PLANNING AND PREPARATION FOR MEASUREMENT OF SOUND CHARACTERISTICS: SOUNDSCAPE RESOURCE INVENTORY

INTRODUCTION

The collection of data should be undertaken purposefully and strategically. If data is to be useful, forethought must be exercised in how data is collected, where it is collected, and how much or how often it is to be collected. Data collection should be oriented to a set of anticipated management issues, most of which revolve around management objectives for sound in the various zones of the park. This paper presents places data collection within this context, and provides guidance on planning a data collection or inventory effort. Monitoring the acoustic environment, relative to management standards, is discussed in another paper in this series.

Relationship of Resource Inventory to Planning

This direction represents standard planning methods, since it is necessary to determine the existing situation in planning all proposed management actions. Inventorying resources can help determine baseline conditions, from which planners would evaluate potential changes due to proposed management activities. For soundscape management planning, an inventory of soundscape resources represents the affected environment in either an EA or EIS through which alternative plans would be evaluated against the need to restore or enhance the natural soundscape. It is the basis for determining what human-caused sounds (both types and levels) are consistent with park resources and values, and what sounds are deemed to be inappropriate. Development of an inventory is normally a short-term process of finding out what resources are located where, and measuring the extent to which those resources are vulnerable to management activities or other park uses.

In order to match planning goals or objectives with the means for measuring soundscape resources, and effects on them, the development of techniques and use of metrics must translate to terminology used in the objectives. Conversely, objectives must be formulated in terms that can be measured using available means. A common language is needed for the inventory (and monitoring) of soundscape resources so that alternative effects can be estimated, and so that progress toward plan goals can be measured effectively. The following section presents metrics to be used in inventorying soundscape resources. After that, discussions specifically on the measurement of natural soundscapes and existing sources of human-caused sound may be found.

A fundamental difficulty with defining soundscapes, including natural and human-related components, is that no single metric or measure can adequately describe a soundscape. Rather, a combination of acoustic metrics and biological measures are needed to quantify and qualify soundscapes. Put simply, we need acoustic metrics to quantify (measure) the soundscape, and we need biological measures to qualify (identify) the soundscape. Acoustic metrics and measures include sound pressure levels (minimum 33one-third octave bands, from 12.5 to 20,000 Hz), L_{eq} (an average), L_{90} and L_{50} (overall exceedence metrics), event exceedence metrics (for events over a given amplitude and duration), SEL (a sound exposure measure), Noise Free Interval, percent time above a given level,

percent time audible to a given animal or visitors (and area of audibility for a given animal or visitors), and several others. Some metrics and measures are appropriate for defining the natural soundscape, while other are appropriate for defining the human-related soundscape.

Inventory Preparation

Collection of acoustic data to support soundscape management planning must follow specific, standardized methods and protocols. This section provides guidelines for collection of acoustic data in national parks for use in assessing the natural ambient soundscape, the existing ambient soundscape, and soundscape impacts that are necessary to the purposes of the park and its management. Specifically, this section provides guidelines for planning data collection, selection of measurement locations, determination of adequate measurement periods, acoustic data to be collected, parameters to be measured, and equipment to be used.

Planning for data collection must include consideration of specific acoustic characteristics of each park as well as consideration of specific management areas and objectives of each park. Preparation for data collection includes selecting representative acoustic areas, selecting specific measurement locations, and defining the period of time for taking measurements.

Selecting Representative Acoustic Areas (Acoustic Zones)

Generally, measurement locations should be placed in the primary land/vegetation types of the park, with consideration of park management zones and specific soundscape management objectives of those zones, and any sound-sensitive areas. Areas of like vegetation and topographic types are often referred to as "acoustic zones," with the assumption that, in general, the same animals, birds, insects, and other sources of natural sounds occur in similar habitats, and, as a result, similar habitats will have similar natural sound levels, and propagation properties.

In some management zones, patterns of human-caused sounds (travel corridors, visitor centers, air traffic routes, seasonal patterns, etc.) generate different, non-natural acoustical conditions. In developed zones, there is less sensitivity to noise, and there is a greater incidence of human sound that may be regarded as consistent with or necessary for park purposes. In natural or wilderness zones, the soundscape is expected to be natural, and few human-caused sources of noise may be conducted there or would be present as a necessity for park purposes.

For parks having great seasonal variability, the natural acoustic landscape may change radically through the year, and acoustic measurements must account for this variability. It is probable that many parks will have so much variability that acoustically representative zones will be defined by a range of values, and these values may vary due to seasonal differences within those zones..

The purpose of identifying acoustic zones is to develop a set of base units for characterizing the soundscape resources within a national park. Data for each of the primary acoustic zones in a park, in conjunction with management zones, will provide a means of assessing sensitivity to human-caused noise. Acoustic zones are intended to be

acoustically representative units for which data are collected and stratified, and by which the data may be extrapolated to other similar areas. Defining acoustic zones is an iterative process whereby data are inspected to determine if there are statistically significant differences in acoustic metrics within and among zones (defined as $P \leq 0.05$). Methods to determine the acoustic and management significance of the differences will be determined over time and as analysis needs become clearer. In the final analysis, acoustic zones previously defined could be lumped or split.

A broad characterization of an entire park unit is necessary to capture its variability, which lies in three general areas. First, variability is influenced by different habitats each with potentially different flora and fauna. Second, variability is influenced by attenuation characteristics of different habitats. These two variables are functions of climate and topography, both of which may add complexity in both temporal (seasonal, diurnal) and geographic terms. Third, park lands are allocated to various uses or prescriptions and objectives that reflect how the area is to be managed, how visitors interface with park resources, and what visitors expect to see, hear and do (management zones). This variable is set in a park GMP, or in subsequent plans that may amend, adjust, or refine the GMP.

Criteria for Selecting Measurement Sites

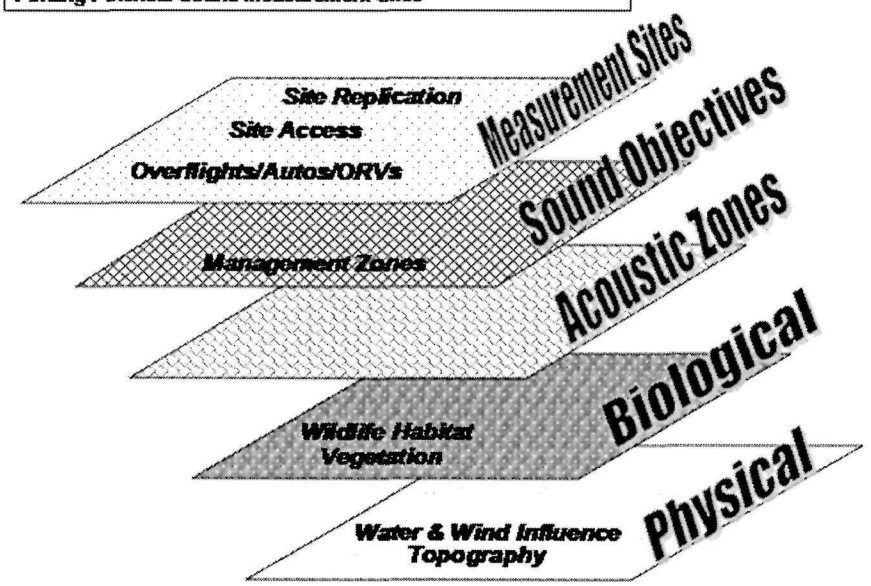
Putting together these three basic overlays, subdivided by resource characteristics that are necessary to define them, represent the starting point in site selection for inventorying the ambient soundscape (see Figure 1, below). From the overlay system, areas of similarity in terms of acoustic "potential" are identified. At the same time, units or types of acoustic landscapes are separated out. A broad assessment of the park's soundscape would entail measurements within each of these representative units. Also, if an acoustic landscape is further subdivided by different management zones, inventory may be needed within each. Potential inventory sites would thus be selected for representative areas throughout the park. In a park with a highly variable landscape, with significant seasonal variations, and where numerous management zones cross acoustic units, it may be seen that many potential inventory sites are possible.

Final selection of places to inventory is made through a screening process of potential sites considering access, equipment availability/capability and maintenance needs, sources of ambient human-caused sound, statistical considerations, and availability of personnel. Listed below are considerations for inventory site selection in rough order of application.

- Physical variability, where natural physical sounds are propagated differently along the landscape: topography, aspect, elevation, rain or snow dominated, arid, and active geomorphic processes like fluvial, coastal, volcanic, glacial, thermal, wind. Consider seasonal variability.
- Biological variability, where natural biological sounds are propagated differently along the landscape: vegetation, habitat, habitat for sensitive species, habitat for species affected by sound or species that produce distinctive or unique sounds. Consider seasonal variability.

- Park management zones, where there are different objectives relating to soundscape resources, visitor experiences, and different expectations about human-caused sound.
- Site accessibility. Ideally, a site is accessible via two-wheel drive vehicle on a road. Other sites may be suitably accessible via 4-wheel drive vehicle on administrative use roads. Other access options may be considered in special situations; access to off-road sites will need to be carefully considered, and the potential impacts of the access itself carefully weighed. Access may also be limited due to restrictions on the use of certain types of equipment or power sources.
- Ambient human-caused sound. Inventory sites should also capture ambient human-caused sound in addition to the natural soundscape. Ideally, both could be characterized by measurements taken at one site over a sufficiently lengthy period of time. Otherwise, sampling in a single acoustical zone may have to be done at two locations – one dominated by, for example, overflights, and one dominated by natural sounds.
- Statistical variation. Characterization of an acoustic unit may require sampling at several sites during the same period.

Figure 1: Overlay System for Mapping Acoustic Zones and Finding Potential Sound Measurement Sites



Setting the Measurement Period

The variability of sound pressure levels and frequency over long periods (weeks, months, seasons, and years) is not well understood. Until this variability is better understood, measurement periods must be of sufficient duration to insure statistical confidence in data

such that data collected from a sample period would not differ significantly ($P \leq 0.05$) from data collected continuously for the same area and entire measurement period. Measurements must include all periods of potential acoustic variability (such as diurnal/nocturnal, seasonal, and annual variability). For the most part, it will not be feasible to collect acoustic data over multiple years for multiple parks; however, data that represent all sources of variability should be obtained. When several long-term data sets are available, it will be possible to reassess this issue and recommend minimum measurement periods. Additional statistic review of long-term acoustic data from other parks is being conducted, and will aid in estimating future needs for measurement duration. It is almost certain that appropriate measurement periods will vary among parks, and will likely vary among different areas within the same park. Only long-term measurements can provide the data necessary to accurately address this question.