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Setting limits for acceptable noise in National Parks

Nicholas P. Miller[a]
Senior Vice President
Harris Miller Miller & Hanson Inc.
77 S. Bedford Street
Burlington, MA 01803 USA

ABSTRACT

The National Park Service has identified natural sounds as one of the park resources that needs to be preserved. The difficult question to answer is: how much natural sound or absence of non-natural / human produced sounds is appropriate for different park settings? Parks are established to preserve specific resources, and often natural sounds are one of the resources identified. Within a park, some areas will be more sensitive to the presence of human produced sounds than will others, depending on the specific setting and associated management objectives. Yet establishing limits for acceptable intrusions can also limit types of recreational or other activities, and hence, may be subject to challenge. Additionally, for parks requiring an Air Tour Management Plan, it will be necessary to define the conditions that define when "significant adverse impacts" on the natural and cultural resources, visitor experiences, and tribal lands will occur.[1] This paper describes basic concepts this author believes could aid in developing quantitative thresholds for inappropriate sounds in park settings, and outlines a process for determining those thresholds.

1. INTRODUCTION – WHAT IS THE ISSUE?

The sounds of human activities, such as those produced by aircraft, buses, boats, mining operations, etc. heard in wild or remote natural areas have long been a concern to both those who pursue recreation in these areas and to those who manage the areas. But it is often the sounds produced by one type of recreation to which others who visit these areas object. In other words, sounds of human activities heard in park areas are often at the center of controversy.[2]

Since the late 1980's concerns have increased about the issue of human produced sounds in many U.S. national parks such as the Grand Canyon National Park, Hawaii Volcanoes National Park, Glacier National Park, Yellowstone National Park, and in parks in other countries such as those of Australia and New Zealand.[3,4]

For management of these areas, the critical question is always: "How much human produced sound is appropriate in a specific park setting?" In this paper, the author suggests an approach for tackling this question – an approach that relies on park management judgment, but also includes quantifiable rigorously (scientifically) collected data. Also, though not discussed here, the process of answering this question will likely include a public process and may involve regulatory procedures. Setting any limits on human-produced sounds will in most cases infringe on someone's activities, and therefore is likely to require a legally defensible foundation and process.

[a] Email address: nmiller@hmmh.com

2. DEFINE DEGREES OF SENSITIVITY TO HUMAN PRODUCED SOUNDS

Decision-makers who are responsible for managing a park's soundscape need to decide how the park should sound. In fact, the area of concern is more specific than an entire park, but rather would almost certainly focus on several or many specific sections of a park.[5] The first step should be to identify the various management zones in the park and draft the objectives for those zones in terms of sensitivity to human produced sounds. How does the General Management Plan or equivalent plan or the legislative mandate address the sounds of the park and its specific resources? What is the desired visitor experience in terms of the surroundings and associated sounds? Are there historic or cultural resources present, and what types of sounds are appropriate? What wildlife resources are present? Are there different times of day or different seasons when a zone is more or less sensitive to human produced sounds? Develop descriptions of sensitivity to human produced sounds that will apply to specific park areas. Consider descriptions such as the following.[6]

A. High Sensitivity to Human Produced Sound –

These are locations intended to preserve as completely a natural state as possible. They may be habitat for rare or sensitive species, contain ancient cultural, historic or religious resources, or be set aside to offer outstanding opportunities to experience solitude, tranquility and quiet. These areas are managed so that there is low probability that visitors will encounter other visitors. Visitor expectations for experiencing this type of soundscape are likely to be highest in locations that are moderate (perhaps a half mile) to long distances (several miles) from road traffic or intense visitor use, and that require a significant portion of an hour on foot (or horse back) for access.

B. Moderate Sensitivity to Human Produced Sound –

Surroundings offer a sense of remoteness and peace, but may be developed to the extent of having clearly delineated and maintained trails and markers. Landscapes may be predominantly natural, or may have historic or cultural structures or meaning. As far as visitor expectations are concerned, such locations are probably close to road access. Some human sounds are unavoidable, but not loud, and do not diminish the visitor experience. There is management expectation that visitors will occasionally encounter other visitors and small groups.

C. Low Sensitivity to Human Produced Sound –

These are moderately developed areas but somewhat removed from roadway traffic and parking lots. Visitors pass through enroute to other areas. Nearby activities are likely to include regular interpretive and educational opportunities. Visitors are likely to expect moderate levels of human produced sounds and frequent encounters with other visitors.

D. Generally Insensitivity to Human Produced Sound –

These are developed areas possibly with services such as shops, restaurants, service stations, fairly frequent and nearby road traffic. There is considerable visitor activity, both pedestrian and automotive. Tour buses may be frequent or motorized boating popular.

The author believes that no more than three or four levels of sensitivity are required. Having more than four levels of sensitivity is likely to lead to problems. First, distinguishing among more than four levels both experientially and in descriptions is likely to be difficult. Second, in most situations / locations, the variability of human produced sounds from hour to hour or day to day is great enough that having many levels of sensitivity is likely to mean that most locations will probably go in and out of conformance with the objective for that site.

Finally, quantifying the objective should not be too narrowly defined or monitoring for conformance is likely to be too time consuming. This time requirement results from the basic concept that in order to have high confidence in determining an average value of a highly varying phenomenon means acquiring a large number of samples of the phenomenon.

3. GET OUT AND LISTEN TO THE PARK

Having determined sensitivities for the park's management zones, the second step is to go to those zones and listen. This listening experiment should be repeated on several different days at specific locations selected as representative of the zone in terms of sensitivity, and, one hopes, as locations that meet the management objective for the zone. The goal is to develop an understanding of how the stated objective conforms to the reality.

This listening should be orderly and conducted at each location for about an hour. To give order to this listening, try the following three-part procedure. **1)** For the first 20 minutes simply listen, and then at the end of the time, write down qualitative impressions of the soundscape. Did the experience conform to the objective? What were the sounds heard and were they present in temporal terms and of a level consistent with expectations. Where the sounds appropriate in light of the objective? **2)** For a second 20 minutes, write down the sources as they are heard, and any impressions. **3)** For the last 20 minutes, keep a log, noting time (minutes and seconds) when each sound is first heard and when it fades away.

This listening experiment is probably best conducted by two (or more) people simultaneously. There should be no discussion before listening / logging is completed at a site. After the listening at a site is completed, it is probably useful to discuss impressions and to come to a consensus about whether or not the site conforms to the objective. If it does not, to what level of sensitivity would it conform? Making these decisions will be necessary for the following step. After all listening has been completed, those who did the listening should meet and come to consensus about each location and the relationship of the listening results to the associated objectives. Which ones meet the objective, which do not and for those that do not, would the soundscape conform to a different objective?

4. TIME TO QUANTIFY

Methods to quantify park soundscapes have been developed and reported.[7,8,9,10,11,12] These methods should be used to collect acoustic data at the locations where the listening occurred. If possible, the measurements can be made simultaneously with the listening and thereby insure that the sounds measured are the same as the sounds heard. Depending on the sound measuring instruments used, quite an array of sound metrics can be either downloaded directly or computed. However, these metrics should not be associated with the listening results until all listening is completed.

Despite the large number of metrics possible, initially, two types should be determined – one a metric of the loudness of human produced sounds relative to the background, and one a measure of how long the various human produced sounds were audible. The author has found that any soundscape must be defined by at least these two concepts – how loud is the sound of interest with respect to the background, and how long is that sound present. The background or ambient may defined in different ways,[13] but for purposes of examining and understanding the presence of any human produced sounds, the use of the natural ambient is appropriate. This is the sound environment that exists when no human produced sounds are audible. A National Park web site provides methods for determining this value.[14]

Figure 1 is a plot of the two types of sound metrics measured for 208 intervals at eight different locations in Grand Canyon, Hawaii Volcanoes and Haleakala National Parks as part of the first quantitative dose-response study.[15] The distribution of these measurements demonstrates the value of using these two metrics. Clearly they are uncorrelated, each metric providing a different type of information about the sound environment. Each point represents a different sound environment with different levels, durations and probably different numbers of tour aircraft. But what does it sound like and what is the visitor experience at any one of these locations when the measurement was made? This question is answered by the results of the listening experiment. The listeners, by examining the measured results for the listening locations, will be able to assign to various areas of this plot the consensus conclusions about the sensitivity objectives they developed for each location. These two types of metrics, when identified with specific sound objectives for sites can be considered, taken together as "indicators" related to the management objective. **Figure 2** shows how the results might look.

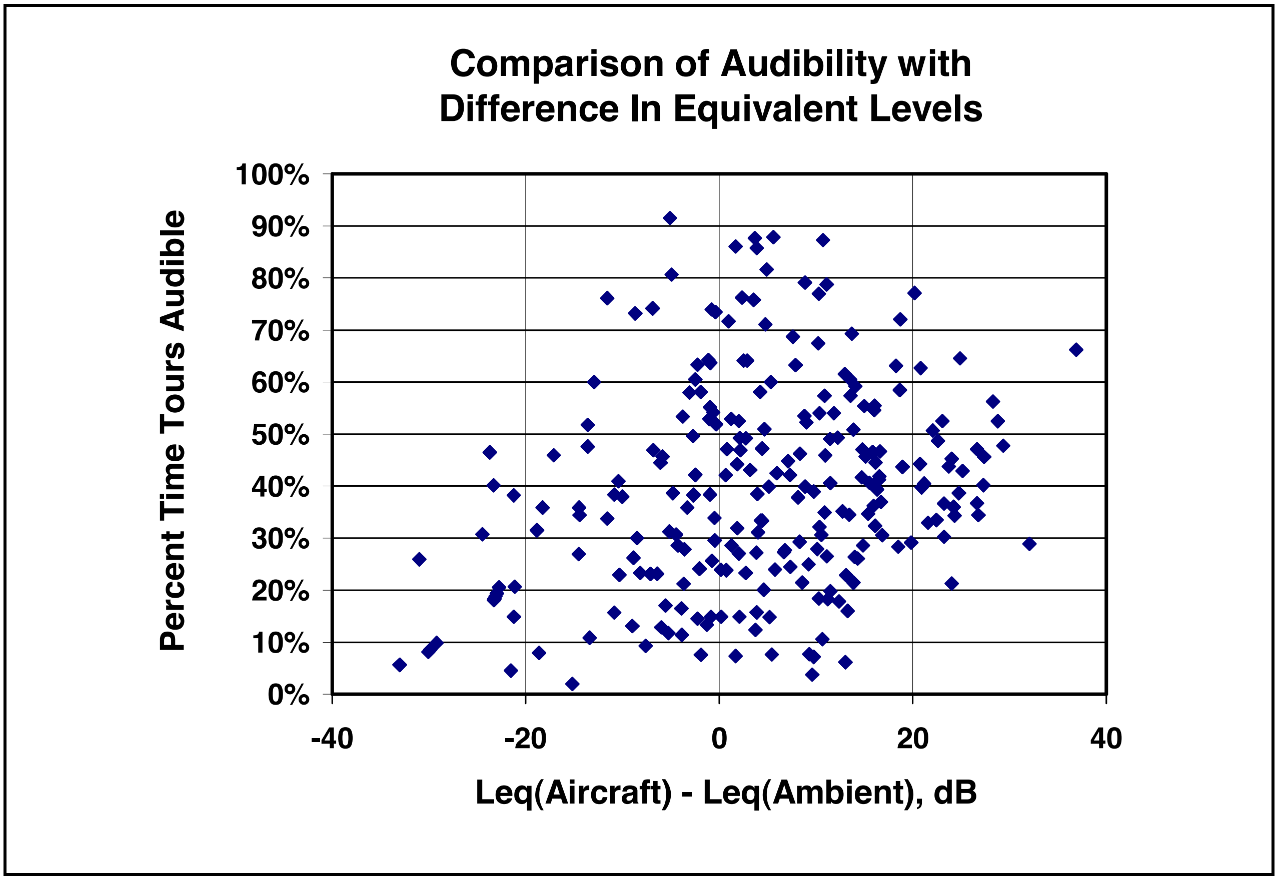

Figure 1 Values of tour aircraft audibility and difference in equivalent levels of 208 measurements

The advantages of this approach to quantifying management judgments are several. First, we have a visual representation of the relationship of sensitivity to the indicators and to location. Those staff involved with managing the soundscapes of the park will eventually be able to understand what a general area of this plot means in terms of the type of soundscape because they will be able to associate plotted points with specific park locations. Second, as we shall see in the next section, these areas can be related to visitor dose-response results. Third, this graphic approach provides an easy-to-understand method for monitoring the locations and progress on either moving the soundscape toward the desired objective for the degree of sensitivity, or on preservation of the soundscape. This monitoring is discussed in Section 6, below. By this method a park will have determined both the indicators and the standards for managing human produced sounds. The listening experiments, together with measurements, can be on-going for different areas of the park, and produce the inventory of the resource, and the continuing measurement of the indicators and comparison with associated plot areas or standards provide for monitoring the status of the resource.

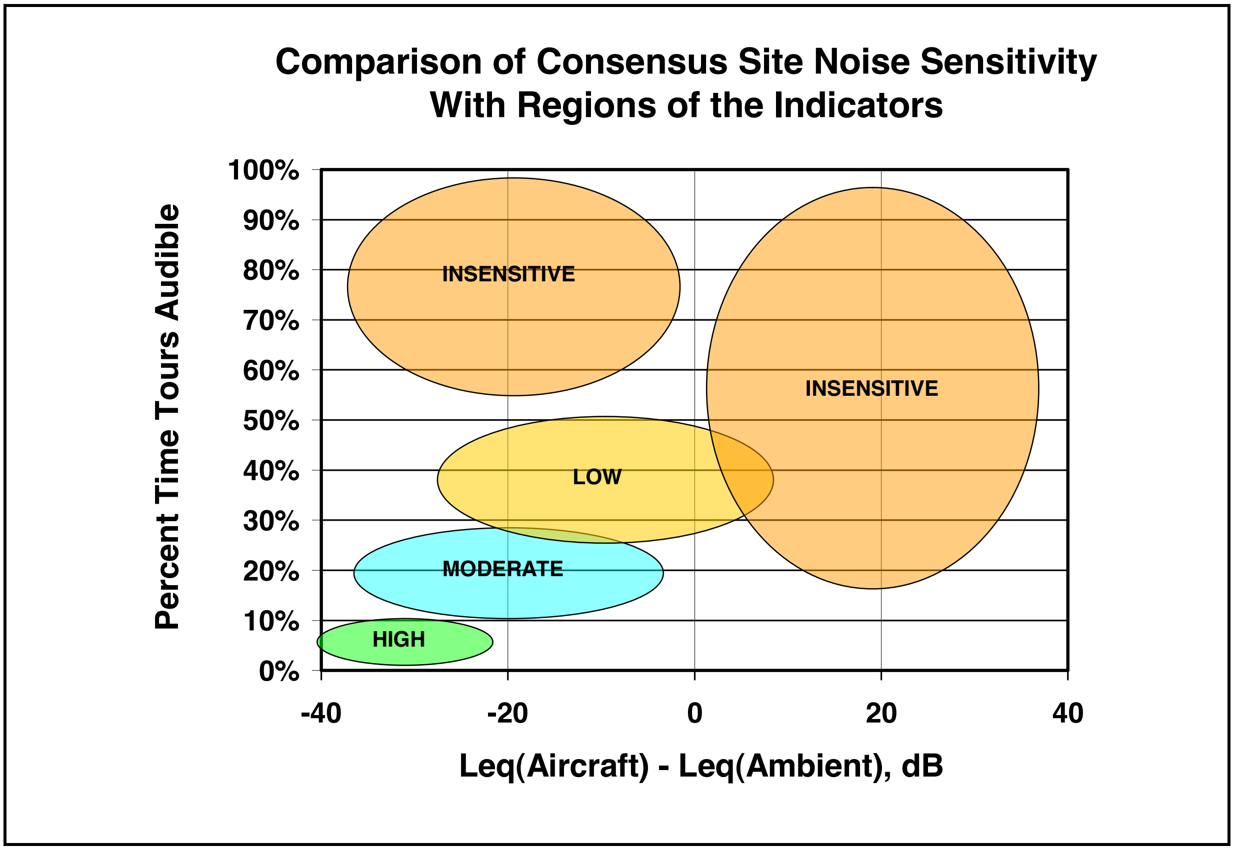

Figure 2 Sensitivities related to indicators (measurable metrics of sound)

5. INCLUDE VISITOR REACTIONS

Figure 3 shows how a visitor dose-response relationship may be brought into the process of deciding on regions of acceptable human produced sound in **Figure 2**. For this example the dose-response relationship shows what percentage of visitors will be moderately to highly annoyed as a function of the difference between aircraft Leq and background Leq. In **Figure 3**, about 12% of visitors would express annoyance when aircraft Leq minus background Leq is -20 dB at short-hike sites. Corresponding percentages can be derived as a function of percent of time aircraft are audible, and regions of sensitivity could be constructed as in **Figure 4** to conform both with the judgments made and plotted in **Figure 2**, and with visitor expressions of annoyance with the acoustic environment. Responses other than annoyance could also be used, such as percent of visitors reporting that the human produced sounds did not interfere with their appreciation of natural quiet and the sounds of nature – a dose-response relationship that has been developed.[16] If visitor reactions are predicted in this manner to be higher than consistent with the management objective for a location / sensitivity standard, the standard could be modified.

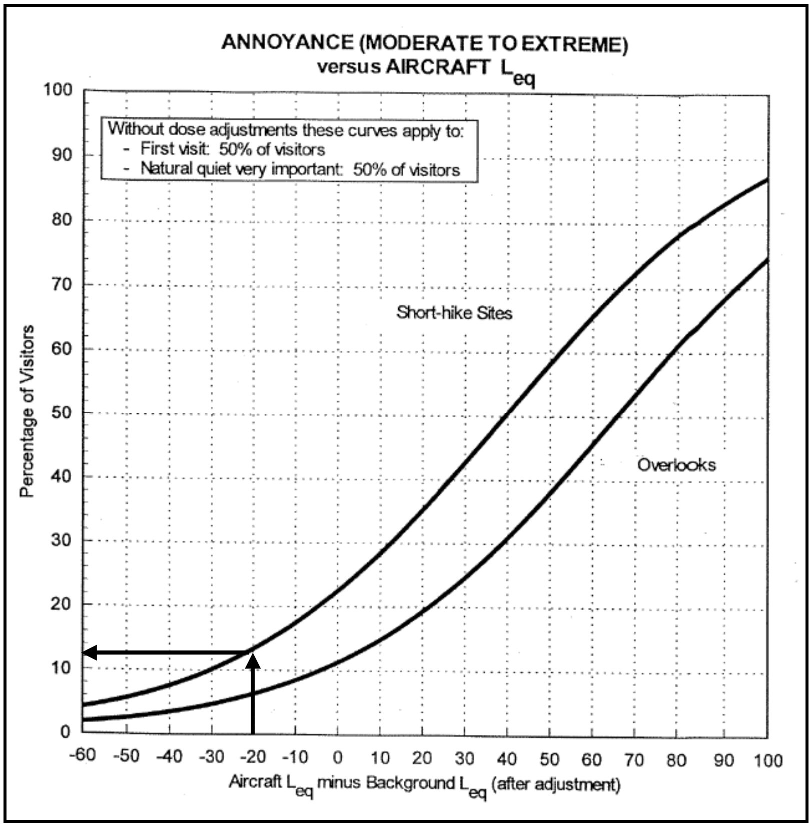

Figure 3 Determining visitor response associated with a specific indicator or metric - difference in Leq

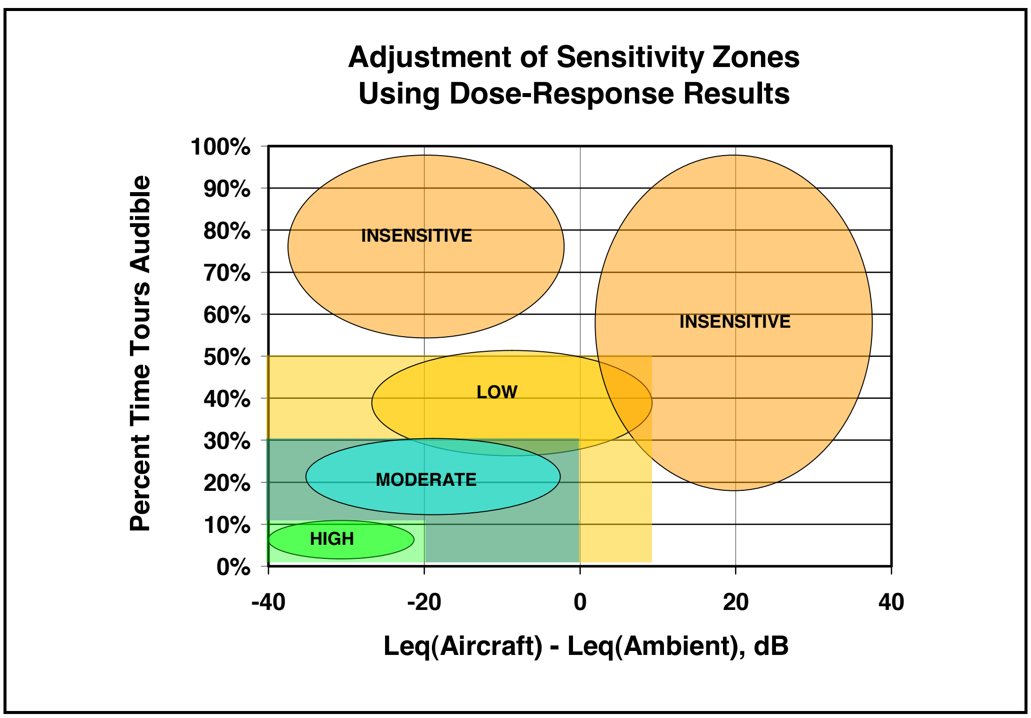

Figure 4 Sensitivity zones adjusted to conform to specific percents of visitor responses

6. MONITOR PROGRESS

The measurement techniques used to first quantify the sounds of the locations may be repeated at intervals, possibly randomly chosen, throughout the seasons / times of interest. Results would be plotted on a graph similar to **Figure 5**. These points are results that might be measured at a site of moderate sensitivity. Scatter is expected, but the long-established statistical processes for quality control in manufacturing could be applied, here on two variables. Data would be collected by sampling measurements and mean and standard deviations developed. An area of some acceptable scatter, say two standard deviations, could be plotted as in the figure, and samples compared with this region. Then, for example, when more than five percent of the samples in some period, say a season, plot outside the area, investigation of the causes is warranted.

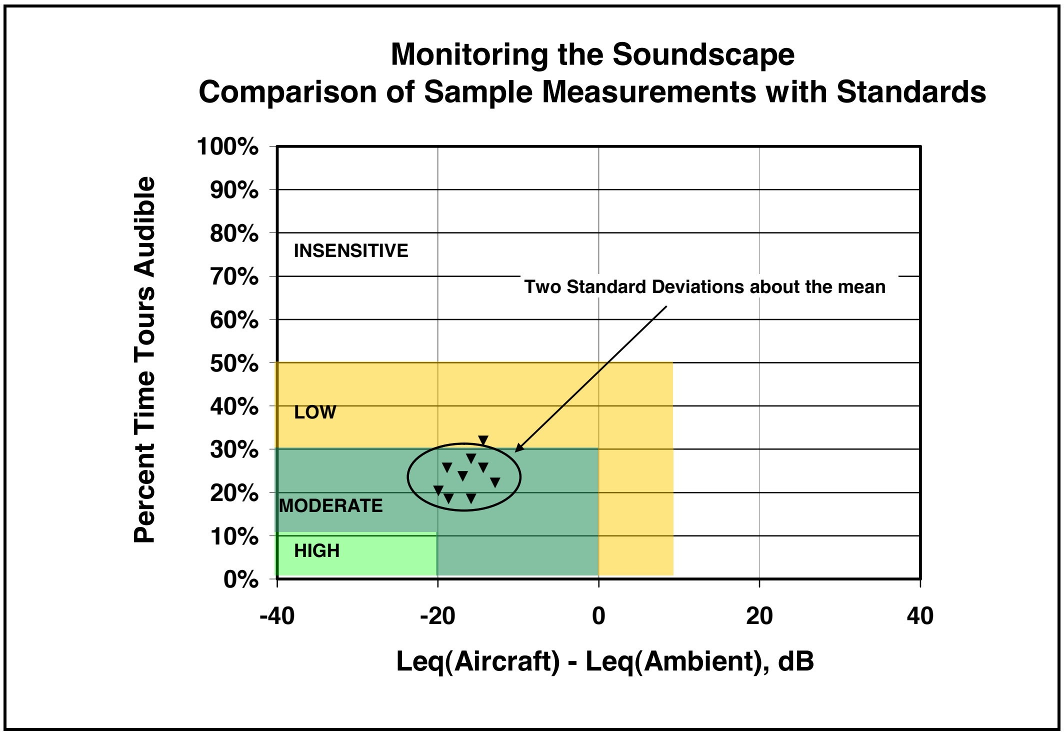

Figure 5 Monitoring results at a location of medium sensitivity to aircraft

Different lengths of sampling time could be tested to minimize the amount of time spent in monitoring. It is possible that samples of only one or two hours, made several times a month would be adequate.

7. CONCLUSION

This proposed method for setting acceptable limits on human produced sounds in parks combines park management objectives, management experience and judgment, scientific knowledge of visitor response, proven measurement techniques, and standard statistical processes to:

1) Establish quantitative indicators (metrics) of park acoustic environments,
2) Inventory the park's acoustic environment resource (through listening and measurement),
3) Establish standards for those indicators (combining consensus judgments, measurement results, and visitor dose-response information), and

4) Establish a straight-forward process for monitoring the resource and its conformance to the standards (by measurement sampling).

ACKNOWLEDGMENTS

Throughout the years, far too many people have contributed to the author's understanding of park and quiet area related issues to fairly acknowledge them all. Rather, this paper is dedicated to the memory of Dr. Wes Henry who was the driving force in establishing the foundation for the current NPS Natural Sounds Program.

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