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Guidelines for Roadless Area Campsite Spacing to Minimize Impact of Human-Related Noises

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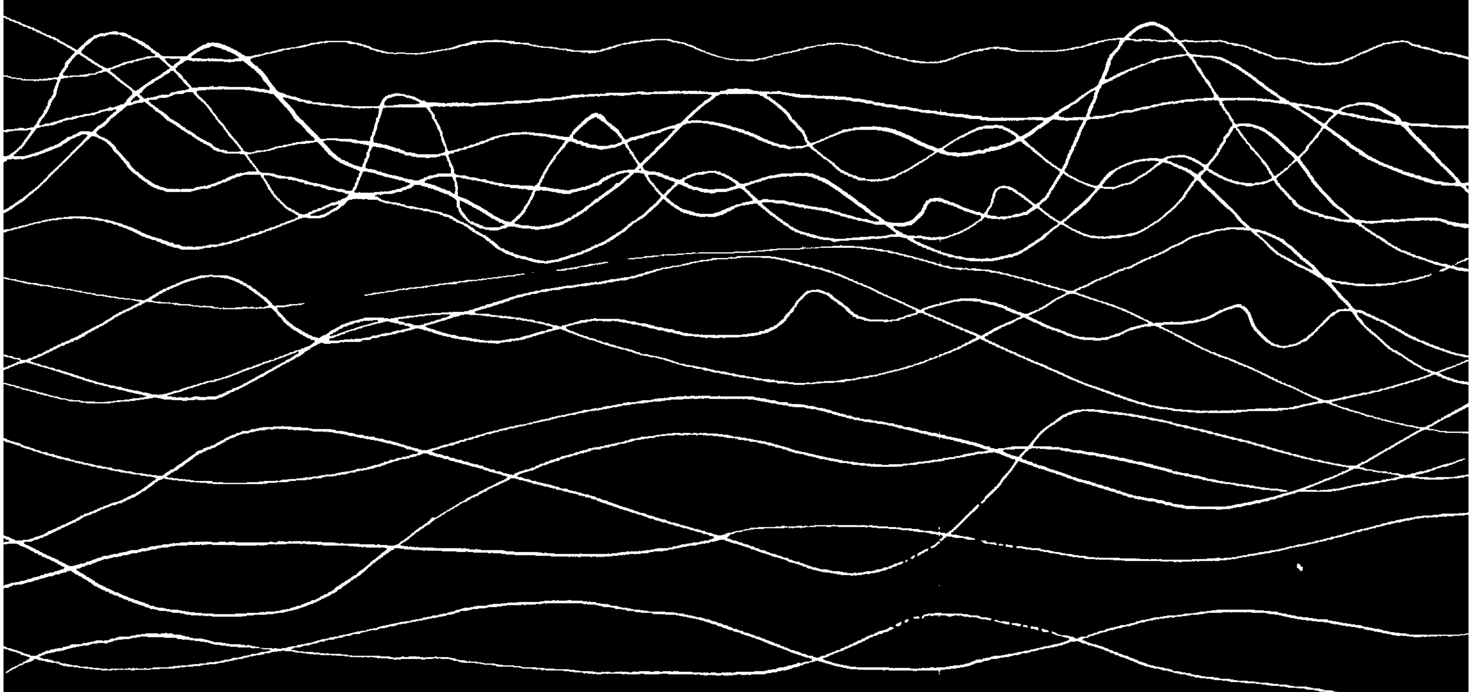

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GUIDELINES FOR *ROADLESS* AREA CAMPSITE SPACING TO MINIMIZE IMPACT OF HUMAN–RELATED NOISES

Reference Abstract

Dailey, Tom, and Dave Redman.
1975. Guidelines for roadless area campsite spacing to minimize impact of human-related noises. USDA Cen. Tech.. Rep. PNW-35, 20 p., illus.

This report offers guidelines for campsite spacing and location in roadless areas to allow several levels of insulation from noise impacts between camping parties. The guidelines are based on the distance that different human-related noises travel in a variety of outdoor settings. The physical and psychological properties of these noises are described and discussed. The effects of different environmental features--ridges, hills, dense woods, low vegetation, still water--on noise transmission are also described. General management actions are suggested for locating camps to minimize intrusive noise from other camping parties.

Keywords: Campsite spacing, amenity values (forest).

RESEARCH SUMMARY
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The desirability of campsites in roadless areas is affected by the degree of insulation the site affords from noise of other camping parties. Research suggests that this insulation is most important in hard-to-reach areas where few contacts with other parties are expected or desired. Campsites which are easily accessible are generally more popular and campers expect less isolation. These differences in visitor expectations and desires suggest there should be corresponding variation in spacing guidelines to achieve varying degrees of isolation. Three sitations--"portal," "primitive," and "pristine"--offering increasing opportunities for noise insulation between camps are proposed.

The distance a noise is audible depends on (1) the intensity and frequency of the noise, (2) the presence of environmental features between the source and the receiver of the noise which may attenuate the noise, and **(3)** the background noise level.

The greater the intensity (loudness) of a noise and the lower its frequency (pitch), the farther it will travel, Field measurements of a variety of human-related noises showed that the loudest were gunshot (136 dBC), yell (78 dBA), safety whistle (76 dBA), and trailbike motor (74 dBA). All measurements were at 50 feet from the noise source. Lowest frequency measurements were obtained for guitar and trailbike.

As any noise spreads from its source, its intensity will decrease at a predictable rate. In addition, intensity may be further decreased by certain features of the environment thro'ugh which the noise travels. The most effective are rigid barriers--hills, ridges, rises, and dense woods. Low vegetation has little attenuating effect, and a still water surface has virtually no effect.

Naturally, the quieter the background noise level against which an intrusive noise is projected, the greater the range over which the noise will be audible,

Background noise level, under low wind conditions, in a mature coniferous forest is 35 dBA and about 30 dBA in an alpine meadow. Near the bank of a small stream, noise level is 45 dBA. An intrusive noise must be reduced 15 dBA less than the background noise level before it becomes indistinguishable.

Spacing requirements for settings with different background noise levels and combinations of environmental features are presented in table 1 for each of the three situations. The spacing requirements are designed to achieve a certain standard of insulation in each situation.

General guidelines for campsite location include taking maximum advantage of environmental features, such as woods and hills, which lessen noise transmission between camps and, where possible, locating sites near areas with high background noise levels. From the standpoint of noise Insulation, lakeshores and meadows are poor locations for campsites.

Table 1.--*Summary of spacing requirements for pristine, primitive, and portal situations*

Standard of insulation	Setting	Threshold level	Space requirements (approximate)
		---dBA---	*----Feet----*
Pristine situation:			
No sounds less than 78 dBA audible between camps (Human yell)	Meadow	10	20,000
	Woods	20	9,600
	Lake-woods[1]	20	9,600
	Meadow with barrier	10	6,400
	Stream and woods	30	3,200
	Woods with barrier	20	1,600
Primitive situation:			
No campsite noises less than 60 dBA audible between camps (Singing)	Meadow	10	4,200
	Woods	20	1,450
	Lake-woods[1]	20	1,450
	Meadow with barrier	10	950
	Stream and woods	30	600
	Woods with barrier	20	400
Portal situation:			
No campsite noise less than 48 dBA audible between camps (Conversation)	Meadow	10	1,950
	Woods	20	500
	Lake-woods[1]	20	500
	Meadow with barrier	10	250
	Stream and woods	30	250
	Woods with barrier	20	200

[1]These spacing requirements between camps at lake sites surrounded by woods are applicable only when the camps are located at least 250 feet from the lakeshore. This location affords both auditory and visual screening by the woods which are not available when camps are situated at the lakeshore.

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Introduction

Increasing recreational use of roadless areas--whether legally designated or de facto wilderness--is creating new management challenges. The conflicting goals of accommodating more visitors and insuring quality recreational experiences demand knowledge, not only of the visitors' expectations but of their physical and psychological. impacts upon each other, These impacts are most critical near campsites where visitors spend much of their time and where their desire for solitude may be greatest (Hendee 1967, Stankey 1973).

Several recent studies[1/] indicate that most campsites in Wilderness and backcountry have been informally established by the campers themselves, and at popular locations they are frequently close to each other. Perhaps this is the result of unplanned growth over time without formal consideration of the many factors that can affect the experience of separate parties of users. However, some managers are now seeking to relocate overused campsites and disperse users. In so doing they have the opportunity to consider the <u>many</u> factors--including noise insulation--which are important to campsite location and affect user experience.

This report offers guidelines for campsite spacing to achieve varying degrees of insulation from noise between camping parties. The guidelines are based on field tests of the intensity and frequency of different human-related noises and on acoustical research on the effect of different environmental features on noise transmission. This is basic information for wilderness and backcountry managers faced with the problem of determining levels of use desirable to increase visitor enjoyment of these environments.

Assumptions

Underlying this study are four basic assumptions relating the "wilderness" experience to the need for adequate space between campsites to preserve these qualities. Most of the studies upon which these assumptions are based have focused on visitors to legally designated Wilderness Areas, However, it seems likely that roadless area recreationists seek similar experiences whether their trip is into a designated or de facto wilderness.[2/]

[1/] Russ Koch and John Hendee. Recreation sites on the Pacific Crest Trail-Junction 2000/951 (Cougar Valley Trail) to Fish Lake, Naches Ranger District, Wenatchee National Forest. Unpublished manuscript, 9 p. , 1975.

Dan Wood. Public use of Forest Roads pilot study, 1974, Deschutes National Forest, Bend and Sisters Ranger Districts. Unpublished manuscript, 20 p. plus appendix, 1974.

Both available from U. S. Forest Service, Pacific Northwest Forest and Range Experiment Station, 4507 University Way NE, Seattle, Wash. 98105.

[2/] Throughout the paper, wilderness, backcountry, and roadless areas will be used interchangeably.

1. Roadless area visitors seek solitude and isolation from nonparty people. Wilderness is legally defined, in part, as providing "outstanding opportunities for solitude" (U.S. Congress 1964). A number of studies of wilderness use and users have demonstrated the importance of solitude (minimal contact between camping parties) as part of the wilderness experience. For example, reporting the results of a survey of almost 500 visitors to four Wilderness Areas, Stankey (1973) concluded that "most visitors consider low intensities of use, involving only few encounters, as an important dimension of the wilderness experience." Hendee et al. (1968) found that a strong preference for solitude among users of three western Wilderness Areas was an attribute which differentiated "wilderness-purists" from more urban-oriented wilderness users. Other studies (Lucas 1973, Burch and Wenger 1967, Hendee 1967) have reported similar findings. Solitude has been demonstrated to be an important feature of the wilderness experience, especially for those visitors holding a "purer" concept of wilderness.

2. The perceived impact of auditory and visual encounters between parties is especially great at campsites. This assumption is supported by two major studies indicating that over 65 percent (Stankey 1973) and 72 percent (Hendee 1967) of visitors to a total of six western Wilderness Areas favored campsites "out of sight and hearing" of other visitors, with an even higher percentage of purist users feeling this way. According to Stankey (1971) the campsite represents the user's "territory," and social interaction with other parties is not welcome in the camp. Campsite location relative to other camps is of more importance to the visitor's experience than is camp location relative to trails. Stankey's (1971) work has shown that "persons passing by the camp... do not create the level of disturbance that a party which establishes their camp nearby does" (p. 160).

3. The distance that human-related noises travel indicates necessary campsite spacing requirements to minimize between-party impacts. In most outdoor settings, auditory stimuli are detectable over a wider range than visual stimuli, Vegetation and relief which can completely screen visual contact between parties might only partially reduce auditory impacts, In addition, sound tends to intrude more.

4. Abundant spacing between campsites is most critical in the "interior" as opposed to "peripheral" portions of a roadless area. Research (Stankey 1973) indicates that encounters near the trailhead are more expected and therefore more tolerated than encounters in the interior. This is supported by wilderness use data indicating that concentrations of users on trails and near the periphery drop sharply as the distance covered increases.

This evidence suggests that the farther removed a camping area is from the trailhead, the more important it is in terms of visitor satisfaction that the campsites be spaced to allow most "people" noises to be screened out.

For the purposes of the present study, three distinct situations are recognized--portal, primitive, and pristine--offering increasing opportunity for auditory and visual isolation of camping parties from each other. This informal categorizing assumes that visitors place themselves according to their abilities, orientations, and desired experiences--and have different expectations for solitude and isolation in each situation.

Studies indicate that users differ in their desire for solitude and seclusion (Hendee et al. 1968, Stankey 1973). Some users, purists, seek greater isolation from other visitors and reminders of civilization. Others are willing to accept some degree of contact in more accessible locations. Using the space required by purists as the standard throughout a roadless area may only hasten the day when all use must be restricted. On the other hand, uniform standards appropriate for less discriminating users will degrade the experience sought by the purist.

It seems best to provide a continuum of campsite spacing standards, whose application depends on practical considerations of accommodating increasing numbers of visitors near the edge of a roadless area and providing greater campsite solitude for those willing to seek it out in the interior.[3/]

Objectives

The objectives of this study were to: (1) describe the physical and psychological properties of various human-related noises, (2) determine the effect of environmental conditions such as land forms and foliage on noise transmission, and (3) recommend guidelines for campsite spacing and location based on (1) and (2).

We examined 11 human-related noises often associated with roadless area recreation. These included:

1. trailbike motor (1974 Honda TL 125),[4/]
2. safety whistle,
3. conversation (four persons),
4. singing (four persons),
5. yelling (one person),
6. gunshot (30.06 rifle),
7. clattering pans,
8. guitar,
9. harmonica,
10. pounding tent stakes, and
11. chopping wood.

[3/] The concept of distinct situations as defined and developed in this paper is presented as a hypothetical abstraction rather than a policy recommendation. We do not imply that all three situations should be contained within a Wilderness. We do, however, encourage recognition of the research findings we have cited which suggest that visitors' expectations for solitude vary directly with the distance they have hiked from the nearest road.

[4/] Mention of product by name does not imply endorsement by the U.S. Department of Agriculture.

These sounds were all "intrusive" as opposed to those "natural" background noises one would expect to find outdoors, such as running water, rustling of leaves stirred by the wind, birds singing.

There are three factors which determine how far the intrusive noise will travel before it is "masked" by the background noise level (Harrison 1974b). These are:

1. the loudness and pitch of the intrusive noise,
2. the presence of environmental factors such as landform barriers or trees which can decrease the loudness of the intrusive noise, and
3. the loudness and pitch of the background noise.

In addition to these physical characteristics of noise and the environment, the psychologically perceived intrusiveness of the noise must also be given consideration.

First we discuss physical and psychological properties of intrusive noise, environmental conditions which can reduce noise level over distance, and properties of the background noise. Finally, we offer spacing standards for campsite location in roadless areas and general guidelines for locating camps to minimize auditory impacts.

Physical Properties of the Human-Related Noises

In this section we discuss the nature of the physical properties of noise and present data describing what these properties are for the 11 noises we studied.

A noise may be described in terms of its intensity and frequency. Basically, intensity refers to how loud a noise is, while frequency is the "pitch" or tone of a sound. Both affect how a sound moves through the air. The sound pressure level, which is a measure of the intensity, is commonly expressed in decibels (dBA),[5/] while frequency is usually expressed in hertz (Hz).[6/]

In general, the greater the intensity (loudness), and the lower the frequency (pitch), the farther a sound will travel. For example, a loud, low frequency such as a trailbike motor will travel farther than a loud, high frequency such as a whistle.

[5/] Acoustic waves generated by sound are a source of power. The amount of power which passes through an area is the intensity of that sound. Intensity is difficult to measure directly, but the pressure that the wave exerts on an area can be measured on a decibel scale. **For** this study, the **A** weighting factor (dBA) of expressing sound pressure level was used. This measure most closely approximates human auditory response to noise.

[6/] Most noises are a complex mixture of a number of frequencies. An octave "represents a band of frequency whose highest component is double that of the lowest frequency component" (Harrison 1974b, p. 3). The frequency of each noise measured was recorded as the octave band having the greatest associated sound pressure level.

We measured intensity with a Bruel and Kjaer, Type 2203, sound level meter. We measured frequency using the sound level meter with an attached octave band filter. All measurements were made according to manufacturer's instructions and at a distance of 50 feet from the source of the noise.

Figure 1 presents the maximum intensity of each of the noises studied. By far, the highest maximum intensity was obtained for a gunshot (136 dBC),[7/] followed by a yell (78 dBA), safety whistle (76 dBA), and a trailbike motor (74 dBA).[8/] The noise level of a trailbike motor could be expected to increase by possibly 10 to 20 dBA when it accelerated. Lowest maximum dBA values were for clattering pans (66 dBA), tent stakes being hammered (66 dBA), chopping of wood (64 dBA), singing (60 dBA), guitar (52 dBA), and conversation (48 dBA).

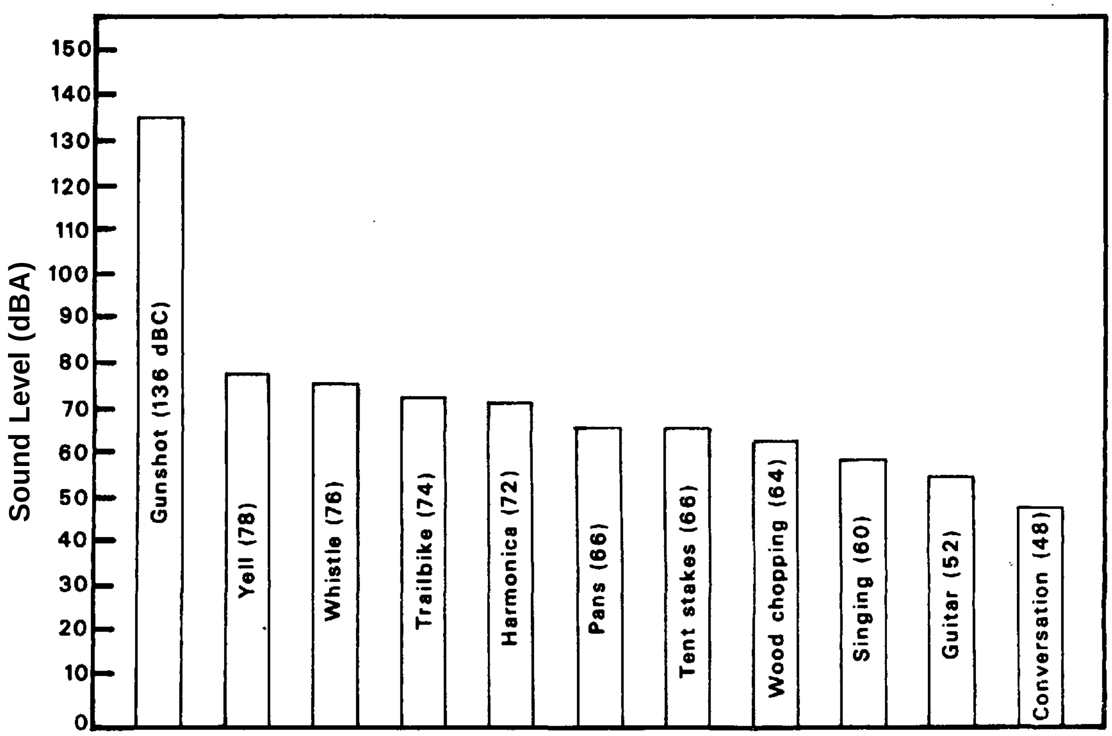

Figure 1.—Intensity of 11 human-related noises measured at 50 feet from noise source.

7/ Proper measurement of an abrupt noise such as a gunshot requires an impact analyzer **which** we didn't have. The value reported here on the C weighting scale is from Harrison (1974b).

8/ **The** noise level reported for a motorcycle is from Harrison (1974a).

Figure 2 displays the frequencies associated with the noises studied. Highest frequency was recorded for safety whistle (1200 to 2400 Hz) and lowest frequency for guitar (75 to 150 Hz).

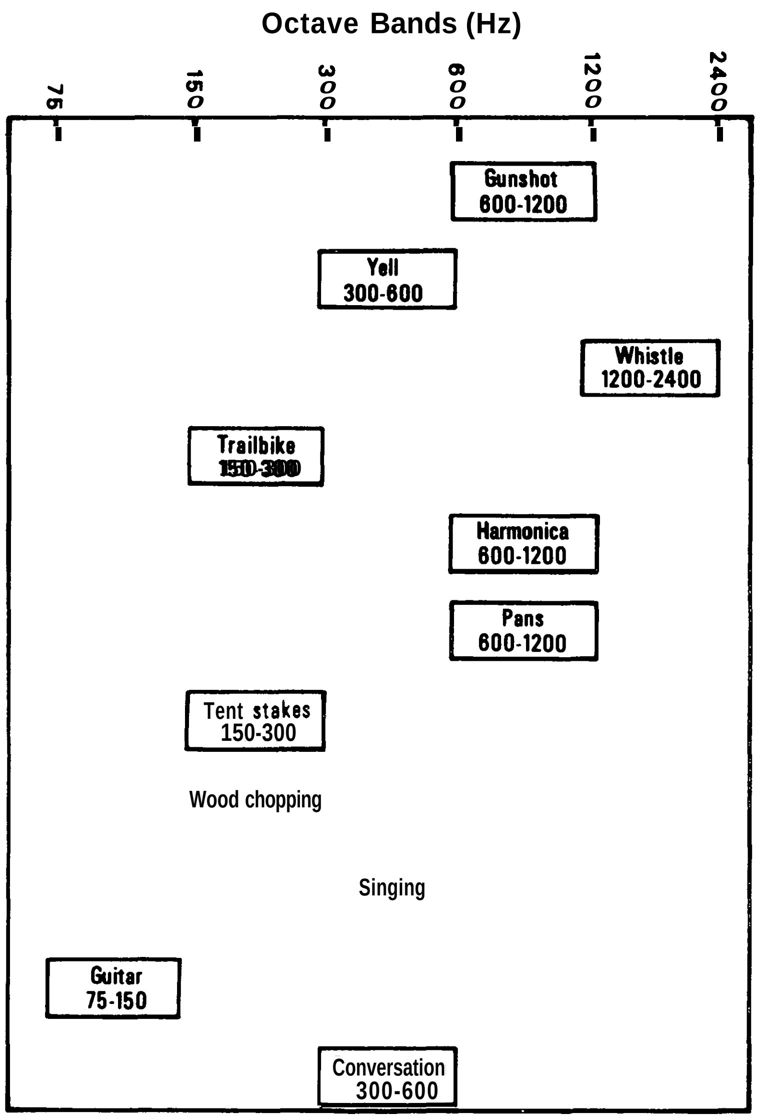

Figure 2.--Octave band frequency of 11 human-related noises.

Psychological Perception of Human-Related Noises

The physical properties of noises are without meaning until they are connected to the way people perceive the noises; knowing that a noise has X intensity and Y frequency does not tell us how annoying it is to the listener. This section outlines those factors which influence the manner in which most humans perceive noise.

There appear to be several physical properties of noise that influence how intrusive or annoying the noise is to a listener (Broch 1969). First, people respond to the intensity, or loudness, of a noise; generally, the louder a sound is judged, the more annoying it is perceived.[9] Second, the frequency, or pitch, of a noise affects its perceived annoyance. Higher frequency sounds are usually more intrusive than lower frequency. Third, the intermittent reoccurrence of a noise--the drip from a water faucet is a well-known example--affects how annoying the noise is perceived. Noises which are rhythmic, irregular, or intermittent are judged more annoying than continuous noises, even when other properties of the noises are the same.

In summary, noises with some combination of high intensity, high frequency, and/or intermittent reoccurrence are more likely to be perceived as annoying than noises not possessing these physical properties. This suggests that among the noises we considered, rifle shot, motorcycle, whistle, yell, harmonica, and clattering pans would be judged most annoying. However, the annoyance or intrusiveness of a noise is not determined solely by its physical properties. In fact, acoustical research has demonstrated that the connotation or perceived meaning of a noise is more important in determining its effect on the listener than the level of intensity or frequency and duration of the noise (Parry and Stephens 1969).

Obviously, the meaning a noise has depends on where it is heard and by whom, We have discussed the desire for solitude and isolation of most visitors to roadless areas. We have also cited studies which suggest that this desire is greatest at campsites and in hard-to-get-to areas. There, any noise suggesting the presence of other people will probably have a negative, intrusive, or annoying connotation. It is not the physical properties of the noise that account for the perceived annoyance; the noise itself may be barely audible. Rather, it is the meaning of the noise that makes it intrusive. In this case, it means that other people are present where they are neither desired or expected,

In areas where the desire and expectation for complete solitude are not so great, the intrusiveness of a noise may be more dependent on physical properties, intensity, frequency, and intermittent recurrence, so long as the noise is perceived as being appropriate for the setting.

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[9] For most people, a 10-dBA reduction in the sound pressure level results in a noise being judged roughly one-half as loud (U. S. Environmental Protection Agency 1971).

Finally, although absence of annoying noise might be considered a necessary condition for proper campsite location, it may not be sufficient if the source of possible noise is still visible. And even when the noise is audible, visual screening of its source may reduce its impact.[10/]

Noise Attenuation

So far, we have described the physical properties of some human-related noises and discussed the relationship between their measurable qualities and the manner in which people experience the noises.

In this section, we discuss conditions which reduce noise level over distance. First, we offer a general discussion of the meaning of noise reduction. Next, we describe the effectiveness of different environmental factors that reduce noise. Finally, we relate the presence or absence of these factors to the types of environments typically found outdoors.

As any noise spreads out from its source, its sound pressure level will decrease at a predictable rate. The decreasing loudness, or "attenuation," of a noise as it travels through an ideal, loss-free atmosphere is at a rate of 6 decibels for each doubling of distance from the source. This phenomenon is known as spherical spreading (Beranek 1960). For example, a noise measured at 70 dBA 50 feet from the source will be 64 dBA at 100 feet, 58 dBA at 200 feet, 52 dBA at 400 feet, etc.

Outdoors, as noise travels through the air, the sound pressure level measured in dBA is further decreased, i.e., attenuated, by the often combined effects of such factors as dense woods and sound absorption in the air. The factors we examined which are fairly constant and affect attenuation of the sound pressure level include: (1) molecular absorption (sound absorption in the air) (2) rigid barriers (rock outcrops, ridges, etc.), (3) dense woods, (4) low vegetation, and (5) a still body of water (a lake). Several other factors affect how far a sound will travel outdoors, but because of their high diurnal or seasonal variability, they were not considered. These variable factors include the effect of rain, fog, snow, wind, temperature, and turbulence.

ENVIRONMENTAL FACTORS WHICH ATTENUATE NOISE

Sensitive campsite location in backcountry or wilderness areas cannot be solely responsive to rigid guidelines. The wide variety of conditions confronting the campsite planner will often require taking maximum advantage of situations which are less than ideal, where the spacing guidelines we will suggest may be impossible to apply. To do the best with what he has, the recreation manager should be familiar with the relative effectiveness of environmental factors which attenuate noise. These "rules of thumb" are indicated in this section by italics.

[10/] Personal communication with R. T. Harrison, San Dimas Equipment Development Center, San Dimas, Calif.

Molecular Absorption

A sound wave traveling through still air loses energy by a process related to the behavior of oxygen molecules in the air., Compared to the basic effect of spherical spreading, molecular absorption has only a minimal effect on most lower frequency noises, For sounds with a frequency lower than 1,000 **Hz** (which includes most of the noises we considered in this report) attentuation due to molecular absorption is only about 2 dBA per mile from the noise source (Myles et al. 1971). *Molecular absorption is not a major factor to consider in campsite location to minimize noise impacts.*

Rigid Barriers

The attenuating effect of a large, rigid barrier, such as a rise or a hill, interposed between the noise source and the receiver, depends on two factors: (1) The height of the barrier (the higher, the more attenuation) and (2) the distance between the noise and the barrier (the closer the source to the barrier, the more attenuation). Barrier height is relatively more important in determining attenuation than is the distance between noise source and barrier (Beranek 1960). The lateral extent of the barrier and location of the noise source laterally from the edge of the barrier also affect the level of attenuation. There appears to be a practical limitation on attenuation due to a rigid barrier of about 25 dBA (Beranek 1960). *Rigid barriers such as rock outcrops or hills can be used to reduce auditory impacts between campsites.*

Dense Woods

A sound transmitted through dense woods is absorbed by the leaves on trees and on the ground and scattered by tree trunks and limbs. Studies of the attenuating effect of woods have varying results. It appears than an approximate "excess" (in addition to spherical spreading reduction) attenuation value of about 2 dBA per 100 feet from the source is obtainable under a variety of dense forest conditions (Weiner and Keast 1959, Myles et al. 1971, Eyering 1946, Cook'and Van Haverbeke 1972). The maximum excess attenuation caused by forests is 10 dBA for lower frequencies (Myles et al. 1971). *Woods can effectively reduce only low intensity auditory impacts between campsites.*

Low Vegetation

The distance a noise will be transmitted over level terrain with low vegetative ground cover (less than 2 feet high) is highly dependent upon temperature and wind conditions. Decrease is small compared to dense woods or rigid barriers. Minimum attenuation, of course, will be achieved when the receiver is downwind from the noise source. Under still wind conditions, excess attenuation over low ground cover will be only about 1 or 2 dBA at 500 feet from the noise source (Eyering 1946, Harrison 1974b). *Low ground vegetation is not important in decreasing auditory impacts between campsites.*

Still Bodv of Water

Little research has been conducted on excess attenuation of sound over water. Harrison (1974b) has shown that the total decrease in loudness of noise over a lake surface is actually slightly less than the loss theoretically produced by "spherical spreading." Although the distance a noise will be conducted over water is highly variable depending on wind and temperature gradients, it appears that the excess attenuation created by the still lake surface is about zero. *Water surface between campsites is a liability rather than an asset in reducing auditory impacts.*

COMBINING THE ATTENUATING FACTORS

Outdoors, the foregoing attenuation factors may be combined in a number of ways.[11/] For example, attenuation due to molecular absorption occurs in any outdoor environment. To this effect would be added the attenuating effect of dense woods if a dense stand of trees is between the noise source and receiver. In general, the individual noise reduction effects of every factor operating in a particular outdoor setting (including, of course, the basic effect of "spherical spreading") are added together to determine total noise reduction over a given distance.[12/]

[11/] As previously discussed, attenuation across a lake must be considered as a special case. Reflection of sound from the water surface creates a condition where total noise reduction can best be predicted by determining the attenuating effect of spherical spreading alone.

[12/] When the sound level of a given noise is known at a reference distance from the noise source, the total attenuation in the same direction but at a greater distance is given by the equation (Beranek 1960):

$$L_1 = L_0 - 20 \log \frac{r1}{r0} - A_e \text{ decibels}$$

Where L_1 = level (in decibels) at r_1 distance from the source, L_0 = level (in decibels) at r_0 distance from the source, where r_1 is greater than r_0, and A_e = excess attenuation (in decibels).

The excess attenuation, A_e, is determined by the sum of its various contributions which are considered independent of each other:

$$A_e = A_{e1} + A_{e2} + A_{e3} + A_{e4} \text{ decibels}$$

Where A_e = excess attenuation:

A_{e1} = attenuation due to molecular absorption,

A_{e2} = attenuation due to rigid barriers.

A_{e3} = attenuation due to dense woods.

A_{e4} = attenuation due to low vegetation.

We examined the transmission of human-related noises in three outdoor settings: (1) woods, (2) streamside in woods, and *(3)* meadow. In each of these settings different combinations of factors affecting noise attenuation may be operational. Table 2 presents a matrix showing which noise-attenuating factors are associated with each of these outdoor settings.

Table 2.--*Presence of factors affecting noise attenuation in three outdoor settings*

Outdoor setting	Molecular absorption	Dense woods	Rigid barrier	Low ground cover
Woods	t	+	t	±
Streamside	t	t	–	–
Meadow	t	–	t	+

NOTE: + = factor present, ± = factor possibly present, – = factor probably not present.

Background **Noise**

The final factor which influences how far noise will travel outdoors is the background noise level. In this section we discuss the effect of "natural" background noise on the distance an intrusive, human-related noise will travel. We also present the noise levels we measured in the three outdoor settings mentioned above.

The louder the ever-present background noise level, the closer a noise source can be to a receiver and still remain indistinguishable. Harrison (1974b, p. 16) suggests that for an intrusive noise to be "completely muffled, its sound level should be. . , reduced to about 15 dBA below the prevailing background noise."

In each of the three outdoor settings which we studied, there was an ever-present background noise level. In the woods, noises included the rustling of leaves. and needles and the creaking of tree trunks. Under low wind conditions *(3* to 5 mi/h), the background noise level in the woods (fig. *3)* was about 35 dBA.[13/]

[13/] For comparison, at midafternoon, mean intensity of background noise in an urban area has been determined to be about 62 dBA, 75 dBA, and 80 dBA for residential, commercial, and industrial sites, respectively. Benjamin Etan Fanta. 1972. Noise generation and transmission in Jasper National Park. Unpublished M. S. thesis, University of Alberta, Edmonton.

Figure 3.--Under low wind conditions, background noise level in a mature coniferous forest such as this is about 35 dBA.

At streamside the turbulence of the water determines the background noise level (fig. 4). Opposite a small rapids on a 10- to 20-foot-wide stream, background noise level was about 45 dBA 3 feet from the bank.,

In an open meadow (fig. 5), the rustling of grasses and brush stirred by the wind together with the distant sound of tree movement contributes to a background noise level of about 30 dBA under low wind (3 to 5 mi/h) conditions.

Figure 4.--Background noise level about 3 feet from the bank of a stream similar to this is about 45 dBA.

Figure 5.--In a meadow such as the one pictured here, background noise level is about 30 dBA under low wind conditions.

Campsite Spacing Guidelines

The spacing guidelines are based only on the physical properties of intrusive and background noises and applicable environmental factors which might attenuate the noise. In some cases, the suggested spacing guidelines may be difficult or impossible to achieve. Where practical considerations require closer spacing, the recreation manager should be especially sensitive to the following:

1. Types of human-related noises to be screened. What are the intensity and perceived intrusiveness of the "people" noises most likely to be encountered in the campsite area?

2. Background noise level. How can camps be located to take maximum advantage of areas with high intensity "natural" noise levels?

3. Attenuating factors such as barriers and foliage. What spatial arrangement of camps best uses the noise-attenuating properties of the environment?

4. Environmental features which can block visibility of noise sources. How can these features be exploited to provide the optimum degree of psychological insulation between campsites?

Insulation from noise is only one consideration in campsite location, but it is an important dimension of the wilderness and backcountry experience. Other factors which influence camp location are amount of level ground, distance from firewood and potable water, dryness of site, and visibility of lake or stream (Brown and Schomaker 1974). Obviously there are cases where the visitor may trade insulation from noise for a view or some other desired campsite feature.

Most noises which are related to human presence in wilderness settings occur in or around a campsite or on a trail. Several noises, such as safety whistles used to signal party members or a gunshot fired while a person is hunting, may be emitted from almost any location accessible to people. We considered only normal campsite and trail noises (singing, harmonica playing, pounding tent stakes, clattering pans, chopping wood, etc.) in determining guidelines for minimum campsite spacing. Since motorized vehicles are prohibited in many backcountry areas, we did not consider trailbikes in our spacing requirements. In areas where motorized vehicles are permitted, they would be expected to have substantial auditory impact. Harrison (1974a) has found that in a forest a motorcycle becomes just audible at distances ranging from 1,400 feet to 3,900 feet from the receiver, depending on the size and type of cycle.

Outdoor settings with differing background noise levels and combinations of attenuating factors require different spacing requirements to achieve the same level of insulation from intrusive noises. For example, campsites in a meadow must be more widely separated than camps in the woods to attain the same degree of insulation from noise.

Also, spacing requirements for similar outdoor settings (woods, streamside, and meadow) will vary according to the situation being considered. In the following we describe a procedure to determine campsite spacing to achieve noise standards that have been proposed for these situations--pristine, primitive, and portal.[14/]

[14/] Willis E. Ragland. 1973. Guides for proportioning wilderness into three situation classes. Unpublished manuscript on file at Mount Baker-Snoqualmie National Forest, 1601 Second Ave. Bldg., Seattle, Washington 98101.

PROCEDURE TO DETERMINE NECESSARY SPACING

1. Establish the standard of insulation. This step requires a determination of the loudest intrusive noise for which adequate spacing must be provided to render that noise indistinguishable from the background noise. For example, the noise might be pots rattling or children yelling--or in a more accessible setting it might be normal conversation.

2. Determine the threshold level of the setting. The threshold level is that sound level to which the noise must be reduced before it is muffled by background noise. This was determined to be 15 dBA less than the background sound level of the setting. For example, in a streamside setting with a background noise level of about 45 dBA, a threshold level of 30 dBA must be achieved before the intrusive noise is effectively masked by the sound of the stream.

3. Calculate spacing requirements appropriate for each setting. This final step involves calculating the distance the noise would travel, subject to the effect of available attenuating factors, before it reaches the threshold level for the setting.

PROPOSED NOISE CRITERIA AND SPACING STANDARDS FOR PRISTINE, PRIMITIVE, AND PORTAL SITUATIONS

Spacing requirements to achieve proposed levels of sound insulation for pristine, primitive, and portal situations are discussed below and summarized in table 1. For each zone different spacing requirements are given for meadow, woods, and streamside camp locations.

Pristine Situation

Here the proposed objective is to locate sites so that all "people" noises are inaudible between camps. This relatively stringent requirement assumes a desire by visitors to the pristine areas for a natural environment providing both solitude and isolation. Therefore, campsites should be located so that even a high intensity noise, such as human yelling (78 dBA), is not audible between camps.

In the woods, when a hill or rise 15 feet high is between the noise source and the campsite, at a distance of about 25 feet from the noise source the minimum spacing is reduced to about 1,600 feet. Next to a stream, the background noise level is higher, thus providing more "masking." If woods are between the noise source and the streamside campsite, 3,200-foot spacing is required before a yell will be inaudible.

In a meadow, noise source and receiver must be spaced farther apart than in a woods environment. Under certain conditions (downwind, high humidity, etc.), a yell will travel nearly 4 miles (20,000 feet) over level ground before it falls below the threshold noise level. Of course, such a large open space is seldom found; in the wilderness setting, most large meadow environments occur in alpine areas where the distance sound will carry is reduced by ridges and hills. If two camps are located at an equal distance from a ridge which is at least 100 feet higher than each camp, minimum spacing is about 640 feet.

Primitive Situation

In the primitive zone, visitors' expectations of solitude and isolation are somewhat less than in the pristine situation and there are likely to be more people. The noise level proposed for this zone is 60 dBA--the level of intensity for four persons singing.

In the woods, minimum spacing of about 1,450 feet is required before the noise of four persons singing is masked by the background noise. When a hill or other rigid barrier 15 feet high is between noise source and receiver at a distance of 25 feet from the source, minimum spacing is reduced to about 400 feet.

In a streamside campsite in the woods, the intensity of singing must be reduced to **30** dBA before it is masked by the background noise. This requires a minimum spacing of 600 feet between campsites.

In a level meadow environment, singing can be heard at a distance of about **4,**200 feet from the receiver, With a 100-foot-tall barrier (a ridge or hill) between source and receiver, minimum spacing is reduced to about 950 feet when camps are located at equal distance from ridgetop.

Portal Situation

In the portal situation, the more accessible and intensly used portions of the backcountry or wilderness, visitors' expectations for ,solitude are assumed to be less than in the more isolated ones, Thus, the standard for isolation in the portal areas is to .locate camps so that the noise of 48 dBA--four people carrying on a conversation--is inaudible between sites.

Conversation becomes inaudible in a woods environment at about 500 feet. When a 15-foot-high barrier is interposed between source and receiver of the noise, spacing of campsites is reduced to about 200 feet.

At streamside campsites in the woods, a minimum spacing of 250 feet is required between noise source and receiver. Conversation is inaudible in a meadow environment over level ground at about 1,950 feet. When a ridge 100 feet high is between the noise source and receiver, spacing of about 250 feet with each camp an equal distance from the ridgetop is necessary to reduce conversation to the threshold noise level.

Campsite Location Guidelines

The foregoing data, literature review, and discussion suggest several guidelines for planning campsite locations where planning is possible, or relocating undesirable campsites:

1. Locate campsites laterally along streams. Managers should take advantage of the masking effect of the background noises of turbulent water and locate camps laterally along streams. Sites should be located as near the bank as is ecologically sound and opposite areas of swift water. Adjacent sites should be separated by dense vegetation and relief.

2. Do not locate campsites near lakeshores. The acoustic properties of the still air above a lake surface do little to decrease the intensity of noise traveling across the lake. Under certain climatic conditions a low conversation (about 45 dBA) is audible at a distance of over 1,000 feet.

Campsites should not be located directly across the lake from another but along the shore on the same side to take advantage of screening vegetation and terrain.

The small size of most high-country lakes precludes more than one camp near the lakeshore if even minimal auditory isolation is desired. If possible, locate sites along an uneven shoreline with vegetation and relief between them. It is also helpful to set sites back into the woods, taking advantage of noise attenuation by dense vegetation and the psychological isolation afforded by visual screening.

3. Meadows are unsuitable location for multiple campsites. The noise attenuation effect of low vegetation is minimal. In addition, except at very great distances, visual impact of other parties accentuates auditory impacts. Locations of multiple camps in a meadow setting should be considered only where they can be separated by ridges or hills or where they can be set back in the timber surrounding the meadow.

4. Take maximum advantage of environmental features which lessen noise. The judicious use of topography in locating campsites greatly lessens transmission of noise between camps. Whenever possible, separate camps by vegetation and rigid barriers--rises, ridges, rocks, or hills--to reduce both noise transmission and visual perception of the human origin of noise.

5. Take advantage of areas with a high background noise level. The turbulence of a rushing stream, a waterfall, the rustling of brush and' tree leaves stirred by the wind, the sound of waves at shore areas all raise the natural background noise level which can help screen out human-related noises. Locating camps in areas with high background noise will allow closer campsite spacing while maintaining auditory isolation.

Conclusions

In this study we reviewed some basic principles of sound transmission and presented empirical findings of the sound levels of various human-related noises. Based on this information we developed guidelines for campsite spacing and location in wilderness and backcountry settings. The guidelines recognize the desirability of different sound standards fitting user expectations in different roadless area situations--pristine, primitive, and portal. In hard-to-reach, interior portions of a roadless area (pristine) situation visitor expectations for solitude are greatest. Here more stringent sound standards are justified, and camps must be spaced more widely apart than is necessary in intermediate (primitive) or peripheral (portal) situations where visitors expect less isolation.

The distances we suggest for campsite spacing are offered only as rough guidelines. They might also be used as diagnostic criteria with which to appraise the experience at currently established sites from a noise-isolation standpoint. It is recognized that other factors are also important to the users' camping experience. Among these factors are availability of potable water, firewood, and dry and level ground.

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