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Research Paper

Noise pollution in national parks: Soundscape and economic valuation

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HIGHLIGHTS

- Soundscape-assessment methods and economic valuation were merged in a national park.
- Outdoor anthropogenic noises degrade the park soundscapes.
- Visitors refer to annoyance by human-made noises.
- Visitors are willing to pay for the noise reduction.

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ABSTRACT

In this study a national park soundscape characterisation was contrasted with an economic estimation of the impact of noise pollution on the park visitors' perception. The main noise sources were identified and the noise-pollution levels were assessed along a pathway that is highly frequented by hikers in a natural park in the mountains of central Spain. The results showed noticeable soundscape degradation during the visitors' leisure experience (sound pressure levels increased approximately 4.5 dB from natural ambient levels). Visitors' voices and conversations were as great of a nuisance to themselves as were aircraft overflights and road traffic. Using the contingent valuation method, the willingness to pay for the financing of a programme aimed at mitigating noise in the park was estimated. The results showed that visitors would be willing to pay an entrance fee of approximately 1 euro if this noise-reduction programme were to be implemented in the park.

1. Introduction

Protected-areas management encompasses diverse aspects in the ways it relates to, for instance, nature conservation and the management of tourism and the public use of places that are supposedly unaltered or slightly altered by humans (Arnberger, Eder, Allex, Sterl, & Burns, 2012; Juutinen et al., 2011). The natural and cultural heritages of a territory compose two of the multi-dimensions of the landscape, as referred by the European Landscape Convection (Council of Europe, 2000). Although most landscape studies are based on visual information, the combination of visual experience with the acoustic environment enhances people's perception and their understanding of nature (Matsinos et al., 2008). Sounds emanate from landscapes and reflect ecosystem processes and human activities over space and time (Krause, Gage, & Joo, 2011; Pijanowski, Farina, Gage, Dumyahn, & Krause, 2011; Raimbault & Dubois, 2005). This collection of sounds makes up the 'soundscape', a term that was first defined by Schafer (1977), the acoustic footprint of a landscape (Farina, Pieretti, & Piccioli, 2011). More than a concept, the soundscape is presently also considered an emerging discipline with alternative foci (Brown, Kang, & Gjestland, 2011; Pijanowski, Farina, et al., 2011; Pijanowski, Villanueva-Rivera, et al., 2011; Slabbekoorn & Bouton, 2008). Under this concept, acoustic environments are studied and their threats are assessed to ensure the maintenance of soundscape structure or functions through quality management (NPS, 2006).

The acoustic environment plays a key role as a component of a positive visitor experience in recreational areas. Some researchers and natural resource agencies have begun to recognise soundscape as a resource worth protecting (Dumyahn & Pijanowski, 2011). Unwanted or disturbing sounds (noise) may not only be

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a harmful pollutant to human health as defined by the World Health Organization (WHO) and European Centre for Environment and Health (2011) but may also become a global and growing matter of concern threatening the preservation of natural areas (Lynch, Joyce, & Fristrup, 2011) because of wildlife disturbance, ecosystems degradation, biodiversity loss, etc. (Barber, Crooks, & Fristrup, 2010; Barber et al., 2011; Dumyahn & Pijanowski, 2011; Francis, Ortega, & Cruz, 2009; Francis, Kleist, Ortega, & Cruz, 2012). This degradation could have negative consequences on ecosystems functioning and ecosystems provision of services linked to human well-being (Balvanera et al., 2006). The impacts of ecotourism tend to concentrate in areas of highest natural value (Manning et al., 2004) and tourism activities often cause noise pollution (Zhong, Deng, Song, & Ding, 2011). Therefore, these impacts are becoming an interesting research theme of conflict between recreation and preservation goals in protected areas (Benfield, Bell, Troup, & Soderstrom, 2010; Leung, 2008). In any case, there is a conceptual linkage between tranquillity, environmental quality, and human health that has been correlated with landscape structure (Votsi, Mazaris, Kallimanis, Drakou, & Pantis, 2013) and nature as a provider of restorative experiences for people's well-being (Gidlöf-Gunnarsson & Öhrström, 2007).

The absence of anthropogenic noise has been valued positively when people visit protected areas (Beal, 1994; Carles, Barrio, & De Lucio, 1999; Cessford, 1999; Saxen, 2008). Starting from the hypothesis that anthropogenic noise degrades landscape quality, whereas natural noise does not, Benfield et al. (2010) analysed the impact of different noise sources in several national parks in the U.S.A. Also, Lynch et al. (2011) analysed noise sources in 43 U.S.A. national parks using different metrics, and Miller (2008) contributed to the discussion of the determination of criteria used to make decisions for national parks soundscape management. Additional research to measure and assess human impacts on soundscapes is needed and recommended (Krog & Engdahl, 2004; Mace, Corser, Zitting, & Denison, 2013; Pijanowski, Villanueva-Rivera, et al., 2011). Moreover, undesired human-made sounds may reduce recreationist welfare or detract from having a quality experience in the wilderness (Barber et al., 2011; Brown, Reed, Dietz, & Fristrup, 2013; Mace, Bell, & Loomis, 1999; Mace et al., 2013; Pilcher, Newman, & Manning, 2009). The study of soundscapes is a complex task, and no single method is able to completely study the complexity of soundscapes or receivers' response to noise (Brown et al., 2011; Job & Hatfield, 2001; Kariel, 1990; Mace et al., 2013); spectrograms or single metrics from SLM data logged alone are not enough (Barber et al., 2011; Lynch et al., 2011). Diverse fields of practice, techniques and methodological approaches have been proposed (Davies et al., 2013; Farina & Pieretti, 2012; Farina et al., 2011; Lynch et al., 2011; Matsinos et al., 2008; Raimbault, Lavandier, & Bérengierc, 2003) bearing also in mind land spatial patterns or working-scale considerations (Iglesias Merchan & Diaz-Balteiro, 2013; Votsi, Drakou, Mazaris, Kallimanis, & Pantis, 2012).

Nevertheless the implementation of noise-mitigation measures for soundscape management may be restricted by social-economic factors (Arenas, 2008) demanding the complementing environmental studies dealing with economic assessment of visitors' welfare. Some authors have modelled the monetary impact of noise on urban ecosystems (Barreiro, Sanchez, & Viladrich-Grau, 2005; Bjørner, 2004; Dekkers & Van der Straaten, 2009; Fosgerau & Bjørner, 2006; Xie, Liu, & Chen, 2011), but we do not know of similar studies in national parks. Among the possible methods to assess the benefits that could be obtained from noise reduction are those based on stated preferences (Matos, Flindell, Le Masurier, & Pownall, 2013), such as the Contingent Valuation method (CVM).

The main objective of this work is to evaluate the soundscape in a protected natural area and assess the visitors' willingness to pay for a noise-mitigation programme after their own visiting experience. Four hypotheses have been defined in this study:

H1. Anthropogenic noise exists in the park. Our initial hypothesis was that anthropogenic noise exists in the park. We proceeded to characterise the acoustical conditions in two ways (Lynch et al., 2011; Miller, 2008): identifying audible sounds (audibility) and assessing noises intrusion with dB readers (sound energy).

H2. Visitors are able to identify noise sources. While taking measurements, we identified a set of anthropic sources, which does not necessarily mean that all of the sources act simultaneously or that visitors were able to perceive and identify them. We have no common hypothesis for the sources of all of these anthropogenic noises, but our hypothesis is that visitors perceive and are able to identify noise sources measured in the soundscape characterisation. This hypothesis was tested using an acoustic-experience survey of park visitors.

H3. Noise negatively impacts visitor experience. The initial hypothesis is that the noise prevents full satisfaction of the park experience, as demonstrated in several studies (Mace et al., 2013). This hypothesis was tested using a visitor survey conducted in the park.

H4. Visitors are willing to pay money to combat noise pollution. Previous experiences in transport economics invite us to predict that visitors would be willing to accept a required payment to combat noise annoyance (Fyhri & Klæboe, 2006; Lera-López, Faulin, & Sánchez, 2012; Navrud, 2002; Östberg, Hasselström, & Håkansson, 2012). Like the previous hypothesis, this hypothesis was tested using the visitor survey.

2. Methods

2.1. The study area

The study was conducted in Peñalara Natural Park (PNP) and its Socioeconomic Influence Area (SIA) that covers almost 15,000 ha under park authorities' management, which are located in the Lozoya valley (Spain). It is part of the recently declared Sierra of Guadarrama National Park. The SIA is crossed by the M-604 road, a 60 km/h limited-speed regional road that has an annual average daily traffic (AADT) of approximately 850 vehicles (more than 2000 in the summer holidays). Aircraft flyover occurs randomly and is unpredictable because it depends on weather conditions at Madrid-Barajas international airport (located at 55 km to the southeast), which determine changes in taking off or approaching operations and routes.

The study area comprises a 2.6 km hiking trail called The Water Pathway (TWP). This trail is a hikers' "there and back" route, supposed to be completed in only 2 or 2.5 h (Fig. 1), that is used by approximately 70,000 people per year (20,000 on weekdays and 50,000 on the weekends) according to data provided by the park managers'. The more demanded recreational activity is to hike along TWP. It ranges from an easy hike through a Scots pine forest that starts at the park visitors' centre (1850 m in altitude) with the goal of resting by the glacier lagoon of Peñalara (2020 m). TWP Fewer visitors are able to continue climbing to the mountain peak of the same name (2428 m).

2.2. Soundscape evaluation

Fieldwork was conducted on different dates from August 2011 to February 2012. The first monitoring station (MS-1) was located close to TWP, and a second (MS-2) was situated by the lagoon (Fig. 1). These two locations were selected to summarise the two extremes of the most common visitor experiences based on