Anatomy of the Soundscape: Evolving Perspectives

Article *in* Journal of the Audio Engineering Society. Audio Engineering Society · January 2008

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ANATOMY OF THE SOUNDSCAPE: Evolving Perspectives

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The concept of the soundscape was first introduced by R. Murray Schafer in his 1977 book *Tuning of the World*. Schafer's definition of soundscape includes all of the sound from a particular environment that reaches the human ear. Schafer considered that we are linked to the natural world through its perceived voice, and he encouraged us to examine what first stirred human communities to form sound into cohesive and expressive patterns such as music, dance, and even speech. In the past several years, mostly as a result of technological developments in field recording and data analysis, it has become necessary to focus more specifically on the complex sources of soundscape acoustics in order to more accurately explain and probe the roots of this phenomenon. In the following article the soundscape is described as comprised of three basic active acoustic sources: biophony, geophony, and anthrophony. These sources are sometimes independent of one another while at other times intrinsically related in various combinations. In addition, the active soundscape can only be understood in light of the passive surrounding environment in which the source is transmitted. The connection between the natural soundscape and early human culture and spirituality will be addressed. Furthermore, this article will touch on the ways in which natural soundscapes are currently thought to be linked to the fields of ecological resource management, geology, medicine, biology, physics, sociology, and many other disciplines.

INTRODUCTION AND HISTORY

Schafer defined the soundscape as "the sonic environment ... any portion of the sonic environment regarded as a field for study." His approach to the study of soundscapes was greatly influenced by the need to respond to a serious gap in the traditional acoustic models otherwise informed by abstraction and deconstruction of the sounds of the natural world into vast collections of single species recordings. By characterizing acoustic phenomena in a more holistic manner, Schafer set the stage for whole new fields of discovery, particularly in Western traditions where most humans are primarily visually oriented and cued. Furthermore, his work left open the advancement of new language to describe acoustic occurrences as yet unexplained in our limited sonic vocabularies.

Despite a growing interest in the collection of natural soundscapes that began in earnest in the early 1980s, researchers were at a loss to express in a single term a particular component of the natural soundscape that included only the nonhuman sounds of biological origin in a particular habitat. In my 1998 book *Into a Wild Sanctuary*, I coined the term biophony—derived from bio (Greek for life) and phon (Greek for sound)—to express the combined aural sensation that groups of living organisms produce in any given biome. However, two other major acoustic components that comprised the complex sound environment as experienced by humans were still left unrevealed.

In 2001 and 2002, under contract to the National Park Service (NPS) to create a baseline data bank of soundscapes from different habitats within Sequoia National Park, I worked with Stuart Gage of the Envirosonics Lab at Michigan State University <www.cevl.msu.edu/envirosonics/maindocs/resources.htm> to consider additional terms to flesh out the remaining elements of the soundscape. In our NPS report, "Testing Biophony as an Indicator of Habitat Fitness and Dynamics," Gage posited that two other components were required to complete the overview. One was the term geophony: the nonbiological sources of natural sound, such as landslides, wind, weather, water, and geophysical acoustic phenomenon (earthquakes, avalanches, volcanoes, and other geothermal events). And finally, he added anthrophony, defined as all of the human-generated sounds that occur in a given environment: physiological (talking, grunting, body sounds), electromechanical, controlled sound (music, theater, etc.), and incidental (walking, clothes rustling, etc.).

BIOPHONY

By far the most complex and laden with information, this unique feature of the soundscape is comprised of all of the biological sources of sound from microscopic to megafauna that transpire over time within a particular territory. In biomes rich with the density and diversity of creature voices, organisms acoustically structure their signals in special relationships to one another, cooperative and/or competitive, much like instruments in an orchestra so that each one can be heard distinctly from another, thus reducing the chance of masking effects. Originally labeled the niche hypothesis, this partitioning of animal voices into temporal, fre-

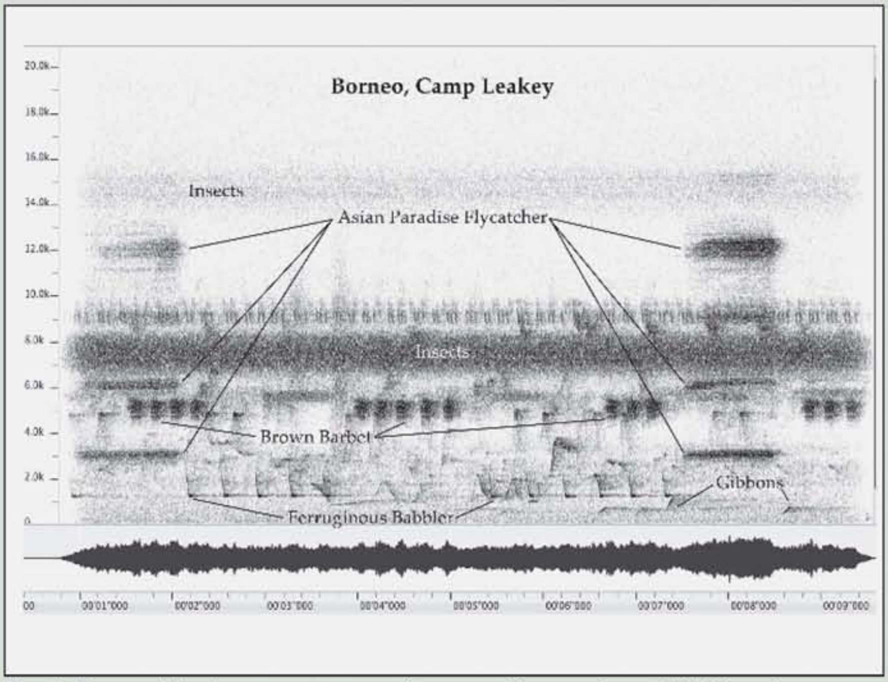

Fig. 1. Borneo biophony spectrogram (courtesy Krause, from *Wild Soundscapes: Discovering the Voice of the Natural World)*

quency, and spatial niches provides indicators of habitat viability and certainly once inspired humans to realize music and language (see Shepard's *The Others: How Animals Made Us Human*). The spectrogram in Fig. 1, taken from a short 10-second audio clip recorded in Borneo, is an example of such partitioning. In this display are the sounds of birds, insects, frogs, and mammals, each in its own temporal, frequency, and spatial niches.

Only a few references exist in academic literature that directly focus on the notion of the aural interdependence of vocal organisms in a given biome. In "Sound Transmission and its Significance for Animal Vocalizations: I. Temperate Habitats," Marler and Marten suggest the possibility that creatures may be vocalizing in some yet-to-be explained relationship to one another. In his 1909 paper "Umwelt und Innenwelt der Tiere," von Uexküll, a behavioral physiologist of the early twentieth century, refers to the notion of sensory niches in general. More recently in "Cicada Acoustic Communications: Potential Sound Partitioning in a Multispecies Community from Mexico," Jérome Sueur, a French etymologist, has demonstrated how biophonic partitioning takes place between multiple species. According to Sueur, "All these specific [acoustic] features appear to separate the ... species acoustically and lead to a partitioning of the acoustic environment."

More recent allusions give support to the thesis that we are quite late realizing the major import of specific acoustic niches and their relevance in natural world behavior. While aural niches have long been known and put to practical application by many nonindustrial cultures globally, in the chronicles of science, it is only within the final two decades of the twentieth century that initial inquiries were made by Western academics considering the implications of this phenomenon and reviving it as one of importance. It is a period when entire biomes are disappearing at a rate so rapidly that within this century there may be none left to record of any type unaltered or intact without the presence of human noise.

The concept of biophony may hold the key to many unanswered questions related to the human effect on various environments. The noise generated by humans may be harming the incredible biophonic bounty that untrammeled wild places have to offer. A deep connection to the natural world depends on our ability to keep natural soundscapes in general, and biophony in particular, intact; keeping them intact despite a sharp drop in habitats throughout the world that can be heard in their natural state without the incessant intrusion of anthrophony.

In undisturbed natural environments where human noise is either minimal or nonexistent, the idea that creatures can be heard vocalizing in special relationships to one another has been well understood in many human forest-dwelling groups since the ice last receded eons ago. It was a time when humans were able to "read" the stories revealed in the natural soundscape (see *Babaka: The Extraordinary Music of the Babenzélé Pygmies* by Sarno) in much the same way that histories are now disclosed in the books we get from the library. It was also a time when groups of humans utilized the biophony as a natural karaoke orchestra, singing to it and with it; thus, it was that animals taught humans to dance and sing.

On land, in particular, this delicate biophonic fabric is as well defined as the notes on a page of music when examined graphically as spectrograms. For instance, in many healthy habitats, certain insects occupy specific frequency and temporal niches of the creature bandwidth and moment, while birds, mammals, and amphibians occupy others not yet taken and where there is no competition. Thus the biophony, which only human quietude makes plain, has evolved in a manner so that in many habitats each voice can be heard distinctly and each creature can thrive as much through its iteration as any other aspect of its being. The same types of events also occur within marine environments. Aside from a habitat's physical condition, the biophony also conveys data about its age and level of stress and can provide an abundance of other valuable new information; especially the ancient connection between collective forest voices and human music, dance, and spirituality, as described by Feld in *Sound and Sentiment: Birds, Weeping, Poetics, and Song in Kaluli Expression.* (The terms "voices" and "singing" will be used throughout this text in a loose sense to represent all forms of sound-producing mechanisms and sound signatures, like stridulation, oscillation of wings, chomping and crunching of mouth parts, movement through different media like digging through soil or the pith of a tree, and with some organisms possibly by the signature of metabolic rate alone.)

GEOPHONY

Geophony is framed as natural sounds emanating from nonbiological sources in a given habitat. Generally, this is broken down into four subfields: the effects of wind, water, weather, and geophysical forces.

One cannot hear or record wind, per se. Only its effects can be perceived: wind rustling leaves or grasses; the sound of pitched wind blowing around snags or across the open end of reeds by a lake or river; wind through the needles or branches of conifers in a forest; wind causing the branches of trees to rub together and creak; wind in a microphone as it blows across the capsule. The only gray area might be the breath of animals, human and nonhuman, in an environment. This spiritus (breath, in Latin) may be the main intersect between the biophony, geophony, and anthrophony because in many cultures, whether its origins are trees in a forest or a creature breathing, the effect is recognized as a significant source of spirituality (see Abram's *The Spell of the Sensuous*).

Sounds created by water have many intricate permutations. For instance, each ocean beach of the world, as a consequence of its rake, composite materials, weather patterns, salinity, water temperature, and other dynamics has its own acoustic signature. The beach at Coney Island east of New York City will (and does) sound—over its entire dynamic range—very different from the beaches in Dar es Salaam on the Indian Ocean in Tanzania, Ocean Beach in San Francisco, or Ipanema in Rio de Janiero. Natural streams in still viable riparian habitats create a wide range of sound depending on terrain, vegetation, time of day, season, precipitation, and flow rates. Each, given a series of combined natural dynamics, likewise creates its own acoustic signature. Fresh- and salt-water inland lakes, no matter what their size, create shore waves that tend to be much more rapid in sequence and frequency than those at the ocean. And they sound vastly different from each other depending, again, on surrounding habitat, position of the listener relative to the sources, and all of the other conditions described earlier in this paragraph.

Weather creates its own range of acoustic variations. Thunder can be perceived as distant or nearfield, dry (as in a desert environment), reverberant (as in many rainforests), or accompanied by rain and/or wind. Wind can be raging or light, gusty or a gentle, constant breeze. Sometimes combined with other weather elements, it can have the force of a tornado or hurricane. Rain at different rates often accompanies phenomena described as "weather" and in so doing creates its own acoustic signature depending on its environment: urban, natural, or rural. Variations over land or sea result in different soundscape experiences, altogether. And, finally, snow creates an acoustic environment that is as variable in range as conditions can be imagined or experienced.

Geophysical sound sources include among others avalanches, earthquakes, thermal mud-pots, and the whole mass of a glacier as it calves, melts, or advances slowly over the terrain forming the moraine. These permutations, too, depend on the listener's perspective.

The notion that there can be a profound effect on soundscapes by the introduction of human-induced noise, anthrophony, has long been understood by nonindustrial cultures dependent on the integrity of undisturbed natural sound for determining a sense of place as well as for spiritual and aesthetic reasons. In fact, the very physical and mental health of earth-centered groups with their respective feet on the ground, spread out from the equatorial to polar regions of the planet depends, in large part, on the special relationship between the undisturbed natural soundscape of their habitat and themselves. Anthrophonies, particularly the unregulated, incidental, random, and mechanical kinds, have a profoundly negative effect on those essential connections. The same is true for those humans living in noisy cities who endure stress levels that impair both the quality of life and health (see *The Noise Manual* by Berger and "Noise and the Sacred" by Lyon in the May/June 1995 *Utah Wilderness Assoc. Review*).

The anthrophony consists of four types: electromechanical, physiological, controlled sound, and incidental.

James Watt, U.S. Secretary of the Interior during the Reagan presidency, once observed that noise and power go hand in hand. The machine that operates quietly—industrial, personal, recreational, military, political—is much less impressive. "The increased domination of the soundscape by machine noises," according to Murray Schafer, "has up to now been sanctioned as progressive: the hum and throb of a good motor is a symbol of authority and prosperity." At a conference related to natural soundscapes initiated by the U.S. National Park Service in the year 2000, a biologist from Aberdeen Army Proving Grounds described how researchers there employed Howitzer cannons to frighten birds from the runways. He went on to say, "... and cannons, of course, are the sound of freedom," his point being that noise of certain types has symbolic value: the noisier we are the more powerful we are perceived to be.

Figs. 2 and 3 are graphic (sonogram) examples of the effect of a military jet fighter performing "contour flights" (flying at approximately 100 m above ground level regardless of the terrain) over the Mono Lake Basin, just east of Yosemite National Park in the Sierra Nevada Mountains. Pilots from the Naval Air Station in Fallon, Nevada, north of Yosemite, and from Lemore Naval Air Station in the southern part of California often use these areas as training grounds. The effect on wildlife and the soundscape as a direct result of these intrusions is notable. Spadefoot toads (*Spea intermontanus*) emerge from under the high desert surface only when conditions are optimized—a circumstance becoming more rare with each passing drier and warmer season—to breed, lay eggs, and mature before digging down a meter into the difficult terrain where they remain sometimes for years encased in an almost impermeable membrane before surfacing to go through their cycle once again. When they do appear,

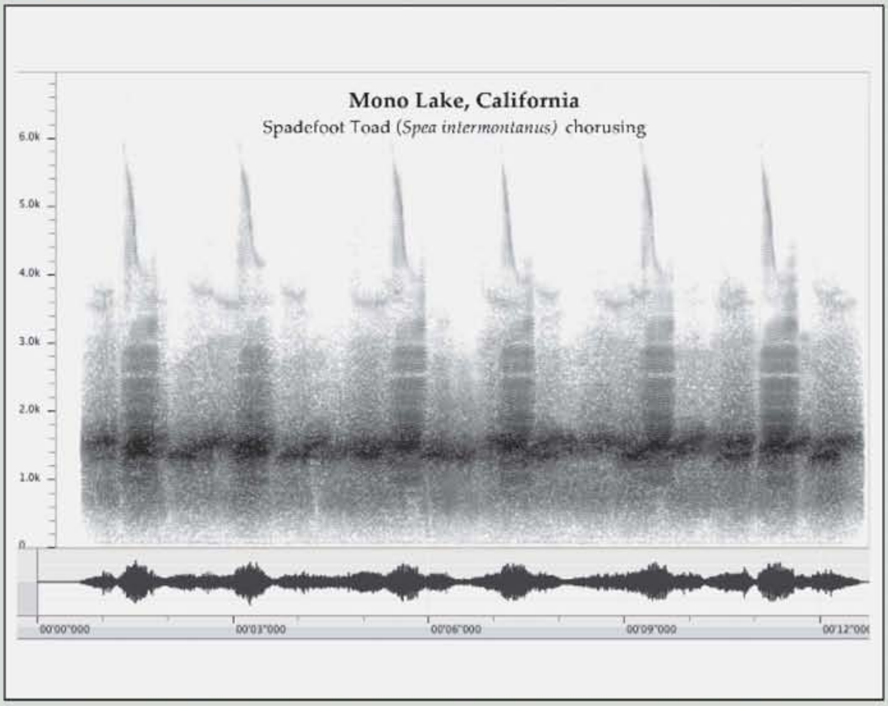

Fig. 2. Sonogram of a 10-second audio clip of spadefoot toad chorusing without jet flyover.

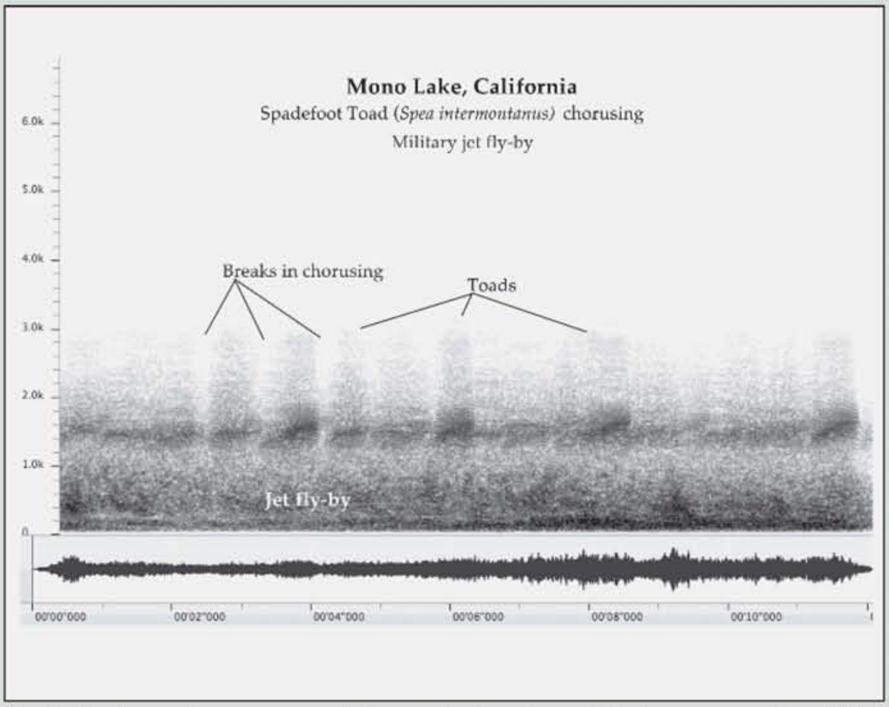

Fig. 3. Jet flyover interrupts spadefoot toad chorusing, which increases vulnerability to predation.

they gather around vernal ponds to vocalize in well-calibrated choruses. This is done so that predators, especially the great horned owls (*Bubo virginianus*) and coyotes (*Canis latrans*), have difficulty hearing any one toad. Fig. 2, a sonogram of a 10-second audio clip, demonstrates spadefoot toad chorusing without any breaks in the sequence. Fig. 3 demonstrates what happens to the spadefoot toad chorusing when military jet noise masks the toad vocalizations. Note the breaks in the chorusing and how the toad chorusing energy diminishes. These breaks allowed predation to occur immediately after the overflight. Spadefoot toad populations in the Eastern Sierras, especially around Mono Lake when low-level military jet overflights began, have dropped precipitously since acoustic monitoring was first initiated in the mid-1980s. This occured in conjunction with a worldwide decline during this period in frog and toad populations in general, as reported in "Status and Trends of Amphibian Declines and Extinctions Worldwide" by Stuart et al. in 2004 in *Science*.

Other examples of the masking and disruption effects on the biophony because of the noise created by straight-piping motorcycles, ATVs (all-terrain vehicles), ORVs (off-road vehicles), jet-skis, powerboats, snowmobiles, generators, chainsaws, certain types of light, commercial, and military aircraft, and some types of automobiles are numerous and disturbing. For instance, I live 18 miles (29 km) from a NASCAR race site. For acoustic energy to reach my home, it must travel over two small mountain ranges, a small wetland, many farms, and two villages to get to where we live. Yet I am able to hear and record the drag races whenever they occur on any given Sunday in July or August, even with the wind blowing in the opposite direction.

THE HUMAN NOISE ISSUE

Industrial noise is regulated in many European countries, but in the United States the legally acceptable levels, although monitored and controlled, remain a significant health issue. In many cases, dangerous levels exceed even those allowed by regulatory agencies (OSHA) and have seriously affected workers in industrial and urban environments. Because noise carries beyond the borders of industry, it also affects wildlife.

In the 2002 paper "Snowmobile Activity and Glucocoricoid Stress Responses in Wild Wolves and Elk" in *Conservation Biology*, Scott Creel of Montana State University reported that the acoustic presence of snowmobiles in Yellowstone, Voyageurs, and Isle Royale National Parks caused the stress enzyme levels in elk and wolves to elevate notably. The glucocorticoid stress responses, an enzyme found in the feces of these animals, diminished to normal levels when snowmobiles and attendant noise were not present. In human subjects, noise studies from the early 1980s (see "Noise and Stress in Humans" by Raloff in 1982 *Science News*) confirm the rising stress level indicators even though the subjects were consciously unaware that their bodies were reacting to the introduced sound.

Physiological human sound created by talking, grunting, or involuntarily by the body is by far the least intrusive but is still, at times, problematical. Controlled sound, such as that produced in enclosed or limited theatrical or cinematic settings, where music or theater is performed, is not usually an issue except for venues and shows relying on excessive levels. Incidental sound induced by walking, clothes rustling, sneezing, or coughing would only create a sense of presence in some settings that would cause alarm to particularly sensitive animals.

SOUNDSCAPE ECOTONE

A sizeable intersect of disciplines comes into play when trying to comprehend the biophony. This phenomenon cannot be fully explained without recognizing the complex roles geography, humidity, wind, weather, vegetation density, time of day or night, and season play in this scenario. While the biophony, geophony, and anthrophony comprise the active sound sources, another important passive element is germane to the reception and experience of the soundscape, a feature left omitted from the earlier historical equations. This concept is discussed by Blesser and Salter in the 2007 book *Spaces Speak, Are You Listening?* As a general example, in many terrestrial and marine habitats, the creature vocal behavior of certain birds, insects, amphibians, reptiles, and mammals has evolved to occur at night when dew settles on the ground or on the leaves and branches of trees. For some nocturnal terrestrial creatures, whose voices need to carry over distance, the nighttime serves as a reverberant theater and becomes the most productive time to vocalize. A nightjar called the Pauraque (*Nyctidromus albicollis*), hyenas (*Crocuta crocuta*), baboons (*Papio anubis*), coyotes (*Canis latrans*), and wolves (*Canis lupis*) often choose those acoustically reflective habitats or special times when the conditions in the environment produce reverberation in which to vocalize. Some creatures, such as baboons, will alter their vocal expression to accommodate the acoustics of the landscape. Elk (*Cervus canadensis*) rutting in the fall often use the echoes of the forest to project their voices in order to extend their territory and secure their harems. Some insects, birds, and mammals like to vocalize when the habitat dries out, such as after sunrise when the forest has given up its surface moisture and when the sonic territory becomes redefined by the acoustic properties of the habitat. In marine habitats, water temperature, salinity, and currents in a diverse environment of different bottom contours alters the transmission of sound in both subtle and profound ways. Killer (*Orcinus orca*) and humpback (*Megaptera novaeangliae*) whales sometimes vocalize in air, bouncing their voices off nearby cliffs near the shores of Glacier Bay, Alaska and other environs such as Johnstone Straight along the eastern shore of Vancouver Island in Canada (see my 2002 book *Wild Soundscapes: Discovering the Voice of the Natural World*). Blesser has observed: "We know that any given acoustic environment hosted competing species with competing solutions to the task of survival. Each species evolved its specific solution in response to the solutions adapted by other species. A summary of the basic acoustics of early environments illustrates the evolutionary complexity of adapting the auditory system and vocalization strategies to a local ecology. Evolution provided both genetic and learning adaptation so that small groups could respond to the specifics of local environments. Both solutions are evident in a variety of species."

The soundscape is unusual because to capture and understand it to any degree one will necessarily have been engaged with a conscious or unconscious working knowledge in any of several fields. This is especially important to note because of its implications for education. Many young individuals these days tend to block out or deny the effects of the acoustic world in which they live. Sound emanating from iPods, video games, and new digital technologies being introduced almost daily into the culture aggressively masks the noise of the industrial and natural world with multiple layers of additional noise at levels often measurably harmful. But perhaps these phenomena can be put to informed use. Based on the extent to which these recent acoustic structures can be broken down and understood from the perspective of those engaged with these sonic events, educators may be able to reach out and connect with more impressive results in many areas. These various disciplines are discussed below.

Biology (bioacoustics)

Every living organism is potentially capable of creating an acoustic signature. This field involves an examination of known and already-recorded species and an evaluation of techniques to capture the signatures of those not yet noted from microorganisms to megafauna, as exemplified by Cooper in "Direct and Sensitive Detection of a Human Virus by Rupture Event Scanning" in the September 2001 issue of *Nature Biotechnology*. In addition, emphasis is given to the study of whole systems that include the soundscapes of larger areas of terrestrial and marine venues.

Additional areas of inquiry include ethology of animal acoustic communication and associated behavior: evolution, ontogeny and development of acoustic behavior, sound production anatomy, and neurophysiology. Further areas of investigation embrace auditory capacities and hearing and vocalization mechanisms of animals including sound-reception capabilities. The areas of inquiry also comprise bioacoustic sensing: avian, whale and dolphin, fish, fisheries, and plankton, insects, echolocation of bats and dolphins, infrasonic signals, relationships between animal sounds and their environment, use in population assessment, identification, and behavior, and the effects of human-made noise on animals. Another area is the application of acoustic signals for taxonomic studies and calibrating biodiversity and other practical bioacoustic applications.

Field protocols, encoding, streaming formats for delivery, information ➡

storage, search and retrieval, mixing, and postprocessing systems are part of the scope of enquiry.

Computational mathematics

This discipline evaluates the current analytical frameworks used to interpret acoustic phenomena in heterogeneous landscapes. These include a review of relevant hardware and software to record, process, and analyze massive amounts of acoustic signals correlated with satellite imagery. The analysis of soundscapes provides the information necessary to study the relationships between the spatial and temporal distribution of unique species and the environmental characteristics of their habitats, including the amounts and configurations of land-cover types. Both local-scale spatial variables, such as distance to edge in a habitat patch, and landscape-level spatial variables, such as proportions of different land-cover types in areas surrounding habitat patches, may influence the species composition and distribution of a region.

Physics (acoustics)

Acoustic signals transmit differently in different habitats depending on time of day, weather, season, geological conditions, flora types and density, and sources. An understanding begins with fundamental acoustic premises and expands to more complex theories of natural transmission of sound in different types of biomes, structures, and through different media.

Anthropology

The connection between natural soundscapes and the development of human language, music, physical expressions such as dance, and spirituality is essential for an understanding of human cultural development. From the perspective of the soundscape, the investigation meets at the intersection between humans and their acoustic environments, including the impact natural, rural, or urban acoustics have on individuals.

Music

The origins and development of human music are influenced by the natural soundscape, biophony, and geophony in particular. Historically, the question addresses ways in which the natural soundscape affected or influenced musical development throughout history particularly in the cultures living closely connected to the natural world. Given the current paucity of natural soundscapes, what influences can the urban-trained composer utilizing either traditional or newer media models derive from what remains of the natural world? How can the natural soundscape help us recalibrate our sensitivity to sound? What does music of the past 300 years that claims links, however ephemeral, to the natural world reveal about our relationship to the wild?

Natural history

The study of how and why the human experience of natural sound has developed in the manner it has over the course of human history is addressed. The effect of anthrophony on the behavior of nonhuman organisms should also be considered.

Environmental studies

The impact of soundscapes (biophony, geophony, and anthrophony) on whole ecosystems is an important subject yet to be considered. For instance, what information is revealed by each component individually and collectively? How have our perspectives of the natural world been influenced by the ways in which natural sound is generated by specific sources?

Resource management

From the perspective of resource management, as the interrelationships of biophony, geophony, and anthrophony on whole ecosystems are revealed, the interaction between soundscape components and the ways in which these relationships may be employed as additional tools for evaluating habitat health are also revealed.

Sociology

An examination of the ways in which different socioeconomic groups experience the soundscape (urban, natural, rural) and the impact on human life is an essential step in our understanding of place within the natural world. In particular, the impact of noise (unwanted or random) on the life experience may be studied and evaluated in comparison to those not affected by this intrusion on everyday life.

Perceptual differences in soundscapes between normal and impaired (visual and hearing) subjects and methodology designed to engage and inform the public about the creation, protection, or perception of valued local soundscapes can thus be effectively framed into the cultural education.

Medicine

Indigenous cultures living in conditions more closely connected to the natural world have long understood and relied on the healing properties of their environment when sick or under stress from outside sources. In several human groups, the natural soundscapes of the forest are utilized as an analgesic that serves to heal many types of pathologies. The focus concentrates on studies now under way or being developed and addresses how natural soundscapes may be employed to relieve symptomatic or systemic disorders such as asthma, tinnitus, stress, and hypertension. Furthermore, these studies test the efficacy of both anxiety and perceived pain reduction related to procedures where natural sound can be delivered as an analgesic. And finally, natural soundscapes are also shown to have palliative applications in hospital settings either as masking sound, alarms or operational equipment noise replacement, or general ambience to make stays in those types of sterile environments shorter (because healing is more rapid) and more pleasant.

GIS/GPS related to the acoustic landscape

While maps have been overlaid with information pertaining to geographical and land-cover features, the map of the soundscape has yet to be explored or fully realized. Currently we are interfacing with Google Earth to develop soundscape zooms to give a new layer of acoustic meaning to the visual aspects of mapping (go to earth.wildsanctuary.com/index2.htm). Studies of how this soundscape layer (urban, natural terrestrial, and marine) can be addressed and employed will be the subject of this discipline.

Psychology

The psychological effects of noise (anthrophony) on the human condition are well known. The psychological effect of natural sound on urban human responses has yet to be thoroughly evaluated. This series of courses will address a review of the available literature and investigate ways in which this area of discovery might be further studied, including childhood development and treatment possibilities.

Communications (sound and web design)

Sound design has been utilized in media (theater, broadcast media, public spaces, the Internet) for as long as each medium has been in existence. However, the use of natural soundscapes as a vital and expressive resource in these media, especially in public spaces such as museums, aquariums, and zoos, is relatively recent. Despite the fact that expressive new technologies—delivery systems that control levels automatically, identify animal voices within the context of the programs, and which are nonredundant—have been available for almost two decades, their application in public spaces have been not utilized extensively.

Philosophy

The information contained within natural soundscapes gives us a perspective of the world in which we live. An ontological understanding of that expression provides a mirror to reflect the biological niches we inhabit. Furthermore, the soundscape gives us insight into how well we are doing in relationship to the nonhuman critter world outside of our awareness. For some the connection is spiritual, while for others the link is merely a numbers game: scientific, abstract, and secular.

Western and Eastern literature

Western literature has thoroughly addressed the visual aspects of our world. But little has been written about aural components. To close this gap, there is a need to examine references from biblical times to the present where sound plays a role in the expression of the world in which we live. New perspectives reveal how literature is defined, its relative importance to the other senses, and the ways in which different authors have articulated their experiences of the issue. Based on the sources of the various storytellers, the narratives are very illustrative the aural components of the encounters.

Business

Soundscapes are a resource for business. Currently used in film, public spaces (theater, museums, zoos, and aquariums), games, and on the Internet, each soundscape has inherent and intrinsic value as intellectual property to be studied, developed, and licensed. Archival library holdings and academic curricula can be explored with other educational and commercial models to extend the reach and dynamic collaboration of work in progress. Special emphasis on the pairing of research and technology development in multiple media offers exciting potential for new product development in a variety of applications.

Architecture

Most architectural spaces of the 20th and early 21st centuries (except theaters and concert halls) have been developed and created from the visual perspective. Little attention has been paid to the acoustics of most public spaces and the ways in which psychoacoustics determines, to a large extent, how humans react to and what they experience within those spaces. A new realm of enquiry, as discussed by Thompson in *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America*, examines the history of acoustic architecture and addresses those spaces that are successful or unsuccessful in terms of their sonic environments. Special emphasis is placed on nontheatrical public spaces such as museums, aquariums, zoos, spas, hospitals, and lobbies because of their stated missions and the manner and extent to which architectural acoustic engineering has helped meet those criteria. Sound design ideas for the new "greener" LEED (Leadership in Energy and Environmental Design) construction will be addressed with site-specific approaches to promote the building of better and healthier urban and green-space environments. Also being developed are quieter and energy-conserving HVAC (heating, ventilation, and air conditioning) design techniques, the use of renewable resources in sound design, quality of life designs, and enhancing landscapes by using bioacoustic treatments.

CONCLUSION

As an aural expression of the physical and spiritual worlds, the natural soundscape in particular carries within it a huge resource of seminal information. We have come to understand the limits of isolating single species from the context of their environment, deconstructing and recording them and trying to derive meaning, while the biophonies of entire biomes contain so much more detail about the ways in which sound sources are related to one another and what the links mean. We have also come to understand that the music we've created has been influenced by the natural world and contains messages that are the complete opposite of what the composer claims to have intended, thus reflecting older scientific approaches and cultural attitudes. As stated by Ferry in *The New Ecological Order*, "Nature is beautiful when it imitates art."

Meanwhile, the affects of anthrophony on the human and nonhuman animal worlds are just now beginning to be understood for the profound levels of stress and impairment these sources create. As a key to a greater understanding of the physical world in which we live, the study of soundscapes brings one into contact with a working knowledge of many disciplines, adding important new layers of insight. The will to listen in new and discriminating ways is germane. The soundscape contains within it the seeds of new approaches to education (through acoustics) in ontological ways yet to be thoroughly developed because the field is relatively new. The implications in terms of defining and creating new models for managing urban and natural environments, resources, and approaches to human health are formidable. Once the relationships between biophony, geophony, and anthrophony are more thoroughly understood, we will be able to make more informed decisions about our respective environments that will carry much more weight and make our world a more healthful place in which to live.

ACKNOWLEDGMENTS

The soundscape idea as it has materialized surfaced largely because of the insight of three individuals and a group heretofore unrecognized. The concept was first identified by R. Murray Schafer who defined the skeleton during his tenure at Simon Fraser University in the 1970s and whose seminal efforts brought soundscapes to the surface. Sinew and muscle were added by Stuart Gage from the Envirosonics Lab at Michigan State University. He put names to several of the important appendages. For an unfailing eye and ear, a thorough review of and response to early drafts of this article, and for putting into place a major piece of the puzzle (active versus passive elements), Barry Blesser (former MIT professor and a founder of digital audio) added both face and form. And finally, to the valiant nature recordists who have steadfastly risked life, limb, and financial security to capture the few remaining natural soundscapes that exist in this world, my gratitude and admiration.

AUTHOR

Since 1968, Bernie Krause has traveled the world recording and archiving the sounds of creatures and environments large and small. Working at the research sites of Jane Goodall (Gombe, Tanzania), Birute Galdikas (Camp Leakey, Borneo), and Dian Fossey (Karisoke, Rwanda), he identified the concept of biophony (a.k.a., The Niche Hypothesis) based on the relationships of individual creatures to the total biological soundscape within a given habitat. Through his company, Wild Sanctuary, he has recorded over 40 natural soundscape CDs, and he creates interactive environmental sound sculptures for museums, zoos, and aquaria throughout the world. During his life as a professional studio musician, he and his late music partner, Paul Beaver, introduced the synthesizer to pop music and film. Their work can be heard on over 250 albums and 135 feature films between 1967 and 1980. Krause's latest book is *Wild Soundscapes: Discovering the Voice of Natural Soundscapes* (Wilderness Press, 2002).