Aircraft Overflights Quarterly Focus - Fall 2004

Last quarter's Focus article was on the "***Report on Effects of Aircraft Overflights on the National Park System***" to Congress. The article was a review of the original goals and objectives written for Grand Canyon National Park (GCNP) as part of the National Park Service's (NPS) efforts to substantially restore natural quiet to the canyon.

This quarter's article is an educational effort to provide definitions of terms used in sound characterization and sound measurements conducted at GCNP. The following list of terms and definitions are being used by the NPS National Sounds programs:

Glossary Of Acoustic Terms

Acoustics
: The science of sound.

Ambient Sound, Existing
: All sounds in a given area (includes all natural and all human-caused sounds).

Ambient Sound, Natural
: The natural sound conditions found in a given area, including all sounds of nature. The natural ambient sound level of a park is comprised of the natural sound conditions in a park which exist in the absence of mechanical/electrical human-produced noises. Some human-caused sounds (talking and walking) may be part of the natural soundscape, but not those generated by mechanical, electrical, or other non-natural means. These conditions are actually composed of many natural sounds, near and far, which often are heard as a composite, not individually. In an acoustic environment subjected to high levels of human-caused sound, natural ambient sounds may be masked by other sound sources. Natural ambient sound is considered synonymous with the term "natural quiet," although "natural ambient sound" is more appropriate because nature is occasionally not quiet.

Ambient Sound, Traditional
: All sounds in a given area excluding the specific sound of interest. For example, when assessing the potential impacts of air tour aircraft, the ambient sound level less source of interest would be all sources of sound except air tour aircraft.

Ambient Sound, Non-natural
: The ambient sound level attributable to human activities. The sound levels associated with these sounds are usually composed of many human-caused sounds, near and far, which may be heard individually or as a composite. In a national park setting, these sounds may be associated with activities that are essential to the park's purpose, they may be a by-product of park management activities, or they may come from outside the park. These sounds and sound levels need to be measured and evaluated in park planning processes to determine whether they are consistent with or destructive to soundscape management objectives.

Amplitude
: The instantaneous magnitude of an oscillating quantity such as sound pressure. The peak amplitude is the maximum value.

Area of Audibility
: The area within which a specific sound or sounds are audible.

Audibility
: A measure of the biological properties of sound. Audibility is the ability of animals with normal hearing, including humans, to hear a given sound. Audibility is affected by the hearing ability of the animal, and by the frequency

content and amplitude of the sound. Use of the term as an acoustic measure and an indicator of potential impact on the natural soundscape and on species residing in the area of that soundscape has been challenged from some quarters as it may be interpreted to mean impacts only on visitors. Use of audibility in soundscape management has applications beyond the ability of humans to hear a sound, and it will be used as appropriate. In search of a more apt term, wherein several have been suggested (detectability, discernability, noticeability, etc.), none better has been found. Human-caused sound is often audible to wildlife and humans far from the sound source. The impact on natural sound is represented by a "sound footprint" or a "soundprint," the area where the sound level from the source is greater than the natural ambient sound level. This soundprint occurs whether or not there are people or animals present to hear it. Soundprint is an indicator of the area of direct impact of a noise source on the soundscape. The noise source could, as a secondary or indirect impact, affect visitor experience, wildlife habitat, cultural or ethnographic resources, or other resources and values.

Average Sound Level (L_{AVG})

The logarithmic average of the sound level during a specific measurement period. If an Exchange Rate of 3 is used, then L_{AVG} is the same as L_{TWA} and the same as L_{eq}.

Decibel

A logarithmic form of any measured physical quantity and commonly used in the measurement of sound. The decibel provides the possibility of representing a large span of signal levels in a simple manner as opposed to using the basic unit Pascal. The difference between the sound pressure for silence versus a loud sound is a factor of 1,000,000:1 or more, and it is not practical to use these large numbers.
Doubling of Sound Pressure = 6 dB
Doubling of Sound Power = 3 dB
Doubling of Perceived Sound Level = 10 dB (approximately)

Energy Equivalent Sound Level (L_{eq})

The level of a constant sound over a specific time period that has the same sound energy as the actual (unsteady) sound over the same period. In park situations, L_{eq} is useful for quantifying intruding sounds because its magnitude depends heavily on the loudest periods of a time-varying sound. L_{eq} of an intruding source by itself, however, is inadequate for fully characterizing the intrusiveness of the source. Research has shown that judgments of the effects of intrusions in park environments depend not only upon the amplitude of the intrusion, but also upon the sound level of the "background," in this case, the sound level of the non-intruding sources, usually the natural ambient sound levels. L_{eq} must be used carefully in quantifying natural ambient sound levels because occasional louder sound levels (gusts of wind, birds, insects) may heavily influence (increase) its value, even though the sound levels are typically not so loud.

Events per Hour

The number of times a human-caused source is heard, on average, in one hour (this may be specific to a particular human-caused sound or to all human-caused sounds). If this information is known, presentation and documentation provides another easily comprehended measure of how often the particular intruding sounds are heard. It provides an additional means for communicating the sense of the soundscape.

Frequency

The number of times per second that the sine wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz). Frequency equals Speed of Sound / Wavelength.

Hearing Range (human)

A healthy young person generally can hear frequencies from approximately 20 Hz to 20000 Hz, and sound pressure levels from 0 dB to 130 dB or more (threshold of pain). The smallest perceptible change is 1 dB.

Infrasound

Frequencies below 20 Hz. Humans perceive frequencies below about 20 Hz as pressure rather than sound.

Loudness

The subjective judgment of intensity of a sound by humans. Loudness depends upon the sound pressure and frequency of the stimulus. Loudness was defined by Fletcher and Munson (1933) as a physiological description of the magnitude of an auditory sensation. The definition of loudness was later refined as a definition of the attribute of

auditory sensation corresponding most closely to the physical measurement of sound intensity, but is not always accurate. Loudness is a subjective quantity and all measurement techniques are based on assumptions and interpretation.

Masking

The process by which the threshold of audibility for a sound is raised by the presence of another (masking) sound. A masking noise is one that is intense enough to render inaudible or unintelligible another sound that is also present.

Noise

Traditionally, noise has been defined as unwanted, undesired, or unpleasant sound. This makes noise a subjective term. Sounds that may be unwanted and undesired by some may be wanted and desirable by others. Noise is sound, as defined in this document: a pressure variation, etc. In order to keep terms used in soundscape management as non-subjective as possible, sounds should be classified as either appropriate or inappropriate, rather than as "noise." or "sound." The appropriateness of any sound in a given area of a park will depend on a variety of factors, including the management objectives of that area.

Noise Free Interval (natural sounds only)

The length of the continuous period of time during which only natural sounds are audible. Though little research has been conducted to relate how this measure correlates with visitor judgments or with common experiences in park settings, it should provide a reasonable measure of the existence and availability of periods with only natural sounds. It is also a metric that requires no acoustics knowledge to be meaningful. Over the coming years of soundscape data collection, the NPS will acquire such data and develop an understanding of how this metric can best be used to aid in assessing and managing park soundscapes.

Octave Band

The segment of the frequency spectrum separated by an octave.

Percent Time Above Natural Ambient

The amount of time that sound levels from human-caused sound(s) are greater than sound levels of natural ambient sounds in a given area. This measure is not specific to the hearing ability of a given animal, but a measure of when and how long human-caused sound levels exceed natural ambient sound levels.

Percent Time Audible

The amount of time that various sound sources are audible to animals, including humans, with normal hearing (hearing ability varies among animals). A sound may be above natural ambient sound pressure levels, but still not audible to some animals. This information is essential for measuring and monitoring human-caused noise in national parks. These data can be collected by either a trained observer (attended logging) or by making high-quality digital recordings (for later playback). Percent Time Audible is useful because it is a measure that is understandable without any acoustics knowledge. It is a measure that can be specific to a given animal, and it is a metric that correlates well with park visitor judgments of annoyance and with visitor reports of interference from certain noise sources with natural quiet and the sounds of nature.

Spectrum (Frequency Spectrum)

The amplitude of sound at various frequencies. It is given by a set of numbers that describe the amplitude at each frequency or band of frequencies.

Sound

A wave motion in air, water, or other media. It is the rapid oscillatory compressional changes in a medium that propagate to distant points. It is characterized by changes in density, pressure, motion, and temperature as well as other physical properties. Not all rapid changes in the medium are sound (wind distortion on a microphone diaphragm).

Soundscape

The total ambient acoustic environment associated with a given environment (sonic environment) in an area such as a national park. It is also refers to the total ambient sound level for the park. In a national park setting, soundscapes are usually composed of both natural ambient sounds and human-made sounds.

Sound Exposure Level (SEL)

The total sound energy of an actual sound during a specific time period. SEL is usually expressed using a time period of one second.

Sound Level

The *weighted* sound pressure level obtained by frequency weighting, generally A- or C-weighted. The weighting used must be clearly stated: For L Aeq, "A" denotes that A-weighting was used, and "eq" indicates that an equivalent level has been calculated. Hence, L Aeq is the A-weighted, energy-equivalent sound level.

Sound Level Floor

The lowest amplitude measurable by sound monitoring equipment. Most commercially available sound level meters and microphones can detect sound levels down to about 15 to 20 dBA; however, there are microphones capable of measuring sound levels below 0 dBA.

Sound Pressure

Fluctuations in air pressure caused by the presence of sound waves. Sound pressure is the instantaneous difference between the actual pressure produced by a sound wave and the average barometric pressure at a given point in space. Not all pressure fluctuations detected by a microphone are sound (e.g., wind over the microphone). Sound pressure is measured in Pascals (Pa), Newtons per square meter, which is the metric equivalent of pounds per square inch.

Sound Pressure Level (L_P or SPL)

The logarithmic form of sound pressure. In air, 20 times the logarithm (to the base 10) of the ratio of the actual sound pressure to a reference sound pressure (which is 20 micropascals, and by convention has been selected to be equal to the assumed threshold of human hearing). It is also expressed by attachment of the word decibel to the number.

Sound Speed

The speed of sound in air is about 344 m/sec (1,130 ft/sec or 770 mph) at 70° F at sea level.

Time Weighting

The response speed of the detector in a sound level meter. For Slow response, the response speed is 1 second. Slow time weighting is frequently used in environmental sound measurements. Fast response time is 1/8 second (0.125). This is less frequently used, but will detect changes in sound levels more rapidly. Both Fast and Slow time weightings have been used in previous NPS acoustic studies, and, when compared over long measurement periods (over several days), there is very little difference in results (differences are often less than the accuracy of the meter). Fast and Slow time weightings were developed, in part, to slow needle movement (called a "decay" factor) in analog meters so investigators could read and record sound levels. New digital sound level meters, while changing numbers rapidly on the screen, store sound level data in memory for later analysis, thus, the ability to read numbers on the screen is less important. Hence, the most accurate "weighting" is none. Generally, 1-second Leq data are appropriate; however, when measuring sudden onset sound events such as sonic booms, more frequent data (many readings per second) may be appropriate.

Ultrasound

Sounds or a frequency higher than 20,000 Hz.

Wave

A particular type of disturbance that travels through a medium by virture of the elastic properties of that medium.

Wavelength

Wavelength is the distance a wave travels in the time it takes to complete one cycle. A wavelength can be measured between successive peaks or between any two corresponding points on the cycle. Wavelength (ft) = Speed of Sound (ft) / Frequency (Hz).

Windscreen

A porous device used to cover the microphone of a sound level measurement system. Windscreens are designed to minimize the effects of wind disturbance on the sound levels being measured.

REFERENCES

(These definitions were derived from several sources, including):

Acoustic Alliance. 2001. Glossary of Terms, Acoustic Alliance Products and Services Catalog. Provo, UT.

American National Standards Institute. 1976. Standard Acoustical Terminology, S1.1. American National Standards Institute, New York, NY. 1976.

Bruel & Kjaer. 2002. Environmental Noise. Bruel & Kjaer Sound and Vibration Measurement. Naerum, Denmark.

Everest, F. A. 2001. Master Handbook of Acoustics. McGraw-Hill, New York, NY.

Hirschorn, M. 2002. Noise Control Reference Handbook. Sound & Vibration, Bay Village, OH.

Kelso, D. and A. Perez. 1983. Noise Control Terms Made Somewhat Easier. Minnesota Pollution Control Agency, St. Paul, MN.

U. S. Environmental Protection Agency. 1976. About Sound. Environmental Protection Agency, Washington, D. C.