Beyond Noise Mitigation:

Managing Soundscapes as Common Pool Resources

S. L. Dumyahn[1], B. C. Pijanowski[1]

ABSTRACT

Noise has been regulated as a negative externality of human industry and transportation networks that affect human health and quality of life. The United States enacted the Noise Control Act in 1972 to regulate noise impacts; however, the funding and enactment of this law ceased in 1981. Noise continues to grow and is impacting once quiet locations, such as U.S. National Parks. Following the government control approach to managing resources, the National Park Service (NPS) has supported and created many policies to protect park acoustic environments, or soundscapes. We conducted a survey of NPS managers to determine how noise impacts park soundscapes. The survey showed that a variety of human produced sounds have serious impacts on the quality of visitor experiences and potentially impacts wildlife communication. Using a common pool resource (CPR) model, we describe the multiple soundscape users, difficulty of exclusion and subtractability and degradation of soundscapes. Soundscapes offer a flow of benefits to many people: natural sounds, ecosystem function, cultural and historical heritage, silence or natural quiet, ability to communicate with one another, creating a sense of place, and wellbeing. Rather than viewing noise as only a negative externality to be regulated, we pose the normative argument that the right to a quality soundscape is a right belonging to all. The national parks hold in trust the resources, including soundscapes for this and future generations. We posit that a new institutional approach is needed to manage soundscapes where the norms of all soundscape users are recognized and respected.

Keywords: soundscapes, noise control, National Park Service, CPR, biophony, geophony, anthrophony

1 INTRODUCTION

Humans have altered the Earth's ecosystems and biodiversity significantly (Chapin et al. 2000, MEA 2005). Between 40-50% of the ice-free land has been transformed by humans into agriculture or urban systems (Foley et al. 2004; Haberl et al. 2007). With the conversion of land and the loss of biodiversity, the world loses its natural sounds (Wrightson 2000, Pijanowski et al. in press). The loss of natural sounds is compounded by the growing intrusions of motorized noises. Noise pollution is a ubiquitous problem in cities around the world, and these unwanted sounds have become the focus of regulations and frustrations in recent years. Indeed, it has been argued that we ought to focus our efforts on preserving the quieter, unique, and natural sounds of an area (Schafer 1994). The soundscape, or entire acoustic environment of a given area, is a

[1] Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana 47906

resource just as air and water are resources, and it too can be degraded and polluted by human actions (Krause 1987; Schafer 1994; Truax 1999). It is argued that an unimpaired soundscape is a right of all people, a right that should not be masked by noise (Franklin 2000; Karlsson 2000). Yet, the saliency of this issue has not taken hold in the U.S. as soundscapes continue to be impacted by unnatural sounds (Evans et al. 1995; Blomberg et al. 2003).

The current U.S. approach to addressing noise is neither effective nor sustainable. The former national noise policy, the Noise Abatement and Control Act of 1972, is no longer enforced and the Environmental Protection Agency is not funded to address noise issues. Human generated noise is increasing, providing additional need for a different approach (Berglund and Lindvall 1995). The U.S. National Park Service (NPS) has identified park soundscapes as a resource worth protecting (NPS 2006). NPS approach to soundscape management provides interesting and telling insights into the benefits and shortcomings of managing soundscapes as natural and common-pool resources.

In this paper we provide some basic background information on research related to soundscapes. We then summarize a survey conducted of National Park Service managers across the country illustrating that past policy has been ineffective and that managers are seeking new paradigms for managing sounds in the National Parks. Our discussion focuses on addressing the following questions: 1) Can CPR theory be used to manage soundscapes?; and 2) What are the challenges of applying CPR to managing soundscapes in the National Parks? We argue that formalizing soundscapes as common pool resources shifts the management paradigm from a command-and-control necessity to a resource that needs to be managed so that that the right to a quality soundscape is a right belonging to all. We also briefly discuss what we believe is the "way forward" using common pool resource management paradigm to manage soundscapes.

2 SOUNDSCAPES AS NATURAL RESOURCES

R. Murray Schafer formalized the concept of soundscapes in his book *The Tuning of the World* and later expanded in *Soundscapes: Our Acoustic Environment* and the *Tuning of the World* (Schafer 1977; 1994). Schafer defines soundscapes as "any acoustic field of study" (1994, p. 7). This broad definition can be ascribed to musical compositions as well as to the sounds comprising a landscape. Bernie Krause (1987; 2002) furthered the definition and lexicon of soundscapes linking it more closely with the environment referring to soundscapes as all of the sounds present in an environment at a given time (Krause 2002). Recently, Pijanowski et al. (in press) proposed a more formal, ecological definition of soundscapes as the "interaction of biophony, geophony and anthrophony over different spatial and temporal scales. The term anthrophony, or human-generated sounds including motorized vehicles, was added to the soundscape to account for noise and other human produced sounds (Pijanowski et al. in press).

Krause (1987) also posited that soundscapes are finite resources which vocalizing species compete for spectral space. Labeling this concept as the Acoustic Niche Hypothesis (ANH), Krause clearly links soundscapes to other natural resources that

species compete for or adapt to have access to the resource (1987). The importance of the soundscape resource for wildlife becomes clear in cases where it is degraded. The addition of noise pollution in soundscapes masks interspecies communication, impairs predator avoidance, and can elevate stress hormones (Barber et al. 2009).

The U.S. National Park Service (NPS) recognizes soundscapes as a natural resource important not only for wildlife but also park visitors (2006). NPS defines natural soundscapes as "all the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships among park natural sounds of different frequencies and volumes" (2006, p. 56). The importance of park soundscapes as a resource have been addressed in research on park visitor experience (NPS 1995), landscape perception (Carles et al. 1999), natural soundscape values (Fisher 1998). Unimpaired or high-fidelity soundscapes have been found to provide several benefits to humans, such as improved health (Stansfeld and Matheson 2003), cultural and historical connections (Torigoe 1995; O'Connor 2008), sense of place (Schafer 1994), and aesthetics (Fisher 1998). Researchers and NPS are also interested in soundscapes reflecting of environmental quality (Pijanowski et al. in press; in review). Soundscapes could be used as indicators of human disturbance, biodiversity, or habitat complexity (Pijanowski et al. in review).

Managing and protecting soundscapes is an increasingly important concern as noise is spreading to more remote areas, including national parks, due to air travel, motorized recreation, and urban sprawl (Miller 2008). In response to initial noise disturbance findings and overflight safety issues, the National Park Overflights Act of 1987 (P.L. 100-91) was passed. This legislation required NPS to determine the impact from overflights on the national park unit resources and visitors. It also mandated that an overflight plan for Grand Canyon National Park be developed. NPS conducted research of park visitor perceptions and found that natural sounds were as important to most visitors as the scenic views (NPS 1995). From the subsequent research, the impacts from air tour overflights in the national parks warranted the passing of the National Parks Air Tour Management Act (NPATMA) in 2000. NPATMA mandates that national park units with air tours work with the Federal Aviation Administration (FAA) to develop air tour management plans (ATMPs).

NPATMA authorized the formation of two groups to assist with the development of park ATMPs: 1) the NPS Natural Sounds Program to assist parks with technical expertise and the environmental review process and 2) the National Park Overflight Advisory Group (NPOAG) representing key stakeholders to provide counsel during the plan development. The air tour management planning process involves the collaboration of NPS, FAA, air tour operators, Native American tribes, environmental organizations, and interested citizens. This collective-choice arrangement is developing the rules for interaction between NPS, FAA and the different users groups. This collaborative process has taken much longer than originally estimated and, to date, not one plan has been finalized or implemented for any of the 106 park units with air tours.

In addition to addressing aircraft noise, NPS has advanced soundscapes as a natural resource. In the NPS 2006 management policies, soundscapes are addressed as a

unique resource that should be conserved stating, “The Service will restore to the natural condition wherever possible those park soundscapes that have become degraded by unnatural sounds (noise), and will protect natural soundscapes from unacceptable impacts” (p. 56). Cultural and historic human-generated sounds are important soundscape components at some parks, such as cannons at Civil War national battlefields. Additional efforts include acoustic monitoring and research by the Natural Sounds Program, issuing a NPS-wide directive (Director’s Orders #47) for soundscape preservation, and creating NPS management policies specifically addressing soundscapes (NPS 2006). NPS recognizes the importance of healthy soundscapes for park visitor experiences, wildlife survival in the parks, and the intrinsic value of a rapidly disappearing resource (Miller 2008).

3 METHODS

This study was designed to gain insight into soundscape issues, in particular overflight impacts facing national parks. Twenty-five NPS units were randomly selected from a stratified sample of parks (n=55) that were either prioritized for ATMPs or reported moderate to extreme air tour overflight concerns in a study by Voorhees and Krey (1999). Natural resource managers with the greatest knowledge of their park’s noise issues and soundscapes were identified by contacting the parks’ natural resource division. The data were collected through phone interviews conducted from April 2007 through April 2008. The interviews ranged in length from 0.5 hours to 1.5 hours. Of the 25 parks contacted, 17 completed interviews for a 68% completion rate. A total of 23 individuals were interviewed in order to answer all of the primary questions for the 17 parks. The interviews were recorded and transcribed verbatim and/or memoized during the interview based on interviewee preference (following Wengraf 2001).

The interview format was semi-structured focusing on soundscape impacts in the park, specific aircraft noise impacts, and park soundscape management strategies. The interview guide ensured that the basic questions were covered and provided respondents the ability to elaborate or explain answers in-depth. The survey addressed first different types of noise sources and the level of perceived level of impact that they have on the park soundscape, visitors, and other park resources. The degree of impact was evaluated by the park managers on a scale of none, slight, moderate, and major impact. The managers had the opportunity to elaborate on responses as needed. Managers also had the opportunity to address noise sources that were not included in the provided list. From the noise sources provided or added, the manager was asked to select the noise source of greatest management concern. Specific types of aircraft overflights were listed to determine if parks experience them and then identify the type of overflight that has the greatest negative impact on the park. The interview also included questions about management actions for noise sources with the greatest perceived impacts and if the park was using any other soundscape management actions.

4 RESULTS

Natural resource managers were asked to respond to the degree of impact that particular noise sources have on park soundscapes and park resources. The results are summarized in Table 2. Aircraft overflights were identified as the having the serious impact (n=8) and were identified as being the greatest management concern for 59% of the park interviewed. The parks selected for this study had air tour overflight concerns; however, several other noise sources were identified as having a serious or moderate impact on the parks, such as traffic on park roads (n= 10). Motorcycles were singled out from general traffic impacts and were cited by 4 parks as the noise source of greatest concern.

The survey also reflected the diversity of noise sources, even if of slight to moderate concern. Traffic outside the park was identified most often as a noise of slight concern, followed by several sources of noise that were created by park operations (e.g., park construction, park power sources). Interestingly, “rowdy visitors” were mentioned 16 times, once as a serious concern.Other noise sources cited as being the greatest management concern to parks include park construction operations, snowmobiles, ATVs or ORVs, campground generators, park maintenance activities, and logging outside the park.

The types of overflights the parks experience and type of greatest management concern are included in Table 3. Air tour overflights were identified by 46.2% of the parks interviewed as being the overflight type of the greatest negative impact. High-elevation commercial overflights were cited by 25% of the parks. Voorhees and Krey’s (1999) results for overflight impacts park service-wide, military (26.1%) and general aviation (21.5%) were cited most often as moderate or major concern (Table 3).

Resource managers were also asked about different management strategies that their parks used for soundscapes. All but four of the parks included in the study (n=13) had acoustic studies completed or were conducting long-term acoustic monitoring. The four parks that had no acoustic data mentioned that they would like soundscape and acoustic data for their parks. As one manager stated, “It’s really hard to talk about soundscapes without baseline data.” Reflecting the diversity of parks and noise impacts, there are a variety of measures that parks are using to protect soundscapes and other park resources. Three of the parks mentioned using shuttle bus systems to decrease traffic noise. One resource manager stated, “Before the shuttle bus system, it was basically a constant drone of cars.” Other management strategies focused on park planning efforts, such as working on a soundscape management backcountry or wilderness management, and winter-use planning. Other strategies included enforcing designated campground quiet hours, conducting maintenance and construction activities during low visitor-use, and providing visitor education about park soundscapes.

Management strategies for overflights were varied as well. Parks in this study were selected from a stratified sample of parks prioritized for an ATMP or parks with moderate to major air tour overflight concerns. One park was in the plan development

phase and 4 parks had acoustic monitoring conducted in anticipation of beginning the process. National parks in Alaska are exempt from NPATMA. One Alaskan park in this study had created a working group of air tour over overflight stakeholders to collaboratively develop a management plan for the park. Some parks utilize an administrative decision-making process for park use of aircraft. Some parks kept logs of overflights and tried to record aircraft that were flying low. Management of aircraft overflights in more sensitive settings for both visitors and wildlife were highlighted as an important issue facing parks. As one manager stated, “the greatest impact is the intrusion into the otherwise relatively quiet wilderness experience."

5 DISCUSSION

5.1 NPS Case Study Discussion Points

The study findings in this paper contribute to the understanding of the complexity of soundscape management. . Much of the research on noise impacts and resulting policy has focused on aircraft. As this study clearly identifies that managing air tours and other types of aircraft overflights is still a salient issue for park natural resource managers. However, the parks face many other noise impacts besides aircraft. The variety of noise sources mentioned as impacting park soundscapes and other resources demonstrates diverse nature of parks. These findings also point to the growing awareness of park managers for the importance of managing soundscapes for park visitors, wildlife and other resources. Managers want to have acoustic monitoring data to understand their park soundscapes and impacts.

Acoustic monitoring data alone will not be enough to guide park management actions. Visitor perception studies, wildlife impact research, and a shared understanding of what constitutes acceptable sound within the park are needed. Soundscape management is made even more complex by the number of stakeholders involved. The NPS is required to work cooperatively with the FAA to develop air tour management plans, but is also mandated to incorporate public input. In order to account for key stakeholder interests, the two agencies created a collaborative working group. Developing ways to improve this collaborative process will aid with future air tour management planning. Alaskan parks are excluded from the air tour legislation, but are working on collaborative alternatives will be interesting cases to follow, as well.

Some respondents indicated that there were soundscape education programs at the park. Providing educational information to park visitors and the various types of recreationist in parks will begin to create a shared dialogue among these stakeholders. NPS manages resource for this and future generations. Soundscape education can be promoted in parks to build awareness of this unique resource so can be experienced by all.

5.2 Soundscapes as a CPR

We use the term common pool resource (CPR) defined by Ostrom (1990) as a resource that is (1) used by multiple users, (2) where the use of the resource by one user results

in subtractability of use or benefit to other users and (3) the exclusion of users is difficult and costly. CPRs can be differentiated from other types of resources based on the difficulty of exclusion and level of subtractability of use (see Table 1). CPRs unlike pure public goods are subject to subtractability of use that can result in overuse, degradation, congestion and destruction of the resource system (Ostrom et al. 1999). Also, unlike private goods characteristics of CPRs make excluding beneficiaries from the resource difficult. Recognizing these characteristics of resources allows researchers to examine the core theoretical problems in managing them.

Based on these characteristics, soundscapes are best classified as CPRs. They have multiple users and the two other defining characteristics: high difficulty of exclusion and high subtractability of use. A soundscape lacks clearly defined boundaries and can be a sufficiently large area making the exclusion of those who benefit from using it very difficult. In contrast to pure public goods, soundscapes can be overused and degraded leading to their subtractability of use (Ostrom 1990). As a resource a soundscape has multiple uses and values that often conflict or are incompatible. For instance, noise contributed to the soundscape by one person subtracts from the availability and enjoyment of natural sounds or quiet for another person.

Soundscapes have been recognized as CPRs other researchers. Hardin (1968) addresses the issue of noise pollution of open access soundscapes in his article stating, “There is almost no restriction on the propagation of sound waves in the public medium. The shopping public is assaulted with mindless music, without its consent. Our government is paying out billions of dollars to create supersonic transport which will disturb 50,000 people for every one person whisked from coast to coast 3 hours faster” (p. 1248). The soundscape has been compared to other open access CPRs, such as oceans and the atmosphere, where pollution added to the system degrades the resource for others (Karlsson 2000). The noise pollution added to the soundscape limits the availability of healthy soundscapes and the flow of benefits for other users to access (Franklin 2000).

The characteristics of CPRs lead to many challenges; two of the primary challenges identified are appropriate allocations of use and limiting access (Ostrom et al. 1999). Hardin (1968) describes the inevitable “tragedy” that results in the case of an open-access grazing CPR. He claims that rational herdsmen are compelled to maximize their benefits without regard to the carrying capacity of the CPR resulting in “ruin to all” (Hardin 1968, p. 1244). In this setting without rules or incentives to graze sustainably the herdsmen followed their own rational short-term interests. In a CPR system this can result in free-riding, or using the resource without concern for future outcome and rent dissipation (Ostrom et al. 1999). User incentives to free-ride result in increasing use and decreased sustainability of the CPR. The difficulty of excluding users who could benefit from the CPR leads to additional pressures on resource carrying capacity. Ostrom (1990) argues that there needs to be agreement between individual incentives and the collective interest in the sustainability of resource systems. For soundscapes these challenges of allocating use, limiting access and aligning incentives are relevant management issues.

5.3 Applying CPR Theory to Soundscape Management

Three major proposals have been developed to address CPR management: privatization (Demsetz 1967), government regulation or command-and-control (Hardin 1968), and institutions for collective action (Ostrom 1990). Privatizing CPRs would result in the division of rights to access and control the resource. Privatization is seen as a solution to better internalize the benefits and costs of individual actions (Demsetz 1967). Hardin (1968) argues for government control of CPRs stating that individuals need external incentive to prohibit resource degradation and depletion. In contrast to these two previous proposals, Ostrom (1990) proposes the third management option of collective action institutions. Privatization and government control assume the rational actions of resource users and, therefore, the eventual ruin of the resource system. Ostrom (1990) argues that collective action institutions can be developed to manage CPRs sustainably. These institutions are created by the users collectively developing a set of rules and norms for using the CPR (Ostrom 1990). Many different variants of these three proposals are applied currently to CPRs (Dolsak and Ostrom 2003).

In the U.S., government regulation was the first approach used to manage noise. Motorized and other human-generated sounds are a negative externality of growing populations, transportation systems and poor planning. Coase (1960) argued that noise or other externalities could be considered a producer's right stating, "The cost of exercising a right (of using a factor of production) is always the loss which is suffered elsewhere in consequence of the exercise of that right-the inability to cross land, to park a car, to build a house, to enjoy a view, *to have peace and quiet*, or to breathe clean air" (p. 22-23, emphasis added). To change this inequitable burden of noise pollution cost, the U.S. government passed the Noise Control Act in 1972 (NCA). The U.S. Environmental Protection Agency was responsible for propagating regulations promote "an environment for all Americans free from noise that jeopardizes their health or welfare" (NCA 1972).

The noise pollution achievements made by the EPA ended less than 10 years later. In 1981 the Reagan Administration stopped funding the Office of Noise Abatement and Control ending the EPA's ability to enforce NCA. Although the policy was not withdrawn, funding has never been reinstated and no new national noise policy has replaced it. Despite the efforts made in the 1970's, "not a single federal emission regulation promulgated by the EPA in a major source of noise remains operative today" (Beranek and Lang 2003, p. 125). Prior to the termination of funding, the EPA faced several challenges in implementing NCA. Researchers have speculated on the reasons for this noise policy failure including lack of clearly defined implementation mechanisms and the confrontational approach to working with industries (Finegold et al. 2002). The command and control approach to natural resource management is a seemingly straightforward solution. However, this approach is best applied to resource problems that are simple and well-defined (Holling and Meffe 1996), and soundscape conservation is neither (schafer 1994; Miller 2008).

Typical CPRs often are thought of as a resource with one predominant use and one type of property right associated with it, such as a forest or grazing pasture. However,

Steins and Edwards (1999) identify the existence of complex, multiple-use CPR systems and define them as “resources that are used for different types of extractive and non-extractive purposes by different stakeholder groups and are managed under a mixture of property right regimes” (p. 242). Soundscapes fit this category well being complex resources with multiple-uses. Ostrom (2007) further elaborated on resources that are part of complex socio-ecological systems by developing a framework to assess interactions and outcomes. This diagnostic framework can be applied to soundscape management using the NPS case (Figure 1). As the framework demonstrates, the governance section is only one group of variables that could affect behaviors of the multiple actors involved in the system. The framework allows the researcher to consider the complexity of the system and understand which interactions influence the outcomes.

Soundscape complexity presents many additional challenges to developing sustainable governance systems. The following issues need to be addressed in the institutional design.

-*Scale of soundscape impacts is diverse*. Soundscapes are highly variable in space, time and composition (Pijanowski et al. in review). Spatial variability arises from the heterogeneity of sound sources; roads (anthrophony), rivers (geophony) and vocalizing animals (biophony) are located across a landscape in a complex spatial arrangement. Sounds are emitted at different times of the day (e.g., birds sing most intensely during the dawn chorus and during the spring when they breed) and with variable intensities (e.g., cars on a highway produce sounds that vary in amplitude depending upon speed) and thus give rise to complex temporal patterns. Human activities that produce sound are highly variable on a temporal scale as well. Studies by Gage and Krause (in review) at the Sequoia National Park showed that airplane overflights occurred in remote areas of the park on average of 6 times per hour. Thousands of commercial overflight occur each day (Miller 2008). The pattern of recreational vehicles in National Parks depends on the season, time of day, and route.

Soundscape composition is also highly variable in important ways. Some soundscapes can be very unique – for example, the trumpeting of elephants at a salt marsh surrounded by rock outcrops in the Congo is unique as their bellows echo throughout a canyon. Other soundscapes may be very sensitive to noise and thus require protection; chorusing of rare frogs could be severely impacted by noise if it occurs during critical breeding times.

Visitors to the parks can experience highly variable natural sounds as well. Hiking in the national parks may mean that a visitor experiences rushing water from a stream flowing through a canyon at one location, the unique sounds of a geyser at another, or the cacophony of many vocal organisms, like amphibians, insects and birds, emanating from a swamp encountered during the outing.

- *Clear recognition of user rights.* Common-pool theory was developed to analyze how open access and subtractability affect resources, such as aquifers, forests and fisheries. The lack of agreement between individual incentives and collective interests results in

crowding, rent dissipation, and often resource depletion (Ostrom 1990). Schlager and Ostrom (1992) posit that the type of property rights a person holds influences the incentives, actions, and resource outcomes. Schlager and Ostrom (1992) separated property rights into different bundles of rights identifying 5 different types: access, withdrawal, management, exclusion, and alienation (Table 4). The rights described here are validated by rules recognized by law (de jure) or by resource user norms (de facto) (Schlager and Ostrom 1992). For the most part these property rights bundles can be applied to soundscapes with the exception of the "owner" property right type. The normative right of all to access quality soundscapes or experience park soundscapes is the right that needs to be recognized.

-*Noise producers do not realize subtractability exists*. We are only now beginning to understand the extent to which noise or anthrophony impacts animal communication (see Warren et al. 2006 for an excellent summary of urban bioacoustics and Barber et al. 2009 for an excellent review of impacts of noise on animal communication and wildlife physiology). Other factors related to subtractability, such as how soundscapes provide a sense of place and how humans related to nature through auditory senses, is still research in its infancy. Human produced sounds also travel underground potentially impacting subterranean activities of burrowing animals and sounds in oceans, rivers and lakes are known to negatively impact aquatic animals. Subtractability exists when others attempt to enjoy natural soundscapes which are then corrupted by the introduction of noise. Noise is also a very common by-product of most human activities. Vehicles produce a variety of noises (road noise, engine noise, honk of a horn); planes are now frequent and ubiquitous. The human need for quiet is also recognized as an individual right in a normative sense. The loss of soundscape quality- but linked to other carrying capacity issues that will affect them.

5.4 Challenges Facing US NPS Soundscape Conservation Efforts

Subsequent to the" government control approach" to managing CPRs, the NPS has supported and created many policies to protect park soundscapes, such as the Air Tour Management Act of 2000 and the NPS Policies of 2006. The NPS is attempting to regulate the negative externalities of noise on park resources and visitor experiences. Approaching the soundscape protection using the government regulation approach has, thus far, not been an effective or timely solution. The Air Tour Management Act has failed to produce a single management plan for a park and the winter use plans for snowmobiling in Yellowstone are a constant controversy (Tranel and Hall 2003). Park regulation of soundscapes has resulted in gridlock, litigation, lobbying (Layzer 2000).

However in addition to the aircraft regulations, NPS has established the Natural Sounds Program that assists parks with acoustic monitoring and soundscape plan development. The Program works with Department of Defense on military overflight impacts, too. The establishment of the Natural Sounds Program is improving the NPS knowledge base about soundscapes and management issues institutionalizing the concept of soundscapes. It also reflects a unique agency bridge in addressing a park system-wide issue at the park unit scale. NPS addressed the complexity of the resource issue with more complex institutions to govern soundscape management.

NPS approach to soundscape management has endured as long as NCA, but unlike the national policy, it shows strong signs of persisting. Soundscape management by NPS serves as a unique case to study the successes and shortcomings. Soundscape management may vary in different park units due to the differences in park unit types, noise issues facing different parks, and the mix of collective-choice and legislative regulation. The lessons learned from NPS soundscape management also may be applicable outside the park system. For instance, other national federal land management agencies could apply soundscape conservation measures in national forests and fish and wildlife refuges.

5.5 A Way Forward

Using the CPR model, it can be recognized that the soundscape has a flow of benefits to many resource users: natural sounds, ecosystem function, cultural and historical heritage, silence or natural quiet, ability to communicate with one another and even creating a sense of place (Krause 1987; Schafer 1994; Dumyahn and Pijanowski, in review). So rather than viewing motorized recreation noise as only a negative externality to be regulated, we pose the normative argument that the right to a quality soundscape is a right belonging to all. The national parks hold in trust the resources for this and future generations. It is a right of the park visitors and more broadly the general public to access and experience these soundscapes. In order to create a setting where these norms are recognized, the battling recreationists could develop a new institutional arrangement. Following Ostrom (1990), another approach to managing park soundscapes is to develop collective action institutions where the norms of all park users are recognized and respected. As Sagoff (2004) deliberation and collaboration is needed to learn and understand the multiple “ethical views of the same landscape” (p. 184). As many have also identified, it is possible, and a reality that individuals can organize and sustainably manage CPRs (Ostrom 1990; Ostrom et al. 1999).

NPS has initiated several policies and actions to address soundscape management. They have also created a dialogue of soundscape conservation that extends beyond the parks. Beginning with air tour overflight management and now spreading to park unit soundscape management plans the NPS is converging on a vision of soundscape quality in parks. The NPS Natural Sounds Program serves as a national scale communicator working with Department of Interior and helping individual parks. Individual park units are addressing noise issues in a variety of manners as glimpsed at from this study. The process from here should be one of continued development of institutional dialogue on park soundscapes at the national, regional, and park unit scales. NPS should then present the vision of soundscape quality in parks to stakeholders. Communication between these otherwise non-communicating interests facilitates the means to reach the NPS mandated environmental quality. This discourse will improve the understanding of quality soundscapes as a right of all and will pave a way to establishing soundscape norms within parks.

6 ACKNOWLEDGEMENTS

We thank the National Park Service natural resource managers who agreed to participate in this study. We also thank the NPS Natural Sounds Program staff who provided additional insight on air tour and soundscape management service-wide. This program of research was funded by Purdue University's Department of Forestry and Natural Resources partially by an U.S. EPA STAR Fellowship to SLD. This paper has not been formally reviewed by the EPA and solely reflects those of the authors'. The EPA does not endorse any products or services that were mentioned in this paper. Survey was approved by the Purdue IRB #0704005210.

7 LITERATURE CITED

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2009. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology and Evolution:180-189.

Beranek, L. L., and W. W. Lang. 2003. America Needs a New National Noise Policy. Noise Control Engineering Journal 51(3):123-130.

Berglund, B., and T. Lindvall. 1995. Community Noise. Stockholm: World Health Organization.

Blomberg, L., P. Schomer, and E. Wood. 2003. The interest of the general public in a national noise policy Noise Control Engineering Journal 51(3):172-175.

Carles, J. L., I. L. Barrio, and J. V. deLucio. 1999. Sound Influence on Landscape Values. Landscape and Urban Planning 42:191-200.

Chapin, F. S. I., E. S. Zavaleta, T. V. Eviner, R. L. Naylor, P. M. Vitousek, H. L. Reynolds, D. U. Hooper, S. Lavorel, O. E. Sala, S. E. Hobbie, M. C. Mack, and S. Diaz. 2000. Consequences of Changing Biodiversity. Nature 405:234-242.

Coase, R. H. 1960. The Problem of Social Cost. Journal of Law and Economics 3(1):1-44.

Demsetz, H. 1967. Toward a Theory of Property Rights. The American Economic Review 57(2):347-359.

Dolsak, N., and E. Ostrom. 2003. The Commons in the New Millenium: Challenges and Adaptions. Cambridge, MA: The MIT Press.

Evans, G. W., S. Hygge, and M. Bullinger. 1995. Chronic Noise and Psychological Stress. Psychological Science 6(6):333-338.

Finegold, L. S., M. S. Finegold, and G. C. Maling. 2002. Previous Attempts to Develop, Implement and Enforce a U.S. National Noise Policy. Paper read at International Congress and Exposition on Noise Control Engineering at Dearborn, MI.

Fisher, J. A. 1998. What the hills are alive with: In defense of the sounds of nature The Journal of Aesthetics and Art Criticism 56(2):167-179.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, F. S. Chapin, M. T. Coe, G. C. Daily, H. K. Gibbs, J. H. Helkowski, T. Holloway, E. A. Howard, C. J. Kucharik, C. Monfreda, J. A. Patz, I. C. Prentice, N. Ramankutty, and P. K. Snyder. 2005. Global Consequences of Land Use. Science 309(5734):570-574.

Haberl, H., K. H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, S. Gingrich, W. Lucht, and M. Fischer-Kowalski. 2007. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. Proceedings of the National Academy of Sciences 104(31):12942-12947.

Hardin, G. 1968. Tragedy of the commons. Science 162:1243-1248.

Holling, C. S., and G. K. Meffe. 1996. Command and Control and the Pathology of Natural Resource Management. Conservation Biology 10(2):328-337.

Karlsson, H. 2000. The Acoustic Environment as a Public Domain. Soundscape: The Journal of Acoustic Ecology 1(2):10-13.

Krause, B. 1987. Bioacoustics, Habitat Ambience in Ecological Balance. Whole Earth Review 57.

———. 2002. Wild Soundscapes: Discovering the Voice of Our Natural World. Berkeley, CA: Wilderness Press.

Layzer, J. A. 2006. The Environmental Case: Translating Values Into Policy. 2 edn. Washington, D.C.: CQ Press.

Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Synthesis*. Washington, D.C.: Island Press.

Miller, N. P. 2008. U.S. national parks and management of park soundscapes: A review. Applied Acoustics 69:77-92.

National Parks Air Tour Management Act of 2000. P.L.106-81.

National Park Service. 1995. Report on the Effects of Aircraft Overflights on the National Park System, edited by D. o. Interior. Denver, CO.

———. 2000. Director's Order No. 47: Soundscape Preservation and Noise Management, edited by D. o. Interior. Washington, D.C.: National Park Service.

———. 2006. Management Policies 2006, edited by D. o. Interior. Washington, D.C.: National Park Service.

(NCA 72) Noise Pollution and Abatement Act of 1972. P.L. 92-574.

O'Connor, P. 2008. The sound of silence: Valuing acoustics in heritage conservation. Geographical Research 46(3):361-373.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. New York, NY: Cambridge University Press.

———. 2007. A diagnostic approach for going beyond panaceas. Proceedings of the National Academy of Sciences 104(39):15181-15187.

Ostrom, E., J. Burger, C. B. Field, R. B. Norgaard, and D. Policansky. 1999. Revisiting the Commons: Local Lessons, Global Challenges. Science 284(5412):278-282.

Pijanowski, B. C., A. Farina, S. Gage, and S. L. Dumyahn. In Review. What Is Soundscape Ecology? . Landscape Ecology.

Pijanowski, B. C., L. J. Villanueva-Rivera, S. L. Dumyahn, A. Farina, B. Krause, B. M. Napoletano, S. H. Gage, and N. Pieretti. In Press. Soundscape Ecology: The Science of Sound in the Landscape. BioScience.

Sagoff, M. 2004. Price, Principle, and the Environment. Cambridge, UK: Cambridge University Press.

Schafer, R. M. 1994. The Soundscape: Our Sonic Environment and the Tuning of the World. Rochester, VT: Destiny Books.

Schlager, E. and E. Ostrom. 1992. Property rights regimes and natural resources: A conceptual analysis. Land Economics 68(3): 249-262.

Stansfeld, S., and M. P. Matheson. 2003. Noise pollution: non-auditory effects on health. British Medical Bulletin 68:243-257.

Steins, N. A., and V. M. Edwards. 1999. Platforms for Collective Action in Multiple-Use Common-Pool Resources. Agriculture and Human Values 16:241-255.

Tranel, M. J., and A. Hall. 2003. Parks as Battlegrounds: Managing Conflicting Values. In The Full Value of Parks: From Economics to the Intangible, ed. D. Harmon and A. D. Putney. Lanham, MD: Rowman and Littlefield Publishers, Inc.

Truax, B. 1999. Handbook of Acoustic Ecology. 2nd edn. Vol. CD rom version. British Columbia, Canada: Cambridge Street Publishers.

Voorhees, P. H., and L. Krey. 1999. Prevalence and Severity of Overflights on U.S. National Parks: Results of the 1998 Survey of National Park Superintendents. Noise Control Engineering Journal 47(3):107-111.

Wengraf, T. 2001. Qualitative Research Interviewing: Biographic Narrative and Semi-structured Methods. Thousand Oaks, CA: Sage Publications.

Wrightson, K. 2000. An Introduction to Acoustic Ecology. Soundscape: The Journal of Acoustic Ecology 1(1):10-13.

Table 1. Classification of resource types based on attributes of subtractability and exclusion (Adopted from Ostrom 1990).

	Low Subtractability	High Subtractability
Low Difficulty of Exclusion	Club or toll goods	Private goods
High Difficulty of Exclusion	Pure public goods (e.g. knowledge)	Common-pool resources (e.g. fisheries, livestock grazing areas, and soundscapes)

Table 2. Number of parks reporting specific noise source impacts to park soundscapes and the source of greatest management concern.

	Number of Parks Reporting			
Type of Noise	**Slight**	**Moderate**	**Serious**	**Greatest Mgt Concern**
Aircraft overflights	4	5	8	10
Traffic on park roads	7	6	4	1
Park construction operations	10	4	2	1
Snowmobiles	2	1	2	1
ATVs or ORVs	8	1	1	1
Motorboats or watercraft	5	4	3	
Park power sources (generators)	11		1	
Industry outside park	5	2		
Traffic outside of park	12	1		
Trains	4			
Rowdy visitors	10	5	1	
Vehicle radios	6	1	1	
People talking	7	2		
Pets	9			
Horses or mules	1			
Park Specified Noise Sources				
Motorcycles			4	4
Campground generators	2	2		1
Maintenance (mowing, leafblower)	3		1	1
Chainsaws	4		1	
Park gravel pit	1			
Snowplowing equipment	2		1	
Naval base noise	1			
Car related noise- parking areas	1			
Trail rides safety message	1			
Park sewage treatment plant		1		
Logging operations		1		1

Table 3. Overflight impacts by time compared with results from Voorhees and Krey (1999).

Overflight Types that Parks Experience	**Number Of Parks**	**Greatest Negative Impact**	**Moderate-Major Concern** Voorhees and Krey (1999)
Commercial Air Tours	13	46.2%	16.90%
High-elevation Commercial	16	25.0%	8.50%
Military	16	18.8%	26.10%
General Aviation	16	18.8%	21.50%
Park Management	14	12.5%	7.70%
Emergency Services	16	0.0%	N/A
Other Agencies (state or federal)	12	0.0%	N/A

Table 4. Property rights with soundscape applications (adapted from Schlager and Ostrom 1992).

Property Right and (Right holder) Types	**Definition**	**Soundscape Application Examples**
Access (Authorized user)	Right to enter a defined area and enjoy nonsubtractive benefits	Listen to natural sounds in a park, hear the sounds of a busy city
Withdrawal (Authorized user)	Right to use resource units or products	Add sounds or noise to the soundscape: talking, playing a radio, or using motorized transportation
Management (Claimant)	Right to regulate internal use patterns and transform the resource by making improvements or changes	Limiting decibel levels in communities, not permitting building construction after a certain time, diverting road traffic away from green spaces
Exclusion (Proprietor)	Right to determine who will have access and withdrawal rights and how those rights can be transferred	Not permitting motorized vehicles in wilderness areas, limiting number of snowmobiles in national parks, expanding an airport
Alienation (Owner)	Right to sell or lease management and/or exclusion rights	Is it applicable for soundscapes?

Figure 1. A multitier institutional framework for analyzing natural soundscape issues in U.S. National Parks (after Ostrom 2007).