Transportation Noise and the Value of Natural Quiet

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Introduction

The transportation system in the U.S. creates noise, and since the 1970s analysis and mitigation of this noise where people live has become a routine part of the transportation planning process. This analysis generally focuses on specific projects for specific transportation modes. It is, in the author's experience, rare that a systems approach has been applied to examine multimodal trade-offs in transportation performance and environmental effects. The focused analyses aid in limiting the most significant effects of noise in the immediate vicinity of the source, and feasibility considerations always play a role in determining the area over which noise effects are examined and mitigated. The result is that there has been little or no real attention given by either government agencies or the acoustics community in the U.S. to the summed effects of all sources of noise over wide areas of the country.

This is not to say that there are not many professional individuals and organizations worldwide that are concerned with a broader perspective of the "soundscape." This broader perspective may address the quantifiable effects of all noise sources on people living in built environments (see, for example, Berglund and Lindvall 1995; Berglund et al. 1999; Miedema 2001), on developing a coordinated approach to use of noise indicators and assessment methods for examining environmental noise (CEC 2000), on the qualitative values and effects of the soundscape (Schafer 1977), or on soundscapes in national parks (NPS 2000). These types of professional efforts are significant and necessary if we are to develop an understanding of the relationship of the sound environment to human health and well-being, and if the soundscapes are to be managed to preserve or improve the quality of life.

This paper suggests yet another perspective on soundscapes. The complexity and extent of the modern transportation system, and the ways in which that system is planned, modified, and expanded, mean that, in the U.S., there is little attention given to the countrywide extent of its influence on the acoustic environment or soundscapes across the country. Further, if the extent of acoustic influence of the transportation system were better understood, there might be, on the one hand, more emphasis on total system acoustic design and, on the other, the public perception of the value of managing and preserving natural soundscapes might be altered.

The goals of this paper are to: (1) estimate the geographic extent of transportation noise in the U.S.; and (2) raise the question: What is the value to society of seeking to manage natural soundscapes for restoration and preservation?

Geographic Extent of Transportation Noise in U.S.

The method used here for estimating the geographic extent of transportation noise is based on separately examining the layout and noise "influence" of each of the three major transportation networks. These networks may be defined as: (1) highways, including primary limited-access highways, primary roads, and secondary roads; (2) freight railway lines; and (3) commercial air carrier jet routes.

In order to generalize the noise "influence" of these three transportation systems for the U.S. (for simplicity, this examination focuses on only the contiguous forty-eight states), a simplified calculation method is used. The method used here is based on several assumptions:

1. All calculations are done county-by-county.
2. All calculations are for a typical daytime hour.
3. Population density is used to derive a "baseline" sound level.
4. This baseline level, produced primarily by

the local vehicular transportation network, serves to determine the area in which the noise of the three major networks will be "noticed." A transportation source is assumed to be noticed when its sound level equals the background or baseline level (in A-weighted decibels; for background, see Green and Swets 1988; Miller 2000; Potter et al. 1976).

5. The higher the baseline sound level, the smaller the area over which the transportation networks will be noticed, and conversely, the quieter the baseline, the greater the area over which the noise of the three networks is noticed.
6. "Influence" by the noise of each of the three networks is determined by: (a) determining the maximum distance from the transportation corridor at which the transportation noise source can be noticed; (b) multiplying this distance by the length of the corridor in the county, giving an area within which the noise of the particular transportation corridor can be noticed; (c) comparing the area in each county over which each of the three transportation networks can be noticed with the total area of the counties to compute the percentage of each county in which each network can be noticed.
7. Nationwide, the degree of influence is depicted by categorizing the counties by the percentage of land in which each transportation noise can be noticed.

In the U.S., there are federally approved mathematical models for computing the sound levels produced by any of these types of transportation (Anderson et al. 1998, for highway traffic noise; DOT 1995, for rail noise; FAA 1999, for aircraft noise). For present purposes, however, the approach is to use only the source sound levels and propagation algorithms of these models to produce estimates of the maximum distance at which the source can be noticed.

Baseline sound levels. The baseline levels used to determine the maximum distances at which the various transportation types can be noticed are derived from a long-standing simple relationship between community sound level and population density. The relationship of day–night sound level, Ldn (a measure of the sound in an average 24-hour day) to population density was investigated by the U.S. Environmental Protection Agency in 1974 (EPA 1974), and recently reconfirmed (Stewart et al. 1999). This relationship is:

$$L_{dn} = 22 + 10\log\left(\frac{\rho}{\rho_0}\right) \quad (1)$$

where ρ

is population density in people per square mile, and ρ_0

is 1 person per square mile. It is intended to estimate the day-night sound level due to general community activity, and assumes that no major highways or airports are affecting the sound environment.

The relationship of equation (1) was applied to the population densities of U.S. counties to produce Figure 1. As might be expected, higher sound levels are in the counties with significant urban/suburban populations. Because of the map size, some areas of high baseline sound levels, notably San Francisco and metropolitan New York, cannot be distinguished.

For determination of areas of noticeability, the comparison made is between the sound level of the specific transportation source (highway, rail, aircraft) and the "baseline" sound level derived from the levels given in Figure 1. The best representation of such a baseline level is assumed to be the daytime median sound level, or L50. Equation (1) yields Ldn, so this value must be transformed to L50. Using information collected in 18 communities (Wyle Laboratories 1971), the following approximate relationship was derived:

$$L_{50} \approx L_{dn} - 5dB \quad (2)$$

Hence, for each of the transportation sources, the comparison is between the maximum sound level of the source and the base-

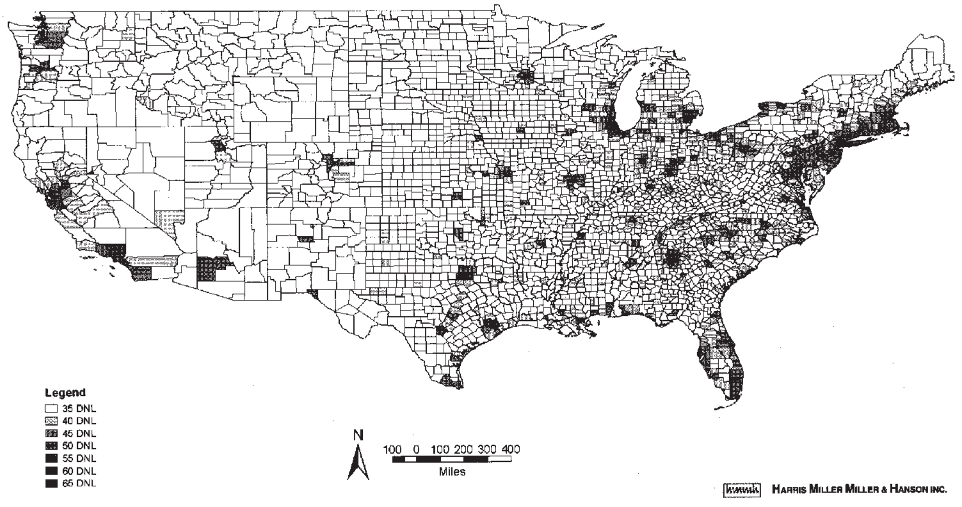

Figure 1. DNL by county, developed from population density, equation (1)

line of Ldn – 5 dB. The distance from the transportation track to the point where the maximum level equals Ldn – 5 dB is the distance of noticeability.

Highways. Figure 2 shows the results of the noticeability calculations for highway traffic noise. The specific divisions that depict the percentage of county area where the noise is noticeable were chosen assuming that the greater the estimate of noticeable area, the higher the likelihood that the estimates are inaccurate. As the area of noticeability

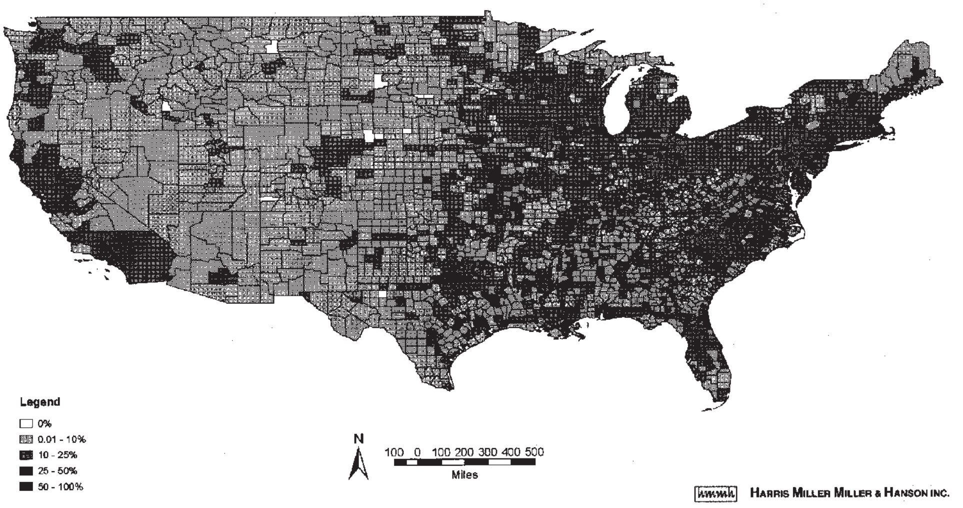

Figure 2. Percentages of county areas in which highway traffic noise is noticeable during the day

increases, the greater the probability that individual noticeability areas from different transportation segments will overlap. Hence, the divisions increase in size, as the percentage increases.

The percentage of a county in which noise is noticeable depends upon two variables: (1) the number of transportation corridor segments in the county, and (2) the baseline sound level in the county. Thus, a county may have a low percentage of noticeable highway noise either because the baseline level is high or because there are few highways in the county.

Railways. Figure 3 shows the results of the noise influence calculations for railway noise.

Figure 4 are all jet departures that occurred between 3:00 PM and 4:00 PM on October 17, 2000, using the full track to the first destination. The period 3:00–4:00 PM was chosen as typical of the numbers of flights during the day, and should include most common routes.

There are a few areas of the country where the estimation method is probably inaccurate. For some locations, the method likely overstates the extent of the audibility of jet traffic. Those areas that have several flights following a relatively narrow corridor are likely to have overestimates of areas. In areas that have both high baseline levels and airports, such as Los Angeles, Dallas–Fort Worth, and Atlanta, the method is likely to underestimate the noticeability. For simplicity, all tracks are assumed to be at 30,000 feet, and hence there

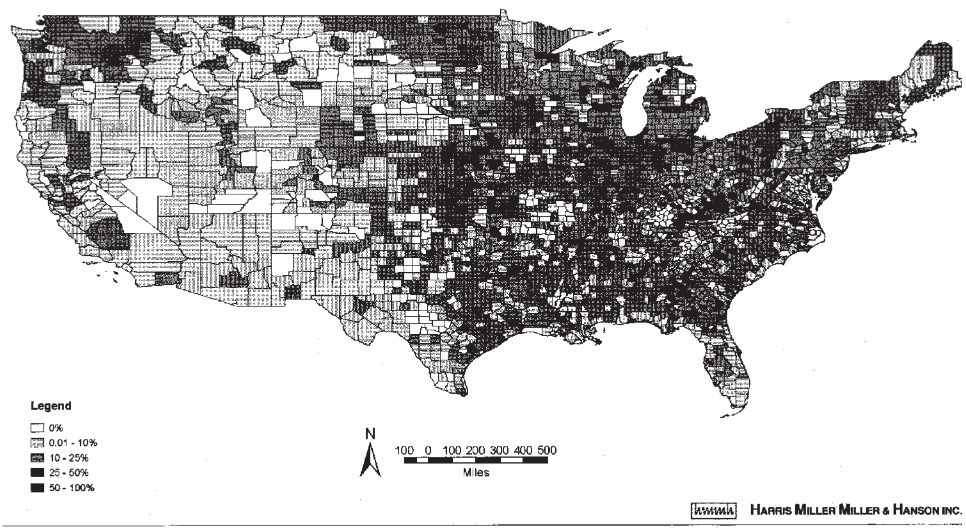

Figure 3. Percentages of county areas in which rail traffic noise is noticeable during the day

Commercial jet routes. Figure 4 shows the results for high-altitude jet routes. Unlike traffic on highways and railways, each jet follows a unique path. Though in some cases there are fairly distinct corridors, for much of the country the paths are quite dispersed.

The tracks used for the calculations of

are no climb and descent portions so that these segments around airports have predicted sound levels that are lower than the actual levels. This combination of high baseline sound levels and aircraft sound levels, which are too low, probably results in underestimation of the area affected.

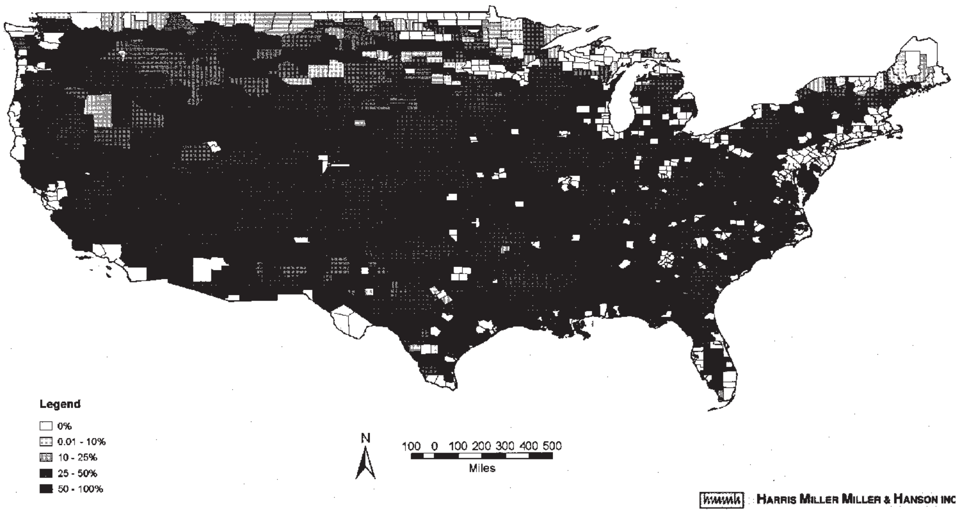

Figure 4. Percentages of county areas in which jet traffic noise is noticeable during the day

Interest in Preservation of Natural Soundscapes

Can knowledge of the extent of transportation noise alter our perceptions of the value of preserving, restoring, and managing selected natural soundscapes? As we continue to strengthen our transportation systems, making them more effective in geographic reach, will recognition of the nationwide spread of the associated noise alter how the public (and our government) views the value of managing to preserve areas where natural soundscapes can be experienced? Will it matter if there are no locations in the U.S. where one can sit for an hour and hear only the sounds produced by the natural environment?

It can be said that there is currently no national consensus on the value of natural soundscapes. On one hand, the U.S. Congress (supported by various interest groups) and various federal agencies have traditionally demonstrated a commitment to preserving natural settings, including the natural soundscapes. On the other hand, some businesses that provide motorized park activities, such as snowmobile rides or air tours, and their associated user/interest groups are concerned that preservation of natural soundscapes will prevent the businesses from meeting park visitor needs and make these recreational activities unavailable to those who want them.

U.S. public lands are designated through acts of Congress. These acts identify the purposes to be served by the specific land or type of land, and several types of public lands carry the mandate of preserving, restoring, and providing for an experience of the natural soundscape. National parks can be established for many different purposes, but overall, the National Park Service (NPS) was created primarily to preserve the resources of national parks (cf. National Park Service Act of 1916 and Redwoods Act of 1978). Although NPS management policy has identified the importance of preserving natural sounds, the director of NPS recently issued Director's Order 47, which states that:

> The purpose of this Director's Order is to articulate the National Park Service operational policies that will require, to the fullest extent practicable, the protection, maintenance, or restoration of the natural soundscape resource in a condition unimpaired by inappropriate or excessive noise sources (NPS 2000).

The Wilderness Act of 1964 established a process to identify specific areas as "wilderness," each of which would be an "area of undeveloped Federal land retaining its primeval character and influence ... which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation...."

The Wild and Scenic Rivers Act of 1968 also established a study process to identify and protect free-flowing rivers. Two relevant management objectives for the system are: (1) provide recreationists with the opportunity to experience a river setting similar to that seen by the first explorers, and (2) ensure that the rivers retain an essentially wild and pristine nature (BLM 1980).

Federal areas of the continental U.S. that might be the subject of soundscape management account for about 3% of the 48 states; these are national parks, national seashores, wild and scenic rivers, designated wilderness areas, and areas considered to have the potential to be designated as wilderness.

These different public lands have been established for various reasons, most of which are preservation-oriented, and NPS has specifically identified natural soundscape preservation as a management objective for national parks. Users of these public lands and associated interest groups, however, can have a wide range of expectations that may or may not include experiencing the outdoors in a natural state. The popularity of snowmobile use in Yellowstone, the use of personal watercraft in parks or recreation areas such as Glen Canyon National Recreation Area, and the many passengers on air tours over Grand Canyon National Park and over the Hawaiian parks suggest that many visitors seek experiences other than witnessing natural settings free of the effects of "man's work."

The validity of such park experiences is not in question here, but these experiences conflict with another view of the purpose of parks, as expressed by Joseph Sax (1980). In this view, parks are to provide the opportunity for members of the public to experience nature on its own terms. Visitors should be able to temporarily leave behind their to-do lists, their pursuit of objectives, even if recreational, to discover what they themselves are like when surrounded by the natural environment. Clearly, to provide opportunities for both this type of experience and for the more active motorized recreational experiences (bus, air and car tours, power boats, snowmobiles, etc.), management of park soundscapes is required.

Can Natural Soundscapes be Preserved?

It has long been recognized that portions of the nation's natural heritage should be preserved, and the extent of transportation noise throughout the U.S. emphasizes the importance and difficulty of this preservation as applied to natural soundscapes. Yet several current attempts to preserve/restore natural soundscapes in national parks are being strongly resisted through both political and legal means. From an acoustical perspective, the technical complexities of characterizing and assessing natural soundscapes are significant and open many opportunities for dispute. This combination of significant resistance and significant complexity suggests that development of a uniform, feasible, and effective soundscape management approach will at best be extremely difficult and time-consuming.

References

Anderson, G.S., C.S.Y. Lee, G.G. Fleming, and C.W. Menge. 1998. *FHWA Traffic Noise Model, Version 1.0 User's Guide.* Federal Highway Administration Report no. FHWA-PD-96-009 (January). Washington, D.C.: FHWA.

Berglund, B., and T. Lindvall. 1995. Community noise. *Archives of the Center for Sensory Research* 2:1.

Berglund, B., T. Lindvall, and D.H. Schwela. 1999. *Guidelines for Community Noise.* Geneva: World Health Organization.

BLM [U.S. Bureau of Land Management]. 1980. *Upper Missouri National Wild & Scenic River, Maps 1 & 2, Floater's Guide.*

Washington, D.C.: Government Printing Office.

CEC [Commission of the European Communities]. 2000. *Proposal for a Directive of the European Parliament and of the Council Relating to the Assessment and Management of Environmental Noise.* COM (2000) 468 final, 26.07.2000.

DOT [U.S. Department of Transportation]. 1995. *Transit Noise and Vibration Assessment.* DOT-T-95-16, Federal Transit Administration (April). Washington, D.C.: USDOT.

EPA [U.S. Environmental Protection Agency]. 1974. *Population Distribution of the United States as a Function of Outdoor Noise Level.* Report 550/9-74-009 (June). Washington, D.C.: EPA.

FAA [Federal Aviation Administration]. 1999. Integrated Noise Model, INM. Described in INM User's Guide, FAA-AEE-99-03 (September). Washington, D.C.: FAA.

Green, D.M., and J.A. Swets. 1988. *Signal Detection Theory and Psychophysics.* Los Altos, Calif.: Peninsula Publishing.

Miedema, H.M.E. 2001. Noise & health: how does noise affect us? In *Proceedings, INTER-NOISE 2001, August 27-30.* The Hague: N.p.

Miller, N.P. 2000. A-weighted level differences compared with detectability. Report included in April 25, 1997 memorandum to W. Henry, National Park Service; published in *Review of Scientific Basis for Change in Noise Impact Assessment Method Used at Grand Canyon National Park.* Washington, D.C.: NPS.

NPS [National Park Service]. 2000. *Director's Order no. 47: Soundscape Preservation and Noise Management.* Washington, D.C.: NPS.

Potter R.C., et al. 1976. Detectability of audible warning devices on emergency vehicles. Bolt Beranek and Newman, Inc., Report no. 3333, July.

Sax, J.L. 1980. *Mountains without Handrails: Reflections on the National Parks.* Ann Arbor: University of Michigan Press.

Schafer, R.M. 1977. *The Tuning of the World.* Toronto: McClelland & Stewart.

Stewart, C.M., W.A. Russell, and G.A. Luz. 1999. Can population density be used to determine ambient noise levels? Paper presented at the 137th Meeting of the Acoustical Society of America, Berlin, Germany, March.

Wyle Laboratories. 1971. *Community Noise.* EPA Report NTID300.3, 31 December.