WILD SOUNDSCAPES IN THE NATIONAL PARKS:

An Educational Program Guide to Listening and Recording

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October, 2002

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A guidebook of Education Programs

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I. Introduction to Natural Soundscapes

An important part of the NPS mission is to preserve and/or restore the natural resources of the parks, including the natural soundscapes associated with units of the national park system. Natural sounds are intrinsic elements of the environment that are often associated with parks and park purposes. They are inherent components of "the scenery and the natural and historic objects and the wild life" protected by the NPS Organic Act.

Educating the American public about the nation's natural and cultural heritage is one of the fundamental responsibilities of the National Park Service and is central to its resource preservation efforts. Superintendents will use educational and interpretive materials . . . on the natural soundscape and its values to educate visitors about their soundscapes.

NPS Director's Order 47:
Soundscape Preservation
and Noise Management.

This is an introduction to the development of natural soundscape programs – programs intended for both children and adults. It is designed to be implemented by National Park Service staff, support groups, and volunteers. This guide supplements and complements The Nature of Sound material (NPS Sound Education Plan Materials, Revised Edition, 1999), and offers a series of programs designed to produce a revitalized experience of the wild through listening. In fact, by teaching you to listen in new ways, it is designed to help enhance the staff and visitor experience of the national parks to more fully understand and appreciate the vast implications of natural soundscapes as a precious resource - the intent of the educational directive in D.O. 47.

From the perspective of this directive and to help interpret natural soundscape for visitors, the objective of this guide is to encourage visitors of all ages to spend more time in the field peacefully but actively enjoying the natural world from the perspective of sound. As binoculars and microscopes aid our vision, some easy-to-use audio aids are introduced into this experience to boost our ability to listen as well.

Background and history

Key to an understanding of the natural world is the sound emanating from every habitat. In general, habitats generate two types of non-human sound: biophony - meaning those sounds produced by living organisms that relate to one another in a symbiotic relationship defining each habitat and its relative health, and geophony - non-creature sounds like streams, weather, and effects of wind in trees and grasses. All of these sounds help define the boundaries of each habitat in ways not previously considered. When lumped all together, these concepts fall into broad categories referred to as natural soundscapes.

Historically we have come to understand the natural world mostly through what we see. At the same time we have forgotten the extent to which our ears are able to provide the necessary additional information and drama. One cannot hear a wolf howl or a bird sing by sight. While our experience of the natural world is enhanced through the use of all our senses, our ears alone are able to provide a dynamic and dramatic source of information - once we again learn to listen with the discrimination our forest-dwelling ancestors understood.

Long ago, we were able to know the place in which we lived as much by sound as by sight and smell. We humans walked the forests and deserts of our respective worlds and knew our location, not by a global positioning system (GPS), a topographical map, or compass, but by the delicate fabric of creature, liquid, and airborne cues received by ear. In genuine response, we, in turn, learned to sing and dance using the sounds of our natural surroundings as a kind of karaoke orchestra with which we performed. Human life was greatly enriched by giving back in kind through movement, story, and song what was received from the forests, deserts, mountains and oceans of the world. This ancient connection, the one that once made us functional and healthy, hasn't been particularly valued for a time longer than modern time longer than modern history. However, that oversight appears to be changing. Because of the increase in human-induced noise, renewed public interest in quietude and the sounds of the natural wild are beginning to bring about significant changes in thinking. This includes a heightened appeal for new visitor experiences within the national parks as natural soundscapes are increasingly being seen and understood as a valued resource.

Natural soundscape is nature's voice

For years, the National Park Service considered the natural soundscape as a valued ingredient; a concept as important to visitor experience as its wide vistas and its individualized inventory of flora and fauna. Today, however, in order to hear this wonderful resource unobstructed, visitors need to be encouraged and taught to be especially quiet because the fabric of soundscape is often quite delicate. A jet flying at 30,000 feet ten miles distant can (and sometimes does) mask the voice of a creature or alter its behavior. Most notably, human mechanical noises can and do profoundly affect visitor experience of the wild.

This guide provides a range of approaches to listening with renewed and considered respect. Many of those who have learned this sensory skill, have found their lives transformed and drawn to new discoveries with each new venture into the wild natural world. The power of natural soundscapes can now be more effectively introduced to national park visitors.

II. Education and Natural Soundscapes

Soundscape education is an exciting, multi-dimensional way to teach and learn about aspects of the natural world.

Background and history

There are two compelling reasons for implementing programs related to natural soundscapes within national parks. First, many of these parks provide some of the few places left in the United States where certain key types of undisturbed habitats remain for study, visitor enjoyment, and the health of local fauna. And second, to date, no comprehensive natural soundscape inventory has yet been attempted. These vital indicators of habitat health and other precious sources of information need to be discovered, identified, and archived.

There are other reasons, as well. From the perspective of National Park Service educational programs, natural soundscapes offer many new and fresh opportunities to enhance visitor experience of both wilderness and other aspects of the parks. These include aural experiences encountered in many distinctive and different habitats, e.g., riparian, meadow, edge, lake-side, different types of forests, fresh and salt water marine. Other aural experiences include specially designed and informative soundscapes in interpretive areas, at visitor centers, and other key locations throughout the parks, guided programs for children and adults, and web-based sites that inform and engage a curious public attuned to the virtual world. Information that will help National Park Service staff understand and inform visitors about the nature of sound and natural soundscapes is offered in the remainder of the document.

The nature of sound

Sound is an atmospheric vibration that causes stimulation of the brain's auditory centers. If the physiology of the mechanism is intact, an average unimpaired human listener will be able to hear between 20 Hertz (vibrations per second) to 20kHz - the full range of human capability. To some degree, all humans whose hearing is unimpaired or relatively intact, can hear. Listening in discriminating ways, however, is another story. Listening is primal, physical, sensual and most of all mysterious because sound can't be seen. It is precisely because it cannot be grasped in the hand and because it is illusive that the medium of sound and, in particular, the voices of the natural world are so compelling. As a resource in the sense that most other resources are considered, natural soundscapes are unusual because they have no intrinsic economic value. They can be appreciated only for themselves and what they bring to the experience of the visit to a particular natural or virtual site. Yet each natural soundscape contains vital information that is just beginning to be valued and understood both for it's own sake and for its positive effect on humans. It is this knowledge-to-be-gained component that Park Service staff and visitors alike can help provide through the listening programs that are outlined in this guide.

A soundscape is the voice of a place

Identified and first studied in the 1970s by Canadian R. Murray Schafer and his colleagues at Simon Fraser University in Vancouver, B. C., natural soundscape is the special way in which all the sounds of a natural environment, including resident and seasonal organisms, blend into what we call a biophony. Think of a biophony as the unique and distinctive symphony of creature voices that defines each particular habitat. The expression of biophony depends on location, season, weather conditions, time of day or night, whether the biome is wet or dry, whether the habitat is primary or secondary growth, clearcut or unchanged, and many other combined factors. Given certain conditions, biophony is as clear an indicator of individual place, its fitness, and age, as a thumbprint is to each human individual.

Ties to our evolutionary past

Culturally, natural soundscapes have affected the human world in profound ways. For instance, recent evidence indicates that it was the animals who first taught us to dance and sing. The Bayaka Pygmies who live in the rainforests of the Central African Republic, the Kaluli of New Guinea, and the Jivaro of the Western Amazon basin use the sounds of their respective habitats as a natural karaoke orchestra with which they sing, dance, and create their music. Biophony also serves as an acoustic territorial guide during night hunts and journeys. This was also the case with many Native American groups from the tropical and subtropical rainforests of the Americas and to the vast sub-arctic and arctic regions in the north prior to the encroachment and masking effects of human mechanical noise.

It appears that ancient human beings learned well the lessons imparted by natural sounds. Their lives depended as much (if not more) on their ability to hear and understand the biophonies of their surroundings as those given by visual cues. Not only can the Jivaro, Bayaka and Kaluli distinguish one creature sound from another within a din of natural soundscapes, but they can recognize the subtle differences in sound between various mini-habitats as small as twenty square meters in a forest. Moreover, when one closely observes the effects of chimpanzees, mountain gorillas, and orangutans pounding out complex rhythms on the buttresses of rainforest trees in Africa or Borneo, one cannot help but be struck by the articulation of the message, its effect on other groups of primates within hearing range of the sounds, and the natural origins of the human art of drumming and making music - particularly when combined with the rest of the forest sounds.

Several years ago, while working with the Jivaro, this author was invited go out on a night hunt guided only by the sounds of the forest which the tribe uses as a kind of natural GPS. The hunters had no artificial source of light; no starlight penetrated the dense canopy above. It was otherwise completely dark. Mostly, from subtle changes in the biophony of the forest, the hunters and trackers could determine exactly where they were, what animal was several hundred meters distant, what direction it was heading, and whether or not it was worth following. Contemporary cultures, considered more advanced, once knew those skills as true hunters a very long time ago. Most of those talents are forgotten or neglected in the modern world. The programs contained in this guide are designed to reeducate and to reintroduce some of those useful listening skills and to reawaken a sense of natural soundscape awareness.

Science of natural sound

Since the end of the Nineteenth Century, researchers in the natural sciences predominately focused on the study of single isolated creatures in an effort to understand an organism's connection to the whole environment. This abstraction or fragmentation is based on the assumption that isolated studies are always easier to grasp and measure within the canons of pure and carefully considered academic terms - that once the part is understood, the whole can somehow be extrapolated. It is easier to impose controls on these types of studies - the quantified results offering models that fit common expectations. Indeed, even in the relatively new field of bio-acoustics (bio = life, acoustics = sound), when portable and professional quality tape recorders and microphones that could be used outdoors first emerged in the late 1960s, field researchers enthusiastically taped single creature sounds and isolated individual animal vocalizations only to find that significant parts of the messages eluded them altogether. It is what Stephen Jay Gould calls "...the invisibility of larger contexts caused by too much focus upon single items, otherwise known as missing the forest through the trees." Indeed, we have a great deal of difficulty grasping the larger, more complex concepts - even when they may hold the key to simpler truths. Bearing this in mind, we are just now beginning to realize the important role ambient sound plays in our environment. Hearing the sounds in a context with every other creature voice reveals a more complete and compelling story of a habitat. From traditional methodology, taking the voice of a single animal from a habitat and trying to understand it out of context is a little like trying to comprehend an elephant by examining only a single hair at the tip of its tail (before cloning, of course).

Our ancestors had intimate knowledge of what successfully excited many forest inhabitants into vocal action. It is the knowledge, still applicable today, that in every biome within the realm of the wild natural where the environment is still completely intact, a unique voice, made up of the complex relationship between all vocal creatures, is quite unequaled. These organisms, when vocalizing, produce niches measurable by time (rhythm), amplitude (loudness), frequency (pitch), and timbre (quality of sound). Furthermore, they have evolved sound-generating communication mechanisms which create audio output complementary and relative to other noise-producing creatures and the particular acoustical properties of their respective habitats. Again, this phenomenon is referred to as biophony.

The combined symbiotic sounds that whole groups of living organisms produce together in any given biome at one time are so singular and important to creature life in certain locations that if one creature stops vocalizing, others tend immediately to join the chorus to keep the acoustic integrity of the habitats intact. This symbiotic acoustic relationship occurs, to one degree or another, in every type of habitat on the planet - marine and terrestrial - as far as can be determined.

What is especially noteworthy is the way in which the acoustic niche changes as one moves short distances throughout a forest - even where vegetation and the geological features appear to be visually constant. While there are general or regional similarities, any subtle change in the mix of creatures alters the manner in which the biophony is expressed. Thus territorial grids of many shapes and sizes are often in a state of flux. These biophonic zones are vastly different in shape from the usual scientific grids of 100 square meters scientists were originally taught to use as guidelines for data collection and mapping.

Biophony

Illustrated below is a graphic example how biophony works: Figures 1 and 2 reveal simple and complex habitat ambient niche spectrograms (or voice prints) where consistent dark lines running horizontally across the page represent a unique mixture of insect voices occupying several "bands" of a 20 - 10,000 Hertz frequency spectrum in Figure 1, and a 20 - 20kHz. spectrum in Figure 2. Note that the darker the line, the greater the amplitude in that particular range. The four short dashes toward the bottom of the page in Figure 1 represent the low voice of a Zenaida dove (Zenaida macroura), a common species of bird living in the Virgin Islands on St. Maarten and in this hemisphere. (This particular sample was taken on Pic Paradis, a 400m mountain on the French side of the island).

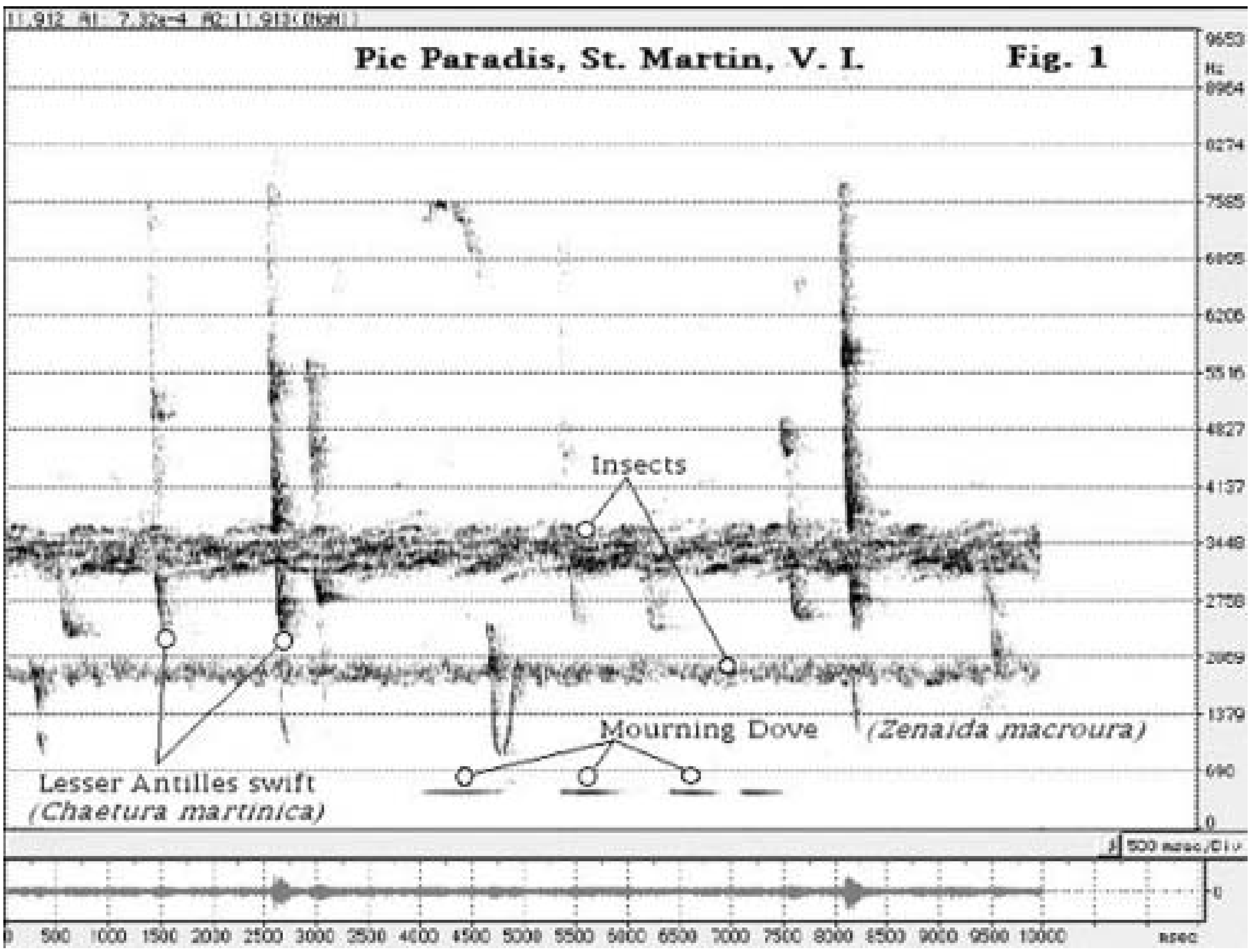


Figure 1 Spectrogram of soundscape at Pic Paradis, St. Maarten, V.I.

The Figure 2 sample was recorded recently in Borneo. Again, the dense horizontal lines running across the middle of the page represent insect voices. However, notice the Asian paradise flycatcher (Terpsiphone paradisi) vocalizations at both the left and right sides of the spectrogram. Its voice is made up of three harmonic components called formants. And they fit uniquely and exactly into several niches where there is little or no vocal energy. These spaces are represented by either light or white spaces. It turns out that in every unaltered habitat recorded, many birds, mammals, and amphibians find and learn to vocalize in acoustical niches unimpeded by the voices of less mobile creatures such as near-ranging insects. It is suspected that similar models hold true for sites within the national parks; a hypothesis in the initial stages of investigation.

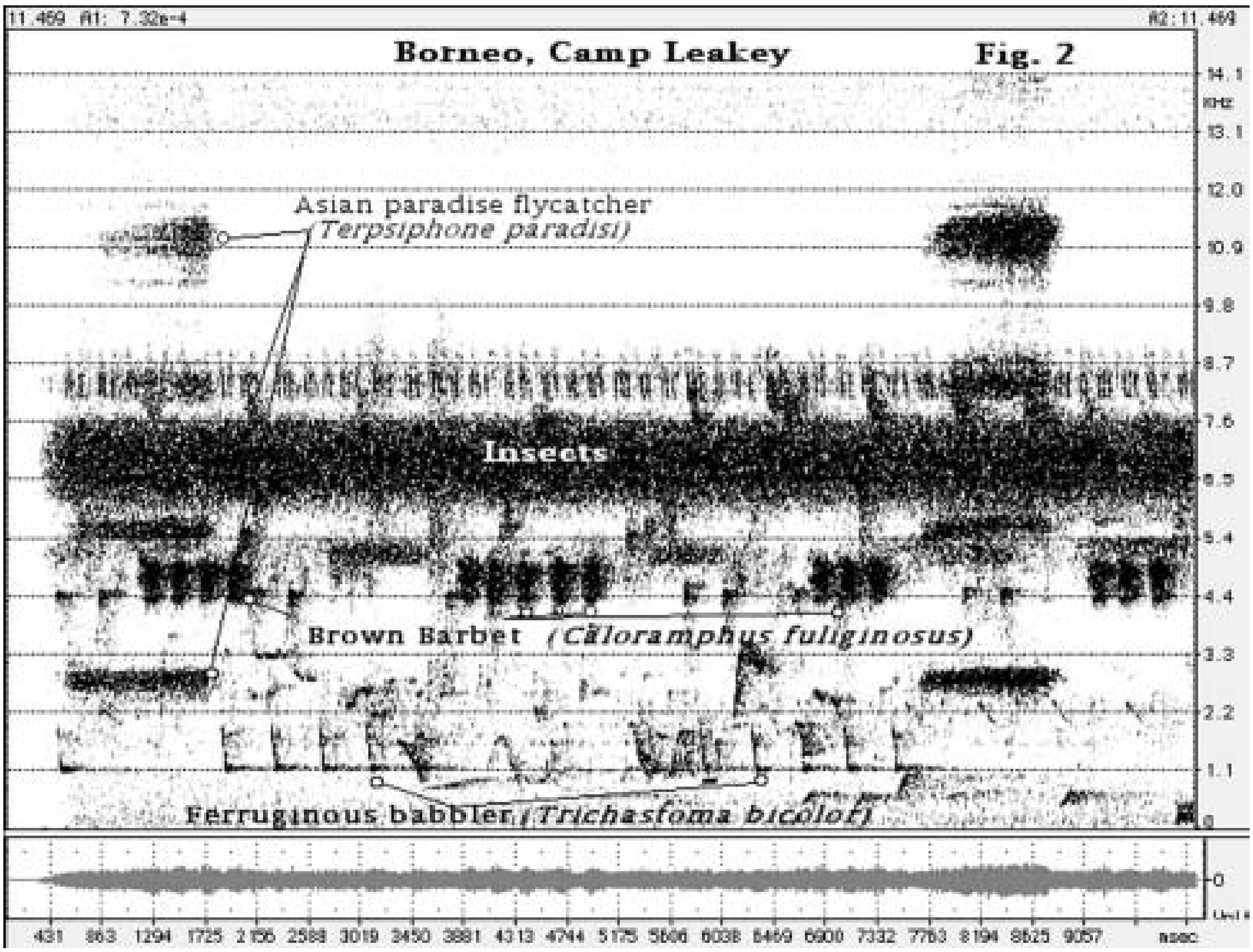


Fig. 2 Camp Leakey, Borneo, primary old-growth biophony spectrogram

Biophonic dating.

When examined from an aural perspective, territory becomes defined in dimensions well beyond the 3-D topographical one might experience on a traditional map. Furthermore, examining habitats from an aural perspective may allow us to actually determine their approximate age. For instance, in younger environments, birds and mammals seem to occupy only one niche at a given moment such as in Fig. 1, a secondary growth habitat that has recovered from the stress of clear-cutting. However, in older environments, some tropical rainforest animal vocalizations, like the Asian paradise flycatcher in Fig. 2, are so highly specialized that their voices occupy several niches of the audio bio-spectrum at the same time thus laying territorial claim to several channels. Early indicators hint that this must have taken a particularly long period to develop, thus revealing a sense of habitat history.

Determining habitat health

These types of observations may also reveal a great deal more about the ways in which birds respond to the sounds of their environment. For example, many migrating eastern American warblers, able to learn only one song and call in their lives, might find themselves unable to adjust to the changes in ambient sound when they fly to their rapidly disappearing Caribbean or Latin American wintering sites. Where these environments have been deforested, and when birds try to move nearby to ostensibly similar or secondary growth habitats, they may discover that they are unable to be heard. Analyses of field recordings are beginning to indicate the possibility that survival might be impaired because territorial and/or gender related communications are masked. As a result, the concept of biophony might be utilized as an indicator of habitat health insofar as it demonstrates soundscape's relevance to the support of creature life.

Around the time it was realized that what is represented through biophony is an animal orchestra with each creature vocalizing in its own niche, it was noticed that when a bird sang or a mammal or amphibian vocalized, the voices appeared to fit in relation to all of the natural sounds of the immediate environment. Over a number of years one could return to the same sites only to find, when the recordings were analyzed, that each site revealed significant bioacoustic continuity - much like one would expect to find from fingerprint matching. The unique groupings from each of these locations all tended to remain the same (given time of year, day, and weather patterns) no matter where one worked, as long as the habitat remained relatively undisturbed or unaltered.

Noise issues. At the beginning of the 21st Century, it often takes some time and patience to locate quiet places in which to listen and record. The long wait is due primarily to the introduction of human-induced mechanical noise(s) like chainsaws (heard from twenty miles away), aircraft, ATVs, ORVs, jet skis, snowmobiles, etc., coupled with a serious depletion of undisturbed habitat. Mechanical noise is endemic and nearly universal. It has become so virulent that noise is now included as a component of niche studies to see how it affects creature voices, behavior, and visitor experience to wild places. The national parks, in particular, still occasionally provide uniquely quiet habitats that field recordist, Gordon Hempton, describes as having noise free intervals (NFI), fifteen minutes of natural sounds unimpeded by mechanical noise and where recordings of even longer duration are possible.

Ethics and responsibility. During the past four centuries modern humans have moved some distance away from two important methods of connecting to our natural world. One has been the apparent need to abstract creatures out of context in an attempt to study and understand them. The other has to do with the manner in which we have forsaken our reliance on hearing as a necessary window of knowledge. This unwitting deafness has impaired our ability to make ethical and responsible decisions with regard to the preservation of precious habitats and, in particular, the natural soundscape that so eloquently defines them and reveals their respective stories.

Because we have become so visual as a culture, we have learned to hear mostly what we can see. Waves at the ocean shore are a good example. Stand at the waterline and look at distant breakers several hundred yards offshore and you will hear the pounding thunder they produce. Look at the waves at middle distance and you will hear the splash of curls as the waves break and fold. And, finally, when you look at your feet, you'll hear the bubbles on the sand as the leading edge of the water fizzles and crackles as it advances and recedes. Of course, all these events are happening at the same time. But we have learned to use our eyes to isolate one component of the experience from all the others. As our eyes catch the orange breast of a robin in a tree, we hear it singing - conspicuous among the many other species that also may happen to be singing at the same time. It, alone, catches our eye/ear. Because we now use our eyes as hearing aids, we have actually become a little deaf, having been desensitized to other possibilities. Hard of hearing in that special way, we cannot expect to gain the relevant knowledge needed to help us make completely informed decisions about the well-being of biomes we care about. However, by discovering how other creatures in the natural world use their ears to see, we can come to realize wonder through the process. After all, when creatures need to be heard, they must learn to use their voices in a way that will blend with other animals or the natural sounds around them - just like the performances of human music. When all these creatures sing together, they form a chorus of sounds so special that even the finest composers haven't been able to write music nearly as breathtaking. Our responsibility is to find new ways to listen.

Educating visitors about natural soundscape. Generally this involves two stages. One is learning to listen in discriminating ways to the textures of sound with our ears, alone. The second involves the use of simple tools. In much the same manner as we would employ binoculars or microscopes to enhance our vision, we amplify sound to expand detail and heighten the sense of our aural perspective.

III. The Importance of Natural Soundscapes to Visitors

In general and historically, a large percentage of visitors have experienced only limited aspects of the national parks. The greatest share of visitors encounter the parks from the interior of their vehicles, leaving them for the relatively short periods of time it takes for picnics at a turnout, short walks on well-maintained trails not terribly far from parking lots or visitor center locations where there are interpretive displays, shops, restaurants, and well-advertised dramatic geological features. While some few prefer to hike into the backcountry and wilderness to get away from greater human density, these do not typify the largest block of park visitors.

Programs through the NPS visitor centers offer sojourners a large number of options to further enhance their experience of the particular park being explored. From Junior Wilderness Ranger programs, informative nature walks and videos, to those promoting wilderness etiquette and low impact contact, these programs have served the visitor base quite well. Most, however, have been traditionally focused on visual aspects of the park experience. But, as noted, this trend has begun to shift as a result of increasing noise and the desire to hear natural sounds of the national parks unimpeded.

Since the early 1990s, visitors began to exhibit a trend in response to park experiences that called particular attention to human mechanical noise issues). "Many surveys show that quiet, solitude, and natural sounds play important roles in recreation experiences. Recreation area users consistently state that escaping noise and enjoying the sounds of nature are among the most important reasons they visit natural areas. Other, more recent studies, confirm this inclination. That is why it is so important that the National Park Service realize new programs aimed at visitor engagement with the wonderful and powerful natural soundscapes offered in the wildlands of the National Park System.

Natural soundscapes matter to visitor experience. Soundscapes are a major component of the national park adventure. Natural soundscapes can rarely be found elsewhere.

Soundscapes within the non-human world define territories of whole groups of creatures, provide information about the well-being of habitats, and to the extent of our human ability to understand them, they furnish us with a fairly accurate measure of our connection to the natural world and wilderness, in particular. We are just beginning to understand that long-range communication is made possible by elephants, right whales, and even the ruffed grouse because of the low frequency signals they transmit through the various media (air and water) they inhabit. Higher frequency signals, like those of bats and dolphins cover shorter distances. In fact, the highest voice in the animal kingdom is the blind Ganges dolphin (Plantanista gangetica) at over 350kHz - five octaves beyond the highest note a human being can hear. To be effective, all of these voices have to "fit" somehow within the conditions of their respective environments which are often determined by a combination of creature and non-creature mixes of sound. It is this natural soundscape that helps determine the ways in which creature voices develop over time. Visitors want to increase the joy of their experience within the parks. This occurs when they gain an intuitive understanding of wilderness through their encounters with natural sounds.

Healthy ecosystems

Ecosystems demonstrate their level of fitness partly by the ways in which all of these creature and non-creature sounds fit in relationship to one another. If a creature voice is masked by another and cannot be heard, and if that voice is necessary to its survival, then it will have to find a place for itself within the aural fabric of the habitat that does not obviate a chance for clear communication. Otherwise it probably will not survive. When examining a spectrogram as seen in Figs. 1 and 2 in Chapter 1, a healthy environment will show evidence of significant discrimination between voices. A healthier habitat will feature a spectrogram highlighting more discrimination and detail. The soundscapes of stressed or destroyed habitats will result in spectrograms either mostly black (loaded with sounds trying to find a place for themselves and indistinguishable from one another) or white (places with little or no creatures, at all).

Cultural and Social Implications to Humans.

As a visual culture, sound has tended to play a secondary role in the ways we inform ourselves about the natural world. This general tendency has deep cultural roots beginning nearly 10,000 years ago when we became an agriculture-based civilization. As forests were cleared for the planting of crops, firewood, and materials to build villages and cities, habitats where natural soundscape could be heard grew more distant from centers of population. This was the first level of detachment. Later, the level of noise from domestic animals, wheels over cobblestone with grinding axles, then the Industrial Revolution and all of its offspring interceded, masking most of what was left.

In the 33 years this author has been in the field, old growth forests in the United States have been reduced from 45% of their original stands, to 2%. That, coupled with the noise issues noted in The Nature of Sound educational material, means that only certain of the national parks and other protected wildland areas are left as major residual locations where visitors can to rediscover the subtle but powerful impact these sounds have on the human experience of the wild.

It is notable that natural soundscape is the primary source of our dance and music. As the late Paul Shepard remarked:

> "Why and how did we first dance, sing, and make instrumental music? What was the idea behind it? Perhaps we did not invent music at all but appropriated it as an expression of our own felt rhythms. Like much else in the human repertoire, music may have been already there when we arrived and its performance was everywhere audible and visible. The classical Greeks told of Orpheus, who created music and taught it to the astonished beasts. But the Orphic myth had it backward. It was the animals who first made music and Orpheus' ancestors who listened. Hearing and mimicking the natural world gave us our ear. When humans uttered their first words, birds, frogs, and insects were already whistling, dancing, drumming, trilling."

Subsequent research with the Bayaka and Kaluli (Sarno, Feld, et al) demonstrate clearly that humans closely linked to the wild natural make no distinctions between themselves and their other-creature worlds. In their languages no word exists that is the equivalent of our word for “nature.” No ego exists that determines or rationalizes a hierarchical place when compared to other living organisms. The Kaluli, Bayaka, and Pitjanjarn are living examples of groups whose integration with the natural world is total as the language of their music demonstrates. In our remarkable wild lands we have the chance, through programs implemented in national parks, to offer others the wellspring of inspiration – what Paul Shepard refers to as “the mark of a healthy culture” once again

IV. Interpretive Themes and Natural Soundscapes

The natural sounds and soundscapes of wild America are a rare and diminishing resource, and a resource that is accessible to fewer and fewer members of an increasingly urban society. Indeed, the strong visual orientation of contemporary society means that it is an enormous task to alert and educate the American public to what is being lost. National Park Service management philosophy includes education as an important aspect of managing all its resources. In addition, educating park visitors on this diminishing resource is consistent with the National Park Service Mission to '...conserve the scenery and the natural and historic objects and the wild life therein and to provide for the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

It is clear that programs are needed that will broaden awareness, understanding, and appreciation for the natural soundscapes of national parks and protected wildlands. While it is an individual national park responsibility to develop and implement such programs, this guide has been prepared to facilitate the work of park educators and interpreters in this regard.

The National Park Service is increasingly using an interpretive planning process from The Effective Planning of Park-wide Interpretive Programs developed by the National Park Service Intermountain Support Office. Through this process, individual national parks are preparing comprehensive interpretive plans; it is vital that the interpretation of natural soundscapes be addressed in these plans, especially at the major natural parks.

This planning process first generates *Significance Statements* that clearly define important aspects of the park or subject to be interpreted. These express the fundamental rationales that provide connection between the park or program's enabling legislation and the interpretive programs developed in the park. Where does the natural soundscape fit in the context of a specific national park? It may be a fundamental resource or may have an important support role. But the question needs to be asked! The following are some examples of possible Significance Statements related to natural soundscapes:

- Places where vital soundscapes exist unimpeded provide significant scientific laboratories where collateral research can be conducted supportive of other investigative disciplines.
- Learning to listen to natural soundscapes unimpeded by human mechanical noise provides important information with regard to conservation, preservation, ecosystem management, and resource stewardship along with other disciplines.
- Wilderness soundscape experience provides necessary links with our ancient roots helping us appreciate the inspiration for aural aspects of our culture and those preceding.
- Natural soundscape, as nature's voice, connects with humans on a

physical and spiritual level leading to a sense of well-being and a profound reduction of stress. It provides places of tranquility, peacefulness, and a timeless haven for contemplation, reflection, and solitude.

- ♦ Pure natural soundscapes speak to hope, imagination, renewal, and inspiration and enhance the visual and tactile sense of national parks and wilderness.

- ♦ The risks and common fears inherent in wilderness experiences are abated somewhat as humans learn to read the subtle changes in the expression of biophony.

- ♦ Undisturbed natural sound is the pure expression of wildness through the voices of organisms and natural features of any given habitat. The vitality and discrimination between the various voices can provide a sense of wildness expressed by no other element.

Significance Statements like the above can be used to generate primary ***Interpretive Themes*** for the specific park of programs being planned. Within this context it will be essential for the interpreter or educator to address natural sounds. This can be integrated into these educational plans either as a stand-alone theme or as a supporting component of identified themes. As already noted, modern society is visually oriented, and existing interpretive plans are likely to reflect that. Interpreters are encouraged to look at their plans with "fresh eyes" to explore how to use natural sounds in their programs. Parks with significant natural soundscape resources should consider addressing natural soundscapes as one of the resources they need to explain to visitors. At these and other parks, consideration needs to be given to using natural sounds to help visitors experience their interpretive themes in a different and more exciting way. Ignoring natural sounds as an aspect of learning, teaching, and guiding within the natural world is a bit like turning off the soundtrack to the movie Star Wars and trying to understand the plot.

Although the ***Interpretive Themes*** can only be built by park educators and interpreters, this guide can provide suggestions on programs, media, and services that are useful to every audience's enhanced understanding of the natural world where the soundscape is a seminal component-the unique voice of a specific national park.

V. Programs and Activity Sites

The following series of programs, from simple to complex, will help guide visitors on the path to discovery of good listening and field recording.

To explore the awesome wonder of natural soundscapes National Park Service staff will need to help visitors readjust their perspectives away from the frenetic mechanized everyday world and simply let natural soundscape engulf them. Programs 1 – 5 offer visitor activities that can be done by experiencing wild soundscapes with unaided listening. Programs 6 and 7, because they involve hearing creatures either too small, with voices too soft, or because they inhabit marine environments, requires simple technology. It is comparable to the use of binoculars or microscopes to enhance vision.

Many programs can be developed that can help visitors engage with the creature world in new ways. As part of The Nature of Sound material, Miriam Graham from Canyonlands put together a useful program outline a few years ago for experiencing natural soundscapes. The following is some of what she offered:

Program Name: The Nature of Sound

Theme:

Units of the national park system are special places that preserve natural sound environments that are important qualities of natural ecosystems. National Park Service sites also provide people the opportunity to experience tranquility, natural quiet, solitude, and contemplation. These diminishing resources contribute tot he health of the environment and are important for our well-being and that of our children.

Public appreciation of these assets must be nurtured to reduce degradation of natural soundscapes in national parks and restore opportunities to hear and enjoy the sound of our nation's natural and cultural heritage.

Goals:

This program will help visitors focus on natural soundscapes that exist in national parks.

Visitors will appreciate natural soundscapes as important to natural ecosystems in national parks and as significant aspects of a quality visitor experience which has both physical and emotional benefits.

Objectives:

A. Visitors will be able to state, in their own words, the importance of natural sound environments to themselves as visitors.

B. Visitors will be able to state two ways in which natural soundscapes are important to their park experience and their own well-being.

C. Visitors will be able to list at least one way that natural sounds are important to natural ecosystems.

Logistics:

As Required

Materials:
As Required.

An audiocassette of natural and cultural sounds should be available, but only if conditions prevent the interpreter from introducing visitors to natural soundscapes in wild places. 35mm color slides included in the National park Service Sound Education Plan Materials may be used in interpretive slide presentations.

Reference Materials:
A. Nature of Sound Interpretation Support Package.
B. Sound Education Plan PowerPoint Presentation (See List of Re sources)
C. Nature of Sound audiocassette or CD from National Park Service Sound Education Plan Materials.

Program History:
This program was initiated in 1998 in support of the National Park Service Sound Education Plan.

(Note: The sample program Miriam Graham developed is included in Appendix B.)

How can the soundscape program readjust visitor perspectives? The following activity and site plans provide an insight into that question.

Activity Sites are locations within the park where interpretive programs may occur. In the table that follows, seven types of programs for park visitors of all ages are identified along with suggestions as to where they might be implemented. Each of these could have a website equivalent. In the remainder of this chapter, these seven programs are explored in greater detail.

Program 1. Locating Quiet Natural Soundscapes

A. Questions to ask:
Prepare a list of questions to engage visitors in the process of this discovery. Sample questions might be:

1. What do we mean by a quiet spot?
2. What do we mean by "noise?"
3. What types of natural sounds within a given habitat make us feel good?
4. What types of natural sounds help us feel relaxed?
5. What types of sounds interfere with our experience of the wild natural?
6. What kinds of sounds are acceptable within this park?
7. How can we take what we've experienced soundscape-wise in the park to our cities, rural areas, or other places in which we live or vacation?
8. Add you own questions…

B. Activities:
1. Help visitors find quiet spots - meaning places where there are no mechanical or other human noise of any kind but where there are only creature or what we call geophonic natural sounds (natural sounds created by non-living phenomena). A stream. A meadow. A favorite forest. A mountain. A beach. A muskeg (Ojibway word for bog).
2. Encourage them to give the experience enough time to discover that there is a special aural fabric unique to that particular location. Unlike any other, the sounds visitors might hear at dawn, midday, afternoon,

dusk, and nighttime, will define the space more clearly and with more detail than an Ansel Adams photograph.

3. To reach these spheres of sound, visitors may need to be encouraged to walk some distance away from roads, lakes, well worn trails, or aircraft flight patterns where human noises tend to be greatest, but the rewards are sublime.
4. Encourage visitors to put away their watches, cell phones, pagers and other technologies and let natural time define itself by waves of creature music.

C. *Equipment needed:*

1. Visitor Center for an introduction to natural soundscapes through staff orientation and available exhibitry.
2. Outreach programs in local and regional school programs introducing school youth and adults to the power of natural soundscapes.
3. Interpretive talks specially prepared by park staff for programs that take place in the field.

D. *Activity site(s):*

1. Visitor Center for an introduction to natural soundscapes through staff orientation and available exhibitry.
2. Outreach programs in local and regional school programs introducing school youth and adults to the power of natural soundscapes.
3. Interpretive talks specially prepared by park staff for programs that take place in the field.

A summary of program 1 is shown on the following table

PROGRAM 1 LOCATING QUIET NATURAL SOUNDSCAPES

SUBJECT	*ACTIVITIES*	*EQUIPMENT*	*RESULT*	*ACTIVITY SITES*
1. What is a quiet environment?	Find locations with no human noise (noise: unwanted sound).	Ears. Pencil. Notebook. Binoculars. Chair. good pair of walking shoes.	Acceptable sounds defined. Unwanted noise considered and identified.	1, 2, 3, & 4
2. What sounds are acceptable in this national park?	Find locations where one hears only creature or natural sounds (streams, weather, etc.) without any human noise (mechanical, electronic, talking, rustling of clothing, etc.)		Lists of only those sounds that are acceptable to promote the value of listening carefully.	
3. How can this experience help enhance the quality of habitats within the parks? Cities? Rural areas? Other vacation spots?	Note the difference between the ways noise-free natural sound makes one feel and environments with lots of unwanted noise.		Experience the calming and reassuring effect of noise-free natural sound.	

Table 1 Description of Program 1, Locating Quiet Soundscapes

Program 2. Identifying and comparing "natural sound" and "noise"

A. Questions to ask:

1. How many different types or families (birds, insects, amphibians, mammals, etc.) can be heard?
2. Within each family, how many different species can be identified?
3. Can the distinction between one habitat and another by natural soundscape, alone, be made?
4. What defines the limits of boundaries of a particular biophony?
5. What types of sound interfere with the experience?
6. What types of noise cause vocal or behavioral changes in either a single species or the whole biophony?

B. Activities

1. Have visitors listen (preferably with eyes closed) to the ways in which the combination of creature voices (birds, insects, mammals, amphibians, etc.)define the space - a biophony, or animal symphony of sounds that appears to be different as day and night, seasons and weather shift through their cycles. Each type of habitat - even within the same park - will provide a unique sound signature, just like our individual voices. The natural world is alive with vibration. Even one's concept of time will change as it is defined by sound.
2. Demonstrate how, in certain types of forest, some creatures prefer to vocalize at night when dew is on the ground, leaves, and branches of trees. Using the forest as a reverberant theater, this becomes their time to "sing." Certain nighttime birds, coyotes and wolves sing with reverberant habitats changing their voices slightly to accommodate. Elk rutting in the fall sometimes use the echoes of the forest to project their voices further. Even killer and humpback whales vocalize in air bouncing their voices off nearby cliffs near the shores of Glacier Bay and other similar environs. Other creatures like to vocalize when the habitat tends to be drier - after sunrise when the forest has given up its surface moisture and animal voices don't need to carry so far, while yet others prefer transition periods neither dry or with echo. Some visitors will prefer to list and identify the sounds of single animals rather than biophonies. By all means, invite them do either or both at the same time. No matter which format they prefer (individuals or whole habitats), the times of greatest density are generally the dawn chorus - just before, during, and after sunrise - or the evening chorus in spring and early summer. Very quickly, visitors will find that creatures can be heard at all times of day, under a wide variety of weather conditions, and in all seasons, and most habitats. Some sounds may be very subtle. That is why learning to listen is the key.

C. Equipment needed.

1. Ears
2. Pencil or pen
3. Notebook

D. Activity site(s)

1. Visitor Center for an introduction and orientation to various quiet natural soundscape sites conveyed by staff, multi-media, and available exhibitry.

2. Outreach programs in local and regional school programs introducing school youth and adults to the potential experiences of natural soundscapes with your park. Demonstrations of how human noise affects both the human and non-human experience of the wild.

3. Interpretive talks specially prepared by park staff for programs that take place on site in the field.

A summary of program 2 is found in the following table.

PROGRAM 2	**IDENTIFYING AND COMPARING NATURAL SOUND vs. NOISE**			
SUBJECT	*ACTIVITIES*	*EQUIPMENT*	*RESULT*	*ACTIVITY SITES*
1. What are the components of natural sound?	Identify creature sounds that contribute to the natural soundscape (biophony). Identify the non-creature sounds that contribute to the natural soundscape (geophony).	Ears. Pencil. Notebook.	Familiarization with the ways natural soundscpes work as indicators (voices providing information) of a habitat.	1, 2, 3, & 4
2. What are the components of noise?	Identify all human mechanical and non-mechanical noises that intrude on the experience of listening to pure natural soundscapes.		Determines how noise affects human and non-human experience of the wild.	

Table 2 Description of Program 2, Identifying and Comparing Natural Sound vs. Noise

Program 3. Identifying Sources of Natural Soundscapes

A. Questions to ask:

1. How is biophony expressed in the natural world?
2. How is geophony expressed in the natural world?

B. Activities

1. Have visitors listen (preferably with eyes closed) to the ways in which the combinations of creature voices (birds, insects, mammals, amphibians, etc.) create a soundscape and comprise a biophony. Each type of habitat – even within the same park – will provide a unique sound signature, much like our individual voices.
2. Have visitors listen critically to zones with few creature voices but where there is a stream, a waterfall, the effect of wind in the trees, the effect of snow and other weather conditions on sound. These geophonies are distinctive. Characterize the subtle differences expressed by a stream as one follows its course, or moves nearer or further in proximity.
3. Demonstrate how, in certain biomes, some creatures prefer to vocalize at night when dew is on the ground, leaves and branches of trees. Using the forest as a reverberant theater, this becomes their time to "sing." Certain nighttime birds, coyotes, and other mammals choose reverberant habitats, altering their voices slightly to accommodate. Elk rutting in the fall sometimes use the echoes of the forest to project their voices over longer distances. Even killer and humpback whales vocalize in air bounding their voices off nearby cliffs near the shores of Glacier Bay and other similar environs. Other creatures like to vocalize when the habitat tends to be drier – after sunrise when the forest has given up its surface moisture and animal voices don't need to carry so far; while yet others prefer transitional periods neither dry or echoy.
4. Explore the ways in which creature voices are affected by the sounds created by geophonic sources.
5. Some visitors will be drawn more to the sounds of individual creatures. Encourage them to listen to the ways in which these voices "fit" within the context of other creature sounds in a given habitat.

C. Equipment needed.

1. Ears
2. Pencil or pen
3. Notebook
4. Binoculars

D. Activity Site(s)

1. Visitor Center for an introduction and orientation to various natural soundscape sites throughout the park. This information will be conveyed by staff, multi-media, and available exhibitry.
2. Outreach programs in local and regional school programs introducing school youth and adults to natural soundscape sites within your park. Demonstrations of how biophony and geophony provides vital information necessary for protection of habitats.
3. On site interpretive talks and activities specially prepared by park staff for visitors in the field.

A summary of program 3 is found in the following table.

PROGRAM 3	IDENTIFYING SOURCES OF NATURAL SOUNDSCAPES			
SUBJECT	*ACTIVITIES*	*EQUIPMENT*	*RESULT*	*ACTIVITY SITES*
1. How is biophony expressed in the natural world?	List mammals, birds, insects, amphibians and any other creatures heard in the natural soundscape.	Ears. Pencil. Notebook. Binoculars.	Notice the distinct definition of sounds in undisturbed habitats (especially when compared with those impacted by noise).	2, 3, & 4
2. How is geophony expressed in the natural world?	List effects of wind in the grasses, canopy of trees, over water. List effect of thunder or other weather conditions. List expression of different types of streams (rushing, trickling, water falling, etc.)		Notice the ways in which creature residence is affected as proximity to streams gets closer, for instance.	

Table 3 Description of Program 3, Identifying Sources of Natural Soundscapes

Program 4. Defining Habitat Territory by Natural Soundscapes

A. Questions to ask

1. What can creature and non-creature voices tell us about the ways in which natural territories are defined?

B. Activities

1. Have visitors explore the boundaries of a given habitat as it is expressed by geophony, biophony, or a combination of both natural sound sources.
2. Have visitors walk and map the limits of any given zone where the sound remains relatively unchanged.
3. Have visitors note how many different zones are defined by a distinctive soundscape within a relatively small area of land.
4. Ask visitors to listen and describe how the soundscape expands and contracts depending on weather, season, time of day or night.

C. Equipment needed.

1. Ears
2. Pencil or pen
3. Notebook
4. Good pair of walking shoes

D. Activity Site(s)

1. Visitor Center interactive exhibits with GIS maps and related sound will demonstrate the concept of

aural territories and their weather- or time-related mutability. These exhibits will also provide good bio-phonic sites for visitors to explore.

1. How is time expressed through bio-phonies?
2. How are seasons expressed through biophonies?

2. On site interpretive demonstrations by park staff will help inform visitors what to look for and how to define territories.

A summary of program 4 is found in the following table.

PROGRAM 4	DEFINING HABITAT TERRITORY BY NATURAL SOUNDSCAPES			
SUBJECT	*ACTIVITIES*	*EQUIPMENT*	*RESULT*	*ACTIVITY SITES*
1. What can creature and non-creature voices tell us about the ways in which natural territories are defined?	Locate a habitat rich with creature sound. Walk and listen to the outside limits of the biome where biophony remains unchanged. Draw a map representing the boundaries as defined by sound.	Ears. Pencil. Notebook. A good pair of walking shoes.	Note how a soundscape map differs from a topo or other territorial representation.	2, & 4

Table 4 Description of Program 4, Defining Habitat Territory By Natural Soundscapes

Program 5 Defining Temporal Aspects of Natural Soundscapes

A. Question to ask

1. How is time expressed through biophonies?
2. How are seasons expressed through biophonies?3. What creature voices are present in the pre-dawn and dawn chorus at one location?
4. What creatures voices are present during midday, afternoon, dusk, and evening choruses at one location?
5. What causes changes in the biophony?
6. How do the acoustic properties of a site (reverberation, no reverb, etc.) affect experience of the sound?

B. Activities

1. From a single location encourage visitors to enjoy the vitality of a spring or early summer dawn chorus, arriving on site half an hour before sunrise and remaining still until about half an hour after.
2. Have visitors compare that experience with what the soundscape is like in the late morning, mid-afternoon, at dusk, then in the evening.

C. Equipment needed:

1. Ears
2. Pencil or pen
3. Notebook
4. Good pair of walking shoes

D. Activity Site(s)

1. Visitor Center orientation by park service staff using exhibits that feature GIS maps and audio to convey concept to visitors and preparing them for the scope of the program.
2. On site field briefing to familiarize visitors with the tasks necessary for a successful foray into the selected biome.

A summary of program 5 is found in the following table.

PROGRAM 5	DEFINING TEMPORAL ASPECTS OF NATURAL SOUNDSCAPES			
SUBJECT	ACTIVITIES	EQUIPMENT	RESULT	ACTIVITY SITES
1. How is time expressed through natural soundscapes?	Find a single location. Over the course of a day, note dawn chorus beginning 1/2 hr before sunrise to 1/2 hr after. Note evening chorus beginning 1/2 hr before sunset to 1 hr after.	Ears. Pencil. Notebook. Chair. A good pair of walking shoes.	An understanding of a biome's acoustic dynamics over time as this is an expression of the habitat.	1 & 4
2. How are seasons expressed in the natural soundscapes of different habitats?	Compare soundscape temporal expressions in different biomes over the course of several seasons.		An understanding of a biome's acoustic dynamics over time as this is an expression of the habitat.	

Table 5 Description of Program 5, Defining Temporal Aspects of Natural Soundscapes

Program 6. Experiencing Unusual Components of Natural Soundscapes

A. Questions to ask

1. How can we listen to ants, termites, and other small ground-dwelling creatures?
2. How can we listen to insect larvae and small creatures in pools of fresh and salt water?
3. How can we hear fish and crustaceans in their respective habitats?
4. What can some of these sounds tell us?

B. Activities

(Note: requires amplification or recording gear...see Appendix A)

1. Find a carpenter ant (or other species) nest and lay a small lavaliere microphone over the entrance to the mound. Turn on the recorder or amplifier and listen.
2. Compare sounds of different species of ants. Compare ant stridulation with sound made by termites or other ground-dwelling arthropods.
3. In fresh water pools during spring and summer, drop a hydrophone (underwater microphone) into a nearby pool. Hear waterboatmen and insect larvae.
4. In saltwater tide pools, listen to barnacles twisting in their shells, gently drop a hydrophone into the belly of an anemone to hear it try to digest the element, and hear small rock fish and larvae present in the habitat.
5. In littoral off-shore ocean environments, listen to reef fish, cetaceans and other present marine mammals with a hydrophone.

C. Equipment needed

1. Magnifying glass
2. Lavaliere or stereo microphone
3. Hydrophone
4. DAT or minidisc recorder

D. Activity site(s)

(where the ground was warmer). You can also set up an inexpensive exhibit which conveys the idea. It would contain a cricket in a glass jar with open top, a (hidden but accessible) temperature gauge, and a chart with the formula printed on it. The question: “Using the sounds of the cricket chirps and the following formula, what is the temperature here?”

A summary of program 6 is found in the table on the next page.

Don’t let the visitor get stuck on the megafauna. The very small creatures, nearly microscopic, sing (meaning they have an audible signature) too, and they have wonderful voices. Several species of ants sing. Insect larvae in pools of water sing. Water boatmen, anemones, and fish sing. Even earthworms create a signature as they navigate through the soil. Some, as with many species of bats, insects and dolphins, require specialized (but not-too-expensive) equipment to hear their amazing voices. (See Appendix B)

Listening can be done as a group effort, but only if everyone is dedicated to being very quiet. Leave the CD players home or in the car. No talking. No rustling of Gortex clothing. No shuffling of feet, coughing, clearing of throats, or sniffling. Visitors don’t have to hold their collective breaths. Just be cool and considerate. Suggest that they leave all other thoughts behind and concentrate on the experience of hearing.

PROGRAM 6	EXPERIENCING UNUSUAL COMPONENTS OF NATURAL SOUNDSCAPES			
SUBJECT	*ACTIVITIES*	*EQUIPMENT*	*RESULT*	*ACTIVITY SITES*
1. How can we listen to ants, termites, and other small ground-dwelling creatures?	Lay a small lavaliere microphone over the hole of a carpenter (or most other types of) ant mound. Turn on recorder or amplifier and listen. Compare sounds of different species of ants. Compare ant stridulation with sounds made by termites, gophers, etc..	Magnifying glass. Lavaliere microphone. DAT or Minidisk recorder or amplifier. Headphones.	New worlds of soundscapes reveal themselves.	1 & 4
2. How can we listen to insect larvae and small creatures in pools of water?	In fresh water pools during spring and summer, drop a hydrophone (underwater microphone) into the pool. Switch on recorder or amplifier. Hear larvae and waterboatmen. In saltwater tidepools, listen to barnacles twisting in their shells, anemones, small rock-fish, larvae.	Add hydrophone to recorder or amplifier.		
3. Fish and cetaceans?	Listen with hydrophone.			

Table 6 Description of Program 6, Experiencing Unusual Components of Natural Soundscapes

Many species of fish around coral reefs of the world generate some kind of aural signature and create (together) unique biophonies that exist only in marine environments. Anemones, small rock fish, and barnacles create their own biophonies in tide pools at the ocean's shore.

Many varieties of ants and insect larvae "sing." Earthworms, as they move through the soil, create a sound signature unique to their species. And recently, Matthew Cooper and colleagues at Cambridge University isolated the sound signature of viruses.

Certain vegetation creates sound signatures as it grows or as cells respond to changes in osmotic pressure.

In many desert locations throughout the American Southwest and around the world, sand dunes sing.

Make up new words. "Biophony" came into being when this author was looking for a word to describe the combined and related sound creatures make in a particular location. Animal symphony was too cumbersome. That was July of 1998. We need lots more where that came from. You might make a game out of it and offer a special prize for the best word describing natural sound contributed each day or week or month.

Before introducing simple audio recording equipment, put together all the different programs into one extended agenda. Most of the parks that feature natural settings contain many marine and terrestrial options…none more than Glacier Bay…which is why we are introducing this as an all-inclusive hypothetical example:

While introducing visitors to the listening and recording of natural soundscapes in the vicinity of Glacier Bay in Alaska, for instance, have them create a list of habitats, natural occurrences, and creatures actually heard. There are many different varieties in Southeast Alaska, both marine and terrestrial. This example provides the visitor with a wide range of possibilities to explore. In and around Glacier Bay, the following list of biome types can be identified that exhibit distinctive biophonies:

Whole habitats (biophonies):
Muskegs
Coastal coniferous
Marshes
Lakes
Bays (inner tidal zones)
Riparian zones (fast and slow water)
Inland coniferous forest
Open marine environments (with whales, seals, birds and airborne voices)
Submarine environments (same as above only marine voices with birds replaced by fish, whales, crustaceans)
Tide pools
Shoreline

The following is a list of natural habitat sounds that are non-biological in nature that our group also identified:

Non-creature sounds:
Rain
Wind (Not recordable, per se. Only its effect across broken reeds, through trees, etc..)
Fast and slow streams
Different types of lake, ocean, and inland waterway wave action
Glacier masses moving over land
Glaciers crackling (as ice melts)
Glaciers calving

Finally, your visitors can put together a list of birds and mammals that they hear. In and around Glacier Bay it may include four species of whales, bear, wolves, two types of seals, sea and river otters, sea lions, anemones, barnacles, seventy-four species of birds plus snapping shrimp and fish. This exercise can serve as a dramatic indicator of the habitat's health. Note that because this example is a northern temperate/southern sub-arctic transitional zone, insect activity (except for mosquitoes) tends to be a bit lighter.

When comparing the biophonies of two or more different habitats, the mix of creatures will help identify and provide a sense of location. For instance, in one coastal coniferous zone recorded, the group might hear varied thrushes, Swainson's thrushes, robins, marbled murrelets, and bald eagles, red-tailed hawks, mourning doves, ospreys, yellow-rumped warblers, ubiquitous ravens and crows, and an occasional bee or mosquito. In any of several locations, visitors may also hear wolves. Non-creature sounds included the effect of wind blowing through the canopy of the forest.

Moving inland a short distance to a small lake fed by a stream with a tiny waterfall, visitors will notice the biophony immediately changes to include a mix of common loons, robins, American dippers, a great horned owl, a flock of herring gulls, hairy woodpeckers, and swallows. At this site, they see a river otter but it made no sound while they were present. Non-creature sounds at this location differed from the coastal coniferous by the nature of the gently flowing stream and the waterfall in the distance.

When we dropped a hydrophone into the water just off-shore, we were able to hear the sounds of humpbacks bubble-netting followed by their “contact” or feeding calls. We also heard snapping shrimp, and even some harbor seals. Lowering it into a tide pool, and then into the tentacles of an anemone, we allowed it to be sucked into its belly, which then tried to digest it. Finding nothing of nutritional value the anemone expelled the hydrophone with a hearty grunt, backed by the biophony of barnacles twisting in their shells, and tiny rock fish darting from rock to rock in the pool.

Inland fresh water ponds provide wondrous sound generated by larvae and creatures like the ever-present waterboatmen gnawing on segments of rotted wood.

As mentioned earlier, new studies of biophony and the Niche Hypothesis strongly suggest that we may now be able to redefine the territorial boundaries of habitats by their bioacoustic constituents. For instance, recently, it was observed that certain migrating song birds fly through grids (territories) of sound until they find those where their voices won’t be masked. Some types of frogs and toads express territorial voices at the tadpole stages and can be heard in shallow pools and ponds in the springtime.

The voices of wolves, elk, and coyotes define territory and among other signals, help determine who mates with whom, and which individuals are allowed to remain within the herd or pack.

A few years ago, just outside the boundaries of Glacier Bay at the Hubbard Glacier, we made the first recording of the entire glacial mass slowly moving over the ground creating the moraine beneath by burying a hydrophone deep in a crevasse and picking up the forceful vibrations of ice in motion.

Using this as a template, the staff (or interns) might draw up its own list of unique biomes, creature, and non-creature sounds that are accessible to visitors with little or no experience. Lots of folks like lists where they can check off things seen or heard. Encourage visitors, also, to travel with binoculars and regional bird and mammal guides so they can identify what they have heard (assuming what is heard can also be spotted).

After the visitors have familiarized themselves with one spot, have them move a few hundred feet away and listen to the different ways in which natural soundscape defines their new location. What is different? What is the same? Explore its acoustic boundaries to get a sense of its shape as defined by sound. The vegetation may look the same. So might the geological features. However, the biophony is different simply because the creature mix is defining the territory with even more articulation then is seen through our eyes, alone. This may be a factor of the territorial syntax of one or more bird species, groupings of insects, mammal mix or all of the above. Make a game out of this discovery or, if the group is large enough, divide it up into teams to identify territories by either biophony or geophony -- non-biological sound generated by wind, water, or other geological features such as sand.

Program 7. Tools for enhancing and recording natural sounds.

As binoculars aid in viewing the natural world, simple audio field technology aids the visitor's sense of hearing. Appendices I - III provide the necessary information related to a range of equipment for introductory to intermediate levels of assisted listening and recording, field techniques, and the use of collected data.

A. Questions to ask:

1. How can soundscapes and species-specific creature sounds be captured in terrestrial environments in order to be reproduced, studied, and saved?
2. How can soundscapes and species-specific creature sounds be captured in marine environments in order to be reproduced, studied, and saved?

B. Activities

1. With a small DAT, minidisc, or standard audio cassette recorder, a microphone, and a pair of headphones in hand, have visitors set up their systems at a site where there is a well-known biophony without the presence of human-induced noise and listen from this enhanced perspective. This can be done as a group of 4 or 5 people, or individually.
2. Have visitors record small (5 – 10 minute) samples of one or more sites with different aural textures.
3. Help visitors evaluate the quality of their recordings by playing them back either as a group or through individual park staff involvement.

Note: Assisted listening. As binoculars and microscopes aid our vision in numerous ways to see objects either far away or too small to be seen with the naked eye, so we must be willing to aid our ears in much the same way in order to bring habitats into clearer focus and to understand them better.

To listen to ants and termites, one needs a small microphone and some type of amplifier. To listen to the sounds of insect larvae, tadpoles, fish, or whales, one needs a hydrophone (underwater microphone) and amplifier.

Assisted listening can be done easily - even for the most obsessed technophobe. If one can turn on the radio in a car or home, this is as easy.

Among the simplest is a stereo amplifier/microphone combination and a pair of earphones. Total cost: $35.00 from Radio Shack (see Appendix A for more details). It's a device about the size of a pack of cigarettes that hangs around a person's neck resting at chest level. It has an on-off switch and level (volume) control and a place to plug in headphones. This simple gadget has been known to be a life-changer.

C. Equipment needed

1. Recorder or small amplifier
2. Microphone/hydrophone
3. Headphones

Assisted listening is recommended because it is the only way to hear many of the voices of the natural world. This is certainly true of those sounds coming from marine environments. It is also true of most of the creature world not megafauna in size. E. O. Wilson suggested that 90 percent of the worlds living tissue was made up of insects and much of that was comprised of his beloved ants. One needs a microphone to hear these wondrous voices.

D. Activity Site(s)

1. Equipment and site-specific orientation to be given by staff in the field.

A summary of program 7 is provided in the table below.

PROGRAM 7	TOOLS FOR ENHANCING AND RECORDING NATURAL SOUNDSCAPES			
SUBJECT	*ACTIVITIES*	*EQUIPMENT*	*RESULT*	*ACTIVITY SITES*
1. How can soundscapes and species-specific creature sounds be captured in terrestrial environments?	Small DAT or minidisk (MD) recorders recommended. Also, different types of mics depending on creature or biome to be recorded.	Sony PCM M1 DAT recorder. Several different types of minidisc recorders. Many different types of headphones (noted in text)	New worlds of soundscapes reveal themselves that most folks have never though of.	4
2. How can soundscapes and species-specific creature sounds be captured in marine environments?	Use hydrophone (underwater mic). Experiment with recording in both salt and fresh water environments. Record fish around coral reefs, crustaceans in brackishand salt water, large mammals in salt water.	Add hydrophone to recorder or amplifier.		

Table 7 Description of Program 7, Tools for Enhancing and Recording Natural Soundscapes

VI. Use of Natural Sounds in Visitor Center Programs

Interpretive.

Audio media takes many forms and can be the most powerful and most informative exhibit component at a national park visitor center. In public spaces, recorded sound was first introduced to exhibitry in the early 1950's, after the development of inexpensive monaural reel-to-reel analog tape recorders. Mostly these early designs featured a single sound source and speaker typically performing one of two types of programs: push-a-button-hear-a-sound, or repeated extended linear sound loops representing a snippet of a given habitat.

In 1989, Wild Sanctuary, Inc. was hired to do a study on the impact of sound in natural history installations. This informal study was conducted at the California Academy of Sciences in San Francisco. With feedback already in hand about the effect on personnel and visitors regarding sound loops ("...boring, not educational, not informative, not helpful to an understanding of the exhibit, etc....") the study concentrated instead on the more common push-a-button-hear-a-sound technologies.

The theme of the exhibit was California Wildlife. About 10 feet from the exit, a panel consisting of photographs of 5 common California birds was located at eye level on a wall. Below each panel was a push-button and a small speaker. When any button was pushed, the voice of the related bird was played for the visitor. We set up a table at the exhibit exit. It took visitors an average of 4 seconds to walk from the panel to our survey table. At the table we had a CD player containing each of the 5 sounds represented at the panel. As they left, only the visitors that were observed pushing all five buttons were asked if they could identify the sounds on the CD. Of 125 respondents over a 2 day period, only one person was able to correctly identify all 5 sounds (she happened to be an amateur ornithologist). Two were able to identify 2 each. Two were able to identify only one bird song. One hundred and twenty people – all ages and genders – were unable to correctly identify any bird song. When the respondents were asked why they pushed the buttons in the first place, 78 replied (in one way or another) that pushing the buttons gave them something to do. In other words, the exhibit itself did nothing to engage or enlighten them, however the button-pushing offered the promise of at least some kind of delivery in return, i.e., something would happen in an otherwise static exhibit.

The push-button and sound-loop formats, then almost 40 years old, are still widely used. This format gives the designers the feeling that they were at least trying to inform the visiting public and provides a technology that is affordable, even if it brings little or nothing to the value of the exhibit. Still, the largest percentage of dollars and time is the expertise being thrown at the three-dimensional seeable components of the exhibitry. Our proclivity as a culture is to focus on visual aspects of the natural experience. For designers and fabricators, sound has not been considered a primary component of their design for two reasons: they have not grasped the power of the aural medium and earlier paradigms still dominate.

While delivery and interpretive technologies have improved radically over the past decade, there are clear signs that visitors are more and more drawn to the drama created by well-delivered audio media. To test the impact of this thesis, try a modest presentation: With a $16.00 themed CD representing a soundscape from any type of habitat, four speakers, a surround amplifier, and a CD player, place a group of visitors in a room without other distractions, and play the material for them. Our experience has shown that this experiment will provide a more forceful portrayal of biodiversity with drama and depth not remotely possible with several million dollars of design and fabrication of resin molded trees, thousands of detailed and painted leaves, and the standard mural, or any other exhibit component. That is because well-produced and delivered soundscapes and other types of audio programs convey both energy and information at the same time. No other component of exhibitry is capable of this result.

The California Academy of Sciences study caused a reevaluation of exhibit design installations. Technology now exists that integrates all performance aspects of exhibitry -- lighting, sound, interactives, electro-mechanical, videos anything designed to engage visitors with comprehensive programs. These systems:

1. Control all media throughout an exhibit eliminating competition between other exhibits,
2. Identify (in real time) what is being heard in the context of a holistic performance,
3. Control levels as a factor of crowd density so that they are always comfortable,
4. Provide non-redundant performances of sounds of the natural world more or less as they would be experienced in the wild. This feature also engages visitors with a new adventure each time they return to an exhibit venue while preserving the sanity of the folks who have to work in proximity to exhibit areas and hear the same program repeated over and over again.

With the aid of GIS mapping and resolution, visitors could get a sense of soundscape in any part of the park. By logging onto a web site or a visitor center computer kiosk, visitors would be able to find a location and listen to samples of the soundscape it represents. Also, locations could be revealed on a computer screen map in sync with the soundscape performance. And finally, well-crafted audio programs furnish the biggest bang-for-the-buck of almost any exhibit component one can think of. When linked to web media, the impact is even more compelling.

Other forms of interpretive product resulting from the data can take the form of customized audio CDs, CD-ROMs, and streaming audio media delivered on web sites that provides on-going, in-depth information about a national park venue that visitors can take with them when they leave the area.

Technology is now available and within the scope of reasonable budgets to transmit live audio and video from park sites like the Lamar Valley in Yellowstone where wolf activity can be observed and heard as live action both at visitor centers and on the web.

Mixing programs for exhibit performance, presentation, CDs or mixed media.

(1) Formats.

There are many different philosophies about mixing what we call, in the vernacular, finished product. Audio product is defined as finished program mixes stored on hard drive, DAT, CD, CD-ROM, sound for video, sound for public spaces (interpretive exhibits), power point presentations, web sites, or interactive displays. Each medium has it's own format requirements. For personal use and performance, however, sound is usually relegated to either of two media: CDs or stored on hard drives for playback. Sometimes it is stored on DAT cassettes, and almost never these days, standard audio cassette since analog tape-based media have proven to be far more problematic and less stable for storage and frequent playback. Indications suggest that DVD will be a popular format in the near future since it can store more than 14 times the amount of data possible with a standard CD.

(2) Production.

With the raw material in hand, the recordist needs to determine how he/she wants to represent the existing data in an exhibit, on a web site, or on a CD. This is the production phase. Time, space and species-specific programs are usually the three options if one is re-creating a particular habitat. One can do one or the another, or combine aspects of any two or three in the same mix.

(a) Time - With natural soundscapes, time is represented by doing a mix that features, for example, a dawn to dusk representation. It can also feature a short period of elapsed time like a pre-dawn to dawn chorus or an evening chorus to dark. (In real time some dawn choruses take as little as 20 minutes while others can take more than an hour and a half depending on the biome.) A natural soundscape can also be seasonal, say from winter through spring, summer and fall in a given habitat. Soundscapes can even be portrayed annually.

(b) Space – Wild Sanctuary has created several exhibits where a drop of water is followed from its source in the mountains, along its course through several biomes all the way to the sea. Or have taken the listener on a journey, say, from the seashore on the beach, under the surface of the ocean, down into the pelagic depths, then back to the beach once again. For example, consider following the dawn choruses in spring from parks on the east coast, along the Gulf of Mexico to the west coast.

(c) Species-specific – Occasionally it is important to create a program that isolates the voice of one creature from another. When that option is appropriate, find the best and clearest sample available from any source to make the point.

(d) Combo sandwich - It is possible to combine any or all three options noted above, taking the listener on a journey through both time and space, and providing highlighted samples of individual species within the context of the ambient soundscape like, for instance a springtime example from the Teton Valley floor through summer in the mountains.

In a CD soundscape, the Lamar Valley of Yellowstone for instance, the recordist may have some great recordings made on a dawn spring morning with the wolves howling. The visitor has recorded these sounds over the course of several days (Time) traveling from east to west in the valley. By arranging the samples on a simple computer program from just before sunrise when the birds begin to sing to about a half hour after the sun comes up, the recordist can then take the best recordings from his or her movement across the valley (Space), incorporating those into the mix. From moments where individual species were recorded, these can then be edited and placed at given moments within the mix (Species-Specific), after which all the components (representing time, space, species-specific) can be mixed together in one final sound sculpture presentation (Combo sandwich).

Within exhibits, programs should be accompanied by signage or with interpretive information provided automatically by the new technology that identifies creatures as they are being heard in real time. One such delivery system is called the Intelligent Show System™ (ISS™) developed by Wild Sanctuary in the early 1990s. It provides the following performance options for comprehensive exhibits in visitor centers and museums:

1. A hard drive system that mixes sounds non-redundantly so they never repeat in one's lifetime.
2. It identifies featured creature sounds for the visitor as they are heard in the system.
3. It changes volume or audio levels based on cumulative visitor presence in a particular exhibit zone (when crowds are heavy, the level rises to a comfortable but audible level, and when they're light, the level reduces to an equally comfortable level).
4. The ISS™ engages visitors interactively, triggering events unexpectedly as they move through a space.
5. It controls lights, electromechanical, and other interactive components of exhibits so that none interfere with others.
6. The whole system can be controlled externally and diagnosed by modem from anywhere in the world.
7. The system requires no maintenance.
8. The system is turn-key.

Levels of expertise.

(1) Visitors can derive a great deal of joy from recording and minimally archiving soundscape material. Armed with a strong desire in being outside in the natural wild and the ability to hear, they can simply plug in two cables, and push a few buttons (Play, Record, Stop, and Rewind) and begin the adventure. These can provide very exciting moments and are worth all the effort. Just watch the smiles on the faces of those you play the sounds for folks when you return home from your journey into the field.

(2) To do serious field recording, analysis and production, however, takes time, experimentation, dedication, incredible patience, persistence, and a bit more understanding. At this level it is possible that one might sit for 30 hours in one spot without moving to capture the sound of a single creature. After all that, what the recordist is looking for may or may not happen. The more knowledge one has

about the habitats and creatures a person wishes to record, combined with a working knowledge of the equipment being used, the more likely one is to enjoy a measure of success in the field.

(3) And, of course, there's middle ground here, as well. However, remember that the natural world is full of surprises. Nature is very slow to reveal its secrets and even the most informed naturalist/recordist is moderate with his or her expectations.

Web site audio.

When creating web sites with audio, MP3 and MP4 are the most common download formats as of this writing. There are others, like RealAudio™, Shockwave™Audio, Liquid Audio™, QuickTime™ and more to consider, including MPEG and Java Audio. More detail on these can be found in a book by Ron Simpson called Cutting Edge Web Audio (Prentice Hall PTR, 1998). Another source for MP3 information can be found by downloading the MP3 Handbook at www.MP3handbook.com

(Note: Because these technologies are changing almost daily, this guide will not attempt to explain what is already concisely documented elsewhere.)

Suffice to say that the web is a marvelous medium on which to post audio information about a particular national park wilderness site. If done right, visitors will be drawn to the site with a delightful aural preview of what they can expect during an actual visit. And it can be linked to many others of a similar nature.

Also by this method, one can create audio postcards located at park concessions. These might take the shape of an envelope the size of a CD (5" square) with both graphic and an audio CD of a favorite site.

VII. Conclusion

What can be learned from soundscapes? Natural soundscape informs us about many aspects of a particular habitat. Natural sound calms us, provides us with a profound sense of place and a connection with the wild natural. It is at once relaxing and engaging, stimulating and contemplative. To be heard and enjoyed, natural soundscapes require some distance from the clamor of human machinery. Once we become receptive to the messages these natural interactions convey, soundscapes become invaluable to us. Partially conscious by artifact or intuition, we plan our vacations to the seashore, the mountains, and/or the desert actively seeking peace and quiet. We learn that we must be particularly quiet lest the urban noise we are escaping from is shadowing not far behind to destroy the solace and joy we seek from an experience in the wild.

We learn that it is emblematic that there is usually a TV in every hotel room and a radio or CD player in every car. So we have to face the contradictions. With everything else shut down, the only noise we are likely to hear in our well-sealed rooms is that of the air conditioner. The natural world is literally on the other side of the double pane window, one that is sealed tight, shutting out the natural world. Many visitors jump into a helicopter or light plane to see the view because we're unwilling to walk the turf to really get to know it. By engaging in these activities, we become more removed and detached from the otherwise free and nurturing powers the wild natural provides. We forget that peace and quiet within demands peace and quiet without.

The desire to know natural soundscape changes the rules and expectations. To accomplish this, quiet places must be preserved whether it's one square inch of quiet as recordist, Gordon Hempton, suggests, or ten square miles. Most important, for both creatures and the visitor experience, quiet listening zones need to be identified, established, and protected within national parks. This is the most important lesson about soundscapes.

By recognizing natural soundscapes as a resource, the opportunity to protect the whispers of the remaining untouched forests, grasslands, meadows, and coral reefs remains in the hands of park staff and visitors, alike. As visitors demand more vigorous enforcement of quietude and the opportunity to hear the voices of the natural world they have journeyed so far to experience, quiet zones within the park boundaries need to be established and educational programs expanded to support and channel the growing demand. The rustling of every leaf and murmur of every creature implores us to love the natural sources of our lives, which, indeed, may hold secrets of love for all things, especially our own humanity. This divine music is otherwise fast growing dim. This is our opportunity to connect with this marvelous resource, to understand it, and protect it for future generations.

Appendix A - Equipment

Background

The recording of natural sounds began two days after the first public display of Edison's wax cylinder recorder in the late 1870s. Myth has it that Edison accidentally captured the sound of an American robin near enough to the "sound horn" so that the song left an impression on the wax surface of the rotating spindle. At that moment, the field of bioacoustics was born. However, it would take another ninety years until this discipline became a full-blown recognized academic topic.

Soon after the wax cylinder became popular, Vlademar Poulsen, a Danish scientist, invented his Telegraphone in 1898. It was the first electronically driven system used to record sound. Commonly known as a wire recorder, it consisted of a thin wire fed from one reel to another at a constant rate past an electronically magnetized record head. By doing this, Poulsen prepared the way for storage, manipulation and the study of large, extended samples of recorded information in more minute detail. The problem with this technology was that the wires on which the sound was recorded tended to become crimped or knotted. Although editing became possible for the first time by cutting the wire and tying knots in the ends, this proved to be obviously impractical and was soon abandoned. Around the same time, various forms of flat disk recording systems patented by RCA, Edison, and others became popular for recording and storing sound. However, it wasn't until the late Twenties, after the invention of the Vitaphone, a method of capturing and reproducing sound for film and referred to in the industry as optical sound tracks, that capturing aspects of natural sound became remotely practical.

The film industry had already approached the Cornell Department of Ornithology offering to work with the department to record the sounds of birds on film. The inventors would demonstrate the technical excellence of their invention and Cornell would identify the creatures. Light was at the heart of the technology. Tiny stripes, like narrow expanding and contracting vertical bar codes, ran the length of the film strip synching sound to picture. This medium, when read by a light projected through the moving opaque and translucent bars of code, would project the pattern variations onto a photo-electric cell which would then create pulses of sound. This was the method used to capture the now-extinct Ivory-billed woodpecker by Arthur Allen, Albert Brand, and Peter Paul Kellogg, who formed the first field recording team in the spring of 1935. Also used at this time was what Brand referred to as a sound mirror - actually the forerunner of the parabolic dish. The bulky, awkward, and heavy equipment was loaded onto the back of an old mule-drawn wagon and dragged through marshes in the southeast U. S. to a remote location where the team captured the elusive sound of the last few woodpeckers left in North America. The technology was so complex that it required two men to operate it.

In the late thirties, when a German group invented the Magnetaphone, the possibilities of field recording of extended samples became even more feasible and possible. Using thin 1/4" strips of paper tape impregnated with fine particles of iron oxide, this new medium, like its wire predecessor, was drawn at a constant speed across an electro-magnetic head. The head delivers a variable magnetic impulse representing an analog of sound that rearranges the particles of oxide in patterns that symbolized the speech or music captured at the input of the system. Once recorded on tape, it could then be easily rewound and played back and manipulated by editing. Used as a surveillance device during World War II, the technology was picked up by the Ampex Corporation during the American occupation of Germany. Based on the German invention, Ampex engineers improved both the frequency response and dynamic quality of the audio tape by tweaking the recording electronics. Ampex obtained several patents on the process in 1948. This type of reel-to-reel system has endured for the past fifty years.

Between Edison's day and the late 1960s, and with the exception of researchers associated with Cornell, very few people were interested in or committed to the recording of natural sounds. Most chose, instead, to try to capture the essence of the natural world with images on film or canvas and paid almost no attention the principal thrust of animal communication, their special voices and sound signatures. Even those in academia were more interested in isolating the sounds of single creatures. This component was so overlooked that as recently as the late 1970s the call of the Australian kookaburra birds could be commonly heard inserted in the sound effects tracks of both popular and nature films obviously shot on location in the Amazon or Costa Rica. Producers cynically thought the general public would never know the difference. To most of the public, the call of the kookaburra, as heard as early the original Tarzan and Jane movies, came to symbolize the sound of the "jungle." It was not the job of the movie or TV commercial director to either educate or disappoint us. Screams of red-tailed hawks are still heard over the image of bald eagles and Andean condors.

In addition to the general lack of interest, there were also the problems of cumbersome technology that was heavy, awkward, and limited in its recording and reproduction capacities; further exacerbated by insufficient power supplies and the technology's sensitivity to moisture or other extreme conditions that make it otherwise not terribly reliable in the field.

Recorders

There are two types of portable equipment: analog and digital.

Analog

Analog recorders come in two categories; cassette or reel-to-reel. Because reel-to-reel recorders tend to be quite heavy, expensive to buy and operate, and otherwise obsolete for field recording, this category of equipment is not addressed in this document. While limited in recording quality, cassette recorders provide an inexpensive and perfectly respectable introduction to field recording. Standard audio cassette recorders (as opposed to mini-cassette machines) are recommended because they sound better and the results will be less frustrating for the user. Portable units can be purchased from any consumer audio supply outlet for anywhere from around $100 to around $700 in price. Recommended tape is Type II (CrO2). Disengage noise reduction (like Dolby NR which reduces tape hiss) while recording. Ambient noise picked up by the microphone will usually exceed most tape hiss you are likely to hear.

Pros:

1. Inexpensive introduction.
2. Cheap but limited operation.
3. Can stand a fair amount of abuse.

Cons:

1. Limited quality (dynamic range and frequency response).
2. Fairly high attrition (failure) rate after relatively short usage time.
3. Maintenance is required ("record", "playback" heads and transport mechanism, need to be regularly cleaned and demagnetized).
4. No easy way to archive sounds because tape times and location meter readings are not accurate.

Digital

Digital recorders range in price from around $700 - $15,000+. After testing several brands, including mini-disc recorders, the Sony M-1 (Fig. A-1) system is recommended because it offers several advantages over other types of systems. The Sony D-8 is another small one and is slightly less expensive but a bit larger and heavier than the M-1. The M-1 is economical to operate requiring only two AA cell batteries that last about 3 hours. The D-8 has four AA cells that last less than two. However, one can get (or build) an outboard rechargeable gel-cell battery that lasts 15+ hours for either machine for around $30 up depending where it is purchased. In the $700 range, the M-1 is so small and light (about the size of a pack of cigarettes) that it fits easily into an average sized pocket. Recording quality is professional and superior to analog cassettes. The data can be transferred directly to computers for editing, analysis and/or production with no loss in quality - in other words, an exact clone. The recorder takes DAT (Digital Audio Tape) cassettes which are of a size designed especially for the recorder. No other type will fit.

Figure A-1 Sony PCM M-1

Pros:

1. Medium priced, the equipment will last a long time. (We're using Sony DAT machines that are 10 years old.)
2. DAT cassettes last for anywhere from 90 to 120 minutes without having to flip the cassette (as with analog cassette recorders), allowing the recordist to record for exceptionally long periods without having to worry about running out of tape.
3. Archiving is easy because real time/date and tape time are all encoded on your recording (with Sony equipment).
4. They're light and easy to use.

Cons:

1. While they don't require as much maintenance as standard audio cassette machines, the head should be cleaned every 20 hours or so of usage.
2. The machine will not operate well under humid or dusty conditions and special attention must be paid to its protection from these problems (a padded zip-lock bag is usually sufficient).
3. It will not tolerate being dropped or knocked around much without affecting its calibration or operation.
4. The (female) input/output connectors for the mics and earphones are stereo mini-jacks. These require great care so pressure is not put on them causing them to loosen. Service charges on these machines (if you have to send them back to Sony) are prohibitive and very time consuming.

5. New DAT recorder models and upgrades have ceased to be introduced to the market as of the end of 2001.
6. There are only half a dozen brands of DAT tape now available where there were many in the late 90s. This signals a "'phasing out" of DAT product in favor of mini-disc technology in the foreseeable future although the DAT medium is still viable and practical.

(3) HHb MDP 500 Portadisc (mini-disc listed at around $1,545.00) offers several features worth noting for field work. Fig. A-2. Early reliable reports suggest that this is definitely a technology to consider if one can handle the price. For one thing, it offers a six second pre-record buffer. With DAT recorders, for instance, from the time one hears a bird or mammal one wants to record until the time the "record" button is pressed, several seconds elapse before the transport engages and one actually begins to record. The six-second buffer in the MDP 500, on the other hand, actually captures and stores this sound in a memory chip before one hits "record" so you don't lose the beginning of the vocalization desired.

Figure A-2 HHb MDP 500 Portadisc

Pros (MDP 500):

1. The unit is extremely rugged. Also, mini-discs are far more rugged than DAT tape in humid conditions.
2. It is compatible with both PC and Mac formats for downloading data (featuring a Universal Serial Bus), onboard editing, sync recording, comes with many accessories.
3. While DAT tapes tend to sometimes attract molds, the mini-discs are not susceptible to that type of problem.
4. The (disc) media is about a quarter the cost of DAT tape -around $2.00 per disc - although they are generally not re-recordable as are tapes. However, since it is not desirable to record over our field data that should not be an issue.

Cons:

1. It is heavier (4.5 lbs) than the M1 (DAT).
2. There isn't enough information to critique the product adequately at this point, however indications from those who have used the device point to some software and chip problems with earlier versions that relate to the time and date coding and intermittent ability to stop the transport when the machine is in "record" mode. HHb claims to have improved the software and has sent both replacement software and the necessary chip hardware to end-users to install.

Other, less expensive, consumer model MDs (mini-discs for between $250 and $300) with fewer features also exist but none of these have been field tested by Wild Sanctuary, Inc. as of this writing. Figs. A-3 and A-4.

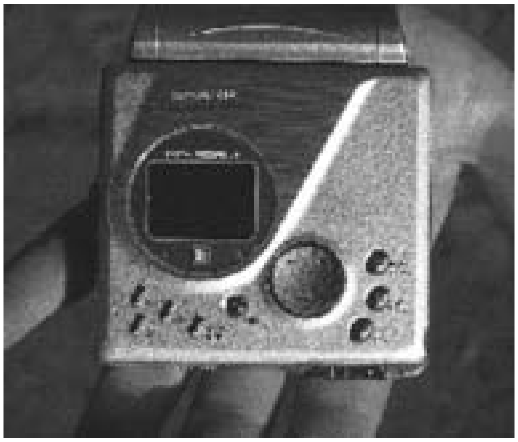


Fig. A-3 Sharp MD (no model number)

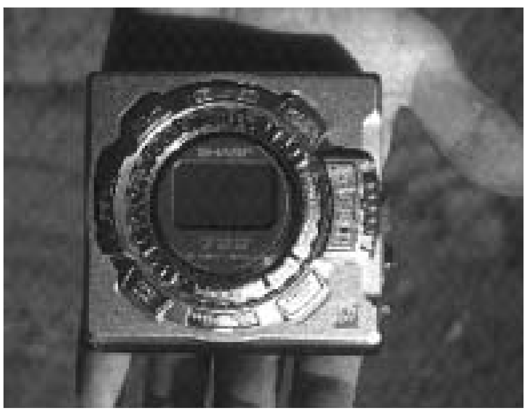


Fig. 4 Sharp MD 722 mini-disc recorder

Microphones (input transducer). There are several types. Some are used for recording terrestrial events, others for marine environments. Only basics are offered here. Some systems are monaural - meaning a single-source microphone that picks up sound within one dimension and typically records on only one track. Others are stereo - consisting of one mic with two pick-up elements or a pair of related mics - receiving sound in a manner that provides a sense of depth, movement through space, and (in some cases) direction. Mics come in many different patterns. The three basic patterns are these: At one end of the scale, omni-directional mics pick up equally from all directions (Fig. A-5).

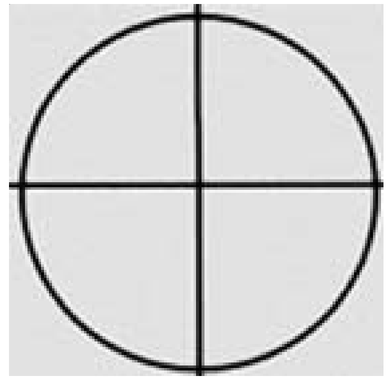


Figure A-5 Omnidirectional pattern

Cardioid mics feature a kind of heart-shaped pattern (hence the name) ranging from hyper-cardioid (quasi-directional) to cardioid (approaching omni-directional) (Fig. A-6).

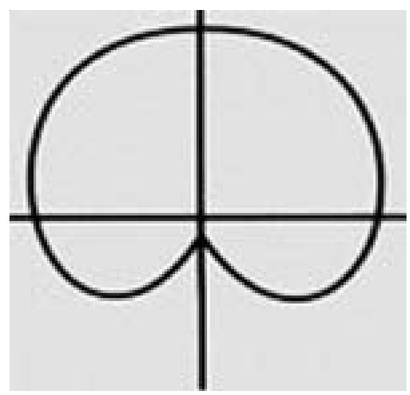


Figure A-6 Cardioid pattern

Shotgun mics, at the other end of the scale, have a very narrow pattern that can pick up individual sounds from some distance (Fig. A-7). These tend to eliminate sound coming from the sides. Hydrophones (underwater mics) are waterproof input transducer systems specially designed for recording in marine environments. In some instances, these can also be used as in-air microphones. All can be configured to work with the recommended recorders.

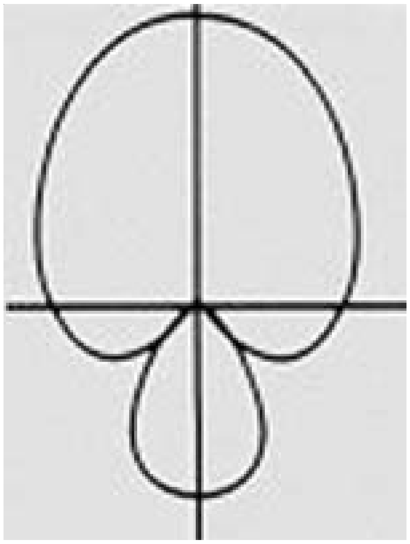


Figure A-7 Shotgun pattern

Types of microphones

Monaural

Monaural systems are usually used to capture individual creature voices on tape separated out from the surrounding habitat. The technique usually employed features either a shotgun mic which is highly directional, or an omni or cardioid fitted into a parabolic dish (See 2(e) below). Another application for monaural recording is to obtain precisely calibrated sound pressure level and frequency response measurements in a given location. Monaural means that the signal is typically recorded on only one channel of a two-track recorder and played back from that single source.

Stereo

While other stereo systems exist, only three types are considered here to keep things simple. XY, binaural, and M-S systems are comprised mostly of two monaural mics either of the same or different types in combination. Sometimes, depending on the manufacturer, both XY and M-S systems are combined into one single unit.

A. XY - (Fig. A-8) a technique developed by the British almost 70 years ago consisting usually of two cardioid (or hyper-cardioid) microphones placed at a 90 degree angle, nose-to-nose, in relationship to one another. Omni-directional mics may also be used. Looking at the set-up from the top down, the right mic picks up sound from the left side. The left mic picks up sound from the right. The sound picked up from the left hand mic usually goes into the left input channel of a recorder. The sound picked up from the right hand mic is usually directed to the right input recorder channel. With this type of configuration, there is likely to be a 3dB loss in the "phantom" center of the program material.

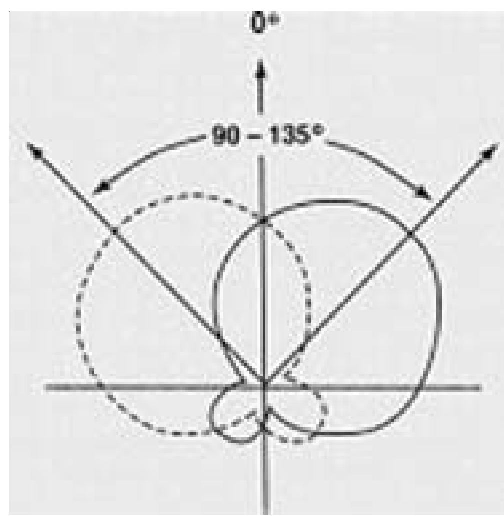


Figure A-8 XY pattern

Good quality mic systems of this type can be purchased for as little $200.00 to as much as $8,000+. Some come equipped with battery-operated internal pre-amplifiers. Others - usually the more expensive ones - require an outboard pre-amp that can cost from $600 to $1,500+.

B. Binaural - a technique that promises a spatial recording illusion similar to what humans hear. Typically, a model of a human head is used - in some cases with a bust from the upper body (shoulders up). Small, high quality cardioid mics are implanted in each of the ears of the head. For most professionals, the results have fallen a bit short mostly because of the cumbersome technologies required for effective playback. While it can pick up some information from about 80 degrees front right, behind a persons back to about 280 degrees front left, depending on the type of binaural technology being used, there is virtually no accurate spatial discrimination from around 280 degrees front left to around 80 front right. However, when tethered to earphones, the primary manner in which binaural recordings can be accurately reproduced, for example, one can hear the illusion of keys jingled behind from the top of ones head to just below waist level and from side to side. But the illusion fails when the keys are held and jingled within the null zone directly in front. Mostly, with eyes closed, the listener will experience the sound being moved overhead from one side to the other. While the stereo effect remains intact (with the -3dB phantom center channel problem) during playback through a pair of stereo speakers, the "surround" effect is lost. This expensive bit of technology with the cumbersome "head" in tow, can cost anywhere from $6,000 to $25,000+.

However, if one wishes to experiment with a much less expensive binaural system, the same result can be adequately accomplished by tying a piece of string around a tree about the diameter of the distance between the ears of a human head, and clip two omnidirectional lavaliere mics opposite each other at the widest point. Mics of this type begin at about $14.00 each at Radio Shack. Sony ECM 55Bs cost about $ 400.00 each and binaural recordings by this method have fooled even the most hardened tech-freak professionals who swear by the more expensive binaural equipment. If one can hold one's head still enough and for long enough, the lavalieres can even be attached to the stems of one's glasses or the rim of one's hat. One needs to breathe very quietly and just be sure that nothing rubs against the thin cables. (You'll not only get great binaural sound, but also a stiff neck and an excuse to visit your chiropractor.)

(C.) M-S - stands for Mid (M) Side (S) (Fig. A-9). This system, unlike the others previously mentioned, combines two different types of microphones in one system and provides the recordist five optional results from one recording. Sometimes one mic is piggy-backed on top of another in a shock-mount. The top mic is a hyper-cardioid pattern (M - which provides some directionality) while the bottom mic is a figure eight pattern (S), picking up all of the related ambient material in the surrounding habitat. Hence, the term M-S. The output from the Mid mic usually goes into the left input channel

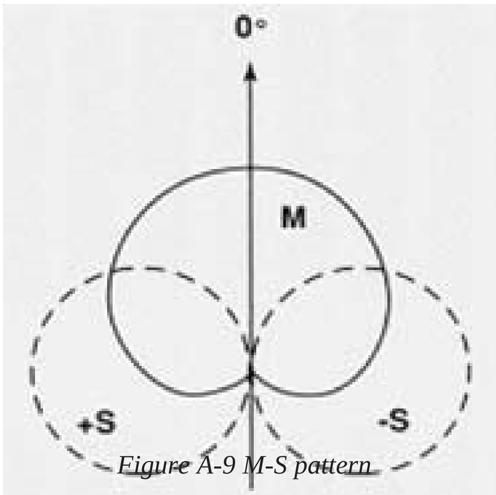


Figure A-9 M-S pattern

of the recorder. The Side (figure eight) output goes into the right input channel. Some current technologies combine both systems in a single, tube-like unit.

The five results are these:

1. A quasi-directional mono signal from the hypercardioid mic (M),
2. The instantaneous surrounding ambience gathered from the figure eight patterned mic(s),
3. A stereo result achieved by combining both the M and S signals into a mixing matrix either in the field or the studio.
4. The recordist can derive the best surround result from this technique. Although we employ all the other mic systems at various times, M-S is the one we clearly favor because of the range of options it gives us when creating final mixes.
5. Assuming not much equalization or other signal processing in the mix, the recordist/producer can decode the M-S stereo mix to get an exact duplication of the original M-S recording (using a matrix).

The matrix controls the width and depth of the stereo image from mono to very wide. The signal output is calculated and derived in the following way: M plus S for the left channel, and M minus S for the right output channel. The width and depth of the stereo image is continuously variable from mono. It is particularly useful since all other stereo configurations (XY and binaural) create up to a -3dB drop in the phantom center channel whereas the M-S system eliminates this phenomenon. (One dB, or decibel, is an audio term referring to the minimum level of change in amplitude that the human ear can detect) The “phantom center” is an audio engineering expression that refers to the illusion of audio information appearing in between a pair of stereo speakers directly in the center. With most stereo mic systems, the drop of level in the phantom center occurs because the patterns of the mics fail to cover information coming from that zone at the same level as the side perspectives.

Hydrophones

Hydrophones such as those in Fig. A-10 are a type of microphone developed for recording in marine environments.

Figure A-10 Hydrophone

Recording in oceans, lakes or ponds, these can be made inexpensively by individuals or purchased complete for around $350.00. More expensive models can cost upward of several thousand but are neither practical or particularly useful unless one is doing arcane research. However, because of their excellent low frequency response, we have recorded elephant and hippo infrasound, in air, and buried the hydrophones under the sand while recording dunes singing. We have also recorded the signatures of earthworms crawling through the soil with these instruments.

Parabolic dishes

Parabolic dishes such as that shown in Fig. A-11 are also used primarily to capture the sounds of single creatures, provide even greater definition than shotgun mics but are a bit more awkward to use in the field - especially the large acrylic or plastic models.

Figure A-11 Parabolic dish

Usually ranging from about a foot in diameter to several, depending on the frequency range of the creature voices one wishes to record, this equipment allows very focused sound over a long distance. Size really matters, however. For instance, if a bird has a particular singing range of about 1kHz (one kilo Hertz is equivalent to a rate of vibration of 1000 cycles per second) or greater, a dish a bit larger than 1 foot will do just fine because it can capture a full wave length of sound at that frequency without a problem. However, if the creature voice is a type of mourning dove that vocalizes around 500 Hz. the dish will have to be at least double in size; 2 feet in diameter. If it's the low guttural roar of an African lion one wishes to record, a dish about 32 feet in diameter will be required and should work quite well -- except for the one who has to pack and carry it. However, if one wishes to record both species-specific creatures and an ambience at the same time, an omnidirectional mic (typically the most favored by recordists using a parabolic dish) will eliminate the need to go to a larger dish to capture lower frequencies. That is because omnidirectional mics tend to pick up lower frequency sound and eliminate wind problems better than other patterned mics. A Swedish company has, with a new space-age plastic, devised a collapsible and foldable dish that expands to about 3 feet in diameter that is a truly interesting compromise. Cost: about $1,100 from Telinga.

The problem with most non-collapsible dedicated parabolic dishes is that they tend to "color" the sound. The same holds true for shotgun mics. Sometimes this is unavoidable if one wants or needs to have an example of a single species among many. But to some extent, all mics color the sound.

Headphones come in many types and brands. Stereo is a must and there are several to choose from. We recommend the Sony MDR 7506 (or equivalent) among others. Under $90 a pair, these provide everything we need for critical listening and last a very long time. Ours are over ten years old as of this writing.

Appendix B - Field Techniques

For those used to photography, video or film cameras, where mostly what is needed to shoot is available light (and occasionally something moving), one will find recording to be quite different. For one thing, microphones don't differentiate like our ears. We can sit across the table from a person in a noisy restaurant and clearly hear (partially by visual contact) what is being said. Place a microphone in the middle of the same table and all you'll hear on tape is noise and very little, if any, distinctive dialog. Mics don't discriminate. Our ears do. While mindful listening can be done in nearly every circumstance, recording is a bit more challenging. Here are different field techniques to keep in mind.

Picking the right transducer (mic or hydrophone)

This is matter predicated on three issues: taste, purpose, and budget. In the professional realm of recording taste, there are as many opinions as there are sets of ears.

1. Taste. Each type of microphone delivers a particular result from a combination of factors including mic sensitivity (ability to pick up detail from loudest to softest, from subtle to robust detail), it's pattern (Appendix A, Section C), and it's frequency response from highest to lowest tones. All of these constituents together create the character a microphone gives to the sound being detected at the input. Because each microphone - even of the same type - is slightly different, one has to pick a mic based on the sound one likes best and that best represents what one expects to hear. This is very personal and there is no such thing as the perfect choice—only a compromise that approaches expectations.

2. Purpose. For this, one needs to take into account what is being recorded and where. If, for instance, one chooses to record in an environment that has a fair amount of humidity, a mic system needs to be fairly impervious to failure under those conditions. Sennheiser, certain Sony and Audio-Technica mics fall into that category. If a fair amount of wind is expected, one normally would normally use either a pair of cardioid mics or a M-S system with sufficient wind protection. When the normal mic wind protection fails to mitigate the problem, in order to retain stereo imaging the recordist may wish to switch to a pair of omni-directional mics set 6 - 7 inches (15 - 17.5 cm) apart from one another. Omnis tend to be less sensitive to the impacts of wind in general.

3. Budget. This is pretty self-explanatory. However, less expensive mics and mic systems tend to be introduce more noise into a recording. Also, they tend to be less sensitive so one can expect a result not quite as robust in terms of dynamic range, frequency response, stereo imaging, and the fragile detail more common in higher end systems. Nevertheless, the Sony and Audio-Technica mic systems in the $200.00 range mentioned (above), are perfectly acceptable, useful, and provide great value in the field. You

will provide an adequate representation of what is present in most habitats and under most conditions by using mics of these types.

Philosophical note: There is no such thing as a “pure” (usually meaning unedited) recording. Every choice one makes from equipment to recording location is an edit. The moment one finds a microphone that is affordable and/or that one likes the sound of, one has made their first “edit” - their first compromise (since no mic does all). That is because no matter what the manufacturer’s claim, every individual mic - even same brand/same type - sounds slightly different. The various patterns, frequency response, and sensitivity calibrations all play a major determining role in this issue. The exact biome location one chooses to record combined with the direction one points a mic and the window of time the tape begins to roll, determines a second type of edit. Since time on DAT tape or mini-disc is typically limited to either 90 or 120 minutes, this window creates the third. Then there are issues of what material the recordist thinks best represents the habitat keeping in mind that maximum time on a CD is limited to around 74 minutes given current and common technology. Finally, and not least important, the manner in which the material is presented in a final mix on CD or audio tape constitutes the most important editing choice of all.

Recording is an illusion. Any recording is an effect of sound as received and processed by all the technology being applied to capture and mix it. Recording natural soundscape is also an abstraction (one gets only what the mics pick up - not what human ears hear or what is actually out there). All the elements in the chain of events from choice of time and place, technology, medium (CD or tape), to playback system, play significant rolls in how the information is received by the listener. To create the best illusion, one needs to choose the best components in the chain that come closest to what you like to hear and that you feel will best represent your final mixes.

Field Problems

Wind.

Where wind is an issue, choose a mic system that features good wind protection. Even the best field mics with super-expensive defenses cannot withstand wind gusts of more than 6 or 8 miles per hour without some interference. Windscreens come with almost all mics - some systems better than others. Note: As noted previously, omni mics are the least sensitive types to use for wind attenuation. In a windy environment, it is desirable to set the mics - typically the Sony ECM 55B lavalieres - very close to the ground (if not on the ground) among grasses or bushes where the gusts will not overload the input. This will change the sound somewhat (loss of low frequency because of ground attenuation). Again, all recording is a compromise. When using the M-S system, either two Sennheiser mics, an MKH 30 (hypercardioid) and an MKH 40 (figure-8); or two Schoeps consisting of a 541 (hypercardioid), and a figure-8; it is recommended that one choose the system which is less sensitive to high wind (usually the Sennheisers). These are set on a Rykote mount that can be perched on a tripod. Then each of the mic capsules are covered by a special type of acoustifoam (porous rubber) screen, then with what looks like a nylon covered zeppelin, which, in turn, is covered by a “fuzzy” that looks a lot like an furry animal created by Jim

Henson (Fig B-1). There is also a type of high wind cover for the Rykote.

Figure B-1 Fuzzy

Rain and humidity.

Rain and humidity are always an issue when recording. If either are likely, mics like the Sennheisers or the Sony ECM 55Bs work especially well. That is because omni patterned mics seem to mitigate wind problems better than other, more narrow patterns. Another mic that is inexpensive and works in wet or windy environments is the Sony ECM 957 or the Audio-Technica AT822, stereo mic systems that are a bit less sensitive than those noted above, and cost around $200.00. The Schoeps will fail in high humidity with sustained use. That is because it is a traditionally constructed condenser mic. Even though the others are also condensers, they are a bit more rugged and seem to be able to withstand more exposure to the elements.

The Schoeps system tends to be more translucent and sensitive - qualities we prefer. But we find that this system can only be used under the most optimal conditions. Unfortunately those moments are rarely found in the natural world.

What happens when mics fail? Recently, while on a summer bioacoustic trip to S. E. Alaska, an older sound recordist found herself some distance down the trail from her tape and battery supplies. A wonderfully close Swainson's thrush had just begun to sing. However, she forgot to check the battery that powered her stereo mic and it went dead. Remembering a detail brought up during a "what if...?" review session, she plugged her headphones into the mic input and used the headphones as a stereo mic system to capture the thrush in a very credible recording — obviating her need to walk several round trip miles through muddy muskeg to get batteries for her mic.

Experiments.

Ants

For carpenter and several other species of ants, try a lavaliere mic and lay it on top of an ant hill covering main entrance. As they gather underneath to clear the hole, some will stridulate. Make certain your recorder or amplifier is switched on and that you've shared your headphones with visitors.

Aquatic creatures

Other than the usual suspects (whales, dolphins, seals, etc.) many species of fish have acoustic signatures created by either gnashing their teeth on coral, creating sound with their swim bladders, or otherwise creating distinctive noises. One can drop in on tide pools by the ocean and lower the hydrophone into the bellies of anemones. They make terrific sounds. Likewise, the barnacles and rockfish which occupy similar biomes make great subjects.

Sand dunes

Encourage visitors to climb a sand dune (like the Kelso Dunes off the Kelbaker Road, north of Highway 40 between Barstow and Needles, California) and bury a hydrophone just under the surface about 30 yards down the leeward slope from the top. (The reason to use a hydrophone is because of the strong desert wind usually prevalent on the dune surface affecting regular microphones.) One can initiate a sand boom by either kicking sand down off the crest, or sliding down on their butt. The dune will burst into a very low frequency song that is exceptional to hear and record. The sound will be loud so make certain visitors who are recording are informed to keep the input levels of their recorder lower than usual. The phenomenon of singing dunes has been part of S. W. Native American mythology and also recounted in the journals of T. E. Lawrence (Lawrence of Arabia).

Pools

Vernal pools left after a spring rain are loaded with insect larvae, tadpoles, and waterboatman - all singing! (We are using "singing" and "vocalizing" in a loose sense here to designate creature-initiated noise which may, in fact, indicate stridulation).These micro-habitats can be found in a wide number of locations throughout most parks. The insect larvae seem to be most active when the angle of the sun is high in a cloudless sky although there is some activity most spring and summer days. We've never tried recording in these pools during winter, but there might also be activity at these times.

Crickets

(see Chapter III, Educational Programs...)

Glaciers

Glacial mass of ice moving over land can be captured by dropping a hydrophone down into a crevasse of the moving body of ice. What one hears is the terrifying and powerful low frequency (signature) of the glacier moving slowly over the ground and, in the process, creating the moraine. Typical of glacial movement throughout the world, these sounds can only be captured on digital equipment (DATs, in particular).

Points to note:

The elements that affect recording most are:

1. Wind
2. Humidity (rain, dew, etc.) affect both the mics and (DAT) recorder
3. Mechanical noise (including auto traffic, leaf blowers, chain saws, snowmobiles, aircraft, ATVs, ORVs, trail bikes, music from boom-boxes, from as far away as 20 miles if wind and other climatic conditions are sufficient)
4. Humans talking, moving
5. Extraneous background noises like streams, effect of wind in the trees, grass, and domestic creatures (dogs, roosters, cows, etc.), unless specifically desired.

Elements that affect the equipment:

1. Insect repellent. Never, touch any non-metallic part of one's equipment with a repellent that contains deet (N.N. diethylmetatoluamide), the main ingredient of many repellents. It will dissolve anything it comes in contact with. It will liquefy paint and even affect the special qualities of Gortex. If mosquitoes tend to think of the visitor as a resource for food, advise them to wear latex surgical gloves. In the summer their hands will sweat, but their earphones won't melt when touched if they happen to have some residual deet on their digits.

2. Moisture. The author once accidentally dropped a new Sony D-10 Pro DAT recorder into a puddle in a rainforest that cost a bundle to get to (not to mention the cost of the recorder). Despite several days of trying to dry it out with blow dryers and every other available means, the moisture got it. The fall to the ground did not destroy it, but the moisture ensured that it never worked again. Equipment must be kept dry, especially the tape supply. Dry equipment = happy field recordists.
3. Dust and sand. The transport mechanism of DAT machines is quite sensitive to any foreign element. It must be kept clean.

Elements that will make a recordist's life easier (and can't be emphasized enough).

1. Always check the batteries before going into the field. Make sure every component that needs them has a fresh supply.
2. Have a sufficient supply of tape and bring extras.
3. Visitors and staff need to make certain they have the equipment they need (recorder, right mic for the job, earphones, flashlight, notebook, pen, a bottle of water, rubber gloves, insect repellent, etc.).
4. Visitors and staff need to take special care to protect their mics and recorder from moisture and dust by carrying a liberal supply of uncompromised zip-lock bags with them.

Recording set up

Once an appropriate site is found, these are the items to check:

1. Make certain that the "input" and "record" levels are set so they won't overload or distort.
2. Always slate the recording with time, date, location, and a brief description of habitat and/or creature-life. This can be done at either the beginning or end of the take or both. Do not assume that the recorder is set with the right information. Also, playback might take place on equipment that does not read time/date information.
3. Once the set-up is secure, detach the headphones (it'll save about a third of the recorder's battery life) and move away from the mics 25 ft. or more. Sit (or stand) still and don't shuffle feet.

Field techniques for finding creatures and locations.

Easy-to-grasp methods and trouble-shooting. As with listening, encourage visitors to find a quiet location that has sounds they want to listen to and record. It can be defined by a type of bird, mammal, insect, amphibian, or fish. Or they can look for a particular type of habitat like, for instance, riparian, coniferous, edge, meadow, muskeg, seashore, small or large stream, various desert biomes (high and low altitude), coastal, estuary, mangrove swamps, sub-tropical swamps, etc. Ask them to try to find both a time and place where there is only natural soundscape without human noise or domestic animal sounds. This is usually before, during, or just after dawn and late evenings. If chosen carefully, it can be a number of times during the day. That is because, where there is sound at dawn or dusk there are likely to be useful soundscapes at other times even though the density may be significantly lighter.

In the National Park Service publication, The Nature of Sound, referenced earlier in this text, Miriam Graham's field program was mentioned briefly (Chapter V, Programs and Activity Sites). Graham also identified a list of creatures one might listen to and record in desert environments. The following is what she offered:

> CANYON WREN
>
> One of the most typical sounds of the desert canyons was described by naturalist Robert Ridgeway in the 1860s in terms of water: "a cascade of sweet, liquid notes, like the spray of a waterfall in sunshine." Seldom seen but often heard, canyon wrens inhabit steep-walled canyons, usually with water in the bottoms. The canyon wren is a reddish brown bird with a white throat and breast, speckled plumage, and a tail sticking up as it nervously pokes with its long bill into every crevice looking for insects and other invertebrates to eat. You can hear these wrens year-round in Canyonlands.
>
> BLACK-CHINNED HUMMINGBIRD
>
> The canyon wren isn't the only animal in the desert to call up images of water. The hummingbird is the "Rainbird" to the southwest native peoples. According to a Pima story, at one time, the wind and the rain spirits left the people. Since they were dying of thirst, they sent out many different animals to bring back wind and rain, but none were successful. Finally, the hummingbird offered to help. The people scoffed at him at first he was surely too small (a black-chinned hummer weighs about as much as one golden eagle primary feather!) and weak. But they were desperate, so they gave in. The hummingbird asked for one thing: some strands of the chief's daughter's beautiful long black hair, which he wove into a rope.
>
> Now, if you've ever watched hummingbirds, you know that they are incredible flyers. They migrate from Mexico every spring, flying at about 25 to 30 miles an hour but, if they catch a tail wind, they can go perhaps twice as fast. This hummer had a white tail feather, which always pointed to the wind. As he flew, he followed the direction of this magic feather and it brought him to the place where the wind and rain spirits were hiding. In an instant, he tied them up with the hair-rope and told them that if they didn't come back, he would never untie them. That's how the hummingbird brought rain back to the Pima people.
>
> WHITE-THROATED SWIFT
>
> You may be more likely to hear the "whoosh" of a white-throated swift as it zips over your head if you're standing at the edge of a cliff. They may be the fastest birds in North America. They've been observed escaping the midair attack of a peregrine falcon at about 200-mph!
>
> They're black, swallow-like birds with white on the throat and underside, and long, slender pointed wings which they hold out stiffly while flying, and a forked tail. White-throated swifts are actually closer cousins to hummingbirds than to swallows.
>
> White-throated swifts spend most of their time in the air. They even mate in the air, free-falling and swooping back up before they hit the ground. In fact, their feet are so weak they have trouble taking off when they do

alight on the ground. Their Latin family name, Apodidae, means "without feet." They can be seen year-round in Canyonlands though they seem to hibernate during the coldest weather.

RAVEN

"Ghastly grim and ancient raven, wandering from the nightly shore, Tell me what thy lordly name is, on the night's Plutonian shore! Quoth the Raven, 'Nevermore'. "

The raven, to Poe, was an evil omen. Europeans have also considered ravens a symbol of death, but American Indian tribes have a better opinion of them: according to the Northwest tribal people, the raven's role is similar to the coyote's role in the Southwest, that of a creator and also a trickster.

Either way, humans have never been indifferent to ravens, perhaps because they are so big and so black, and always seem to be hovering nearby. Even Jesus talked about ravens. He said, "Consider the ravens, for they neither sow nor reap, which neither have storehouse nor barn, and God feedeth them." And it's true — ravens never seem to lack for food. They are both predator and scavenger, feeding on carrion, killing live game, dining on the eggs of other birds, and even eating plants. They sometimes accompany other predators to feed on their kill: in the days of the great bison herds, ravens would travel along with the herds, taking advantage of a carcass if an animal happened to die.

PINYON JAY

Unlike ravens, their close cousins, pinyon jays, do have storehouses. These nuts are their favorite food, and they may become your favorite food if you try one! (Pass pinyons around.) Pinyon jays collect the ripe nuts of pinyon pines in the fall and cache them on the ground, usually far away from the tree. The jays eat most of the nuts throughout the winter, but the ones they leave eventually sprout and start new trees. By taking the nuts far away from the parent tree, the jays ensure the genetic variability of the pinyon tree population. It's a true partnership. While other birds are settling down for a winter routine of survival, pinyon jays actually begin their mating season in November after they have had a chance to collect a large store of food. The pinyon tree has a bumper crop of nuts every six to seven years, and on those years, pinyon jays may hatch several clutches of eggs.

The pinyon jay is an all-blue bird. Like the raven, it is a corvid, a family of birds that includes ravens, jays, crows, and magpies. Corvids are social birds, and pinyon jays often fly in flocks, calling as they fly.

PEREGRINE FALCON

This sound was almost gone from the world at one time. In the late 1940s, its numbers suddenly and drastically declined, so that it was extinct in the eastern U.S. and almost extinct in the West.

Scientists found high amounts of the pesticide DDT in the birds that had eaten small birds, which in turn fed upon insects sprayed with DDT. They also found that DDT was causing the eggs of the peregrines to be so thin that they would usually break before hatching. In 1970, the peregrine falcon was placed on the Endangered Species List, and in

1972, DDT was banned in the U.S. from most uses. (Unfortunately, it's still used in some Latin American countries where peregrines migrate.)
Just taking DDT off the market wasn't enough to bring back the peregrine, so an eleventh hour recovery effort started. In some cases, biologists placed peregrine falcon eggs in foster parents' nests. They also raised the falcons in captivity and then released them into the wild, and in other instances, allowed eggs to hatch in captivity, and then placed the young birds in wild peregrine falcons' nest. This was a heroic act, because not only do peregrines live high up on cliffs, they also have very sharp talons and they hate being disturbed!

The recovery efforts have been successful, and today you can see peregrines hunting for pigeons off urban skyscrapers as often as you might see them cruising the cliffs of Canyonlands. They're as thrilling to watch as to hear as they soar high over their prey, suddenly dropping down and nailing a smaller bird at speeds of up to 200 miles an hour.

GREAT HORNED OWL

The great horned owl is the most common and widespread owl in North America, and probably the bird most often heard in the movies! It is a large owl, brown with black barring and feathery tufts that look like ears but are not. Its actual ears are two asymmetrical openings on its head, and its whole face functions as an outer ear. The shape of the owl's face is like a satellite receiver for sound.

The creatures noted above are best heard and recorded when the habitat is especially quiet, i.e., free from human-caused noises. Microphones hear indiscriminately and it is surprising at how much they pick up - particularly sound that's not wanted. Visitors need to know that they may hear roosters and dogs from five miles away. If they're in hilly country, advise them to find places within the "shadow" of human noise (the opposite side of a hill from a road, for instance). Since road noise travels some distance, they may have to be at least a mile distant to expect quiet - sometimes ten or even more. Finding locations upwind from unwanted noise sometimes helps. If it's very windy and the creature sound is louder and more distinctive than the effect of wind (leaves rustling in trees, for instance), we encourage the use lavaliere mics and place them on the ground sheltered by a tree trunk or grasses.

To record wind, remember that it cannot be recorded, per se. One can only record its effect. However, omni mics are the best for this purpose. For pitched wind (that sounds like a kind of whistling with the frequency moving up and down), the recordist needs to find an old piece of barbed wire along a fence line that whistles as the wind blows. Other options (if the wind is blowing hard enough) include a partially open window, broken reeds, wind catching snags on a corner of a wood-frame structure like a barn or an old house. Recordists need to make sure that their mic elements are not directly receiving the blast or they will overload the input of the mic, their preamp and/or recorder, resulting in distortion.

If the visitor wants to record ants, there are several species that can easily be recorded. For example, carpenter ants (Camponotus pennsylvanicus), common in many places, and harvester ants

(Pogonomyrmex maricopa) are simple to find and easy to record. Others abound, as well. If it's a hot, sunny, relatively windless spring or summer day they will likely get fine recordings after laying a lavalier mic over the entrance hole to the nest.

Tide and fresh water vernal pools are filled with the "voices" of wildlife. Drop a hydrophone into either venue. As mentioned previously, in a tide pool, particularly along the Northwest coast, one can hear anemones, rockfish, and barnacles. In the fresh water pools and ponds, one can listen to and record water boatman, insect larvae, and even (we think) some tadpole sounds.

The most difficult of any non-biological sounds to record are marine sounds like ocean waves and streams. Here are secrets worth noting. It is best not to pick a breezy day to begin this process. Anyone who wants to capture the essence of wave action will need to layer the textures and mix them in the studio. Here's how:

1. One should record wave samples up the beach away from the water's edge -say about 50 yards if that is possible. One wants their mic(s) to pick up an impression of distance, atmosphere, and rumbling surf. Record long samples moving closer to the water, a bit more than half the distance from the location of the first recording nearer to the water's edge just at the point where your mic system begins to get the detail of curling waves crashing and distinct surf.
2. The visitor needs to record long samples of closely mic'd impressions of the water lapping at one's feet where they distinctly hear the bubbles bursting in the sand. When these three stereo elements are combined in the studio, the illusion will be visual, powerful, and palpable.

Thunder and storms are great fun to try. Just remember to take the headphones off your head (so you won't end up like Joan of Ark should lightning actually strike your microphone). Set the input levels of your recorder and pre-amp very low and hope the big one comes.

The most interesting of all is the recording of whole soundscapes. That is because the soundscape (biophony) defines a biome as clearly as its visual constituencies. Research, archiving, and interpretive themes for exhibits centered on re-creating soundscapes representing whole habitats are our immediate goals. Biophonies sound like the best of the greatest symphonies ever written and can be listened to over and over if recorded and mixed properly. After finding a location - sometimes hiking several miles to get to one - we use any of the stereo formats mentioned previously. Choices of mic systems are dependent on expected humidity, temperature, wind, creatures, and the illusion we wish to obtain anticipating how the recording will be used when brought back into the studio for mixing.

Concern in the field is always weight and bulk of your equipment. A normal equipment load isn't heavy: a recorder (with tape and battery supply for 10 days), the lavalieres, and set of headphones can be as light as about 3 lbs.

Appendix C - Applications of Acoustic Data

Identifying

It's always recommended that visitors take a pair of binoculars into the field to glass what they hear. They won't always be successful seeing hidden creatures - particularly in low or no light and heavy vegetation. There are many excellent guides to North American birds, mammals, insects, amphibians, and fish that you might encourage visitors to have on hand.

Absent visual contact, there are a number of birding-by-ear, mammal, and one amphibian guide available through stores like Wild Birds Unlimited, REI, and the Cornell Library of Natural Sounds. Unfortunately, there are no known audio insect or fish guides available. If you are unsure, another option would be to have recordings reviewed by a naturalist familiar with fauna local to the visitor's area of interest. Have him/her listen to the data and note times of occurrences on the DAT tape or CD so archiving will be possible. More references can be found in the bibliography of this guide.

Cataloguing or archiving

There are three stages:

Audition

Audition the tape taking careful notes on the slate information, cues, date/day/night and tape times, species ID, quality of recording (5 excellent, 1 poor), and other special notes. The entries on the page look generally like the table below.

Backup

It is strongly recommended that one create back-up copies of the material. Until very recently both DAT and CD copies were recommended. However, because of both time and cost issues, new paradigms suggest backing up only to CD and storing the disks in separate locations for safety. Recorded data is not considered either safe or archived unless it is on, copied and stored properly. Too many great libraries have been lost to floods, hurricanes, fire, and earthquakes, not to mention just plain vandalism or carelessness. Some libraries are archiving their material with 24 bit/98kHz sampling. However, for most material, this is not necessary or recommended at this time unless one has access to a 24/98 DVD system. Otherwise, this method is too memory intensive.

The final stage in archiving is to create a template that serves the purposes of easy access, complete provenance of the recording, and cross-referenced records that all can read. Our formats change from time to time depending on our requirements. The sample below illustrates the information one might in-

Cue Location	Date	Time	D-time	Sp.ID	Quality & Notes
1. Yukon Delta, Alaska	6/2/94	0450	000	R. ptarmigan	5) No wind. Close. Lite birds in Background.
2.		0632	00:23:30	Arctic loons	4) Nesting pair
3. Askinuk Mtns.	6/3/94	2231	01:04:15	Arctic fox	4) Lite wind. Midfield. Solo.

corporate. The data base shown is File Maker Pro for Mac. Similar software is available for PC. The data with this software is usually transferable to other types as they emerge on the market. As with any equipment, pick something you're comfortable using and that will meet expectations.

The categories selected for this sample are as follows:

Library ID# = the highest number consecutive recording noted in the library.
Title = this is useful to note if it is a completed project.
DAT# = the highest number consecutive DAT in the library.
Mini-Disk (MD) # =
PNO = Program (or cue) number on the DAT.
Duration = length of cut (cue or program)
Analog tape = as distinguished from a DAT tape. Should have separate numbering system.
N/R = refers only to analog recording noise reduction systems like Dolby SR.
Absolute Time Start/End = refers to begin and end times of each cue on tape.
CD # = the highest number consecutive CD backup recording in the library.
CD Cut# = self-explanatory

BIOLOGICAL DATA
Category = bird, mammal, fish, amphibian, etc.
Biome = as in Arctic, boreal, desert, sub-tropical, tropical, etc.
Aquatic Habitat = fresh or salt, stream, lake, pond, marsh, swamp, etc.
Terrestrial Habitat = self-explanatory
Common Name = self-explanatory
Species Name = self-explanatory
Sex = self-explanatory
# of Individuals = self-explanatory
Vox type = actual vocalization, stridulation, arrival, contact, feeding, echolocation, lek, song, etc.
Field notes = Special information related to the recording (not part of the template).

LOCATION
Country = self-explanatory
State/Province = self-explanatory
Site = self-explanatory
GPS = actual Global Positioning System location.
Altitude = self-explanatory

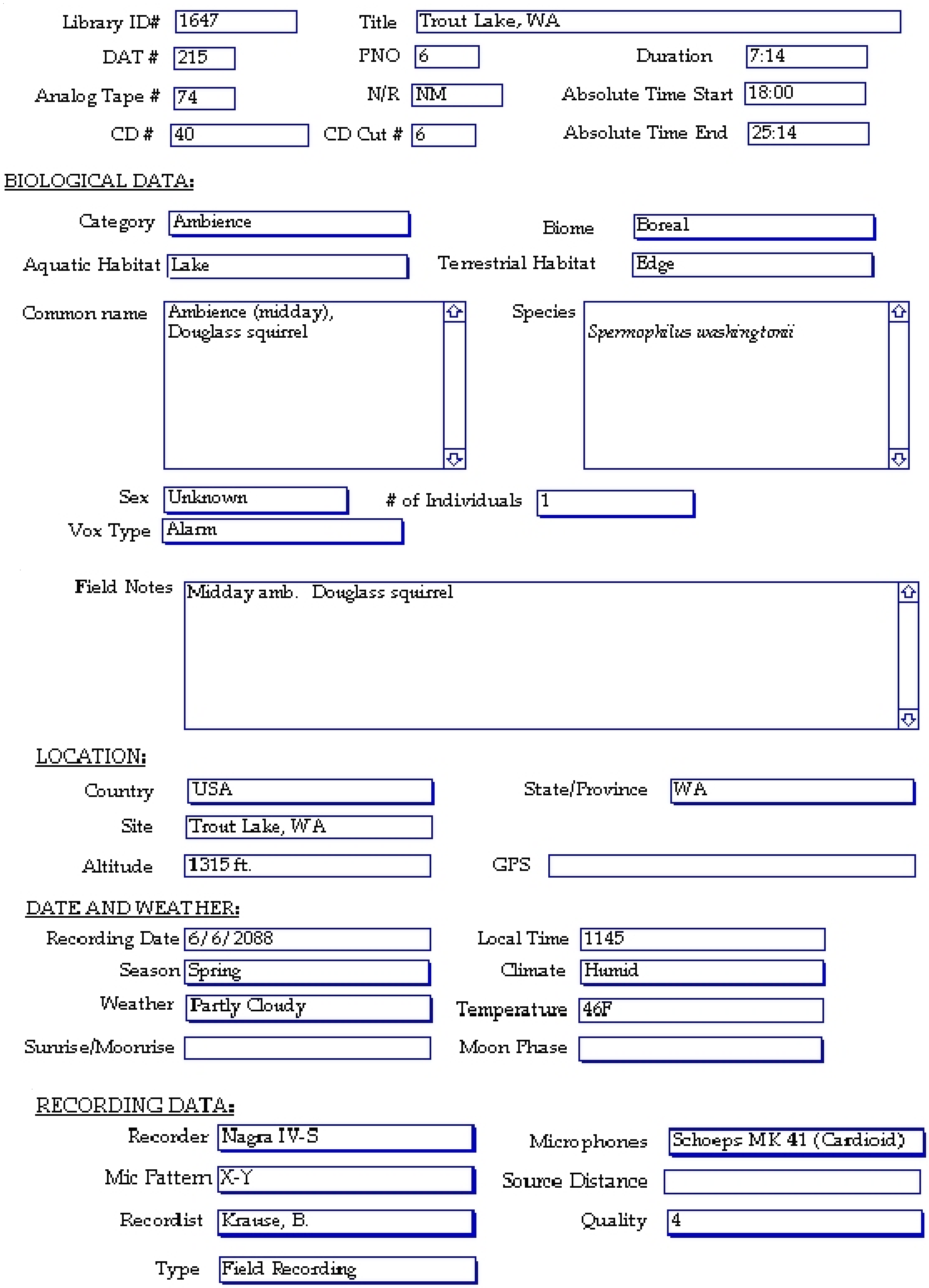
DATE & WEATHER (all categories self-explanatory)

RECORDING DATA
Recorder = if you have a number of machines of the same type, refer to both type and serial number.
Microphones = same as recorder info.
Mic. Pattern = cardioid, hyper-cardioid, omni, shotgun, parabolic, etc.
Source Distance = self-explanatory
Recordist = self-explanatory
Quality = this rating is important because it will help save time during production. We rate our cuts generally 1 - 5 with 5 being excellent.
Type = two-track, four-track, mono, master, copy, production copy, etc.

Analysis

Analysis, assuming raw data is collected and archived properly, can yield all kinds of unexpected and useful information about a particular creature or habitat. Among the issues that can be determined are population density of a par-

Archive information sample layout



Library ID# 1647
Title Trout Lake, WA
DAT # 215
PNO 6
Duration 7:14
Analog Tape # 74
N/R NM
Absolute Time Start 18:00
CD # 40
CD Cut # 6
Absolute Time End 25:14

BIOLOGICAL DATA:

Category Ambience
Biome Boreal
Aquatic Habitat Lake
Terrestrial Habitat Edge
Common name Ambience (midday), Douglass squirrel
Species *Spermophilus washingtonii*
Sex Unknown
# of Individuals 1
Vox Type Alarm
Field Notes Midday amb. Douglass squirrel

LOCATION:

Country USA
State/Province WA
Site Trout Lake, WA
Altitude 1315 ft.
GPS

DATE AND WEATHER:

Recording Date 6/6/2088
Local Time 1145
Season Spring
Climate Humid
Weather Partly Cloudy
Temperature 46F
Sunrise/Moonrise
Moon Phase

RECORDING DATA:

Recorder Nagra IV-S
Microphones Schoeps MK 41 (Cardioid)
Mic Pattern X-Y
Source Distance
Recordist Krause, B.
Quality 4
Type Field Recording

Figure C-1 Typical archive page layout ticular species, health of a biome, patterns of biophony measured by time of day, season, as a function of weather, indicators of distribution, effect of noise on wildlife, and changes that might occur over time.

Techniques

Techniques - range from simple to very complex and arcane.

a. Simple analysis techniques are those that include, for instance, the identification and notation of the songs and calls of birds, voices of mammals, stridulation of insects, and different frog species.

b. More complex analyses might include the identification of bird song by territory. It is well known that the songs of white crowned sparrow (Zonotrichia leucophrys) varies from territory to contiguous territory represented by regional dialect. These differences can be heard with an ear sensitive to subtleties of rhythm and pitch. Also, it can be recorded and analyzed by comparing the graphic representations on a sonogram - a visual indication of time, frequency and amplitude, of an iteration. There are several computer software audio analysis programs that are easy to use and understand. Using the same method, one can compare biophonies (the complex symbiotic orchestration of creature sound) from zone to zone in the same habitat and different habitats at similar times of day/night, season, and under certain weather conditions to see what remains similar and what appears to change as a general, nonspecific indicator and overview. In addition, and using the same analysis method, one can compare habitats before and after the introduction of human noise or before and after a fire, clearcutting, flooding or other natural disasters. In particular, this can indicate the ways in which certain creature voices might be masked and/or impeded.

c. Most complex levels in the hierarchy of analysis levels include the comparative study of noise-to-natural-soundscape issues. This requires a sophisticated knowledge of acoustics, statistics, GIS (Geographic Information Systems) mapping, and recording. Also, at this level, is a more detailed measurement of bioacoustic zones within zones, where biophony defines habitat. This, like noise-to-soundscape, requires a comprehensive knowledge of the fields noted above, with the additional working knowledge of local fauna and flora.

Data structure

Again, from simple to complex, one can arrange the data in any number of ways. Once, while recording at Gray Ranch, a 500 square mile former Nature Conservancy site in the panhandle of New Mexico, we acoustically identified over 40 microbiomes within the 5 square mile portion that was studied - all within a 50 foot altitude variation in the Sonoran-Chihuauan high desert area we worked.

Keeping the data simple and accessible is highly recommended. This includes clear, cross-referenced notes on the original recording (time/date, exact location, weather conditions, altitude, creature ID where possible, types of equipment used, a topographical or GIS map of the territory where possible, etc.), and archiving as noted earlier in the chapter.

Applications

No matter what form the structures or techniques take, the original collection of recorded data has far-reaching applications. As habitat destruction, in particular, and human noise, in general, increases, the rate of loss of natural soundscape is expected to accelerate. Therefore, absent the collective will to preserve and protect what remains, the importance of recording and cataloguing what exists on lasting media cannot be overemphasized. As a reference, for both education and general public information, natural soundscape as currently expressed at the beginning of the 21st Century, is a delicate fabric scientists and visitors will want to hear, know about, and hopefully preserve.

Conforming data for educational and interpretive purposes

There are many ways to conform the data into meaningful and revealing products. In the case of education, there are usually two methods used to explain sound. Generally, these are (1) from a species-specific perspective, and (2) from a contextual perspective as in biophony. The studio equipment used for this purpose is usually digital and consists of software and hardware that can accommodate editing and mixing of more than one stereo pair of tracks. There are many types available that range in price from a few hundred to well into five figures in both PC and Mac platforms. Use medium priced software for either platform. As these products change almost daily, we won't make any recommendations in this document but refer the reader, instead, to the nearest pro- or semi-pro audio dealer.

(1) Educational.

(a) Species-specific. Using this method, individual species are singled out from their aural context for study and review. It is thought that by abstracting these sounds, one can learn the individual voices which may include alarm calls, territorial vocalizations, song, contact calls, feeding calls, mating, etc. This can be particularly useful as an introduction.

(b) Biophony. By this method of study and review, species are heard in context (of all other sounds in a given habitat) and the learner is encouraged to distinguish patterns of relationships between one voice and all the others heard. From our perspective, even though a little more complex, it is the preferred method, because it makes clear from the outset that these voices "fit" as part of a bioacoustic fabric present in any undisturbed environment. It also can make clear the effect of noise on natural soundscape and creature behavior, not the least important of which is visitor experience in the Parks.

Glossary

acoustics - pertaining to the physics of sound.

acoustic ecology - the study of how sound in given environments affects humans and non-humans, alike. A term brought into the lexicon by R. Murray Schafer in the late 1970s.

analog - in the field of audio recording, it refers to the transformation of audio signals into electro-magnetic impulses which are then transmitted to and stored on audio tape made up of a mylar backing impregnated with particles of oxide (the size of smoke molecules) and held together by an adhesive process. As the tape moves by the electromagnetic heads of the recorder, the oxide is reconfigured into patterns corresponding to the audio input. These patterns can later be read on playback as an audio signal.

binaural - type of recording system that comes closest to the playback illusion of sound as we typically hear it coming from all perspectives (up, down, all-around).

bioacoustics - bio = life, acousics = sound. The sounds produced by living organisms.

biome - a specific type of habitat.

biophony - the combined sound that whole groups of living organisms produce in a given biome.

cacophony - a din of noise created by unrelated sound.

cardioid - heart shaped microphone pick-up pattern.

DAT - Digital Audio Tape

decibel (dB) - the common practical unit for the logarithmic expression for ratios of loudness, power, voltage, current, etc.

distortion - occurs when the normal shape of the audio wave form is altered in a manner that it no longer conveys the information cohesively. In professional terms, this occurs when the amplitude of a signal exceeds the ability of the technology to read or record it. That occurrence is referred to as clipping. Another type of distortion introduced by the inability of digital equipment to read very high frequency signals. This type is called aliasing. And yet another is introduced by the inability of a microphone to read and capture certain complex signals that contain unrelated harmonic content.

echo - the discernible repetition of a sound in both indoor and outdoor habitats.

equalizer – a device that can increase signal strength in selected portions of the audible spectrum in a recording.

filter – a device for attenuating selected portions of the audible spectrum.

frequency - the number of complete cycles of a periodic signal occurring in a given time span. The unit in general use is designated in terms of Hertz (Hz) and where 1Hz. is equal to one cycle per second.

geophony - non-human natural sounds such as streams, wind in the trees, thunder, rain, earthquakes, avalanches.

hertz (Hz.) - (see frequency)

hydrophone - an underwater microphone.

infrasound - usually referred to as those sounds lower in frequency (less than 20Hz) than the human capacity to detect.

loudness - refers to the perceived intensity of sound. Loudness is not always a measure of sound pressure level and can be sensed as being loud by virtue of its particular texture or timbre.

M-S - a two channel microphone system consisting of two different types of mics. One is a type of cardioid pattern; the second is a figure eight pattern. The resultant recording provides numerous options for archiving and mixing. An M-S decoder is required to transform a M-S recording into a conventional left/right stereo image.

microphone - a device that transforms vibrations transmitted through the air into corresponding electrical signals.

mix – any choice an artist makes with regard to what remains in the final expression of a recording.

monaural – a single channel recording designed for listening with one ear.

monophonic – a class of recorded sound originating from a single media track.

noise - for the purpose of this document, unwanted sound. Any sound that impairs accurate transmission of useful and helpful information.

octave - a difference in frequency (Hz.) of either double or half in relation to a primary tone. In a Western, diatonic music scale, the eighth tone in the musical scale higher or lower from a fundamental pitch.

optical sound track – a method of producing sound on film by a type of narrow bar-code-like stripe running along one side of the film strip. A beam of light is projected onto and through the stripe as it moves through the film projector sprockets. The beam, modulated by the dark and light patterns of the stripe, is picked up by a light-sensing photoelectric cell that translates the patterns into sound.

parabolic dish – a bowl-shaped apparatus designed to focus and capture sound from a distance.

pitch - often perceived as frequency but more subjective since it is dependent on both the loudness and timbre of the sound produced.

quiet - absence of noise but sometimes the inclusion of desired sound.

reverberation - repetitions of sound that are so closely spaced in time as not to be individually discernable. These phenomena occur in both indoor and outdoor environments.

signal-to-noise – in recording, this is the ratio of “useful information” or signal (i. e. what is desirable to record) to unwanted noise (i. e. noise produced by record electronics, or other background sound). If the signal is loud enough in relation to the noise, the noise will tend to be imperceptible.

soundscape - the entire acoustic environment of our lives.

sound sculpture - taking sound, the medium with which we work, and sculpting it much as artists in any "hard" form (clay, metal, ceramic, etc.) do. The results, when commissioned to the fullest extent of our technical and production capabilities, are three-dimensional performances that fill anything from small spaces to whole large rooms. Expressed in the pieces are textures (of a place), feelings of light and dark, negative and positive space, kinetics, color, form, tension and release, and, of course, content (location, concept, human/environment, day/night, spatial themes, etc.). Additionally, sound sculptures provide listeners with experiences that transport them to places otherwise impossible through the application of alternative media.

spectrogram - (also called sonogram or voice print) a visual representation of sound featuring time on one axis, frequency on another, and amplitude by light or dark gray scale of the image.

spectrum - in audio, the ability of a device (ear, microphone, recorder, etc.) to detect or reproduce sound. Humans have the ability to hear a frequency of between 20Hz and 20kHz. This is typically also defined as the normal range of reproducible sound in most professional and semi-professional recording gear.

stereo - a class of recorded sounds that typically begins with two microphones (or one system with two mic elements) set in relationship to one another so that the illusion spatial information of the environment is captured. For the purposes of this document, it includes XY, MS, and binaural recording.

timbre - the unique quality of a given voice or combination of voices which can signify the character of a particular bird, mammal or amphibian, instrument in a human orchestra, or combinations of instruments or creature voices (see biophony). Sometimes this sound characteristic is referred to as tone color.

tone - usually referred to as a constant frequency or pitch.

transducer – in recording, any device that either receives or transmits audio signals by converting one type of energy into another. These include microphones, headphones, and audio speakers.

ultrasound - usually referred to as those sounds higher in frequency (more than 20kHz) than the human capacity to detect.

XY - a form of stereo using two directional mics set in specific relationship to each other.

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Additional Resources

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Encyclopedia of Reptiles and Amphibians, Cogger, H. G., Academic Press, 1998

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Coral Reef Fishes, Lieske. E., and Myers, R., Princeton University Press, 1996

Music of the Birds: A Celebration of Bird Song, Elliott, L. Houghton Mifflin Press, 1999 (Book and CD)

Organizations to Contact

Nature Sounds Society, Oakland Museum, 1000 Oak St., Oakland, CA 94607 http://www.naturesounds.org. Programs and introductory field workshops.

Cornell University, Library of Natural Sounds, http://birds.cornell.edu/LNS/

British Library of Wildlife Sounds, http://www.bl.uk/collections/sound-archive/wild.html

NatureRecordists (naturerecordists@yahoogroups.com) - an informational chat format for field recording and technology at all levels of interest.

World Forum for Acoustic Ecology, http://interact.uoregon.edu/MediaLit/WFAEHomePage

Noise Pollution Clearinghouse, Les Blomberg, P. O. Box 1137, Montpelier, VT 05601-1137, Tel.:1-888-200-8332, http://www.nonoise.org

Quiet Down America: http://www.quietdown america.com

Wild Sanctuary, http://www.wildsanctuary.com