Research Reports

A program of research to support management of visitor-caused noise at Muir Woods National Monument

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NATIONAL PARKS ARE MANAGED TO PROTECT THE environmental and experiential values of the landscapes they represent. As the nation continues to grow into a more populous, developed, and noisy place, these values have expanded from landscapes to "soundscapes" and include the natural and cultural sounds of national parks. In fact, sounds have been identified by the National Park Service (NPS) as a resource that must be protected. In doing so, the National Park Service is challenged to define "soundscapes," understand the effects of noise on visitors and wildlife, and take appropriate management action when necessary.

A couple strolls through Cathedral Grove on a quiet morning in winter when visitation is typically low. Signage at the entrance to this area reminds visitors that they are in a quiet zone.

Management of environmental and experiential impacts on national parks is increasingly guided by management-by-objectives frameworks such as the NPS Visitor Experience and Resource Protection (VERP) framework (NPS 1997; Manning 2001; Manning 2007). Like other such frameworks, VERP has three principal steps. First, indicators and standards of quality are formulated. Indicators are measurable, manageable variables that help define and quantify desired resource and social conditions. Standards

of quality define the minimum acceptable condition of indicator variables. Second, indicators of quality are monitored over time. Third, management actions are taken to help ensure that standards of quality are maintained. With continued monitoring, VERP is an iterative or "adaptive" process, providing feedback that informs management about the degree to which management objectives are attained and the efficacy of management actions taken. This article describes a program of research designed to support application of VERP and management of visitor-caused noise at Muir Woods National Monument (Muir Woods) in California.

Muir Woods National Monument

Muir Woods, a unit of Golden Gate National Recreation Area, lies just north of San Francisco and is a popular visitor attraction, accommodating nearly three-quarters of a million visits in 2007. The park is known for its 560-acre (227 ha) grove of old-growth redwoods. Most visitors experience the park by walking the main trail, which extends about a mile (1.6 km) from the park entrance and follows Redwood Creek.

Human-caused noise has been a management issue in the park for nearly two decades. Initial attention was focused on protection of the threatened northern spotted owl (*Strix occidentalis caurina*) during its breeding season (Monroe et al. 2007). More recently, this has expanded to include consideration of the impacts of human-caused noise on the quality of the visitor experience (Manning et al. 2005; Pilcher et al. 2009). This work has been guided by the VERP framework and supported by a program of research.

Indicators and standards of quality

Initial phases of research at Muir Woods focused on identifying indicators and standards of quality for the visitor experience. The first phase was exploratory, collecting baseline data about visitors and visitor use patterns and probing for issues that generally affect the quality of the visitor experience (Manning et al. 2005). A survey of a representative sample of visitors was conducted in 2003 and a 55% response rate was attained, yielding 406 completed questionnaires. Using a series of open- and close-ended questions, "peacefulness," "quiet," and "the sounds of nature" were found to have a positive influence on the quality of the visitor experience, and "noisy visitors," "loud talking," and related issues were found to substantially detract from the quality of the visitor experience.

Given the apparent importance of soundscape-related issues in the park, the second phase of research was designed to focus more specifically on soundscape-related indicators (Pilcher et al. 2009). Visitors to the park were asked to participate in a "listening exercise" in 2005. This exercise was conducted at three locations in the park (three points along the park's main trail), and visitors were asked to engage in the exercise as they passed each of the three points. A total of 280 visitors participated in the exercise, which consisted of listening to and identifying the sounds heard in the park and rating the extent to which each type of sound was "pleasing" or "annoying." An "importance/performance" analysis of resulting data (fig. 1, next page) suggests potential soundscape-related indicators of quality (Hollenhorst and Gardner 1994; Manning 2007). This analysis suggests that natural sounds such as water flowing in Redwood Creek, birds calling, and wind blowing in the trees are good indicators of quality that contribute to the visitor experience, and visitor-caused noise, such as visitors talking and boisterous behavior, is a good indicator of quality that detracts from the visitor experience. The former sounds are heard by large percentages of visitors and are rated as very pleasing, while the latter sounds are also heard by large percentages of visitors but are rated as very annoying.

The third phase of research was designed to help formulate standards of quality for visitor-caused noise in the park (Newman et al. 2007). Five 30-second audio clips were prepared that included a range of natural and visitor-caused sounds. (Links to the audio sound clips are available from the Park Science Web site at www.nature.nps.gov/ParkScience/index.cfm?ArticleID=346.) All these sounds were recorded in Muir Woods, and the resulting audio clips were created by the National Park Service Natural Sounds Office. These sound clips were ordered by increasing decibel levels, with visitor-caused sounds increasingly masking the park's natural sounds and ranging from 31 to 48 decibels. In other words, the sound clips started with a relatively quiet natural setting with wind, birds, and flowing water, and became increasingly saturated with human sounds in each subsequent sound clip. The audio clips were incorporated into a survey administered to a representative sample of visitors in 2006. A response rate of 53% was attained, yielding 286 completed questionnaires. After listening to each sound clip, respondents were asked to rate the acceptability of the sound on a scale that ranged from -4 ("very unacceptable") to +4 ("very acceptable"). In addition, respondents were asked to indicate which audio clip was most like the soundscape conditions they had experienced in the park.

Respondent acceptability ratings for each of the five audio clips were averaged, and mean ratings were plotted to construct a social norm curve (fig. 2) (Manning 2007). This curve indicates that respondents find greater levels of visitor-caused noise (and

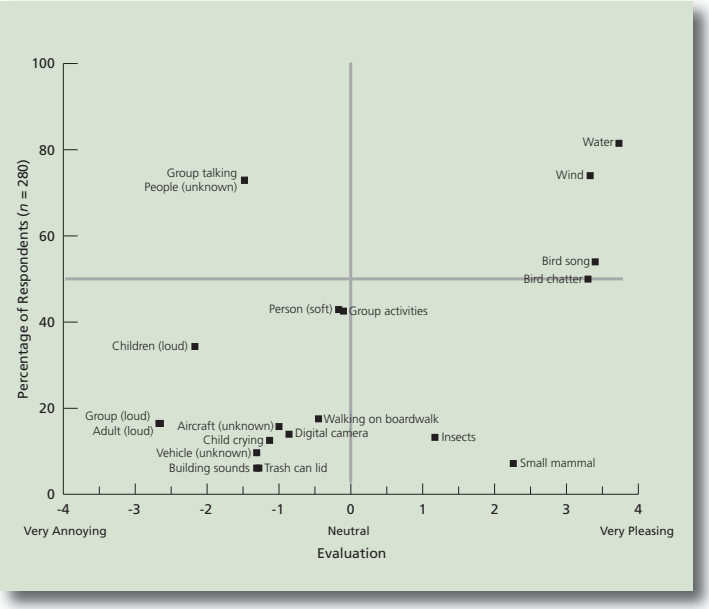

Figure 1. The chart depicts the percentage of study respondents that heard various types of sounds by their mean rating on a scale of very annoying to very pleasing.

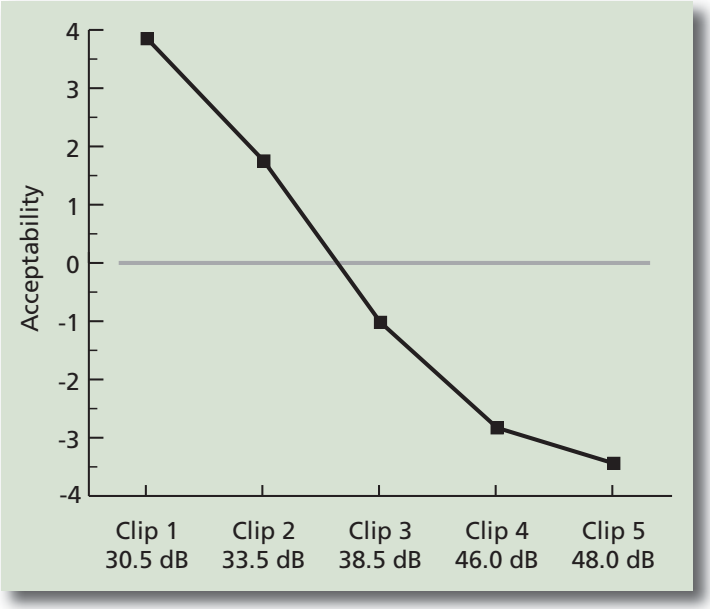

Figure 2. This social norm curve depicts average acceptability of visitor-caused noise on the Cathedral Grove Trail at Muir Woods at various volumes. The sound clips comprise human-caused noise recorded on the trail and played back for survey respondents at varying loudness. Respondents find greater levels of visitor-caused noise (and decreasing levels of natural sounds) to be increasingly unacceptable.

decreasing levels of natural sounds) to be increasingly unacceptable. The point at which aggregate ratings fall out of the acceptable range and into the unacceptable range (i.e., the point at which the social norm curve crosses the neutral point on the acceptability scale) is between audio clips 2 and 3, or 36.7 decibels. Respondents reported the audio clip that best represented the soundscape conditions they experienced in the park on the day they participated in the visitor survey. Most visitors (42.8%) reported that audio clip 2 was most representative, 40.9% reported that audio clip 1 was representative, 12.9% thought audio clip 3 was representative, and 3.4% considered audio clip 4 representative. This means that more than 15% of respondents are hearing visitor-caused noise that is louder than the social norm.

Monitoring

To measure the sound levels in the park, researchers installed a camouflaged acoustic monitoring system approximately 2 yards (1.8 m) off the main trail in Cathedral Grove. This device recorded A-weighted decibel levels (dB[A]) every second. This decibel level is a metric that is an aggregate of sound levels across the range of audible frequencies, weighted to express typical human sensitivities to each frequency band (Fahy 2001). The system used at Muir Woods is certified to measure sound levels accurate to 1 dB(A) and measures sound levels in 31 one-third-octave bands. As noted in the previous section, sound was also monitored by means of a visitor survey that asked respondents which of five sound clips was most representative of the conditions they experienced in the park.

Management

As noted, nearly 15% of visitors to Muir Woods reported hearing more visitor-caused noise than the social acceptability norm as defined in figure 2. Moreover, if visitor use continues to rise, violation of noise-related standards of quality is likely to increase, suggesting that management actions are needed to help ensure that noise-related standards of quality are maintained. But which actions might be effective and acceptable to visitors?

The professional literature on parks and outdoor recreation suggests that a range of management actions can be taken to address the impacts of visitor use (Manning 1999). For example, visitor use levels might be limited or visitor behavior might be altered through educational programs. Generally, educational programs are preferred to visitor use limits because they do not restrict public access to parks and related areas (Peterson and Lime 1979;

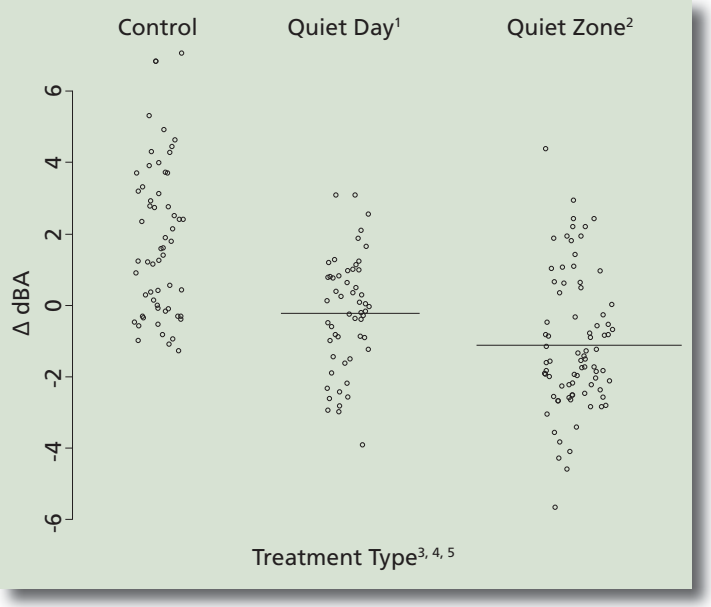

Figure 3. A-weighted decibel (dB[A]) levels during control and treatments.

Notes

[1] The difference between the control and quiet day sound levels is 1.96 dB(A).

[2] The difference between the control and quiet zone sound levels is 2.84 dB(A).

[3] Each circle represents a mean dB(A) level for one hour.

[4] Chart data were measured from 10 a.m. to 6 p.m.

[5] The difference in mean dB(A) among the control and two treatments is significant at the p = 0.01 level.

Table 1. Support for the use of educational programs to reduce visitor-caused noise at Muir Woods

Management action	Percentage*
Quiet Zone	
I strongly support the implementation of a "quiet zone."	71.6
I support the implementation of a "quiet zone."	26.4
I oppose the implementation of a "quiet zone."	1.2
I strongly oppose the implementation of a "quiet zone."	0.8
Quiet Day	
I strongly support the implementation of a "quiet day."	72.0
I support the implementation of a "quiet day."	23.3
I oppose the implementation of a "quiet day."	4.3
I strongly oppose the implementation of a "quiet day."	0.4
Note: Data were derived from a survey of visitors to Muir Woods in summer 2007.	
*x^2 = 5.19, p = 0.158, and Cramer's V = 0.101	

The point at which aggregate ratings fall out of the acceptable range and into the unacceptable range … is between audio clips 2 and 3, or 36.7 decibels.

McCool and Christensen 1996). However, little research has been conducted to test the effectiveness and acceptability of educational programs to address excessive visitor-caused noise.

A program designed to sensitize visitors to human-caused noise at Muir Woods and to encourage them to reduce the noise they generate was applied experimentally at Cathedral Grove ("Quiet Zone") and throughout the park ("Quiet Day") on selected days in 2007. During these "treatments," signs asking visitors to turn off cell phones, to encourage children to walk quietly, and to talk in a lower voice were strategically placed around the park. Visitor-caused noise was monitored during these periods as well as during a "control" period in which neither treatment was applied. A visitor survey was administered during the treatment and control periods to assess how the educational program affected visitor behavior and how acceptable visitors found it to be.

A-weighted decibel readings were significantly lower on treatment days than on control days (fig. 3). During the Quiet Zone treatment, sound level dropped an average of 2.84 dB(A), which translates into a near doubling of "listening area" (Fahy 2001). This means that visitors during the Quiet Zone treatment had a substantially greater opportunity to hear the natural sounds of Cathedral Grove. The reduction in sound level of 1.96 dB(A) during the Quiet Day treatment was not as dramatic, but was still statistically significant. Findings from the visitor survey indicated strong support for both parts of the educational program (table 1).

Conclusion

Soundscapes are an issue of increasing importance in national parks, and visitor-caused noise is in turn a potentially important component of this issue. At Muir Woods, the visitor experience is enhanced by the sounds of nature—water flowing in Redwood Creek, wind blowing through the old-growth forest, animals calling—but visitor-caused noise can mask these sounds and otherwise detract from the quality of the park experience. Find-

ings from the program of research are being considered as part of the new general management plan that is being developed by Golden Gate National Recreation Area (including Muir Woods), and Muir Woods has implemented a permanent quiet zone at Cathedral Grove (see photo, page 54).

As with other types of visitor-caused impacts in parks, the issue of visitor-caused noise can be analyzed and managed through application of the NPS VERP framework by (1) formulating indicators and standards of quality for visitor-caused noise, (2) monitoring indicator variables, and (3) taking management actions to help ensure that standards of quality are maintained. Moreover, this management approach can be supported by a program of research that provides an important empirical foundation for this work.

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