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FACTORS AFFECTING RESPONSE TO NOISE IN OUTDOOR RECREATIONAL ENVIRONMENTS

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As the world gets more and more crowded, silence becomes a rarer and rarer natural resource. (Rennicke 1987, 27)

Rapid growth in outdoor recreation has resulted in increased visitation to forests, parks, and similar outdoor recreational environments. Unfortunately, however, people visiting these areas contribute noise characteristic of the urban, technological society from which they are trying to escape (Kennedy 1977; Thomas 1978; Brownridge 1986; Lucas 1986; Gordon 1987). While in these environments, individuals are exposed to a variety of natural sounds such as those of birds and streams, the sounds of people talking or setting up camp, and technological sounds, such as those of chain saws or aircraft overflights. Some of these sounds are considered pleasing and satisfying, while others are deemed annoying and distract from the quality of the recreational experience which people seek.

Because of the shortage of recreational land resources and increased demand for them, finding and maintaining suitable quiet areas has become a management problem for land resource managers. Conflicts frequently arise between those who wish to enjoy and preserve quiet areas, where natural sounds predominate, and those who wish to use mechanized equipment in such environments. Perhaps the most vivid example is the controversy about aircraft flights over the Grand Canyon, where recreationists are pitted against flight promoters. With the introduction of such mechanized sound sources, some of the very reasons for which Grand Canyon National Park was established are compromised. Similar conflicts, though less dramatic and acrimonious, occur at campgrounds when people have a party, turn the stereo on too high, or run the generator on their recreational vehicles.

Escaping noise and crowds is one of the significant benefits obtained from visiting forests, parks, wilderness areas, and similar types of outdoor recreational environments. Noise ranks fourth in importance of sixteen preference domains, after enjoying nature, physical fitness, and reducing tension, by users of wilderness and non-wilderness recreational areas (Driver, Nash, and Haas 1985). Kaplan and Talbot (Kaplan 1978; Kaplan and Talbot 1983) include the attributes of tranquility, peace, and silence in what they call 'restorative environments.'

As no extensive study has focused specifically on the evaluation of sounds in outdoor recreational environments, this paper has two main objectives: to describe and analyse the relationship between people's evaluation of sounds commonly heard in such environments and their measured dB(A) or loudness levels; and to discuss other factors which are related to the perception and evaluation of these sounds.

Previous Studies

Annoyance from noise and its disturbance of normal human activities in urban areas has received considerable attention. Kryter (1985) synthesized research on the reactions of people to community noise carried out over the past ten to twenty years. Data in these studies, derived from attitude surveys of annoyance, focused primarily on transportation noises, such as those from aircraft, street, and expressway traffic, and railroads. These social surveys on noise annoyance were conducted to assess the magnitude of noise pollution and to develop suitable noise ratings from which one could reliably predict the subjective response to the noise from a measurement of its physical characteristics (Schultz 1978). The accepted metrics for determining annoyance are various sound

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pressure levels with weightings of frequencies which approximate the response of the human ear (dB(A))[1] (Hall and Taylor 1977; Kryter 1985).

In contrast to the numerous studies of noise and its annoyance in urban areas, relatively few studies pertain to noise in outdoor recreational environments. Harrison (1974b) summarized investigations carried out by the U.S. Forest Service on the effects of noise from off-road vehicles (snowmobiles, motorcycles, dune buggies, and all-terrain vehicles) on operators, bystanders, and forest recreationists. Kariel (1978, 1980) studied campers' evaluation of natural, person-related, and technological sounds commonly experienced at highway-oriented campgrounds in Canadian mountain national parks. Harrison, Clark, and Stankey (1980), using the Outdoor Recreation Opportunity Spectrum, discussed the unacceptability of noise in Forest Service recreation areas in general terms. Dailey and Redman (1975), in suggesting guidelines for campsite spacing, described physical and psychological properties of a number of human-related noises often associated with recreation in roadless areas. Dellora, Martin, and Saunders (1984) synthesized their laboratory studies of conflicts between four-wheel-drive users, bushwalkers, picnickers, and other recreationists in Victoria, Australia. They found that at sound levels greater than 68 dB(A) (they did not investigate reactions at lower sound levels) trail bike noise was the main cause of recreational conflicts.

Methodology

Data for the reaction of people to sounds are from two studies by Kariel (1978, 1980), in which evaluations were measured by attitude surveys. In the first study, visitors ($n = 713$) to highway-oriented campgrounds in three of Canada's mountain national parks (Banff, Yoho, and Kootenay) were asked to rate a number of nature-, person-, and technology-related sounds commonly heard in these settings, on a five-point, bipolar, pleasantness-annnoyance scale, even if they had not experienced them all. Mean values of these ratings were computed and then ranked, from the most pleasing (water, campfires, and wind) to the most annoying (car noise, motor or trail bikes, and chainsaws) (Table 1). Questions about trip purpose, type of sleeping accommodation used, ownership of noise-producing items, and experience with particularly annoying sounds were also included. Additional information, such as time-of-day effect, was gained in conversation with interviewees following completion of the questionnaire. Results showed that sounds which are considered annoying represent conflicts which might interfere with enjoyment of the purpose of the trip. Those persons whose major purpose was hiking, for example, were more annoyed by person- and technology-related sounds. Likewise, swimmers found the sound of wind unpleasant. People who slept in tents were more pleased with natural sounds and more annoyed by person- and technology-related ones, and generally preferred a quieter environment than those in other accommodations. There was a close relationship between ownership of certain noise-producing items and the annoyance from their sound. Pet owners like the sound of pets, and chainsaw owners are less annoyed by their noise than non-owners. Of those respondents who had experienced particularly annoying sounds ($n = 487$), nine sounds were mentioned by ten or more persons and of these, the ones most frequently mentioned were person-related (Table 2). Although data on particularly annoying sounds could not be assigned measured sound levels, they were examined in relation to their general sound levels.

Additional data are from Kariel (1980), in which the same procedure was used in a backcountry area. Participants ($n = 46$) of the Alpine Club of Canada were interviewed at a general mountaineering camp held near Glacier Lake, in Banff National Park. The sound ratings were treated in the same way as in the first study and the

Table 1
Mean Rating of Sound Sources, from Pleasing (1) to Annoying (5) for persons staying at highway-oriented campgrounds and mountaineers at a mountaineering camp

Source	Campers	Mountaineers
Water	1.20	1.30*
Campfire	1.32	1.76
Wind	1.40	1.21*
Birds, insects, or other native animals	1.44	1.42
Horses or mules	2.34	2.42
Chopping wood	2.39	2.65
Persons' activities	2.67	3.09*
Persons talking	2.81	3.11
Radio	3.28	4.56*
Pets	3.31	3.84*
Trains	3.53	4.04*
Motorboats	3.75	4.83*
Aircraft	3.78	4.20*
Road or highway traffic	4.00	4.61*
Snowmobiles	4.27	4.61*
Car noises (door slamming, horn blowing, engine running, etc.)	4.29	4.76*
Motor or trail bikes	4.36	4.98*
Chainsaws	4.37	4.48

*Difference between the two grous is statistically significant at $P < 0.05$.

Table 2
Sources of Particularly Annoying Sounds Experienced by Campers

Sources	Frequency
People – hoodlums, drinking, partying, foul language, rowdinesss	136
Music, radio, tapedeck, TV, stereo	124
Motorbikes, motorcycles, trail bikes, scooters	94
Trains	70
People arguing, children crying or yelling, loud talk	66
Dogs barking	50
Cars – drag racing, motors racing, engines revving, tires squealing, absence of mufflers, horn blowing, slamming car doors, motor homes, engines running	47
Highway traffic	27
Engines, oil pumps, generators	17
Chainsaws	9
Wood chopping	8
Birds, crows, Greyjay, magpies	7
Garbage trucks	7
Setting up tents at night	7
Unspecified at night – scary noise, groaning sound in distance	6
Guitar	4
Power boats, motorboats	4
Aircraft	4
Siren from burglar alarm, car theft alarm	4
Gunfire	3
Bears in garbage	3
Firecrackers	2
Sawmills	2
Snowmobiles	2
Pitter-patter of rain	2
Lawnmower	2
Snoring	1
Coffee exploding	1
Mosquitos	1
Road construction – bulldozer	1
Clink of beer containers	1

ordering was similar for both groups ($r_s = 0.91$, $z = 3.74$), with only a few minor reversals (Table 1). While mountaineers differed little from the general public in their evaluation of nature-related sounds, they rated human-related ones as somewhat less acceptable, and technology-related sounds considerably more annoying. I suspect that these differences relate to the fact that mountaineers are generally more wilderness-purist in their viewpoints and characteristics than highway-oriented campers. The reversal for the sound of chainsaws, which is the most striking one, is likely related to the fact that mountaineers at this backcountry base camp considered the use of a chainsaw to cut wood as benefiting such adjunct activities as drying wet clothing, heating water for washing, and enjoying a campfire.

Sound level data obtained in the field were supplemented by those reported in other studies (e.g., U.S. EPA 1971; Dailey and Redman 1975; Harrison 1974A; and Ohlson 1976). Sound-level measurements were made and recorded using a single channel version with a 40 dB range, of the data acquisition system described in Jones and Babott (1977). This system consists of a microphone which picks up the sound, a box containing circuitry which converts the sound into digital form, and a cassette tape recorder for storing the digitized data. The recorded data are then played back via an interface into a computer for analysis and printed out. The printout includes various L_x values, all in dB(A), but only L_{eq} values are reported, since L_{eq}, L_{10}, and L_{dn} are all equally good predictors of subjective response (Hall and Taylor 1977). A few measurements were made by observing the sound level, as measured by a sound-level meter, over a period of time and calculating L_{eq}. Some impact sounds (chopping wood, for example) were read off a sound-level meter, recorded and averaged, a procedure which provides an approximation of L_{50}. The microphone and measuring instrument used was a standard GENRAD 1565-B sound-level meter. All readings were taken on the dB(A) scale, which most closely approximates the human ear.

The microphone or sound-level meter was either positioned or, in a few instances, hand-held approximately 1.5 m above the gound. The distance from the sound varied with the source, but approximated that of the nearest camper, since it was reasonable to believe that those persons nearest the source and therefore exposed to the higher sound level would evaluate the sound as more annoying than those at a greater distance. All recordings were taken at campgrounds or in similar settings except for those for a helicopter, which were taken on a mountain slope at an elevation roughly similar to that of the helicopter (2450 m, 8,500 ft.) and at a distance of about 3 km.

Weather and other environmental conditions were generally good at times of recording. There was no rain, and wind varied from calm to light breeze except when the sound of wind through trees was specifically recorded. Cloud cover ranged from overcast and scattered clouds to clear. Vegetation varied from grassy areas with shrubbery to open forest, and topography was reasonably level.

In order to augment the data collected specifically for this study, data reported in other studies on noise in

Table 3
Range of Noise Levels in dB(A) of Various Sound Sources in Outdoor Recreational Environments
(at different distances, under various environmental conditions, and by different researchers)

83	Chainsaw[a] 15.2 m
78	Person yelling[b] 15.2 m
76	Safety whistle[b] 15.2 m
74	Trail bike[c] 15.2 m
73.6	Aircraft, small 100 m
73	Snowmobile[d] 15.2 m
73	Dogs howling[e]
72	Harmonica[b] 15.2 m
>70	Aircraft, small[f] 300–400 m
70	Aircraft sightseeing, Grand Canyon[e]
68	Helicopter 150 m
66–71	Chopping wood 5 m
66	Pounding tent stakes[b] 15.2 m
66	Clattering pans[b] 15.2 m
65.1	Motorboat trolling 75 m
65–68	Persons talking 20 m
64.8	Car door being slammed 10 m
64	Chopping wood[b] 15.2 m
62.0	Wind, fresh breeze blowing through trees
61.2	Creek,small with rapids 5 m
60	Singing[b] 15.2 m
60	Dogs barking[e]
59.8	Campfire 2 m
57.5	Diesel generator 50 m
57	Trail bikes 100 m
55–68	Persons washing dishes, doing camp chores 15 m
54.8	Wind, gusty, with rustling of tree foliage
53.8	Birds, woodpeckers, call notes 5 m
53.6	Train in distance 1 km
53.0	Persons setting up camp 15 m
52.9	Campfire 5 m
52.9	Birds, woodpeckers, call notes 5 m
52	Radio playing music[e]
52	Guitar[b] 15.2 m
51.9	Persons eating and talking 15 m
50.2	Creek, medium size 15 m
50–62	Birds, terns and gulls callnotes[f]
50	Crickets[e]
49.9	Chopping wood 5 m
48	Wind blowing through trees
48	Conversation[b] 15.2 m
48	Birds[e]
47.8	Persons talking, taking pictures, etc. 15 m
47–48	Creek, small, with rapids 15 m
46.6	Automobile, warming up 30 m
45.1–55.5	Helicopter, ca. 3 km
45	Background, 1 m opposite small rapids of ca. 5 m wide brook[b]
44.9	Birds, crows, call notes 20 m
44.3	Campfire with persons talking 25 m
44	Radio playing music 25 m
43.4	Garbage container being opened and closed 40 m
43	Camp stove 5 m
42.8	Aircraft, small at high altitude
42–52	Road traffic 100 m
40–46	Chipmunks 10 m
39	Squirrel[e]
36.1	Road traffic 100 m
35.5	Automobile, engine idling 30 m
35	Background, coniferous forest, low wind[b]
34–41	Birds, chaffinch song notes[f] 30–100 m
30.7	Bird flying along lakeshore 15 m
30	Background, meadow, low wind conditions[b]
30	Wind, rustling of grass and brush
23.4	Background, open mountain slope
22–27	Insects[f]
16	Background, rim of Grand Canyon[e]

NOTE: Unless footnoted, noise levels are the author's measurements; L_{eq} in decimals, L_{50} and peak values are in whole numbers, and distances are estimates. More than one value for a source indicates measurements were made by different researchers or under different conditions. Distances, where shown, are the author's or as given in the sources.
(a) Myles, Hirvonen, Embleton, and Toole (1971) L_{50}.
(b) Dailey and Redman (1975) peak values.
(e) Harrison (1974a) peak value.
(d) Sound rating tag on Bombardier Nordic Safari 503R, at 15.2 m (50') and 78dB(A) at wide-open throttle, in accordance with Society of Automotive Engineers regulations J1161 and J192A.
(e) U.S. EPA (1971) peak values.
(f) Ohlson (1976) L_{50} values.

outdoor recreational environments were also used. These sounds and their sources are indicated in Table 3.

Results

The loudness of the sounds varied considerably, ranging from a low of 22 to 27 dB(A) for those of insects to a high of 83 dB(A) for chainsaws (Table 3). This variation related not only to the sounds themselves, but also to the distance from the sound source, as well as environmental factors. These sound levels, plotted against their ranking on the pleasantness-annoyance scale, using the broader categories of the questionnaire, revealed no apparent relationship; that is, the level of annoyance appeared to be independent of dB(A) level (Figure 1). The results of the correlation analysis, $r = 0.20$, confirmed the visual impression. Examination of the particularly annoying sounds reported as having been experienced also showed that there was little relationship to sound levels alone.

Cautionary Comments

Before proceeding with a discussion of the findings, some cautionary comments regarding the data on noise levels

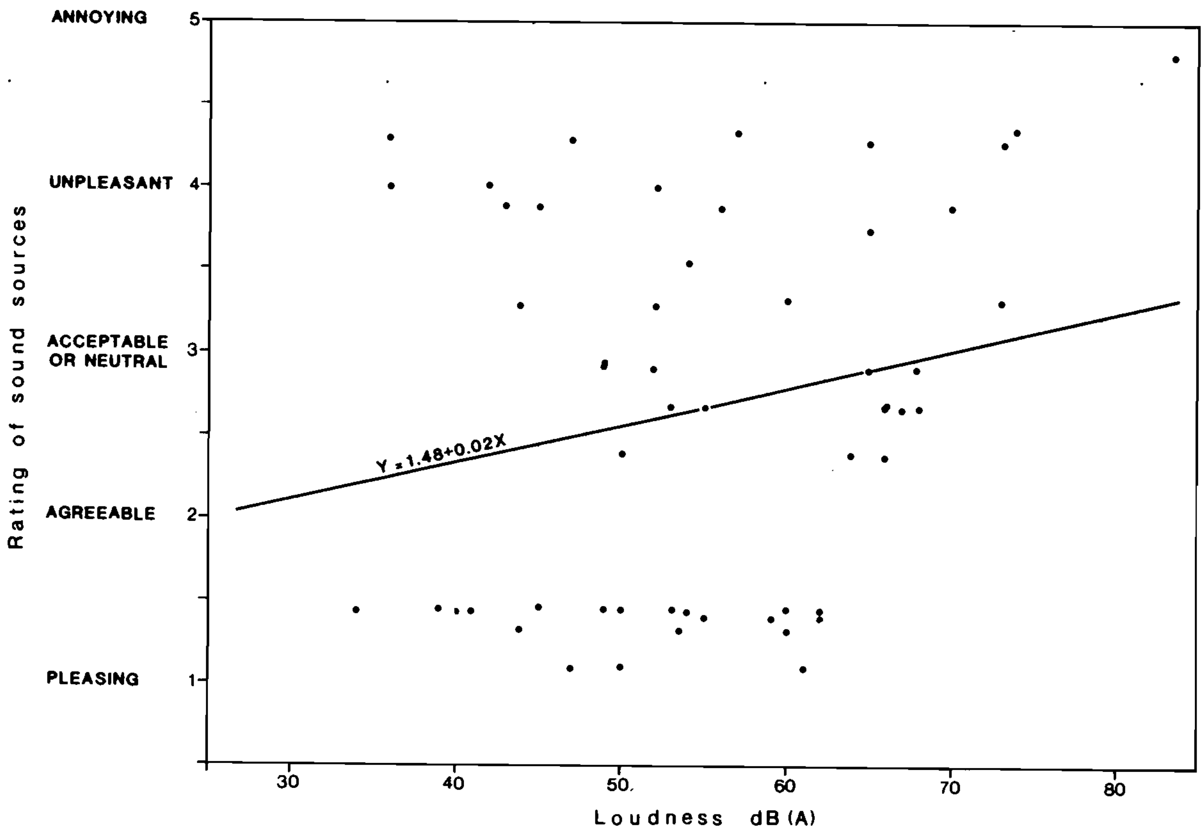

Figure 1
Relationship between the loudness of sound sources and their rating

and the responses given on the questionnaires should be made.

- All sound level values are not directly comparable, since different ones were used in different studies. For example, peak levels were reported in U.S. EPA (1971), Dailey and Redman (1975) used L_{50}, and the author used L_{eq} as well as direct readings of peak values.
- Different methods were used to record data, ranging in sophistication from reading a sound-level meter directly by eye to a complex system involving analysis of the statistics of the noise levels.
- The duration of the noise samples varied, being quite short for direct sound-level meter readings, especially for impact type sounds, and longer for continuous ones.
- Distances from sound sources varied among and within studies. Dailey and Redman (1975), for example, used 15.2 m (50 ft.), while I tried to use the distance from the sound source to the nearest campsite.
- The sound level of a source may have quite a range, depending on various factors, such as whether a radio is just turned on or turned up to full blast; whether a group of people is singing at a normal level or loudly; whether a helicopter is taking off or flying; whether a trail bike is moving at a constant speed or being accelerated; or whether a wild animal is charging or merely ambling along.
- Some differences exist between the sounds measured and those identified on the questionnaire in the attitude survey. The latter included both specific and generalized ones, while the former sounds were nearly all specific. For purposes of analysis, specific sounds such as people talking, were grouped under the generalized sound, persons' activities.
- Questions regarding the duration of sounds were not included in the survey.
- Respondents probably generalized sounds to averages on the basis of past or anticipated experiences, and hence did not include consideration of persistence in terms of duration, frequency, or particular loudness.

Discussion

Despite the limitations and biases mentioned in these caveats the overall finding that annoyance is independent of dB(A) within the range of sound levels studied appears to be reasonable in light of the data available and our present understanding of annoyance from noise in outdoor recreational environments. In addition, measured sound levels appear to be correct, since different researchers consistently obtained similar values for various sound sources.

The question is, if loudness alone is not a good predictor of annoyance, how is it related to annoyance and how else can persons' evalutions of noise in outdoor recreational environments be accounted for?

Several factors that are interrelated in a complex way appear to influence the manner in which people evaluate different sounds. These factors can be placed into two groups: those relating to the physical characteristics of the sounds themselves and those concerning their socio-psychological aspects.

Regarding the physical characteristics of sounds, transportation and community noise studies have found that loudness is related to annoyance (i.e., higher sound levels are more annoying than lower sound levels) (Galloway and Jones 1974; Kryter 1985). Although that finding was not borne out in this study, I suspect that person- and technology-related sounds would also be deemed more annoying at higher levels.

Sounds of higher pitch or frequency tend to be more annoying (and travel shorter distances) than lower-pitched ones. Also, rhythmic sounds, such as those from engines, as well as those that are irregular or intermittent, are judged to be more annoying than continuous ones, even when other properties are the same (Dailey and Redman 1975). On the other hand, noises that have a random component, such as those from wind, flowing water, and other nature-related sources, tend to be considered more pleasing. In summary, noises with some combination of high intensity or high frequency, which have a rhythmic element or which occur intermittently, are more likely to be considered annoying than sounds not possessing these physical properties.

A number of researchers have pointed to the importance of the socio-psychological or perceived meaning or connotation of a noise (Parry and Parry 1972; Harrison 1974b; Dailey and Redman 1975; Schultz 1978). Socio-psychological aspects of sounds are those which deal with their interpretation and the effect on the individual. When a sound is heard, people interpret, evaluate, and attach meaning and significance to it. They judge its appropriateness for the setting, whether it is potentially harmful or helpful, how it relates to past experience, and the like. We have no formal way of assessing these factors, nor are they necessarily subject to scientific analysis.

The total experience in the setting is important in judging a sound's appropriateness. If we consider only the source of a sound (a stream, for example), we take it out of context. We then ignore the larger scene – such as its setting, the vegetation along its banks, distant views, and the sky – as well as the activity in which the person evaluating the sound may be engaged – such as relaxing, fishing, canoeing, or painting – and other persons who might be present. That is, many other sensory experiences are obtained along with those from the sound.

Sounds which are interpreted as aiding or benefiting an activity are evaluated positively, while those deemed as interfering with or being detrimental to an activity or as being harmful are considered to be displeasing or annoying. Sounds may include noises which interfere with conversation, sleeping, relaxing, or other activity. The thresholds interfering with conversation and sleep seem to be approximately 45 and 35 dB(A), respectively (Kryter 1985).

As the primary reasons for visiting outdoor recreational environments are to escape the noise of urban areas, enjoy the natural scene, reduce tension, and obtain tranquility or solitude (Driver, Nash, and Haas 1987), sounds that are felt to interfere with these experiences will be considered as annoying. In this connection it should be mentioned that, since sounds are detectable, and hence identifiable, from great distances and at very low levels, even without registering on a sound-level meter, they can be intrusive and provoke reactions. At distances less than 23 m (75 ft.), acoustic energy loss due to foliage is negligible. It does not increase beyond approximately 107 m (350 ft.) (Dailey and Redman, 1975; Harrison, Clark, and Stankey, 1980). Sound spreading from a source attenuates about 6 dB for each doubling of distance.

Ideas about which sounds are appropriate in a specific environment and at a particular time are also important in determining their annoyance. This helps to explain why people who stay at campgrounds only overnight are more tolerant of noises than those who use them as a destination or for a longer period of time. Although off-road vehicles are not ordinarily heard at campgrounds, it is noteworthy that, where their presence is considered inevitable, as with dune buggies at the Oregon Dunes National Recreation Area, sound levels of 85 dB at 15.2 m (50 ft.) were considered acceptable (Harrison 1974b). Also, the sound of chainsaws, for example, might be considered less annoying in Finland or Sweden, where they are seen as a natural part of forested environments.

Instances of preventability or misfeasance, such as when persons have their radio turned on loudly, or are joy riding a trail bike around a campground, are considered annoying. This reaction is similar to what has been found in transportation noise studies (e.g., Galloway and Jones 1974; Leonard and Borsky 1974). In transportation studies, instances of misfeasance are considered extra annoying, at the same loudness compared with normally anticipated operation of vehicles, while sounds which have a presumed utility and are infrequent are deemed sub-annoying. In addition, sounds over which persons feel they have no control or which are unpredictable, are considered annoying (Glass and Singer 1974).

At the same time people will tolerate or even be pleased with a disturbing sound, at least for a short time period, if they believe that it will aid or benefit an experience or activity, such as the sound of a chainsaw used for cutting wood or the sound of a snowmobile or helicopter when it signifies that rescue is on the way.

A number of other items contribute to the annoyance of a sound. Sounds which engender fear, such as those from wild animals, and prior experiences with sounds, such as unpleasant ones with mosquitos, are also important in determining their degree of annoyance. Time of day and type of sleeping accommodation also relate to annoyance. For sounds which are considered annoying, the degree of annoyance is greater in the evening than during the day and greatest at night, whereas the evaluation of pleasing sounds is constant regardless of time of day. People who slept in tents were more pleased with natural sounds and more annoyed by person- and technology-related ones than those in other accommodations (Kariel 1978, 1980). In addition, I suspect that some sounds will become annoying if they continue for long time periods.

Conclusion

This paper began by analysing the relationship between sound levels of various sound sources commonly heard in outdoor recreational environments and people's evaluations of them. It was recognized that, despite certain limitations which may have been introduced in the analysis, sound levels alone were not good predictors of annoyance within the range of sound levels studied. Some sounds are considered intrusive even at low levels and I strongly suspect that, as has been found in transportation noise studies, if a sound is deemed annoying, it will be more annoying if louder. It appears that it is a combination of the physical characteristics of the sounds themselves and their socio-psychological aspects which determines their evaluation as pleasing, annoying, or acceptable.

The results of this study as well as others can be used for planning purposes in outdoor recreational environments to enhance the recreational experience of users. It appears to be important to keep the level of human- and technology-related sounds generally low, if possible below the background level of about 15 dB(A). In discussing guidelines for planning campsite locations so as to minimize annoyance from noise, Dailey and Redman (1975) suggested that they be located laterally along streams and so as to take advantage of environmental features, such as natural relief and vegetation, but not near lakeshores or in meadows. Disturbance from noise may also be minimized by designating different areas for different types of accommodations, such as recreational vehicles, trailers, and tents. Special sections might also be set aside for late arrivals.

It would also be desirable to restrict or regulate the use of sound-producing items, such as aircraft overflights, snowmobiles, generators in motor homes, motorboats, and radios, in order to safeguard a recreational milieu. This could be done by legally designating recreational areas as noise-sensitive, limiting noise levels, and making quietness a condition of use. Patrolling campsites and equitable enforcement of regulations is obviously tricky and managers are often hesitant to do so. It would appear, however, that the preponderance of campers would be willing to accept regulations as long as they were reasonable and fairly and impartially administered (Hendee et al. 1968). Education concerning the need for low sound levels is probably the most effective way to preserve a quiet atmosphere. Signs such as the ones used in many European cities showing an automobile horn with a red slash through it might be effective reminders.

Future research could pursue the perception of noise by different groups of recreationists and in different cultural settings. Another interesting avenue, I believe, would be to ascertain similarities in responses evoked by different soundscapes and different kinds of music. Recreationists, for example, find natural sounds relaxing, restful, and soothing, a response also provoked by listening to baroque music.

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Notes

1 A decibel (dB) is a unit for measuring the loudness of sounds. The (A) weighting of frequencies approximates the response of the human ear. Various loudness values are referred to as L_x; L_{10} means that the given loudness is exceeded 10 percent of the time; L_{50} is the median sound level (one-half of the time it is quieter and one-half the time noisier); L_{eq} is an energy equivalent sound level which accounts for both duration and magnitude of the sound over a period of time; and L_{dn} is the day night average of loudness. All values are expressed in dB.

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