**I-INCE PUBLICATION: 12-1**

# Outdoor Recreational Noise

## Volume 1: A Review of Noise in National Parks and Motor Sport Activities

Final Report
of the

I-INCE Technical Study Group on
Outdoors Recreational Noise (TSG 1)

Prepared by members of TSG 1
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**International Institute of Noise Control Engineering**

**2012 November**

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## FOREWORD

I-INCE is a non-governmental federation of professional societies from countries around the world. I-INCE is dedicated to advancing the engineering control of noise and vibration. Operational policies and procedures of I-INCE are established by a Board of Directors and approved by a General Assembly. The general Assembly consists of representatives of the member professional societies and the Board of Directors. The Board of Directors and the general Assembly meet at least once a year during annual Congresses sponsored by I-INCE on noise control engineering. This report is in the nature of an I-INCE Technical Report. After the final report is published, it is intended that there be wide consideration of its recommendations.

## PREFACE

The review presented in this report was initiated in 2000 at Inter-Noise in Nice, completed in 2005, and after a first peer review a shortened version was presented at Inter-Noise 2006 in Hawaii. Unfortunately it was not until late 2010 that I-INCE official peer review was obtained, and hence final editing was not completed until 2011. Due to this extended editorial period, some parts of the report refer to outdated documents and do not include some significant research that has occurred in the last six years on quiet areas, particularly in the European Union, and do not include some relevant reports published during that time by the World Health Organization.

The original scope of the I-INCE Technical Report was very comprehensive and the initial report too long for publication. Thus the scope has had to be limited to some particularly important issues of the time such as the sound from outdoor recreational activities in national parks and motor sports events. Minor changes in this final version of the report have been made in response to comments from I-INCE member countries. In response to other comments:

Biodiversity loss due to noise has not been studied but is, at the time of publication, becoming a focus area. TSG 1 recommends expanding the review on this issue in the future.

The relevance of A-frequency weighted hourly levels was questioned, but TSG1 has not discussed this further in more detail. TSG 1 recognises that identifying the relevant noise indicator is a key issue in delimiting quiet areas.

Motor sport activities and street racing have been major issues in some countries, though not in others. The findings of the review should help and inspire the reduction of noise from such activities where relevant.

TSG 1 recommends that efforts initiated on quiet areas by the EU Environmental Noise Directive 2002/49/EC be integrated in future work of I-INCE on noise from outdoor recreational activities.

## BACKGROUND

At the meeting of the General Assembly of the International Institute of Noise Control Engineering held in Fort Lauderdale, Florida, USA, in 1999 December, it was decided to start a program to assess the noise from outdoor recreational activities. With this decision, it was agreed to form Technical Study Group 1 (TSG 1) “Outdoor Recreational Noise”.

Each member of TSG 1 was appointed by a Member Society of the International Institute of Noise Control Engineering (I-INCE). In addition there was a convener and consultants. The following lists the membership of TSG 1

**Convener**: Philip J. Dickinson Acoustical Society of America

| **Member** | **I-INCE Member Society** |
|---|---|
| Kozo Hiramatsu | Acoustical Society of Japan |
| Alessandro Cocchi | Associazione Italiana di Acoustica |
| Ferdinand Deželak | Slovenian Acoustical Society |
| Bo Engdahl | Acoustical Society of Norway |
| Ayse Erdem Aknesil | Turkish Acoustical Society |
| Malcolm Hunt | New Zealand Acoustical Society |
| Marion Burgess | Australian Acoustical Society |
| Sang Kyu Park | Korean Society for Noise and Vibration Engineering |
| Andrew Watson | Institute of Acoustics (UK) |
| Nicholas Miller | Acoustical Society of America and INCE USA |
| Willy Passchier-Vermeer | Acoustical Society of the Netherlands |

**Consultants:** David Eager, Christopher Menge

When the final draft report of TSG 1 was submitted to I-INCE in 2006 it was considered still too large for circulation to Member Societies. It remained with I-INCE until 2009 when it was decided to ask the TSG to rework the report into a much shorter draft and a layout following that used in 2010 by TSG 3.

When the Technical Study Group reconvened in 2010 it had the following members:

| | |
|---|---|
| Philip Dickinson (Convener) | Acoustical Society of America |
| Alessandro Cocchi | Associazione Italiana di Acoustica |
| Marion Burgess | Australian Acoustical Society |
| Andrew Watson | Institute of Acoustics (UK) |
| Nicholas Miller | Acoustical Society of America and INCE USA |

Primary subject classification: 52.7, 13.3; Secondary classification: 66.1, 52.9, 83

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**A REVIEW OF NOISE FROM OUTDOOR RECREATIONAL ACTIVITIES**
**Volume 1: A Review of Noise in National Parks and Motor Sport Activities**

# 1 Introduction

During the years 2000 to 2005, I-INCE Technical Study Group TSG 1 investigated the effects of noise from recreational activities in outdoor areas, and the laws governing such noise emissions across the World. Problem areas of recreational activity (in terms of uncontrolled and/or excessive noise) have been examined, with the aim of producing workable strategies to recommend for solving, or at least mitigating the adverse effects.

Recreational activities can be defined as those pursuits outside one's regular occupation that are usually undertaken for purposes of relaxation or for the refreshment of strength and spirits after work. Noise is produced by many of these recreational activities. While the providers of such recreational activities may be uninterested, unwilling, or unable to control the noise, non-participating bystanders are sometimes exposed to relatively high levels of noise, or to noise intrusion that adversely affects their normal life. For example, the maintaining of natural quiet in national parks and wilderness areas is considered by many to be paramount to the survival of these preserves of the natural environment, but the incursion of recreational activities involving aircraft, road and off-road vehicles, and watercraft in many of these special areas has greatly altered, and sometimes totally eliminated the opportunity to experience the natural acoustic environment. There are many other examples where the incursions of outdoor recreational noise create friction between those making the noise, and the bystanders who are not involved in the recreational activities.

Recreation is a subset of “leisure” (the surplus time available when all other commitments have been completed) and a recreational activity is one freely undertaken for its own personal value and satisfaction to the individual. Often the activity is used to relieve the body of the tensions and inhibitions of the work place. Inevitably noise, sometimes excessive noise, is a byproduct. Regrettably, to many people noise is related to power and the noisier the activity the more power the participants believe they have, and the more enjoyment they get [Keizer 2010].

To other people during the period of leisure, experiencing quietness is their relaxation from the tumult of industry. To them, the experience of enjoying a natural quiet area is to be treasured, and any noise intrusion is unwelcome and may cause them annoyance. The preservation of natural quiet areas faces many problems not least of which is maintaining low noise levels when the areas are visited by the people for whom they were set up and by whom they are directly or indirectly financed.

There have been a number of studies of the effects of noise, other than hearing loss, and these have led to recommendations by organizations such as the World Health Organization [WHO 1999]. The first recommendation from a review of these studies [Environmental Health Council 2004] was that it was important to “recognize environmental noise as a potential health concern”. Effects identified included some evidence of links between annoyance and performance, sleep disturbance, ischaemic heart disease, hypertension and mental ill health in vulnerable groups. It is important to note that most studies have been on the effects of

transportation and industrial noise, which affect a greater proportion of the population, and for longer periods of each and every day, than may be the case for outdoor recreational noise.

It has been realized for many years that some recreational activities cause excessive noise that may seriously impact on the health of the participant and bystanders [Medical Research Council 1985], and that often the noise itself is the main attraction. Few government authorities have set laws controlling the noise output from recreational activities so as to protect the health of unwilling recipients. Controlling noise seems unnecessary to many people. Noise seems not to cause direct harm, is often temporary, and if there are adverse effects, they may not be apparent for years. If, however, the activity is in a fixed location of manageable size, or it is a special event that requires permission from the local territorial authority, there may be a requirement for the control of noise to protect surrounding residential areas and this may well be a challenge for the activity organizers to meet, but they must do so or face being fined and/or the activity prohibited.

At the inaugural meeting of the technical study group at Inter-Noise 2000 in Nice, the working party drew up a line of study for each member of the team. This included studying the problems posed by outdoor recreational noise in each member's own country and neighbouring countries, to assess what has been achieved to limit outdoor recreational noise, what methods have proven effective, and what have not, what regulations have been drafted or promulgated, and what measurement methods have been prescribed. Of particular interest were:

- The preservation of natural quiet in national parks and wilderness areas
- noise from amusement parks and theme parks
- noise from outdoor sports events (particularly motor sports)
- noise from outdoor concerts
- noise from outdoor (civilian) shooting ranges
- music from stereos, boom boxes and vehicles
- noise from low flying sporting and military aircraft including microlights
- noise from motorised recreational watercraft

Excluded from the study are those recreational activities and performances that are undertaken indoors with sound leakage from a building to the outdoor areas surrounding the building.

The team members came from 9 member countries across the world and communicated by email. Actual meetings were difficult, and few, as travel across such large distances was prohibitive. The study cannot be considered really successful as the information collated is quite limited. It was not easy to find any information about noise from some leisure activities, and finding applicable law was even harder. The limited information found by the team may not provide all the answers, but hopefully will lead the way to further study.

The aim of this report is to increase awareness of the effects of recreational noise and to suggest strategies that may be used to ameliorate the situation prevalent in many countries today. As the range of recreational activities is so large, no single report or study may cover all the salient facts. It is hoped that other studies will follow, covering noise from the large number of remaining recreational activities.

Unless otherwise stated:

- All sound pressures referred to in this work are A-frequency weighted, and all sound levels quoted are either maximum sound levels using F-time weighting ($L_{AF,max}$) or time averaged sound levels ($L_{Aeq,t}$) over a specified time period.

- "Noise/time histories" when given show the variation with time of the F-time weighted sound pressure level ($L_{AFp}$) or the 1 second time averaged level ($L_{Aeq,1s}$).

- Noise monitoring means the recording of sound levels over an extended period of time, and usually without an observer present. It is synonymous with sound and acoustic monitoring.

## 2 Initial Findings

Many territorial authorities do care about the levels of noise received in residential areas, and place rules in their plans to control the noise immission in these areas from industry and commerce. For leisure activities there appears to be no law other than in many countries an obligation to ensure that noise emitted from any premises should not exceed a reasonable level. Such a law is a civil law and any disregard only a breach of duty – a "tort". Taking action to correct such a tort usually can only be conducted by a territorial authority and then has to be triggered by a complaint from a citizen. The process is difficult and time consuming, by which time probably the noise may have ceased. So often, loud sounds resulting from outdoor recreational activities go on unchecked. If, however, the noise is from a commercial operation providing a leisure activity such as an amusement park or motor sports track, the operation may be subject to local environmental noise regulations and have to meet certain noise criteria at the boundary. This may be difficult and a number of motor sports tracks have been closed down as a result and some amusement park activities curtailed.

Territorial authorities, on whom the obligation for noise control is placed, clearly are concerned about the effects of noise to which a person voluntarily subjects himself or herself, but be unable to do anything about it as control may infringe upon the person's human rights. A control may be placed on the noise received by local residents from certain recreational activities such as outdoor concerts, but in the main the noise from outdoor recreational activities generally is not subject to control. The effects on the participants themselves do not come within the responsibility of the local territorial authorities, and so are usually ignored.

The technical study group has found that by far the greatest interest and concern is directed towards the preservation of quietness in national parks and wilderness areas. This interest probably reflects the enthusiasm of those people directly involved in the management of such areas, and the broad support by the people who value these areas as critical for preservation of undeveloped areas that contain natural wonders and provide for unique human experiences. Many authorities also have regulations for the noise generated by motor sports. As the study of outdoor recreational noise is so large, the study group concentrated on these two major areas with other outdoor recreational noise being given only limited attention although in many countries there are substantial controls for outdoor concerts in terms of how often and how long they are allowed to take place, and immission noise levels in any surrounding residential areas.

# 3 Preservation of the Natural Environment

## 3.1 Background

Some countries have been able to set aside areas of land in its natural state, to preserve the natural flora and fauna, and to try to retain the natural soundscape for future generations of people to enjoy. Unfortunately people's enjoyment can result in noise that not only is unwanted, but may significantly negate the efforts of those commissioned to preserve the land in its natural state. The management of these national parks and wilderness areas is thus very difficult. One must preserve the environment and still let in people to see it and enjoy it during their leisure time. However careful the management may be, people make noise disturbing the natural environment, and the very presence of people may even destroy some of the flora and fauna the park is set up to preserve. The control of people and noise in national parks, wilderness areas, and areas of natural quietness is thus critical if the natural heritage is to be preserved.

In the United States, the National Park Service through its Natural Sounds Program is actively pursuing development of policies and procedures to uniformly manage the "natural soundscapes" [1] in National Parks. The National Park Service is charged by law with preserving park resources and values unimpaired, for the enjoyment of future generations. This charge has been clarified recently to mean that preservation takes precedence over enjoyment; that is, enjoyment of parks must be done only in ways that also preserve the resources and values leaving them unimpaired. Also, for some parks, the enabling legislation may specifically mandate "solitude" and/or "natural quiet" as resources or values to be protected. Finally, the National Park Service has (e.g., through Director's Orders, revised Management Policies) identified natural sounds or soundscapes as one of the resources that is to be preserved unimpaired.

New Zealand is known world wide for its conservation estates and extensive system of national parks and other protected areas, which cover over one third of New Zealand's land mass. These national parks and protected areas are used by many recreational users for many different activities and hence become an important part of the overall recreational experience associated with New Zealand. These areas managed by the New Zealand Department of Conservation are not only used for recreation by recreational users but are also used in commercial enterprise for many different activities, usually tourism based.

If a private individual or commercial enterprise wishes to access the land administered by the Department of Conservation they must apply to the Department for approval in the form of either a lease, consent, licence, permit or easement. The Acts of New Zealand Parliament which enable the Department to grant consents, lease, licences, access arrangements and easements are the Conservation Act: 1987, the National Parks Act: 1980, the Reserves Act: 1977, and the Crown Materials Act. These Acts, plus other legislation such as the Resource Management Act: 1991 allow the Department to manage the total diverse land and marine areas within New Zealand. Reserves and easements not administered by the Department of Conservation (the remaining 2/3 of New Zealand's land and marine areas) are governed under rules and regulations set out in the Resource Management Act, District and Regional Plans, and New Zealand Standards, if adopted, which latter contain specific rules such as acceptable

[1] For the National Park Service "soundscape" refers to the human perception of the acoustical environment. This distinction allows managers to create objectives for safeguarding both the acoustical environment and the visitor experience.

noise limits.

Studies have found the enjoyment of the natural quietness is an important reason for visiting national parks free from the perceived adverse noise effects of urban areas [Miller 1998, Sutton 1998]. Subject to many goals the Department of Conservation in New Zealand and the U.S. National Park Service - which will be referred to jointly as the *Park Services* - as the conservation managers of these very large conservation estates, are required to foster the use of these lands for public enjoyment, which of course is not an easy task. The Director General for the Department of Conservation has identified the need to protect the value to the "natural quiet" from intrusive noise as a key issue to be addressed in the management of protected areas for a broad range of visitors [Graham 1999].

In fulfilling these integrated conservation and recreation management responsibilities, the management challenge to the Park Services is becoming more complex. There is wide-ranging diversity in the recreation opportunities that they may allow. Consequently, there is similar diversity in the impacts these activities may have on different physical and social values [Cessford 1999].

Though the concerns about inappropriate sounds in parks have been voiced for some time, it is only within the past twenty years that concerted efforts and resources have been devoted to address these concerns, and only within the past twenty or so years that the focus has been on treating the natural soundscape as a protected resource. Because of this relatively recent focus and because of the significant differences between park sound environments and those normally the subject of noise analyses, many new issues have been raised and are only beginning to be addressed. The following attempts to identify these new issues and describe the significant questions they raise that need to be answered.

### 3.2 Special Considerations Related to National Park Management Policy

Two characteristics of the U.S. National Park Service management are of particular interest. First, units of the National Park System, though operating under articulated system-wide legislative direction, regulation and management policies, are managed in accordance with the judgment of the local manager (ultimately the park unit's Superintendent). The local management is most familiar with the park's specific legislative mandates, unique resources, and with the specific visitor experiences to be provided by the park. Thus, for example, strict quantitative standards for determining when impairment occurs have been difficult to develop for park system-wide application. Each park has its particular mandates, policies and unique resources that need to be considered. Hence, any guidance on collecting, analyzing and judging soundscape data must be provided in a way that permits local management to develop the information it believes is necessary to understand the local situation and to apply to local decision making.

Second, effects on visitor experience are only one of several effects that are considered by park management in decision-making. Traditionally, effects on the resource itself are of primary importance, whether the resource is natural (water quality, bio-diversity, wildlife habitat, etc.) or cultural (civil war battlefields, Native American ruins, historic buildings, etc.). Thus, effects of intruding sounds on visitors are only one of several dimensions that park management is likely to use to judge acceptability of intrusions. Other effects, such as those on the resource itself (the natural soundscape), on wildlife, on cultural and historic sites, are also likely to be considered. This diversity of possible impacts means that standard methods

used to assess the likely effects of noise by considering only the effects on people are inadequate.

### 3.3 Special Considerations Related to Parks

The on-going development of an approach to the analysis of sound intrusions in units of the National Parks has raised many issues not encountered historically in most acoustical analyses. Most analyses of environmental noise problems are designed to address noise issues in urban or suburban residential areas. Several specific characteristics of parks that make them very different from these traditional areas of concern give rise to issues that complicate the design of a park-oriented approach.

1) Parks can be **VERY LARGE**, containing thousands to millions of acres (New Zealand's Fiordland National Park with an area of more than 1.25 million hectares is larger in area than several European countries. The Grand Canyon National Park in the United States has an area of about half a million hectares, and there are several others equally as large. Both within parks and from park to park, there are tremendous variations in geology, topography, vegetation, sensitive wildlife species, visitor activities, infrastructure or the lack of it, etc. Such size and number and diversity complicates the quantification of park soundscapes and the identification and measurement of both the natural and intruding sounds.

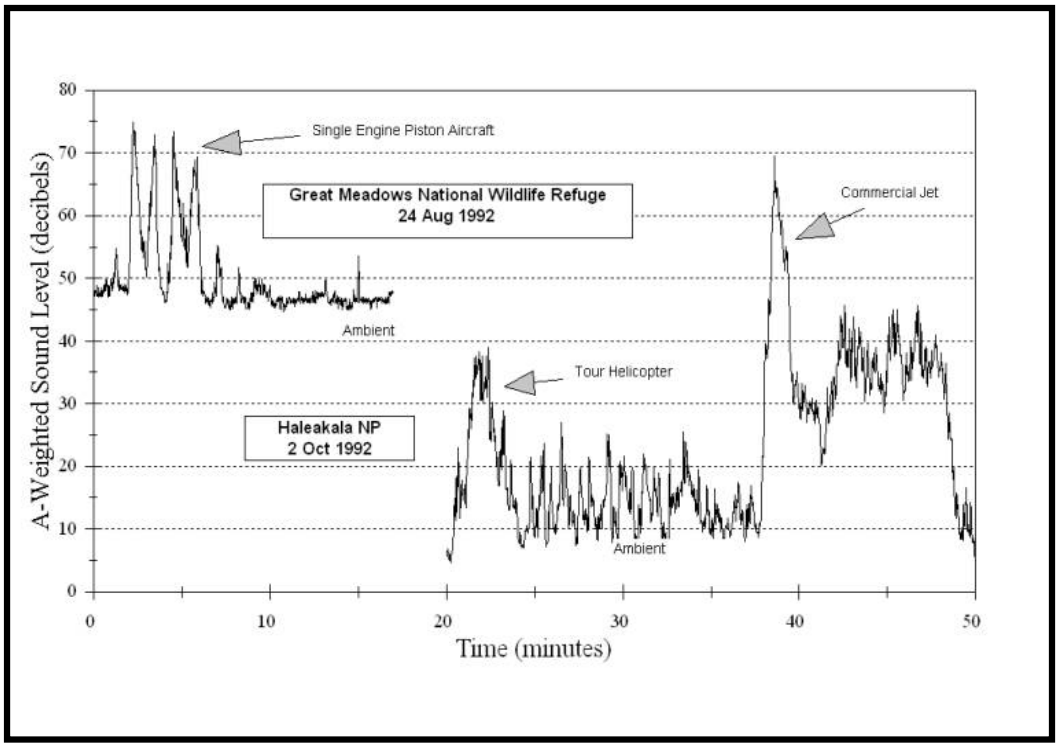
2) Parks can be **EXTREMELY QUIET**. Sound levels in parks can often be well below the sound levels found in typical urban and suburban environments – at times below the human threshold of hearing. Not only do these low levels mean that intruding sounds can be heard, and may need to be measured and/or analyzed at great distances from the source of the intruding sound, but the usual measuring equipment may be unable to accurately quantify these levels and special equipment may be needed.

Figure 3.1 compares sound levels measured in Great Meadows National Wildlife Refuge, located in suburban Bedford Massachusetts USA., near a general aviation airfield, and levels measured in Haleakala Crater in Hawaii [U.S. Nat Park Service 1995]. Some New Zealand national parks are even quieter, with some places more than 80 km from the nearest road, and more than 100 km from the nearest, and only occasionally used aircraft route.

3) The effects of intruding sounds cannot be judged solely on the basis of their sound levels. Whether visitor enjoyment or natural soundscape protection is considered, it is not only the level of an intruding sound that matters, but also the level of that sound *in relation to* the levels of the ambient soundscape. For example, the effects of distant traffic sounds are quite different in forested and desert locations because wind in the former raises ambient sound levels, while wind in the desert produces little sound at all.

4) Finally, the intruding sounds must be quantified in *two dimensions* if their effects on park environments are to be understood. Not only is the *sound level* of the intrusion (and of the natural ambient) required, but the *length of time it is heard* is also needed. Research has shown that considerations of both the sound level and the length of time it is heard are important for judging and understanding visitor reactions [Miller 1999]. Additionally, it has been observed, not surprisingly, that park management is likely to be interested in both how loud the intrusions are, and in how long and at what distances the intruding sound will be audible.

Figure 3.1 Comparison of soundscapes of two National Parks




These four characteristics mean that special approaches to quantifying, measuring, predicting and analyzing sound from intruding sources are required.

The following section addresses the major resulting technical issues.

## 3.4 Technical Issues

The technical issues may be divided into issues related to quantifying the existing soundscape, the metrics to be used, and some specific measurement techniques.

### 3.4.1 Quantifying the Soundscape

At present, existing park soundscapes are quantified primarily through “noise monitoring” at different locations within a park.

The first issue is where to measure. The existing soundscape includes all natural and human-produced sounds in the park. Current investigations assume that parks contain multiple different “acoustic zones” or environments that differ acoustically one from the other. It is assumed that areas having similar topography, foliage, wildlife habitats, and water drainage or flow conditions should have similar natural soundscapes. As far as can be deduced, dividing a park into different acoustic zones should mean that measurements made at a few or several locations within each zone may be sufficient to quantify the existing natural soundscape.

If existing intrusions are also of interest, then it is likely that purposeful measurements of these intrusions, made at known distances and under specific operating conditions, are necessary to quantify the sounds they produce.

A second issue is when to measure. At a minimum, measurements during each of the natural seasons are probably appropriate, though other temporal variations, such as natural changes in vegetation, wildlife activities, water flow and visitor activities may require multiple different time periods. Such timing of measurements assumes that soundscapes change with these temporal changes. If intrusions are of interest, then a measurement and data collection method is needed that will estimate or determine when intrusions are present. However, this determination – identification of sources of intrusion – is a significant problem. The length of measurements should be based on the level of confidence desired in the results. Available data suggest that measurements of the background sound level should be over two to four weeks to provide acceptably narrow confidence bands. Confidence levels in the measurement of intrusions should be determined separately for each type of intruding source.

If only the natural soundscape is to be quantified, it may be sufficient to monitor A-frequency weighted sound pressure levels. However, A-weighted sound pressure levels alone may be insufficient to determine with enough certainty, what are natural and what are intruding sound levels. Additionally, A-frequency weighted levels can overstate the ability of the natural sounds to cover up or mask intruding sounds. Most human-produced sounds (generally motors or engines) contain low frequency energy - below about 300 Hz - which is the range in which human hearing first detects the existence of the sound. A-frequency weighted levels of natural sounds may be dominated by the sounds of birds or insects which contain primarily sound energy above 1000 Hz. Hence the A-frequency weighted level can be quite high, but still permit easy detection of many human-produced sounds.

If identification/quantification of intrusions is of interest, it is likely that frequency information (specifically 1/3 octave band levels) should be measured, either with an observer present, or with concurrent digital audio recordings.

### 3.4.2 Appropriate Soundscape Metrics

For the existing natural ambient sound, the appropriate metrics to use depend upon the purpose of the measurements and analyses. If only the natural soundscape is to be quantified, then the general consensus is that hourly A-frequency weighted levels may be sufficient. The background sound level, with $L_{A,eq}$ and $L_{AF,max}$, by the hour can provide a useful picture of how sound levels vary throughout a day, and throughout a week or several weeks. It is probable that long-term hourly averages, combined with a sampling of audio recordings and observer logs, may provide sufficient documentation to permit identification of significant changes.

If existing intrusions are of concern, and are to be quantified, then additional metrics will likely be required. Maximum levels at different distances from the intruding source, the number of occurrences during specified time periods, the distance to inaudibility, and the duration of audibility may all be useful to management in understanding the effects of the intrusions. As propagation of sound from the intruding sources will affect sound levels and audibility, measurements should be made over fairly long distances (probably several kilometres) through the various terrains, topography and vegetation that could affect this

propagation. Acquiring this information will likely require purposeful measurements, including frequency information and observer logs.

If the effects of future or planned intrusions, or changes to existing intrusions are of interest, then some method of modeling intruding source sounds is required. As long distances (and quiet environments) will probably be a part of any analysis, it is likely that detailed frequency information will be necessary for accurate modeling. Most modeling of acoustic sources to date has not involved long distances (intrusions can be audible at distances of 10 to 15 kilometres), and efforts in this type of modeling are in the early stages of development and validation. Not only will frequency data be needed at great distances from the source, but source directivity patterns will also be needed or need to be estimated.

### 3.4.3 Specific Measurement Techniques

Unique park conditions and metrics require that special consideration be given to measurement techniques.

The low-noise environments in parks may require that some of the acoustic data be acquired with a system capable of accurately measuring the very low sound levels. For example, values of hourly A-frequency weighted background sound level, may be sufficiently accurate only if the equipment has a very low noise floor (i.e., below 5 dB) and utilizes a low noise microphone with a sensitivity in excess of 50 mV/Pa and capable of measuring the lowest sound levels likely in a national park (down to 0 to 2 dB). Collecting the acoustic data in 1/3 octave bands, can lead to higher quality (more accurate) results, even for the A-frequency weighted values. These systems are expensive and delicate, and hence are not likely to be used widely. They do, however, provide the highest quality data currently available, and can be used either with a standard monitor system, or for audio recording. Some modern sound monitoring systems include concurrent digital audio recordings which can provide a means of determining what is the natural sound and what is an intrusion, and data suitable for modeling purposes or for audio presentations.

One important aspect of measuring in park environments is that sound levels are frequently low enough (below about 35 dB), that light wind blowing on the microphone/windscreen will produce measured, yet spurious sound levels. For example, wind speeds of 5 metres per second can produce pressure fluctuations around a standard microphone windscreen that register as sound levels of about 35 dB even with a quality windshield in place [Brüel and Kjær 1996]. Hence, monitoring sound levels in park environments without simultaneously monitoring wind speeds will add an unknown bias to the lower sound levels. Special two-stage windscreens have been found to reduce wind-induced noise by 5 to 12 dB relative to standard windscreens [Anderson et al. 1992]. Consideration should be given to always monitoring wind speed at or near the microphone when conducting noise monitoring in parks.

Ultrasonic wind speed monitors, though about as expensive as an acoustic monitor, have no moving parts and therefore produce virtually no sound, and hence may be placed close to the microphone. The relation of wind speed to wind-induced sound level may be determined and used to adjust measured sound levels if wind speed is measured simultaneously with sound level.

### 3.4.4 Observer Logs

When the park management wishes to understand intruding sound levels, it is necessary to know what the levels of those intrusions are, and how often they occur. The simplest means for gathering this information is through attended monitoring, or at least, through use of observers who keep minute-by-minute logs of the sources heard.

The exact method for producing these observer logs depends upon which of two objectives the measurement serves: 1) identification and measurement of all intruding sounds; or 2) examination of the effects of one specific intruding sound. The first goal means that the observer will identify and log the source judged to be the dominant (loudest) one. The second requires that a specific source identification hierarchy be established for logging. In either case, the intent is to acquire, for several periods during the continuous monitoring, detailed records of the sources that are producing the measured sound levels.

## 3.5 Policy Issues

The special nature of parks and all the issues discussed above mean park management must address many related policy issues. Though there are likely far more than presented here, the following are some that have been encountered.

### 3.5.1 Role of Audibility

Though audibility of intrusions is an easily understood concept and arguably a very valuable one for park application, the objective measurement and prediction of the audibility of an intruding source represents a new and challenging endeavor for the field of environmental acoustics. Observer logs have been used with considerable success to objectively determine the presence of various sources in American studies. Also, there are well-developed algorithms for computing whether or not a human can detect a target sound source in the presence of other sounds. The application of these methods and algorithms to environmental noise analyses is, however, relatively new within the acoustics community, and it is likely that further use and review will be necessary to achieve wide acceptance.

The use of audibility, or detectability, raises several concerns - perhaps because it has not been employed in environmental analyses:

1. When determined through observation, there is concern that it may not be objective – that the opinions, prejudices, biases, etc. of the observers will affect the results.

2. Prediction of audibility requires considerable information. In a perfect world, the frequency time histories of both the background and of the intruding source(s) would be known for all locations where predictions are needed. Lacking this type of extensive information (as will almost always be the case), approximations to both will be necessary. Probably an average background or ambient spectrum will be the best that can be done, and the source time history, especially for a moving source, will be an estimate based on measurements made at a few distances and directions.

3. Some might fear that audibility can perhaps be too easily turned into a very restrictive standard for impact determination. It is easy to imagine having a goal that no intruding sources be audible in a sensitive area. For ground-based sources this

standard would mean that intruding sources could probably be no closer to such an area than 5 to 10 kilometres. For aircraft, this standard could mean that such minimum distances would likely be 15 to 20 kilometres, or more - which may be set in some New Zealand national parks, but few if any elsewhere.

4. Finally, audibility is a human-based concept. Its use to protect a resource or a park environment may be inappropriate if non-human values are important -for example, the preservation of acoustic environments appropriate for wildlife communication.

The use of audibility metrics, however, may be the best means for source identification, as well as decision-maker understanding. Audibility metrics are determined and implemented through use of observer logs and/or automated detection algorithms, and/or digital audio recordings, listened to later. The use of observers, or post-recording listening, introduces the human element, and use of the detection algorithms will require testing and validation. Both observers/listening to recordings, and automated approaches are somewhat complicated and costly. Hence, organizations needing to develop methods for quantification and analysis of sounds in parks / recreational areas will have to judge strengths and weaknesses of audibility metrics, the costs and complexities of their use, and decide whether or not and how to use audibility metrics.

### 3.5.2 Visitor Enjoyment

Visitor enjoyment is a generic concept, relating to the sense of satisfaction or fulfilment from having achieved the recreation experiences being sought. After conservation protection, providing for visitor enjoyment is usually the major objective of most public land management agencies. Noise effects that represent intrusions into the desired recreation experiences of visitors can have a negative impact on the degree to which visitor enjoyment is achieved. People may still consider they have had an enjoyable recreation experience overall, but the quality of their visit may have been compromised. The management task is not simple, however, as people's reactions to different noise types, levels and contexts are highly variable [Kariel 1980].

In some cases, the actions of some visitors may generate the noise effects that impact on the recreation experience of others. The most common examples from recreation conflict research highlight differences between motorised and non-motorised recreation activities [Hunt and Moody 2001].

Through managing a diverse array of land areas and activity types, the Parks Services are faced with many situations where recreational noise has an actual or potential social impact. A selection of results from extensive visitor survey programmes illustrates the diversity of noise issues that can arise.

Audible sound from over-flying aircraft can detract from the amenity of an area, even at levels where there are no direct effects such as communication interference. There can be general annoyance and the feeling of helplessness because of the intrusion by a factor in the local environment that is outside of the direct control by the individual. In natural areas the soundscape can form part of the outdoor experience, and although naturally occurring sound in the environment at high levels does not seem to adversely affect the visitor, frequent sounds at only modest levels from aircraft overhead elicits a negative response [Booth et al. 1997].

Surveys of aircraft noise impacts on visitors to national parks have shown noise is a recognisable environmental effect on the visitor experience, mainly perceived as having a detrimental effect on amenity. The New Zealand Resource Management Act:1991 defines amenity as:

*"those natural or physical qualities and characteristics that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes"*

Research carried out by Booth [Booth 1998] indicates a greater acceptability of aircraft noise in modified environments (such as in a tourist village) compared to natural settings (e.g. people walking in a national park) where aircraft are the only non-natural part of the landscape. Similarly, researchers have found that track users were more disturbed by aircraft while walking on the track, compared to when they were in their accommodation quarters [Sutton 1998].

The implementation of managed separation will, in the end, require decisions on those areas of the National Park within which air traffic maybe restricted in some way, and other areas where noise from aircraft is acceptable. While those decisions remain problematic, the approach to quantifying noise impact is designed to provide useful baseline information to assist in making such decisions.

Currently there are certain provisions under legislation for concessions associated with recreation such as dealing with aircraft activities used for recreation/tourism, such as the positioning of people for recreational purposes, heli-skiing, heli-hiking and scenic landings etc.

Many national parks have spectacular scenery which is a major focus for local and international visitors. The benefits of aircraft access are often not fully appreciated. Aircraft can provide quick and convenient transport, allowing visitors to access areas for many different recreational activities. The ready availability of aircraft combined with the smaller amounts of disposable time available to busy people, also contribute to air activity. While the Park Services recognise the benefits that aircraft can have in allowing visitors to better appreciate or gain easier access to areas in their park, they also recognise that the effects of aircraft can significantly impact upon the values of the land that the Park Services are charged to protect. Examples of such effects are: disturbance to wildlife; physical impacts at particular sites; impacts on historical and/or cultural values; the disruption of natural quiet and the values of solitude, space, scenic and other intrinsic values; effects on the enjoyment, inspiration, recreation and other benefits that visitors gain from land managed by the Park Services. Furthermore, allowing aircraft to position people in areas traditionally accessed by foot, may also impact on the recreational character (a value in its own right) of those areas.

### 3.5.3 Recreational Noise and Natural Quiet

Two types of recreational noise impacts exist:
(a) noise that impacts upon recreational activities; and
(b) noise from recreational activities that impacts upon other activities

In both cases the common theme seems to be disrupting the “natural quiet” soundscape in which these activities (recreational or otherwise) are undertaken.

The definition of “natural quiet” includes the absence of any mechanical noise and containing only the sounds of nature such as bird song, wind or rain. Natural phenomena such as waterfalls and avalanches can be loud (louder than aircraft or other mechanical sources) but many people still view these noises as “good” and sound from aircraft noise as “bad” [Booth 1998]. Studies have found the enjoyment of naturally quiet is an important reason for visiting national parks free from perceived adverse noise effects of urban areas. The annoyance from recreational noise is often due to an increase in ambient noise level due to the introduction of noise from mechanical noise sources such as aircraft, motorboats, or other mechanical devices although one should not under-estimate annoyance due to human voices (shouting etc). In many cases, the noise is unpredictable both in level and in when it occurs – making it even more annoying to many people.

The principal effect of aircraft activity is the impact they have on the value of natural quiet - *the natural ambient conditions or the sound of nature*. Natural quiet is an important component of visitors’ appreciation of national parks and wilderness areas. In protecting natural quiet, visitors and the tourism industry need to be aware of their responsibilities to other visitors. In particular, aircraft flying over such areas require careful management to ensure that aircraft noise does not detract unduly from the visitors’ experience of those areas. The Civil Aviation Acts in some developed countries make provision for restrictions to be imposed on airspace for reasons of national security and the public interest. This may allow the opportunity for the Park Services and other parties to seek restrictions on the use of airspace, for conservation purposes, including the enjoyment of visitors.

There are, of course, occasions where aircraft are used by the Parks Services for fire fighting, search and rescue, and research and inventory monitoring, and produce intrusions. When national parks and wilderness areas are large, there may be no alternative to this aircraft activity which in the large majority of cases would be seen as acceptable by park users.

## 3.6 Other Noise Sources

### 3.6.1 Snowmobiles

Snowmobiles are used in the winter in approximately thirty National Parks in the United States and numerous parks elsewhere. Their use can represent a significant source of intruding sound. In Yellowstone and Grand Teton National Parks, the numbers of snowmobiles has grown so large (something on the order of 80,000 people entering Yellowstone each winter on snowmobiles) that the Parks Service is working to reduce or eliminate their use. In April 2000, U.S. National Park Service banned snowmobile use in most national parks, but it is understood the U.S. Congress delayed implementation of the ban until July 2001, in which time a snowmobile manufacturers association filed a lawsuit to prevent the ban in Yellowstone National Park.

Over the past decade, the National park Service has been studying various winter use plans at the parks. Several environmental impact statements and supplements have been prepared, but no resolution has been achieved as of 2011. The National Park Service has evaluated the benefits of using “best available technology” snowmobiles and snow coaches, which have lower noise and air emissions. In May of 2011 the National Park Service released for public

comment, a Draft Environmental Impact Statement, which studied six scenarios, ranging from ending all snowmobile and traditional snow coach use to allowing continued use of both types of vehicles at different usage levels. The record of decision and plan implementation is scheduled for December 2011 (see Menge and Ross 2000).

### 3.6.2 Rivers and Lakes in Wilderness Areas

In many countries, rivers provide access to communities as well as to wilderness areas. Many national parks have rivers running through them and often by law these rivers are considered public rights of way. Restricting their use in areas of natural quietness is often most difficult, particularly when many people believe they have the right to utilize any such public right of way for their own purposes, wherever and whenever they like. There are cases where the Parks Services have been taken to court for imposing restrictions on the people's right of way along certain waterways. On the other hand, jet boats can be engineered to be very quiet and can be used by park authorities to transport visitors into quiet heritage areas without disturbing the natural ambience – as along the Dart River in New Zealand's Fiordland National Park.

Another problem is that in many countries, lakes are considered aerodromes by the relevant civil aviation authority. One can understand this from the safety point of view in that an aircraft in difficulties must be able to make an emergency landing in such an area free of people. Unfortunately, however, this use in law is not restricted to emergencies and people believe it is their right to fly to any lake and use it for their enjoyment. There is considerable upset when trampers have spent several hours getting to a wilderness lake to enjoy the quietness and solitude, only to have an aircraft arrive and drop off some personal watercraft - such as jet skis and power boats - which then travel up and down the lake at high speed for an hour or two before the aircraft picks them up and goes elsewhere. A way of combating this, or of policing a naturally quiet area to ensure its solitude, has yet to be found unless the civil aviation authority puts the area off limits to aircraft and itself ensures the regulations are kept. Even them policing the territory is extremely difficult when some vary large areas are involved.

### 3.6.3 Motor Racing in a National Park

Many people have heard of "Monza" in Italy, and the Formula 1 competitions held there but few realise that Monza is a national park and, irrespective of the large numbers of people attending and the government not appearing to have any concern whatsoever about noise, the Park Service must somehow balance the need for preservation of the Park's natural environment with the need for the funds the race generates. Added to the noise problems there are other more urgent problems concerning safety and crowd control that take attention away from the noise. The control of noise cannot be a first order priority and the Park Services in Italy do not have an easy time in trying to preserve any sort of natural quietness in the parks. In 2006, however, even at his venue some noise restrictions were introduced.

The Italian decree of April 2001 states that whenever it is not possible to meet levels stated for parks due to car racing, that is to say in Monza, Imola and also Maranello (seat for Ferrari tests), Mugello near Florence (motorcycle racing and F1 racing car tests), Misano Adriatico near Rimini (motorcycle and F3000 car racing), the organizers are obliged to acoustically insulate or protect all schools and hospitals of any kind and size, to bring internal noise levels below certain stated limits.

### 3.7 The Role and Responsibilities of the Park Services

Based on the on-going Park Services experiences, developing uniform methods for managing both the natural and intruding sounds in recreational areas involves significant, complex technical components. Also, as indicated by the brief descriptions of the current major sources of concern, major conflicts are likely to accompany most efforts to limit the sound or use of intruding sources. These conflicts mean that Park Managers will increasingly require scientific data on natural and intruding sounds as a basis for policy decisions to meet the Central Government directed objectives of preserving Park resources and values and providing for visitor enjoyment for present and future generations. Because of the contentious nature of these issues, all technical (and policy) decisions are likely to be scrutinized closely and challenged whenever possible. With these joint characteristics of technical complexity and conflict, it often means that politics has to be involved in the management of noise in recreation areas.

In dealing with these noise problems acoustics specialists must be extremely thorough and objective in their work and recommendations, and must be prepared to defend their decisions in a litigious environment, including the conflicting needs for tourism and “quiet”, and the presumed rights of tourists.

# 4 Motor Sport Activities

As people become more affluent, young people have more access to motor vehicles and some abuse the privilege by engaging in street and drag racing, to the severe annoyance of local residents. This is of concern also to the managers of racing tracks who see this adding to the difficulties already being posed by increasing urban development that threatens the existence of some racetracks, most of which originally were set up well away from residential areas.

## 4.1 Race Tracks

The motor racing fraternity have always been aware of the noise attached to racing and the effect it could have on nearby residents. That was a good reason for siteing of racetracks well away from residential areas. The world population is expanding rapidly with a corresponding increase in housing needs. The once remote race tracks are increasingly being threatened by urban growth. Reverse sensitivity is now the norm for most tracks and some already have been closed down or made to relocate still further away due to environmental law favouring the new neighbours that the racetrack did not want [Dickinson 1990]. Racetrack management is very aware that noise emissions must be kept down to the minimum possible to keep the track viable, and that they still have to fight to keep a buffer zone around the track to protect any neighbouring residential areas from the noise produced, and in reverse to protect the track from legal action to have it closed down and its (valuable) land zoned for housing.

The main sources of noise from a motor sport venue are:

- Exhaust noise from individual vehicles
- Other vehicle noise, including tyre/track interaction and mechanical noise
- Collateral noise from unofficial revving and racing in the vicinity
- Public address systems
- Noise from increased traffic to and from the venue.

In many areas, it is the sound from the public address systems that causes the most annoyance in the surrounding community. Sometimes tyre squeal causes complaint but mechanical noise, and noise from the increased traffic to and from the venue, rarely is of concern; the complaints being focussed on the volume of traffic and the resulting delays rather than the noise produced. The reduction in vehicle exhaust noise over the last few years has made the other sources more noticeable. The vehicle noise on the track does cause complaints but often it is the practice outside of actual race times that stimulates a complaint.

Control of the noise at source is the most effective way of managing the noise emissions from the track. Pre-event control is not the complete answer for where prizes are involved there will always be those that will alter their vehicles to increase the power before using the track. The silencing system also may be damaged while racing and its noise emission increase. Continuous trackside noise monitoring and strict control to be able to remove any vehicle from the racetrack at any time if required, is essential, and part of any good track management.

Planning for the noise emission from the racetrack is difficult as there is a considerable difference in sound levels between events, and throughout the day of track activity. For example: A dealer day demonstrating production saloon cars, will produce much less noise than a day of racing, and during the day between events there may be no noise at all.

Figure 4.1 One minute short Leq levels at a typical race meeting

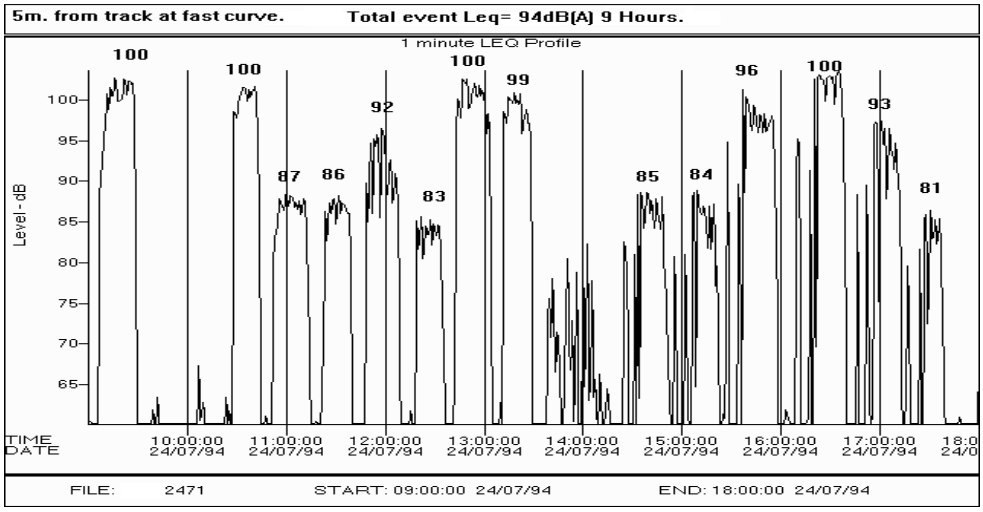



Figure 4.1 shows the variation in 1 minute time average levels ($L_{\mathrm{Aeq,60s}}$) at 5 metres from trackside during a day's motorcar racing activities [MSA]. Each race can be clearly identified and the time averaged level for each race is shown on the chart. The levels vary between 83 and 100 dB, but there are also times when the levels drop to below 60 dB. Indeed for over 50% of the time the level is below 75 dB and only for 25% of the time is it over 90 dB. The daily time-averaged level for the 9 hour day of racing was 94 dB, the highest hourly recorded time averaged level being 99 dB.

It may not be appropriate to use the long term time-averaged levels to predict annoyance, consideration of the range of levels is also needed. Due to these differences in noise level, a time averaged level over an entire day may not be representative of the annoyance if there are some very noisy shorter events during that day. An approach with two criteria better deals with this situation: A long term limit, which may be the average over an entire day, i.e., $L_{\mathrm{Aeq,8hr}}$, and a short time limit, which may be the average over a time representative of a pass-by of a group of vehicles, such as $L_{\mathrm{Aeq,5sec}}$ or one circuit of the track, such as $L_{\mathrm{Aeq,1min}}$.

The public address systems that cause complaint often are badly designed for there is no reason why such a system should cause annoyance outside the venue if it is designed properly. Multiple lower powered speakers facing inwards across the spectators towards the track, rather than a few high powered speakers radiating from the track side towards the spectators, and limits to the power output, agreed with local territorial authorities, can ensure the sound emission is acceptable to the local neighbouring residents. The use of radio headphones in place of the public address system [Sounddec] may be the easiest and best solution to the problem but requires acceptance by the management of the racetrack and those attending the race meeting.

The activities of the local community also must be taken into account when planning racing events, to prevent the highest noise levels occurring during sensitive times of the day. Some racing venues have arranged breaks in track noise during local religious services and many circuits have restrictions on noise at early morning and late evening hours.

Much of the above is extracted from the Guidance Notes on Noise Control at Motor Sports Circuits published by the AMRCO and RACMSA [MRA] which examines each of the issues in greater detail than possible here.

## 4.2 Street Racing and Designer Cars

Unorganised street racing ("Boy Racers") in a number of countries is proving almost impossible to control under local law, and the police through lack of resources have been unable to take action in many cases. Some laws have been brought in allowing the impounding or confiscation of cars for serious unruly behaviour, but when a few police are faced by hundreds of unruly youngsters in high powered vehicles, such enforcement often puts the safety of the individual police at great risk. It would appear a solution to the problem has yet to be found for countries, without strong environmental laws, that cannot provide adequate policing.

Organised street car racing, on the other hand, often is treated as a holiday occasion, and if organised well, with adequate limits to the noise at source, may cause little or no upset to the local community. Indeed such occasions may well bring in much needed funds to help alleviate the tax burden on the community. As mentioned above, at least one country even has motor racing take place in a national park with little or no adverse comment – the famous Monza circuit. Organised street car racing is becoming very popular in many countries, and if due regard is taken of local residents and their needs, there appears to be little annoyance and few complaints to such one off events.

Little or no work, it would seem, has been done on the sound exposure received by participants and spectators in motor sports and other similar motorised outdoor activities where sound levels may be very high over fairly long periods of time.

High power stereo systems in cars are very popular, and it is not uncommon for drivers of cars on the residential roads to have the stereo so loud, that residents hear the bass boom of the car stereo before the sound (and sight) of the car itself. If the levels are so high outside the car, the noise exposure for the driver and occupants could well be such that this would be a significant contributor to the daily sound exposure and increase the risk of noise induced hearing loss in the long term.

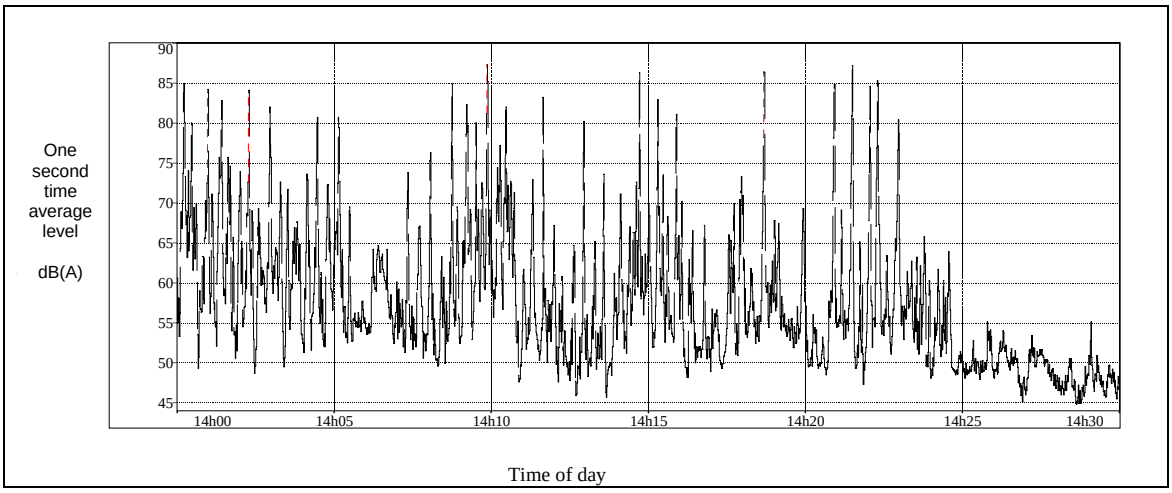
## 4.3 Off-Road Vehicles

### 4.3.1 Wheeled Vehicles

There is little information about the sound emission and related noise annoyance from organized events featuring off-road four-wheel drive vehicles or motorcycles. As in organized street racing such events if organized properly may be treated as a gala occasion involving the local people with little or no complaints. A typical time history of events involving quad bikes, dirt bikes, 4x4s and buggies is shown in Figure 4.2

Overall the sound exposure is not high, but if the events are organized only with approval from local government and not the local residents, for neighbors wanting a quiet weekend such activities can be very annoying and generate complaints and court action. And it is not uncommon for such activities to be closed down by order of the court.

Figure 4.2 Off-road activities measured 12 metres from the vehicles




On the other hand, unorganized incursions on to farm land, wilderness areas and national parks in a number of countries, like unorganized street racing, would seem to be almost impossible to control under local law, and the police through lack of resources have been unable to catch the offenders let alone take action in many cases. As in street racing, some laws have been brought in, allowing the impounding or confiscation of vehicles for serious unruly behavior or damage to land, but the offender has to be caught and the local police in general do not have the vehicles, nor the resources to do this. The problem, however, does not seem to be of a great magnitude. Those engaging in off-road activities would seem generally to belong to clubs who are aware of the need to avoid confrontation with the local people, and they provide some policing against non-club members disturbing the neighborhood.

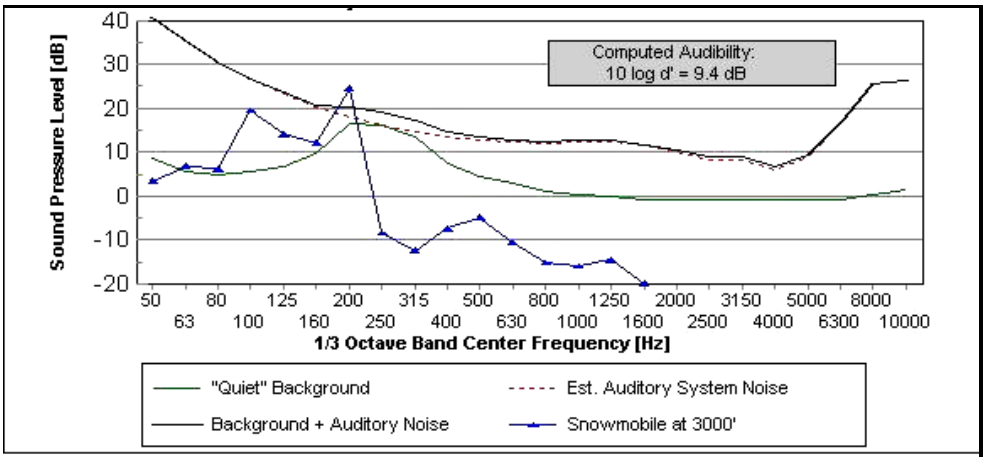
### 4.3.2 Tracked Vehicles

Snowmobiles are a particular problem in areas of natural quietness - such as national parks. When driven carefully, their use elsewhere is not noted as a noise problem - although there is anecdotal evidence from some many years ago of early deafness in members of the Inuit of Northern Canada, due to substandard snowmobiles (sans mufflers) being delivered under a government incentive. Modern snowmobiles are relatively much quieter and problems arise mainly due to low frequency but audible noise being generated by these machines in areas where the low frequency component of the background noise is at, or below, the threshold of audibility. For example, Menge and Ross [Menge and Ross 2000] give the following figure, Figure 4.3, for the background noise spectrum in a national park compared to that of the human auditory system and that of a snowmobile computed for a distance of 3000 feet (~ 900 metres).

The snowmobile spectrum at 3000 feet has a tonal peak in the 200 Hz one-third octave band, which is 2 dB higher than the audible threshold at that frequency and would be audible. In an area where any man-made sound is unacceptable, this is intrusive and can cause annoyance. The authors make the additional observation that the higher frequencies of the snowmobile noise are significantly attenuated by distance over absorptive snow - in this case powder-snow with flow resistance in the order of 400 rayls ($Pa.s/m^2$) - and thus it is the low-frequency components of the source spectrum that are the most significant with respect to audibility at

the longer distances. It is also clear that using A-frequency weighting for describing such sound does not relate to a measure of audibility.

Figure 4.3 Snowmobile noise and background noise in a National Park




If the snowmobile is being used for play, which often is the case, the noise levels may be much higher, more intrusive and quite unacceptable to those living in the vicinity. Strict limitations on snowmobile use in natural quiet areas, national parks, residential parks and wilderness areas, with specific areas set aside for those that want to play with their machines, appears to be the only satisfactory means of controlling unacceptable noise emissions from these vehicles.

# 5 Recommendations

## 5.1 General

Before any noise legislation is considered, or a noise policy developed, some decision must be made for the planned outcomes to be achieved. Without this, the law makers and planners will have no direction to follow and the resulting law may be ineffective. Thus, as a starting point, it is recommended that all countries adopt the World Health Organization environmental noise recommendations for all residential and all noise sensitive areas [WHO 1999]. For dwellings, WHO recommends maximum time average levels ($L_{A,eq}$) in bedrooms for steady state sound should not be more than 30 dB and for any event a maximum level ($L_{AF,max}$) not more than 45 dB. To protect the majority of people from being seriously annoyed during daytime, WHO recommends the outdoor time average level ($L_{A,eq}$) should not exceed 50 dB. At night-time this should not be more than 45 dB so that people can sleep with windows open. In hospitals the time averaged level ($L_{A,eq}$) in most rooms should not exceed 35 dB. This does not take into account, however, areas of the world where background sound levels are very low, in which case even sound levels as low as 40 dB may still cause serious annoyance and legal action.

The criteria to achieve should not be based on the maximum sound that can be tolerated without serious complaint, as is common in many countries for transportation noise, but should be based on those levels that are requisite to protect public health with an adequate margin of safety, as so ably produced by Dr Simone Yaniv and the United States Environmental Protection Agency in 1973 [USEPA 1974]. With modern technology, and the developments in new low noise, energy efficient motors and power-plants, there is no excuse for outdoor recreational noise to exceed the criteria recommended by the WHO in any residential or noise sensitive area..

In the U.S., the National Park Service is beginning to develop Soundscape Management Plans that address human-produced sounds in the many varied park contexts: daytime and nighttime in front-country, backcountry, wilderness and other park-identified management zones. Specific issues addressed include visitor experiences of solitude, opportunity to appreciate undisturbed natural sounds, sense of reverence for historic and cultural sites, audibility of outdoor interpretive presentation, undisturbed sleep while camping. Many metrics of human-produced sounds may be used to set standards including time audible, changes in total sound exposure (equivalent levels), noise-free intervals and time above specified thresholds.

Determination of standards or limits applicable to the various contexts, experiences and metrics is of course difficult, and NPS is still in the process of developing these for different parks. Standards will depend upon management objectives for each type of zone in each park. It is the authors' suggestion that standards be based on recent and on-going research on the restorative aspects of nature, management judgments developed by in-field experience, visitor dose-response data, speech and sleep interference research results and information on the effects of noise on wildlife species present in the park. The standards for each park should probably be developed beginning with a uniform approach across all parks that might include three to five degrees of noise sensitivity, applied to each park's unique set of zones. Three levels might be described in the following manner:

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, tranquillity 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.

Moderate sensitivity to human-produced sound – Surroundings offer a sense of remoteness and peace, but may be developed with 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.

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.

It is possible that for a set of sensitivities, park managers could develop a consensus on the standards that would apply for each. The application to each park would then be uniquely determined by each park's management zones and objectives.

For other sports related outdoor recreational activities it is suggested that much of the noise produced by individuals follows examples of behaviour by sports heroes taken as role models, and by sports fans and outdoor leisure as depicted in the media. A major effort is recommended to get the support of national television icons, and the media, to promote "quiet is cool", and that noise is not related to power.

# 6 Conclusions and Prognosis

The outdoors is a place to enjoy. It is also a place to protect. Our life depends on it as do the lives of our children and the rest of mankind. How we treat the environment would appear to be our choice with regards to noise, for except in a few parts of the world, there are few regulations anywhere set to protect it and the myriad of creatures that inhabit it. Most of the regulations that have been set are not strong, and in many places are almost impossible to police.

Much is the product of our time and the result of our intellectual and technological development. The developments in communication show people the joys others may experience in their leisure times outdoors, and this together with the ease of modern transportation, instils in them the urge to copy, or as they see it do even better. Arguably man is noisier than he has ever been and unless we can achieve a change in culture the prognosis for the future is not good.

A number of naturally quiet areas have been set aside to protect and maintain for future generations to enjoy and cherish. Regrettably the law can achieve only so much and incursion by off-road vehicles, high powered watercraft and aircraft is commonplace. Often, as in the case of aircraft overflights of these areas, no law is being broken as government departments do not always see eye to eye. It requires all government departments to work together to preserve these areas and save our heritage for future generations to enjoy.

Some lawful activities that produce loud noise have serious reverse sensitivity problems in being threatened by aggressive residential development on land that once was deemed unsuitable but has become most desirable through the presence and development of the activity itself. Motor sports circuits are under threat in many areas by new residential development that does not want the noise and uses the law for their own ends irrespective of the motor sports having been there long before any development occurred. The associations set up to govern such sporting and leisure activities rarely have power in law and often their only recourse is to buy the surrounding land to act as a buffer zone.

Much progress has been made in other outdoor community activities to reduce the noise produced. In designing and managing sports venues, many local authorities have succeeded in achieving a good balance between those parts of the community that enjoy a noisy activity with the rights of others to enjoy an acceptable level of quietness. Public address systems have been quoted on many occasions as the prime cause of annoyance at sporting fixtures such as track and field events. The use of radio headsets in place of loudspeakers has been found very satisfactory at a number of prominent events such as the “Goodwood” races and may eventually solve the problem of this type of noise annoyance in the future, as it may from outdoor concerts in the future.

Much progress has also been made in controlling all the machine noise and much of the participants’ noise emitted from amusement parks. Still remaining to be solved is the problem of the behaviour of people themselves. The banning of alcohol (and drugs) has had a significant effect on the behaviour of crowds at sporting events and outdoor concerts, and has made a number of activities much more acceptable to local neighbours who once feared the aftermath of a drunken mob leaving the venue to pass through their neighbourhood. Developments in transportation too can get the crowds away quickly and quietly if sufficient planning and input is made by local territorial authorities.

Remaining to be solved are the problems of street racers, the use of high power stereos outdoors and in vehicles, in a few areas the indiscriminate use of jet skis, and noisy off-road vehicles, and perhaps the hardest problem of all - getting people to change their noisy outbursts of totally unnecessary vocal energy. This will require a change in culture and help by government and media alike to portray quietness as the goal to achieve.

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## Annex A

## Other Outdoor Recreational Activities Noted by TSG 1

| Activity | General Problems | Recommended action | Experience | Useful regulations | Any comments |
|---|---|---|---|---|---|
| Outdoor concerts | High sound levels from music and attendees.<br><br>Community annoyance, often exacerbated by rowdy behavior during and after the event if alcohol allowed. | Careful control of front of house noise levels, and directional control of sound so as to focus on audience alone.<br><br>Alternatively and better: No loudspeakers. Issue individually controlled radio headphones.<br><br>Also for both: No alcohol, no glass bottles. | Alternative action worked very well at high powered religious rock concerts (parachute) in New Zealand's Mystery Creek show grounds. | Limit to number of events per year, and duration of each event, together with special maximum sound and sound exposure level regulations for the time of the event and a substantial bond (money) from the organizers which is forfeit if the regulations are broken. Organizer and performing groups banned from any further use of the facility if regulations broken during more than two concerts. | Can be collateral noise in areas when patrons departing. Letter drop to advise of the event and giving a hotline number to call if there is a problem. |
| Horse racing<br><br>Pony Club events | Public address system (often badly designed) too loud causing annoyance to those outside. | Careful control of the public address system to keep the sound within the venue. Again replace loudspeakers with radio headphones. | It is understood the radio headphone system worked well at Goodwood Racecourse in England. | Limits to noise in residential areas plus limit to number of events per year. | Noise from activity itself and those attending usually not a problem, but good traffic management needed to avoid traffic noise. |
| Amusement Parks | Roller coasters and music concerts are the most problematic sources. | Mechanical noise from steel roller coasters can be reduced by damping rails and support beams. Screaming sound can be reduced by tubular enclosures around the track. | Used in Florida, California and Germany.<br><br>[See Menge 1999] | Limit to noise immission in nearby residential areas and for tall structures with screaming patrons such as roller coasters and long drops, a limit to times of operation, for example daytime only. | Some roller coasters such as "The Big Dipper" in Sydney Australia have been shut down as a result of community noise complaints. |

| Activity | General problems | Recommended action | Experience | Useful regulations | Any comments |
|---|---|---|---|---|---|
| Motorcross | Very high sound levels, revving on the track and in marshalling area,. Noise is continuous during races. | Locate away from residential areas and/or depress tracks below grade. Installing a tall earth barrier around the perimeter of the area in which the motorcross is held has also been effective. Control hours of operation, immission levels in surrounding area, and public address system. | Used in California and Massachusetts in the United States and in Australia and New Zealand. | Limit to noise immission in nearby residential areas and limit to number of events per year. | Revving of motors outside the venue can be a problem if not controlled. |
| Tennis Courts | Impact sound of ball hitting racket can be very penetrating in adjacent buildings. Sometimes intermittent noise from patrons cheering. | Keep away and/or shield from residential buildings. Do not put courts between high rise buildings which can channel and amplify the sound. | Has been noted as a problem in cities with high rise buildings in Korea, Japan and Hong Kong. | | |
| Rifle Ranges<br><br>Clay pigeon shooting | Startling and annoying if located near residential areas. | Enclose in building or use high sound barriers. Limit to day time only. | Limiting shooting noise immission $L_{AX}$ at nearest residence to 1/3 the noise permitted from residential activities, seems to work in New Zealand. | | |
| Aeroclubs | General aviation noise unpredictable. | Strict control of permitted flight paths. | Use of airnoise boundary concept has reduced noise complaints in New Zealand to a very small number. | Regulations in New Zealand based on Standard NZS6805:1991 work well. | |
| Water activities | Noise unpredictable. | Strict control of areas where and times when motorized activities are permitted. | In New Zealand, restricting jet skis to specific areas has lowered complaints and accidents. | | Jet boats can be made very quiet and are used in some national parks and heritage areas. |

**Annex B**

**Noise Monitoring and Control System for Motor Sport Venues.**

## INTRODUCTION.

This is an example of a Noise control and Management system which may be used to as a basis for designing a system applicable to a proposed venue.

## OBJECTIVES.

The venue wishes to agree a system of operating conditions, noise controls and event management which will minimize noise impact.

The objective of the controls is to achieve an acceptable compromise between the operating requirements of the venue and the interests of the community.
It possible to work towards a set of conditions, designed to ensure that best practicable means have been taken to prevent noise affecting the community.

## RATIONALE.

There are four main methods that can be used to minimize and control noise intrusion in the community

a) Controlling the noise levels produced by the source.
b) Limiting the hours of use and the frequency of occurrence.
c) Reducing environmental noise by interrupting the path between the source and receiver.
d) Monitoring the source level contribution to environmental noise.

It is normal to concentrate on a) and b) as the effects are more specific than c). It should be recognized that any future reduction in community noise achieved by c) could mean an alteration in conditions imposed under a) and b).

Noise monitoring, by itself, does not reduce the noise impact and will not totally remove the possibility of complaints. The objective is that the operator should provide information on community noise levels to minimize the need for the Local Authority to spend time and money on investigations.

The track levels can be extremely difficult to measure at residents properties as any measurement must also include the existing ambient noise which will exceed the source noise for much of the time. This means that it is extremely difficult for the Environmental Health Department to deal with complaints.

For motor sport venues, with very variable noise sources which are difficult to measure in the community, it is preferable to measure the source noise close to the circuit to ensure accuracy. The resultant community noise can be established by applying a known reduction between the source and the various areas around the track.

This method has three main advantages:

1. The measured levels represent the source contribution.

2. Trackside measurements at one location, selected to represent the highest source levels, can be used to assess the community levels in all areas around the track.
3. The venue operator can set up an agreed noise monitoring system on his own site which allows the Local Authority access to noise data without having to make constant visits to the circuit.

In order to calculate the community noise levels, the known noise reduction around the site must be known. For planning applications, the Noise Impact Assessment (NIA) should contain information which can be used for this purpose.

**PROPOSALS**

*SOURCE NOISE CONTROL.*
**Purpose.**
To prevent high noise vehicles from using the track.

**Method.**
Static noise test complying with the regulations produced by the MSA/ACU
Results showing the noise levels, ($L_A$ dB) vehicle identification and other details to be recorded using approved forms.

**Equipment.**
Sound Level Meter complying with IEC 61672 Class 2 or above.
Calibrator complying with IEC 60942 Class 1. (For Static and other systems)

*TRACKSIDE TESTING*
**Purpose.**
To provide more information for circuit management and the Local Authority on the environmental noise levels. The results can be used to check compliance with any planning or agreed conditions to control community noise levels.

**Criteria.**
The main requirement of this system is flexibility. It is required to provide source noise data from a trackside location which can be used to assess the environmental effect of the source noise.

**Method.**
The monitoring system uses a simple noise data logger located at agreed trackside locations.
Each day's results are stored and made available to the Local Authority as required.
The format for the data is 1 minute dB (A)Leq levels which are reproduced graphically allowing full analysis of any period Leq levels to be carried out
Records will be kept for at least 12 months.

**CONTROLS.**
The proposed controls will require a management structure to ensure that the system is effective. One of the main requirements is a structure that will ensure the there is a responsible person available at all times when the track is operating.

Management systems will include a Policy statement and Noise control manual to be used by the circuit staff. The system will be based on acceptable environmental noise levels and the method of checking compliance will be by trackside measurements carried out by the venue.

This type of noise control system is in use at other motor sport venues and has been accepted by EH departments and Planning inspectors. One of the important elements is assessing the relationship between community noise levels and trackside levels. An example of the monitoring and control system is as follows:

**Agreed noise levels at nearest noise sensitive property**.
These may form part of the planning conditions.

| CATEGORY OF USE | DAYS USE | LEVELS ($L_{Aeq\ 1\ hour}$) |
|---|---|---|
| Contingency | 8 | >50 |
| Category 1 Days | 50 | 48 dB |
| Category 2 Days | 100 | 45 dB |
| Category 3 Days | unrestricted | <40 dB |

If the noise reduction between the track and the nearest noise sensitive property is established as $L_A$ 40 dB, the trackside levels will be as follows:

**Trackside levels at 10m. from track.**

| CATEGORY OF USE | DAYS USE | LEVELS ($L_{Aeq\ 1\ hour}$) |
|---|---|---|
| Contingency | 8 | No limit |
| Category 1 Days | 50 | 88 dB |
| Category 2 Days | 150 | 85 dB |
| Category 3 Days | unrestricted | <80 dB |

The trackside levels can be used as the agreed method for checking compliance with the planning condition levels shown in the first table.

- **The system significantly reduces the time and effort of the Environmental Health department as the venue monitors the noise and provides access to the results.**
- **It also self policing. If a day designated as Cat 2 produces a highest hourly level of 86 dB, the venue has used one of its Cat 1 days.**
- **The Environmental Health department does not need to take any action.**
- **Used this way, the system GUARANTEES that the agreed annual noise levels are complied with.**

The above is an example and the actual values for a venue will be subject to agreement with the Local Authority.