more complete picture of the true acoustical environment. Data collected during monitoring can help shape park management plans, thus offering hope for a future where visitors can count on national parks to provide that simple yet increasingly elusive sense of solitude and connection to culture.

Opposite page: An NSNSD acoustical technician engaged in an observer logging session at Mount Rainier National Park. All sounds will be logged into a PDA and later analyzed at the NSNSD office. NPS photo.

The Sounds of Hope

This page: The sun rises over gravestones at Antietam National Cemetery. NPS photo by Keith Snyder.

A message from Natural Sounds and Night Skies Division Chief, Karen Treviño

Like thunder rumbling in the distance, threats to natural and cultural soundscapes are increasingly difficult to ignore. From growing demands for park overflights, and expanding energy development, to greater numbers of park visitors, potential noise sources are proliferating. So too, however, are efforts to understand their effects and avert negative impacts.

While we've learned much over the past decade about noise impacts on wildlife, cultural resources and visitor experiences, a noticeable and growing interest in natural sounds recordings alludes to a human craving for solitude and the soothing sounds of nature. The National Park Service has made note and is beginning to take action to better understand and optimize opportunities to characterize and enhance the positive attributes of tapping into Nature's Symphony.

Revisions in NPS Management Policies to include soundscapes among the resources that need protection signify a commitment to preserve acoustical environments at top levels of the Service. Legislation (and in some cases court orders) to limit air tours, snowmobile, PWC, and OHV use in parks are giving teeth to those policies, and a substantial increase in requests for acoustical monitoring throughout the System indicates a growing interest in understanding this under-studied resource. Indeed, the establishment of the Natural Sounds and Night Skies Division itself in 2000 has helped move the National Park Service onto the front lines of natural and cultural sound protection.

The sounds of hope, though sometimes faint, are beginning to resonate, from the walls of the Grand Canyon to the Everglades' sawgrass prairies. In these increasingly noisy times, it is possible to remain hopeful that our national parks will be places where our children can go to savor the natural and cultural sounds of our nation's heritage.

"When I begin to sit with the dawn in solitude, I begin to really live. It makes me treasure every single moment of life." ~ Gloria Vanderbilt

The soundscape for rafters in the Grand Canyon can go from serene to the roar of turbulent waters in a matter of minutes. NPS photo by Mark Lellough.

Resources and Materials

Wildlife Research

For more wildlife research please see the Impacts of Noise on Wildlife annotated bibliography at: http://www.nature.nps.gov/naturalsounds/PDF_docs/wildlifebiblio_Aug08.pdf

Visitor Experience Research

For more visitor experience research please see the Visitor Experience and Soundscapes annotated bibliography at: http://nature.nps.gov/naturalsounds/PDF_docs/VisitorExperience_Soundscapes_AnnotatedBiblio_17Aug10.pdf

Natural Sounds and Night Skies Division

For your "go-to" guide on all things "NSNSD", including in-depth information about soundscape research, NPS planning and policies, park monitoring results and more visit: http://www1.nrintra.nps.gov/naturalsounds

Newsletters

Echoes, The Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY, 11747. Website http://asa.aip.org/echoes.html.

Nature Sounds, The Nature Sounds Society, The Oakland Museum of California, 1000 Oak Street, Oakland, California, 94607. Website http://www.naturesounds.org/NSSpublications.html.

Quiet Zone, Noise Pollution Clearinghouse, P.O. Box 1137, Montpelier VT 05601. Website http://www.nonoise.org/.

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Web Sites

Acoustical Society of America
http://asa.aip.org/

Acoustic Ecology Institute
http://www.acousticecology.com

Audio Browser Sound Files
http://www.findsounds.com/

Cornell Library of Natural Sounds
http://www.birds.cornell.edu/macaulaylibrary/

FAA ATMP Website
http://www.faa.gov/about/office_org/headquarters_offices/arc/programs/air_tour_management_plan/

Natural Sounds and Night Skies Division
http://www.nature.nps.gov/naturalsounds/

Nature Sounds Society
http://www.naturesounds.com/

Noise Pollution Clearinghouse
http://www.nonoise.org/

NPS Social Science Program
http://www.nature.nps.gov/socialscience/

NPS Webrangers Topic
http://www.nps.gov/webrangers/

Western Soundscape Project
http://westernsoundscape.org/

Wild Soundscapes in the National Parks
http://inside.nps.gov/documents/WS%20screen.pdf

World Forum for Acoustic Ecology
http://wfae.proscenia.net/

Online Sound Libraries and Archives

Borror Laboratory of Bioacoustics
http://blb.biosci.ohio-state.edu/default.html
The BLB houses one of the largest collections of recorded animal sounds in the world. It is easy to download sounds here. You must connect to Ohiolink and then can download and save files.

The Macaulay Library – and Cornell Lab of Ornithology
http://animalbehaviorarchive.org/loginPublic.do
The Macaulay Library is the world's largest archive of animal sounds. They have more than 160,000 recordings of 67 percent of the world's birds, and rapidly increasing holdings of insects, fish, frogs, and mammals. As a not-for-profit organization, they charge for the time it takes to retrieve materials and prepare them for distribution ($25 hour). You can listen to these sounds online, but cannot download them directly.

The British Library Sound Archive
http://www.bl.uk/nsa
This is one of the largest sound archives in the world. You can order sounds from them but cannot download them.

Nature Recordings and Photography
http://www.naturesongs.com/
This site has a variety of free wav samples you can download.

U.S. Fish & Wildlife Service Sound Clips
http://www.fws.gov/video/sound.htm
This site has mp3 files and free wav files you can download.

Nature Sounds Society and the California Library of Natural Sounds
http://www.naturesounds.org/clns.html
The CLNS is a resource center whose primary role is to provide information and sound for public information as well as sound for educational and creative projects in all areas of the arts and sciences. For a nominal fee, they can fulfill your requests for sounds in all currently available formats.

NPS Natural Sounds and Night Skies Division
http://www.nature.nps.gov/naturalsounds/gallery/

The boom of cannon fire can help set the tone of a nation divided against itself at Antietam National Battlefield. NPS photo by Keith Snyder.

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Appendix A

Laws and Policies

Significant laws and policies that govern the management of NPS resources have been listed below. Laws and policies relating to management of acoustic resources are specifically identified. For additional information and updates visit the Natural Sounds and Night Skies Division website: http://www1.nrintra.nps.gov/naturalsounds/laws_policies/index.cfm

- **NPS Organic Act of 1916 (16 USC 1).** This act establishes and authorizes the National Park Service "to conserve the scenery and the national and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."
- **Redwoods Act of 1978.** This act affirms and clarifies the NPS mission and authority. It states: "The authorization of activities shall be construed, and the protection, management and administration of these areas shall be conducted in light of the high public value and integrity of the National Park system and shall not be exercised in derogation of the values and purposes for which these various areas have been established."
- **Handbook to Director's Order #12: Conservation Planning, Environmental Impact Analysis, and Decision-making (Preliminary Draft)**. This handbook is an update and revision of DO-12 and supersedes the 1982 version.
- **NPS Management Policies 2006.** NPS Management Policies are an indispensable tool to help NPS employees manage parks responsibly and make rational, well-informed decisions.

Air Tour Management Plans

- **National Parks Air Tour Management Act of 2000.** This act requires the Federal Aviation Administration (FAA), in cooperation with NPS, to develop an Air Tour Management Plan (ATMP) for each unit of the National Park System to provide acceptable and effective measures to mitigate or prevent the significant adverse impacts, if any, of commercial air tour operations upon natural and cultural resources and visitor experiences.
- **Final Rule: 14 CFR Part 136 - Regulations implementing the National Parks Air Management**
- **FAA/NPS Air Tour Management Plan - Memorandum of Understanding (Draft)**

Soundscape Management

- **NPS Soundscape Management Policy 4.9.** This section of the 2006 Management Policies states, "Using appropriate management planning, superintendents will identify what levels of human-caused sound can be accepted within the management purposes of parks…In and adjacent to parks, the Service will monitor human activities that generate noise that adversely affects park soundscapes, including noise caused by mechanical or electronic devices. The Service will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values, or that exceeds levels that have been identified as being acceptable to, or appropriate for, visitor uses at the sites being monitored."
- **NPS Cultural Soundscape Management 5.3.1.7.** This section of the 2006 Management Policies states 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 that are fundamental components of the purposes and values for which the parks were established."
- **NPS Director's Order #47: Soundscape Preservation and Noise Management.** It directs park managers to (1) measure baseline acoustic conditions, (2) determine which existing or proposed human-made sounds are consistent with park purposes, (3) set acoustic management goals and objectives based on those purposes, and (4) determine which noise sources are impacting the park and need to be addressed by management.

Overflights

- **National Parks Overflight Act of 1987 (P.L. 100-91).** In 1987, Congress enacted Public Law 100-91, commonly known as the National Parks Overflights Act. The Act mandated a number of studies related to the effects of overflights on parks and directed the National Park Service to report to Congress its results. In July, 1995, NPS Published Report to Congress on Effects of Aircraft Overflights on the National Park System.
- **NPS Overflights and Aviation Uses 8.4.** This section of the 2006 Management Policies discusses Alaska and Remote Areas, Education, General Aviation, Administrative Use, Military Aviation, Commercial Air Tour Management, Permitted Overflights, and Airports and Landing Sites.

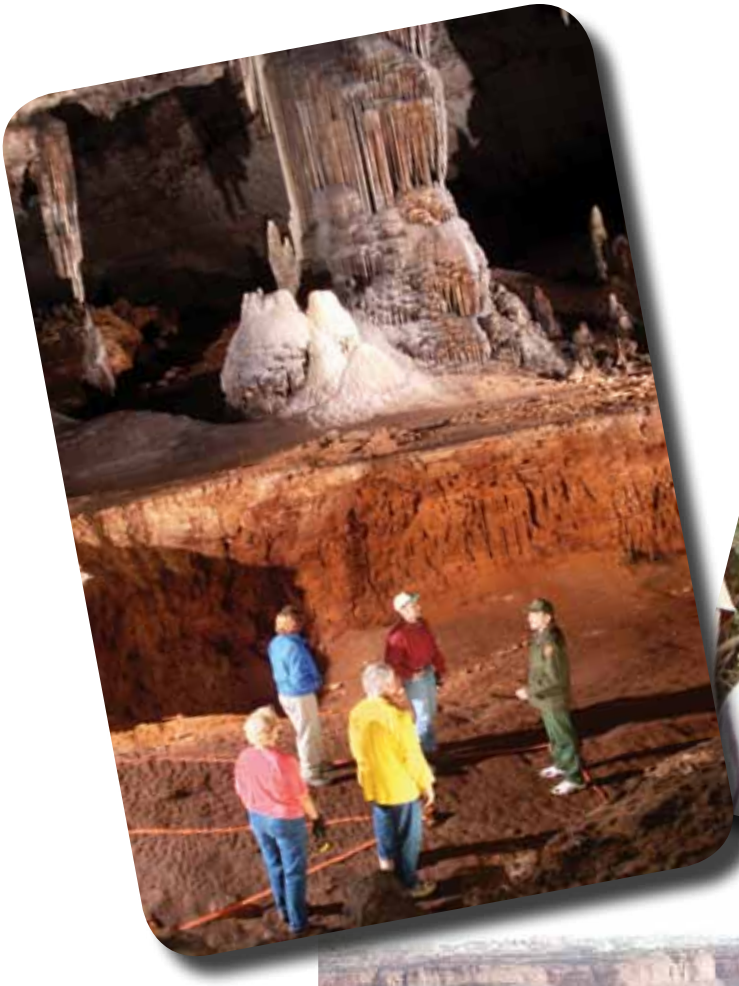
Visitor Use

- **NPS Visitor Use 8.2.** This section of the 2006 Management Policies discusses Visitor Carrying Caparcity, Recreational Activities, Use of Motorized Equipment, Accessibility for Persons with Disabilities, Visitor Safety and Emergency Response, Recreation Fees and Reservations, and Tourism.

Motorized Equipment

- **36 CFR Section 2.12 Audio Disturbance.** Under this section the following is prohibited: Operating motorized equipment or machinery that exceeds a noise level of 60 decibels measured on the A-weighted at 50 feet or, if below that level, nevertheless, makes noise that is unreasonable.
- **36 CFR Section 2.18 Snowmobiles.** Under this section the following is prohibited: Operating a snowmobile that makes excessive noise. Excessive noise for snowmobiles manufactured after July 1, 1975 is a level of total snowmobile noise that exceeds 78 decibels measured on the A-weighted scale at 50 feet.
- **36 CFR Section 3.7 Noise Abatement.** Operating a vessel in or upon inland water so as to exceed a noise level of 82 decibels measured at a distance of 82 feet from the vessel is prohibited.
- **NPS Use of Motorized Equipment 8.2.3.** This section of the 2006 Management Policies discusses Motorized off-road vehicle use, Snowmobiles, and Personal Watercraft Use.

Right: The use of natural and cultural sounds can enhance any park program. Credits (Top left, going clockwise): Carlsbad cave tour – NPS photo by Peter Jones; Ranger Catherine Stanton playing violin at Capital Reef – NPS photo; Geology Talk at Capitol Reef – NPS photo.




COUNTRY
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2001

Appendix B:

Peering into the Toolbox - Interpretive Techniques

The following is a list of creative tools to encourage attentive listening in park visitors. They can be used to enhance a program or incorporated into an entire program on intrinsic sounds.

Activity 1: Create a Wind Sock

The following activity has been adapted from a program by Lindsay Utley.

Materials Needed:

- 1 Tin Can for each participant
- Multiple colors of Crepe Paper or Material strips
- Masking or Duct Tape
- 1-20" piece of string or yarn per participant

Interpreter's Preparations:

Paint the tin can, or cover it with construction paper. Cut 5-6 pieces of crepe paper into 24" strips. (If using fabric, cut the pieces to roughly 2" x 24".) Punch 2 holes directly across from each other in the sides of a tin can as close to the bottom edge as possible. Thread a 20" piece of string through the holes and tie to hang the wind sock.

The introduction to this activity should identify the terms "acoustical environment" and "soundscape" (see "Defining Key Terms") and explain that acoustical environments are unique to every park. Here the interpreter can list sounds that are significant to the experience of his or her park, such as muskets firing or a loon's call. Have the audience consider how these sounds may be different from those they would hear at home. The introduction should also include a discussion about the protection of a park's acoustical environment and make a distinction between desirable and undesirable sounds in a park. The interpreter can encourage the group to list both types of sounds.

Group Activity:

First the group will "collect sounds" in two or three contrasting locations within a park. They are to sit alone for several minutes (as time allows) in each area and write down all the sounds they hear. Interpreters may want to instruct the group on how to focus on sounds, for example, by closing one's eyes, remaining very still and trying to identify the source of a sound.

After sufficient time has passed gather the group to create their wind socks. Have group members list the sounds they heard and then assign a corresponding color of fabric or crepe paper to each different sound.

Give each participant a prepared tin can (see above). They will then tape a colored strip of paper or fabric for each sound they heard to the inside top of their can. The strips should overlap slightly.

Once the wind socks are created, ask for volunteers to share what sounds they included in their windsocks. Encourage discussion of how they felt when hearing the different sounds. Ask if some created pleasant feelings and others created unpleasant feelings. Ask them to ponder how their park experience would be changed if the natural or cultural sounds inherent in the park were drowned out by human noises, such as traffic or loud conversations. Finally, have them consider the 5 sounds they think are most significant in defining the park's acoustical environment.

Activity 2: Layering Sounds

This activity was taken from the soundscape curriculum developed for an NSNSD cooperator, Global Explorers.

Theme: There is a layered world of sound around you.

General Concept: (Onion Metaphor) Students will imagine that the sounds occurring around them are layered.

Students will be able to peel away layers of sound, similar to peeling away layers of an onion. Once one layer is removed, another layer can be revealed. Sometimes human-caused sounds can mask the sounds of nature, so intentionally peeling away an outer layer of human-made sounds may allow students to hear other sounds that were hidden (or "masked"), resulting in a better awareness of the acoustical world that surrounds them.

Logistics:

Find a place outdoors where the students will be able to hear both natural and human-made sounds.

Materials Needed:

Student Journals

Learning Objectives:

1. Students will tune in to both the natural and human-made sound "layers" around them, and will be able to differentiate between the two.
2. Students will express the role of sound in their everyday lives.
3. Students will consider why it may be important to have an awareness of the sounds around them.
4. Students will learn how the NPS Natural Sounds and Night Skies Division manages and protects park soundscapes.

Step A) 30 Second Listening Exercise (All Sounds)

Taking their journals, students spread out and find a comfortable spot to sit where they can still hear instructions. Minimize sounds (clothing, phones, iPods, etc.) Students close eyes and simply listen to all the sounds around for 30 seconds. After 30 seconds, instruct students to open eyes and make a list of all the sounds they heard.

Suggested Discussion Questions:

- What did you hear?
- Of those sounds, which ones were human-made?
- Which sounds were natural?
- What sounds did you like/ not like?
- Do you think there's a difference between sound and noise?*

*Note: The Natural Sounds and Night Skies Division also likes to differentiate between the use of sound and noise. Although noise is sometimes incorrectly used as a synonym for sound, it is in fact sound that is negatively evaluated (undesired) or extraneous to an environment. See the "Understanding Sound and Noise" section.

Step B) 30 Second Listening Exercise (Natural Sounds)

Repeat activity, "peeling away" human-made sounds, listening just for natural sounds. Introduce concept of onion, imagining you can peel away layers of sound, similar to peeling away layers of an onion. Once one layer is removed, another layer can be revealed. Give start/ stop cues and instruct students to make a list of sounds heard in their journals.

Suggested Discussion Questions:

- What did you hear this time?
- Did you hear anything new this time?
- Were you able to peel away the layer of human-caused sounds? How difficult was it?

Step C) 30 Second Listening Exercise (Human-made Sounds)

Repeat activity peeling away the natural layer of sound and focus only on human-caused sound. Give start/ stop cues and instruct students to make list of sounds heard in their journals.

Suggested Discussion Questions:

- Was this easier or harder?
- What did you hear this time?
- Did anything you hear surprise you?

Final Discussion

1. How did this activity affect you? (heightened awareness? surprise? bored? etc.)
2. How did your perception of your environment change when you peeled away the human-made layer vs. the natural layer?
3. What sounds were pleasing / annoying? Why?
4. What sounds did you think were inappropriate for this location? Why?
5. What sounds did you think were appropriate for this location? Why?
6. If you were a Natural Sounds and Night Skies Division researcher helping the park manager, what sources of noise might you suggest he or she try to manage?* (Managing noises might include limiting, eliminating, or determining where and when it is appropriate)

tnt.dc_wikimedia.org

***Introduce the National Park Service dual mission:**

- Protect natural and cultural resources and provide enjoyment to visitors in parks. (Balance protecting resources while making sure visitors are having a good experience.)
- Because of this, what challenges do you think they encounter? (e.g., Need to minimize human-made sound to protect natural resources, but in order to provide a quality experience for their visitors some human-made sounds may need to be allowed, such as visitors talking, cars, etc.)
- With the help of the Natural Sounds and Night Skies Division, it is up to the park managers to decide what sounds are appropriate or inappropriate for a particular park unit.
- The Natural Sounds and Night Skies Division works to protect, maintain, or restore acoustical environments while increasing scientific understanding and inspiring public appreciation for soundscapes. In order to assist park managers and achieve their mission, researchers at the Natural Sounds and Night Skies Division must be able to effectively peel apart the natural, cultural, and human-made sound "layers." This allows them to focus on each layer of sound separately and provide better guidance to park managers on the best strategies for protecting both the acoustical environment and soundscape and for addressing noise pollution issues.

The NPS must constantly balance the challenging dual mission of protecting resources while providing for public enjoyment. NPS photo.

The endangered male Steller sea lion uses a loud bark to show dominance and threaten other males. Lon E. Lauber/USFWS

Activity 3: Communicating in the Wild

This activity was taken from the soundscape curriculum developed for an NSNSD cooperator, Global Explorers.

Theme: Animals rely on sound for communication and survival.

General Concept: Students will participate in an activity about wildlife communication.
This activity will be similar to the game everyone knows as "Telephone." Students will try to communicate a message to one of their fellow students under various noise conditions. The purpose of this activity is to help students to understand what wildlife may experience under unnatural noise conditions.

Logistics:
Find a place where you can play audio clips at various volumes without disturbing others.

Materials Needed:
CD player with speakers, audio clips (Can be downloaded from: http://www1.nrintra.nps.gov/naturalsounds/outreach/) ***Speakers should be placed in the middle of the room between the listeners and the reader.

Learning Objectives:
1. Students will understand the concept of masking (sounds that are blocked by other sounds).
2. Students will be able to explain the importance of sound for wildlife communication.
3. Students will be able to give examples of how masking impacts wildlife communication, courtship and mating, predation and predator avoidance, and effective use of habitat.

Step A) Reading Statement with NO interference
In this activity, students will explore the role sound plays in wildlife communication. One student will try to communicate a message to the rest of the class under different noise conditions (an audio clip will be played at various volumes). Group imagines they're in a natural environment such as a park or a forest, everyone stands up. Begin with introductory question such as: "Why do you think sound is important in the wild?"

Ask for a volunteer to read a question (to follow) standing about 20 feet away from the rest of the group. It is important that they speak in a normal speed and normal tone. *Do not play an audio clip*. Instruct the group that this represents a situation when there are no noise intrusions in the wild.

Question 1:
Did you know that wildlife depends on sounds to communicate, navigate, avoid danger, and find food?

Discussion:
- What was the message? (Their response does not have to be word for word, it should just reflect the main point of the message.)
- Did anyone have difficulty hearing him/her? Why?

Step B) Reading Statement with MEDIUM interference
Ask for a second volunteer to come up and stand 20 feet from the rest of the group. Remind him/her to read the 2nd message at a normal speed and tone when you give the OK.

Prepare to play audio clip at medium volume. Notify group that the clip you're about to play represents a situation when human-made noise intrudes into the wild. Play clip, cue student to begin reading 2nd question.

Question 2:
Did you know that noise can be harmful to wildlife health and reproduction and their ability to find prey and avoid predators?

Discussion:
- What was the message? (Response doesn't have to be word for word, just reflect the main message.)
- Did anyone have difficulty hearing him/her? Why?
- Could you identify any of the sounds in the audio clip?

Step C) Reading Statement with LOUD interference
Ask for a third volunteer to come up and stand 20 feet from the rest of the group. Remind him/her to read the 3rd message at a normal speed and tone when you give the OK. Prepare to play audio clip at loud volume (students should not be able to hear speaker). Notify group that the clip you're about to play represents a situation when a very loud human-made noise intrudes into the wild. Play clip, cue student to begin reading third question.

Question 3:
Detecting predators is a life or death situation for many animals. Did you know that masking makes it very difficult for an animal to hear its predator?

Discussion
- What was the message? (Response doesn't have to be word for word, just reflect the main message.) Did anyone have difficulty hearing him/her? Why?
- Could you identify any of the sounds in the clip? (Sounds include train, helicopter, propeller airplane, and motorcycle).

Final Discussion
1. What are some examples of messages that an animal might try to communicate to another animal?

Some answers: A male trying to court a female; bird using an alarm call to notify other birds that a predator is nearby; animal notifying another animal that prey is nearby; young bird using a begging call to get food from parent.

2. What could the reader have done differently to get the message across (aside from the parameters they were given)? In other words, what might an animal have to do to get a message across when it is noisy?

Some answers: Call louder; use visual signals; move closer to receiver.

3. If an animal had to call louder to get its message across, how would that affect the animal?

Possible answer: Since they are expending more energy to call louder, it could cause more fatigue.

4. If animals were grazing in a noisy area where they couldn't hear as well, what could they do to make sure they are safe from predators while grazing?

Possible answer: They might graze less – they would have to rely more on their sight to see predators, thus foraging less and expending more energy to keep safe.

Close lesson by reading real-life examples of how wildlife have been affected by noise (see below):

1. Titmouse (bird) – responds to human noise by altering the frequency structure of their song. In order for their songs to be heard, they must sing at higher frequencies. (Katti & Warren, 2004).
2. Killer Whales – The noise from fast whale-watching boats was found to be audible to killer whales over 16 km, to mask killer whale calls over 14 km, and to elicit a behavioral response at over 200 m (Erbe, 2002).
3. Nightingales, Zebra Finches, Blue-throated Hummingbirds – All birds increased the sound level of their songs in response to an increase in white noise broadcast to them. Birds that are forced to sing at higher levels have to exert more energy and must bear the increased costs of singing (Brumm & Todt, 2002; Lohr et al., 2003; Pytte et al, 2003).
4. Common Marmosets (monkey) – Marmosets were found to increase both the sound level and length of their spontaneous calls in response to increased levels of white noise broadcast to them. Again, this forced them to exert more energy that would normally be used for other tasks (Brumm et al., 2004).
5. Tree Swallows – One study examined how nestlings' response to calls by their parents is affected by ambient noise. Researchers found that the nestlings' begging call length, sound level, and frequency range all increased with increasing noise levels at nests. This might explain why nestlings have to rely on other methods such as visual signals to get parents' attention (i.e., more body movement) (Leonard & Horn, 2005).
6. Mountain Sheep – Significantly more animals abandoned sampling areas and moved away from helicopter noise. Likewise, mountain sheep changed the vegetation type they occurred in more often with presence of helicopter noise (Bleich et al., 1994).
7. Ovenbirds – One study found a significant reduction in ovenbird pairing success at compressor sites (77%) compared with noiseless wellpads (92%). We hypothesize that noise interferes with a male's song, such that females may not hear the male's song at greater distances and/or females may perceive males to be of lower quality because of distortion of song characteristics (Habib et al., 2007).
8. Chaffinches – Increased vigilance of surroundings as a result of louder background noise led to significantly fewer pecks and an overall reduction in intake rate. This suggests that compensating for the increased predation risk could indirectly lead to a fitness cost (Quinn et al., 2006).
9. Giant Pandas – preliminary findings indicate that ambient noise can have long-lasting effects on stress indices. Days characterized by louder levels of noise were associated with increased movement, restless handling of the exit door of the enclosure, increased scratching and vocalizations indicative of agitation, and/or increased glucocorticoids (classic endocrine response to stress) excreted in urine (Owen et al., 2004).
10. Bottlenose Dolphin – Significant heart rate accelerations observed in response to sound playback stimuli (Miksis et al., 2001).

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Children can easily imitate the call of the barred owl, which seems to be saying, "Who cooks for you, who cooks for you all." Randolph Femmer/NBII

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Activity 4: Create Your Own Soundscape

The following activity has been adapted from submissions by Lindsay Utley and Christine Gerlach

Begin by asking participants to list all the intrinsic sounds of your park. (Intrinsic sounds belong to a park by its very nature, based on the park unit purposes, values, and establishing legislation. In addition to natural sounds, intrinsic sounds can include cultural and historic sounds that contribute to the acoustical environment of a park.) Challenge them to recreate this soundscape by vocally mimicking or finding items that represent individual sounds. Many bird songs have been likened to English phrases. For instance, barred owls seem to say, "Who cooks for you, who cooks for you all?" Frog calls, as well, seem to mimic many human made sounds. For more ideas the interpreter may want to refer to wildlife field guides and the section "Bugles, Peeps and Chirps" earlier in this handbook.

The following is a list of ideas for replicating sounds:

Spring peepers – a set of sleigh bells or Christmas bells
Bullfrog – blow into a bottle
Chorus frog – run fingers over a comb
Cricket – blow lightly on a whistle
Thunder – rattling heavy construction paper, or beat a drum
Soft rain – snap fingers
Hard rain – slap thighs
Leaves rustling – crumple paper
Waterfall – stomp the floor (especially effective on a stage)
Stream flowing – empty water from one container into another

Let visitors explore their own ideas for recreating various sounds, as well. This allows them to stretch their imaginations and better appreciate the qualities of each sound.

Make the activity more specific by imitating the sounds of a thunderstorm. This common activity is often used in children's classrooms, involves no materials and stirs children's imagination. It can be adapted here to augment a discussion about natural sounds and to encourage children to practice attentive listening when outside. The idea is to imitate the sounds of a thunderstorm as it approaches, hits, and tapers off again.

To begin, have everyone in a seated position and instruct them to follow your actions. Begin by rubbing your hands together. Allow everyone to do this for about 15 seconds, then begin snapping the fingers of both hands. Again, have everyone do this for another 15 seconds. If children are having trouble paying attention to your actions, walk around the group so everyone sees what you are doing. Next, switch to clapping hands to imitate a hard rain. Follow with slapping your thighs, indicating that the thunderstorm has hit. Then gradually back off the sounds. Begin hand clapping for a few seconds, followed by finger snapping and finally hand rubbing to indicate the storm tapering off. Put your hands in your lap to indicate the end of the storm.

When all hands are silent again, discuss the experience with the children. You may even decide not to tell them what they are imitating at the beginning, then let them guess when they are finished. Ask questions about what each activity sounded like and what they felt while they were creating the sounds. You can discuss how the children feel about rain and the sound of thunder. Encourage them to explore their feelings about the sound of rain: does it make them happy, sad, or anxious? Ask them what they do if they are outside when they hear thunder. Help them realize that thunder can serve as a warning to find shelter. This can lead to a discussion about how important natural sounds are for wildlife as well. (Refer to the discussion questions in Activity 3: Communicating in the Wild for examples of how animals rely on natural sounds.)

If time allows, you can conclude the activity by taking them outside to listen to nature (see ideas in Activity 6).

Activity 5: Sound Appreciation

The following activity has been adapted from a program by Lindsay Utley.

Theme:
Acoustical environments are an endangered resource.

Goals:
1. Foster audience appreciation for park acoustical environments.
2. Teach audience that acoustical environments are a unique resource that deserves protection.

Objectives:
1. Audience can define "acoustical environment."
2. Audience mutes electronic equipment or avoids using it altogether while in park.

Tools:
Recordings of various sounds, available at: http://www.nature.nps.gov/naturalsounds/gallery/
Bat locator (optional)

Body:
Begin by explaining that sound is a part of the environment, just like air or water. Every place has its own unique sounds associated with it. This is known as an acoustical environment. Encourage the group to close their eyes and imagine what a bus or a rooster sounds like and the appropriate place they would hear them. An example to use could be a rooster crowing. Explain that roosters are typically part of a farm's acoustical environment, and if they were to hear a rooster in your classroom, it might seem out of place.

Subtheme – Acoustical environments are made up of unique sounds.
Clarify further by explaining that an acoustical environment is like a landscape except it is everything one can hear instead of everything one can see.

Have the group participate in a 2-minute listening exercise. During the 2 minutes they should remain as still as possible and listen to all the different sounds they hear. Have them raise a finger every time they hear a different sound.

At the conclusion of the 2 minutes ask them to list what they heard. Ask if they would know where they are if they heard only those noises. Help them understand that the sounds they hear tell a lot about where one is, and that this is a place's acoustical environment. Explain that a park's acoustical environment is unlike any other because of the unique sounds that are present there. Introduce the idea of wildlife communication as an important part of an acoustical environment.

Subtheme – Wildlife, like us, can communicate with sound
Explain that animals rely on communication. They need to communicate warning signals if a predator has been spotted, alerting others about food, and in order to find a mate. Oftentimes, animal conversations enrich the acoustical environment of an area. List an appropriate animal for the park location, such as elk bugling, or geese migrating. Follow with the fact that although humans can hear a lot of animal communication, there are many animals that communicate so high or low that human ears can't pick up on it. You can use an example of a dog whistle and explain that a dog whistle is at a pitch that humans can't hear, but dogs can. This type of communication is constantly occurring among insects, birds, and mammals, but humans are oblivious to it.

Follow by playing bat calls, then slow them down so that they're audible. Lead into the idea that as humans, we are no exception to the acoustical environment because we make noise too. However, our noise can smother (or mask) subtle sounds, especially naturally occurring sounds. For this reason acoustical environments may become an endangered resource. Explain that by talking on a phone, or buzzing through on a snowmobile, we scare off animals that may be trying to communicate to one another. We also cover up the calming sounds of a trickling brook or wind rushing through leaves.

Activity:
Play a recording you have previously made with approximately 10 different natural and human-made sounds. Have the group identify each sound and order them from most calming to least calming. Discuss why they chose the way they did. (Refer to "Online Sound Libraries" section of this handbook for sources for natural sounds.) Conclude the activity by stating that in order to see more wildlife and experience natural sounds we can "eavesdrop on nature" by talking softly, muting electrical equipment when out in nature, and practicing attentive listening. Remind the group that sound is an endangered resource and in order to protect it, we must be aware of how much sound we are making.

Activity 6: Silent Hike/Silent Sit

Conduct all or part of a hike with no talking. Give each participant an opportunity to point out something they find interesting or fascinating to the group, again, without talking. Instruct them to raise their hand when they see something they want to share. Let them be creative in how they show the others what they found, for example: gently poke at a mushroom that is filled with spores, so the group can watch the "brown smoke" billow out. Or they could pantomime a bird singing and point in the bird's direction. The longer this activity lasts, the more in tune the group becomes to their surroundings. To conclude, have the group discuss how the forced silence affected their experience.

Another way to quiet a group is to separate them along a trail and have them each sit for 10 – 15 minutes with a paper and pencil (crayons work, too). Instruct them not to talk (they should be far enough apart to make this difficult) and just listen for several minutes. During this time they may want to draw or write about what they see and hear. Bring the group together to share their drawings or writings. Discuss how it felt to be silent in nature.

Activity 7: American Indian Music

This activity has been adapted from the program "Potawatomi Ways" Environmental Education program offered at Indiana Dunes National Lakeshore.

Theme: American Indians celebrated life by creating music, much like we do today.

Materials Needed:

1. Various native musical instruments such as dried gourds, drums, notched sticks, and recorders. (Many websites exist where one can purchase American Indian instruments or find instructions for making simple imitations.)
2. Tape or CD of actual American Indian music, and CD player.

In this activity children are given American Indian instruments and form a circle to create their own music. The group leader should discuss reasons American Indians created music in the past and compare them with the reasons we make music today. Explain that the American Indian created music to express joy in a bountiful harvest or after a successful hunt, to celebrate the changing seasons, or for rites of passage, such as weddings, among people in the tribe. They also created music as a means to mourn a loss, such as the death of a loved one.

To set the mood it is helpful to dim the lights and ask that no one talk. Select one person to be the head drummer. This person will set the beat for everyone else to follow and when they stop, that will signal everyone else to stop playing as well. The head drummer will also determine the intensity. When he or she beats on the drum more loudly, the others can raise the volume of their instruments as well, when he or she beats more softly, the others follow suit.

This activity is very powerful for setting a reverent mood among the children. You can repeat it several times, changing the head drummer and the rhythm each time.

Discussion:

(During the discussion softly play a tape of authentic Indian music.) The interpreter should ask the participants how it felt to make music and what it was like to participate with others in doing so. Remind them that music and ceremonies were very important to American Indian culture, possibly even more than to ours because it was a community event and a primary form of entertainment. It is also important to point out that American Indians exist today and that their culture is still active. This can lead to a discussion about respect for other cultures and, depending on the group, you can discuss the intolerance of the settlers and early U.S. Government to American Indians.

Activity 8: Stalking Prey

Adapted from an activity submitted by Jaclyn Dostourian

With their "silent" wings, owls are masters at catching prey by surprise. Copyright Neil Solomon.

This activity also represents American Indian and early native cultures. In this game children attempt to sneak up on one another to represent stalking animals while hunting.

Select one person to represent an animal that is being hunted. This person will stand with his or her back to the group, about 30 feet away from the others. Depending on how many children there are, line them up in teams of four. Remind those who are waiting that they need to be as quiet as possible. At a silent signal from the leader the first group of four will begin walking toward the child that is acting as prey. The object is to tag this person before they hear the others coming. If the "prey" hears a sound from the oncoming team, he or she should raise a hand. At this point the team loses its turn and steps outside the playing area. The leader signals the next group to begin and the game continues this way until someone tags the prey. At this point the tagger can replace the prey and the game resumes.

Generally no one makes it all the way to the prey on the first round. At this point gather the group and discuss what they need to do differently. Have them practice stalking – walking very quietly, stepping on tiptoes and rolling toward the soles of the feet, while crouching in a low position for balance. Ask them what other things they might change in order to walk as silently as possible. Some ideas are to remove noisy coats or squeaky shoes, avoid twigs or leaves that might rustle and move very slowly.

Repeat the activity as time allows or until someone tags the prey indicating they have been caught.

Discussion:

Have children relate what it felt like, and how difficult it was to be silent. Remind them of the types of clothing native people wore in the past that might have helped them move more quietly. Talk about feelings of anxiety and fear the Indians might have experienced and how their hunting abilities were a matter of survival.

This can lead into a discussion about the importance of natural sounds and what they meant to people and animals both in the past and today. Get children thinking about their favorite nature sounds. Discuss how important sounds are for animal communication and how our activities when in parks can affect them. Encourage children to practice walking quietly in the woods and listen carefully to the natural sounds around them.

Sunset over New River Gorge National River. NPS photo by Gary Hartley.

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