Society & Natural Resources

An International Journal

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/usnr20

Toward Healthier Parks and People through Integrated Soundscape Research: Applying the International Organization for Standardization Acoustic Environment Taxonomy across Contexts

Trace Gale, Andrea Ednie & Karen Beektink

To cite this article: Trace Gale, Andrea Ednie & Karen Beektink (2022): Toward Healthier Parks and People through Integrated Soundscape Research: Applying the International Organization for Standardization Acoustic Environment Taxonomy across Contexts, Society & Natural Resources, DOI: 10.1080/08941920.2022.2085350

To link to this article: https://doi.org/10.1080/08941920.2022.2085350

Published online: 09 Jun 2022.

SOCIETY & NATURAL RESOURCES
https://doi.org/10.1080/08941920.2022.2085350

Toward Healthier Parks and People through Integrated Soundscape Research: Applying the International Organization for Standardization Acoustic Environment Taxonomy across Contexts

Trace Gale[a,b], Andrea Ednie[c], and Karen Beektink[d]

[a]Centro de Investigación en Ecosistemas de la Patagonia, Center for Patagonia Ecosystem Investigation (CIEP), Aysén Region, Chile; [b]Centro Internacional Cabo de Hornos, Cape Horn International Center for Global Change Studies and Biocultural Conservation (CHIC), Puerto Williams, Magallanes Region, Chile; [c]University of Wisconsin-Whitewater, Department of Kinesiology, Whitewater, WI, USA; [d]University of Maine at Machias, Professional Studies Department - Recreation and Tourism Management program, Machias, ME, USA

ABSTRACT
This work addresses the call for integrative approaches to soundscape research that facilitate interdisciplinary advances, through enhancements to the 2018 International Organization for Standardization *"Taxonomy of the Acoustic Environment for Soundscape Studies"*, included in ISO12913-2 for soundscape data collection and reporting. Specifically, it strengthens natural sound sources and type considerations, enabling integrated approaches across urban and natural contexts. Building on the premise that what people experience in one context (e.g., home; work), they bring into other contexts [e.g., protected areas (PA)], two-phased survey research contrasted Chilean PA visitors' perceptions of Coyhaique National Reserve acoustic environments with prevalent sounds at home and work ($n = 333$). The paper's proposed taxonomy enhancements may enable integration of PA perceptual soundscape research with research from other disciplines/contexts, facilitating better understanding of visitor perceptions that can lead to better informed soundscapes programming and monitoring, and improved Healthy Park, Healthy People outcomes.

ARTICLE HISTORY
Received 8 March 2021
Accepted 29 May 2022

KEYWORDS
Aysén, Chile; Healthy Park, Healthy People (HPHP); interdisciplinary research; protected areas; ISO/TS 12913-2; soundscape; taxonomy

Introduction

The global Healthy Parks Healthy People (HPHP) movement emphasizes the importance of reconnecting people living in urban environments with nature through integrative practices that strengthen their health and wellbeing, and their support for parks, protected areas (PAs), and the ecosystems they protect (Franco, Shanahan, and Fuller 2017; Taff et al. 2019). PA soundscape research has validated that healthy natural soundscapes can contribute to the HPHP dynamic. They shape visitor perceptions of landscapes, attitudes toward soundscape management, and contribute to the human-

CONTACT Trace Gale tracegale@ciep.cl Centro de Investigación en Ecosistemas de la Patagonia, Center for Patagonia Ecosystem Investigation (CIEP), Aysén Region, Chile.

nature interplay, meaning both visitors and natural ecosystems benefit when natural soundscapes are conserved (Benfield et al. 2010; Benfield et al. 2014; Ednie et al. 2022; Francis et al. 2017). Nevertheless, we know little about how PA visitors experience sounds and noise outside of the PA context.

Soundscape research that considers visitors' acoustic experiences and perceptions in a range of typical contexts within daily life may help improve HPHP initiatives and extend their benefits. Common sense tells us that people will experience natural sounds much more frequently within parks, and anthropogenic (i.e., human-caused) sounds much more frequently at home and work. However, PA research has just begun to consider visitor perceptions across various contexts, examining how soundscapes are perceived by individuals in different demographic contexts and whether sound attentiveness varies by context (Ednie and Gale 2021; Gale, Ednie, and Beeftink 2021a). Axelsson, Guastavino, and Payne (2019) recognized the need for a more holistic understanding of peoples' acoustic experiences, calling for tools and models that integrate a wider range of soundscape and participant contexts to facilitate better transferability of findings between contexts. The International Organization for Standardization (ISO) (2018) technical specifications (ISO/TS 12913-2 2018) recommended a *Taxonomy of the Acoustic Environment for Soundscape Studies* (ISO/TS taxonomy) for this purpose; but it has not yet been applied within a PA context.

This research builds on existing PA soundscape HPHP research and responds to increasing calls for research integration across acoustic contexts (Axelsson, Guastavino, and Payne 2019; Ednie and Gale 2021; Gale, Ednie, and Beeftink 2021b; Kogan et al. 2017). We explore the sounds and noises that participants remember from a range of their commonly experienced environments to better understand how "nature" manifests through sound within their daily lives. Also, we employ the recently developed ISO/TS taxonomy to evaluate its potential to facilitate better transferability of findings between contexts. We are particularly interested in better understanding where and how PA visitors experience natural sounds across experienced environments, as we believe a richer understanding of this phenomenon can inform future HPHP research and practice, both within and beyond park boundaries. Research questions (RQ) included:

- RQ1: How do sound sources and types manifest within the PA, home, and work contexts?
- RQ2: How does the ISO/TS taxonomy fit as a tool to document the range of sounds representative of a healthy natural soundscape?

Literature Review

HPHP and Healthy Soundscapes

Recent research validates that soundscape environments can contribute to HPHP benefits. For "healthy parks", soundscape research has shown pertinence for monitoring biodiversity (Rajan et al. 2019) and species health (Alvarez-Berríos et al. 2016; Farina et al. 2011; Randler 2006). For example, soundscape research has examined the effects of noise on species behavior (Randler 2006), species richness (Alvarez-Berríos et al. 2016), and habitat modification (Farina et al. 2011). For "healthy people", natural sounds have been found to support physiological, emotional, and cognitive benefits; including stress recovery capacity, stress relief, cognitive attention restoration, and decreased anxiety and agitation (Benfield et al. 2014; Ferraro et al. 2020; Franco, Shanahan, and Fuller 2017). Francis et al. (2017) focused on the interrelation between "healthy parks" and "healthy people", and how soundscapes provide synergistic benefits for both. Their paper posed that, "soundscapes link human experiences and valuation of nature and ecological systems" (Francis et al. 2017, 251), describing that positive natural soundscape experiences improve soundscape appreciation, attitudes, and engagement in pro-environmental behaviors, while degraded natural soundscapes lead to a downward cycle of negative experiences and less support. Some recent studies support this argument. For example, authors have found that natural sounds increase people's connection with nature (Levenhagen et al. 2020), and noise has been found to be a detractor in peoples' PA experiences (Liu et al. 2019; Pilcher, Newman, and Manning 2009; Rice et al. 2020).

Integrating Soundscape Research across Contexts

While most HPHP soundscape research has focused on the PA visitor experience context (Ednie et al. 2022; Ferraro et al. 2020; Miller et al. 2020: Pilcher, Newman, and Manning 2009; Rice et al. 2020), recent research demonstrates the importance of considering peoples' experiences and soundscape perceptions more holistically by integrating their acoustic experiences with other contexts, including home and work (Ednie and Gale 2021; Gale, Ednie, and Beeftink 2021a; Kogan et al. 2017). For example, comparing soundscape perceptions and affect within varied environmental contexts helped Gale, Ednie, and Beeftink (2021a) explain how urban dwellers experience natural sounds within a PA. Their results indicated that urban visitors found respite in PA natural soundscapes, experiencing them as both unfamiliar and eventful (lively, dynamic, and messy), as compared to home and work. Ednie and Gale (2021) identified complacency toward anthrophony in natural settings, perhaps as place connectedness grows. Their research, about the sounds heard within the natural places with which participants felt most connected, found that those who observed more anthropogenic sounds within these areas perceived those anthropogenic sounds as being more acceptable, in comparison to participants with fewer anthropogenic sound observations. Kogan et al. (2017) attributed urban soundscape perceptions to a mix of three converging conceptual realms: (1) acoustic environment; (2) extra-acoustic environment; and (3) their *experienced environment,* which is influenced in part by inherent factors, including socio-demographic profiles, psychological factors, and the acoustic conditions that listeners are accustomed to and/or prefer.

Growing recognition of the need for research integration across different acoustic contexts has led to the development of international standards for soundscapes research that set a foundation for interdisciplinary work (International Organization for Standardization (ISO) 2014, 2018, 2019). The International Organization for Standardization Technical Specification ISO/TS 12913-1 (2014) defined soundscapes as a perceptual construct through which humans make meaning of the physical phenomena of an acoustic environment. The International Organization for Standardization Technical Specification ISO/TS 12913-2 (2018) provided technical specifications for soundscape research data collection and reporting. It included the ISO/TS taxonomy, a common classification taxonomy for any acoustic environment, based on place types, sound source types, and sound sources. The International Organization for Standardization Technical Specification ISO/TS 12913-3 (2019) provided guidance on data analysis and reporting specifications for the 2018 data collection protocol. While ISO/TS 12913-2 (2018) specified that full-feature soundscape studies must integrate perceptual research and binaural measurements, Aletta et al. (2019) acknowledged that a wide range of other methodological approaches would need to be considered in future revisions to expand disciplinary scope.

Overarching Sound Categories from Soundscape Ecology: biophony, Geophony, and Anthrophony

While the ISO/TS Taxonomy top-level divisions focus on whether sounds are "generated by human activity/facility", the majority of PA research has employed soundscape ecologists' three overarching categories of sounds meant to encapsulate all potential sounds in a given environment: *geophony, biophony,* and *anthrophony* (e.g., Benfield et al. 2010; Gale et al. 2021; Rice et al. 2020). Krause (1987, 2008) first introduced these terms, describing geophony as encompassing the sounds of the Earth and its processes (e.g., wind, water flow, thunder), independent of individual creatures. Krause (2008) separated humans from the rest of living things, describing biophony in the context of an orchestra of animals. Joo, Gage, and Kasten (2011, 260) described anthrophony as "any acoustic signal created by human activities such as musical performance, oral conversation, or mechanical sounds caused by the operation of machinery and automobiles".

Distinguishing biophony from geophony is a useful strategy for research conducted in PAs with a focus on measuring soundscapes to monitor biodiversity and species composition within habitats. Biophonic sounds tend to represent the biodiversity PA managers intend to protect. Although geophonic sounds have been less of a focus of indicator-based research as part of PA management/monitoring studies, numerous connections between geophony and climate may predicate an increasingly important role in soundscape research as climate change becomes more of a focus. There is some question whether domestic animal sounds should be included in the category of biophony or within anthrophony. In some recent urban soundscape studies, dogs barking is included as a biological sound, within the larger category of natural sounds (e.g., Liu et al. 2019); however, other recent research focused on rural environments examines livestock sounds (including dogs) as a separate category from natural sounds (e.g., Ren et al. 2018).

Materials and Methods

In their work toward standardizing soundscape descriptors, Aletta, Kang, and Axelsson (2016, 8) discussed approaches to collecting soundscape data, noting that on-site data collection "provides for the most realistic representation of the external world, and is associated with high ecological validity". Nevertheless, they acknowledge that having participants recall an environment in memory is appropriate when working with participants who are familiar with the investigated soundscapes, particularly when the purpose of the research is to understand the dynamics within environments where participants have high levels of familiarity. As such, this research combined data collected during in-person intercept visitor surveys realized in the Coyhaique National Reserve (CNR) with data collected from a subsample of those same participants, using a follow-up online survey about their home and work settings.

Study Setting

Chile is one of the most urban countries in South America (Gale, Ednie, and Beeftink 2021a), and is one of only 28 countries or areas of the world where 40% or more of the urban population are situated within a single city, Santiago. The CNR is located approximately 1,650 km south of Santiago, in the Aysén Region of Chilean Patagonia, 5 km from the regional capital of Coyhaique. It was chosen as the natural PA setting within this study for several reasons. First, the CNR has been experiencing high national tourism visitation growth over the last decade, as access and affordability to the region has improved (Gale, Adiego, and Ednie 2018). Second, the CNR offered an interesting spectrum of physical and acoustic settings that served the study objectives. Within the 6,531-acre reserve, visitors can experience several natural attributes typical of Chilean Patagonia, including mature native forest groves, areas of second growth and of pine plantations, and a range of natural features, including summits, marshlands, and lagoons (Gale, Adiego, and Ednie 2018; Gale et al. 2021). Yet, some sites are far from pristine and dominated by open fields and non-native reforestation stands. Key activities include picnics, group events, and short hikes (Gale, Adiego, and Ednie 2018). The proximity of the CNR to Coyhaique means that visitors are likely to encounter some city-related sounds during their visit.

Study Design

The first phase of data collection (in-person surveys within the CNR) took place between January 14 and March 17, 2019. Project approval was obtained from the Chilean National Forestry Corporation (CONAF), which administers Chile's National System of Natural PAs, and IRB approval was granted by a partnering U.S. midwestern university. The target population included CNR visitors over the age of 18. Data was collected at eight sampling points within the CNR, chosen to represent a variety of natural settings and soundscapes. During the data collection periods, all visitors encountered at the sampling points were intercepted, apart from repeat visitors and large groups. During 63 days of sampling, 1,108 visitors were intercepted, and 899 respondents completed the survey resulting in an 81.1% response rate. This paper reports on two components of this in-person survey: (1) basic visit and demographic information; and (2) visitor observations of the three most prominent sounds they heard during a two-minute listening activity, where participants listed the most prominent sounds they recalled.

Participants were invited to provide their emails if interested in completing a follow-up web-based survey, and 810 volunteered. "The online survey was initiated in May 2019 with an initial email message followed by up to five reminders stacked 3–5 days apart to maximize participation (Dillman, Smyth, and Christian 2014)." The contact emails contained a unique link associated with each participant, which led them to a Qualtrics survey, developed in both English and Spanish. To complete the survey, participants were required to provide informed consent. Collected responses totaled 389, which after 30 unusable addresses were removed, represented a 49.9% response rate. This study reports solely on Chilean residents, which represented 85.6% (n = 333) of respondents. Two sections of the follow-up email survey are included: (1) demographics, details about the participants' home and work environments, and time spent in acoustic contexts; and (2) prominent sounds heard at home and work. The prominent sounds were collected in open-ended question format, where participants listed the three most prominent sounds they recalled for each context (home, work).

Data Analysis

We sought an approach that could integrate contextual sound sources across the three categories of place in our study (home, work, CNR), combining deductive and inductive coding methods that permitted the integration of data- and theory-driven codes (Fereday and Muir-Cochrane 2006). All coding processes were completed in the same manner for data pertaining to home, work, and the CNR contexts. First, open coding was employed, compiling, and inductively sorting the open-ended responses into a dictionary of sound source codes and their meanings (Elliott and Timulak 2005; Williams and Moser 2019). Then, to respond to the first research question, we employed deductive coding, with the ISO/TS taxonomy serving as our codebook, with its classification based on place types, sound types, and sound sources (Brown, Kang, and Gjestland 2011; Brown et al. 2017; International Organization for Standardization (ISO) 2018). The second research question addressed the breadth of open codes related to the natural sounds that emerged within the CNR. This range of natural sounds exceeded the ISO/TS taxonomy. Therefore, to achieve axial and selective coding for natural sounds across the contexts, we extended the ISO/TS taxonomy, enhancing it with overarching geophony, biophony, anthrophony themes from soundscape ecology (Elliott and Timulak 2005; Williams and Moser 2019). Chi-square tests for independence (X^2 and z; with $p = 0.05$) found relationships between demographic groups (gender, age, city population), based on sound type perceptions. Cramer's V was used to evaluate the effect size of relationships between variables (Vacha-Haase and Thompson 2004).

Results

Gender representation was relatively equal within the study sample (52.4% female; 47.6% male). Most participants (73.8%) were between 18 and 35 years of age, and only 4.2% were 56 or more years of age. Nearly all (96.4%) lived within single-family homes (69.3%) and worked in office settings (69.1%), in urban areas ranging from cities to the metropolis of Santiago. Participants reported spending approximately the same amount of time at their home and work contexts, which together represented more than 70% of their total time; and approximately 16.5% of their total time in nature.

RQ1 – How Did Sound Sources and Types Manifest within the PA, Home, and Work Contexts?

RQ1 results employ the ISO/TS taxonomy's top-level sound types, "sounds generated by human activity/facility" ("HS"), and "sounds NOT generated by human activity/facility" ("NHS"). Chi-squared tests for independence provided a sense of whether overall sound perceptions (without looking between the home, work, and CNR contexts), varied based on demographics. No significant differences were identified in the proportion of "HS" and "NHS" perceived between female and male participants [$X^2(1) = 0.14$, $p = 0.71$, $V = 0.01$], or between age categories [$X^2(4) = 3.51$, $p = 0.48$, $V = 0.05$]. A significant relationship was identified for city population [$X^2(3) = 42.70$, $p < 0.001$, $V = 0.13$], where z tests identified higher proportions of "NHS" perceptions among participants from towns and major cities, and larger proportions of "HS" reported by participants within metropolis areas.

Table 1 depicts the most prevalent sound types perceived by participants for the three contexts (home, work, CNR). Chi-square tests were completed to identify relationships in the proportion of "HS" and "NHS" between the contexts. "NHS" represented a significantly greater proportion of sound observations within the CNR (90.70%) as compared to home and work, and a significantly greater proportion of sound observations within the home context (41.60%), as compared to the work context (13.80%).

Separate chi-square tests for each of the three contexts were completed to identify relationships in the proportion of "HS" and "NHS" based on gender, age, and city population. No significant differences were found between female and male participants across CNR [$X^2(1) = 2.84$, $p = 0.09$, $V = 0.06$], home [$X^2(1) = 0.001$, $p = 0.97$, $V = 0.001$], or work [$X^2(1) = 0.63$, $p = 0.43$, $V = 0.03$] contexts; however, relationships were found between age categories and city populations (Figure 1). For age, there were no significant differences for "HS" or "NHS" within the CNR [$X^2(4) = 0.81$, $p = 0.94$, $V = 0.03$], but differences were found within the home (z tests identified differences between cells but the chi-square model was not significant [$X^2(4) = 7.14$, $p = 0.13$, $V = 0.09$], and work contexts [$X^2(4) = 18.01$, $p = 0.001$, $V = 0.17$]. At home, participants 18–25 years of age perceived more "HS" as compared with those 36–45 years of age. At work, participants 26–35 years of age heard more "HS" than all other age groups, and those 56+ years of age perceived fewer "HS" than all other groups.

For city population, no significant differences were found for male and female participant perceptions of "HS" or "NHS" within the CNR [$X^2(2) = 4.26$, $p = 0.12$, $V = 0.07$], home [$X^2(2) = 4.26$, $p = 0.12$, $V = 0.07$], or work [$X^2(2) = 0.67$, $p = 0.72$, $V = 0.03$] contexts. Within the CNR, participants from metropolis areas perceived a greater proportion of "HS" than participants from major cities; z tests identified differences between cells but the chi-square model was not significant [$X^2(3) = 6.25$, $p = 0.10$, $V = 0.08$]. For both home and work contexts, participants from metropolises perceived a greater

Table 1. Comparison of sound types between the CNR, home, and work contexts.

	CNR		Home		Work		Total					
	n	%	*n*	%	*n*	%	*n*	%	X^2	df	*p*	*V*
Sounds generated by human activity/facility ("HS")	89[a]	9.3%	469[b]	58.4%	543[c]	86.2%	1101	46.0%	979	2	<0.001	0.64
Sounds not generated by human activity/facility ("NHS")	869[c]	90.7%	334[b]	41.6%	87[a]	13.8%	1290	54.0%				
TOTAL	958	100%	803	100%	630	100%	2391	100%				

Note. Cells with different superscript letters are significantly different at $p < 0.05$.

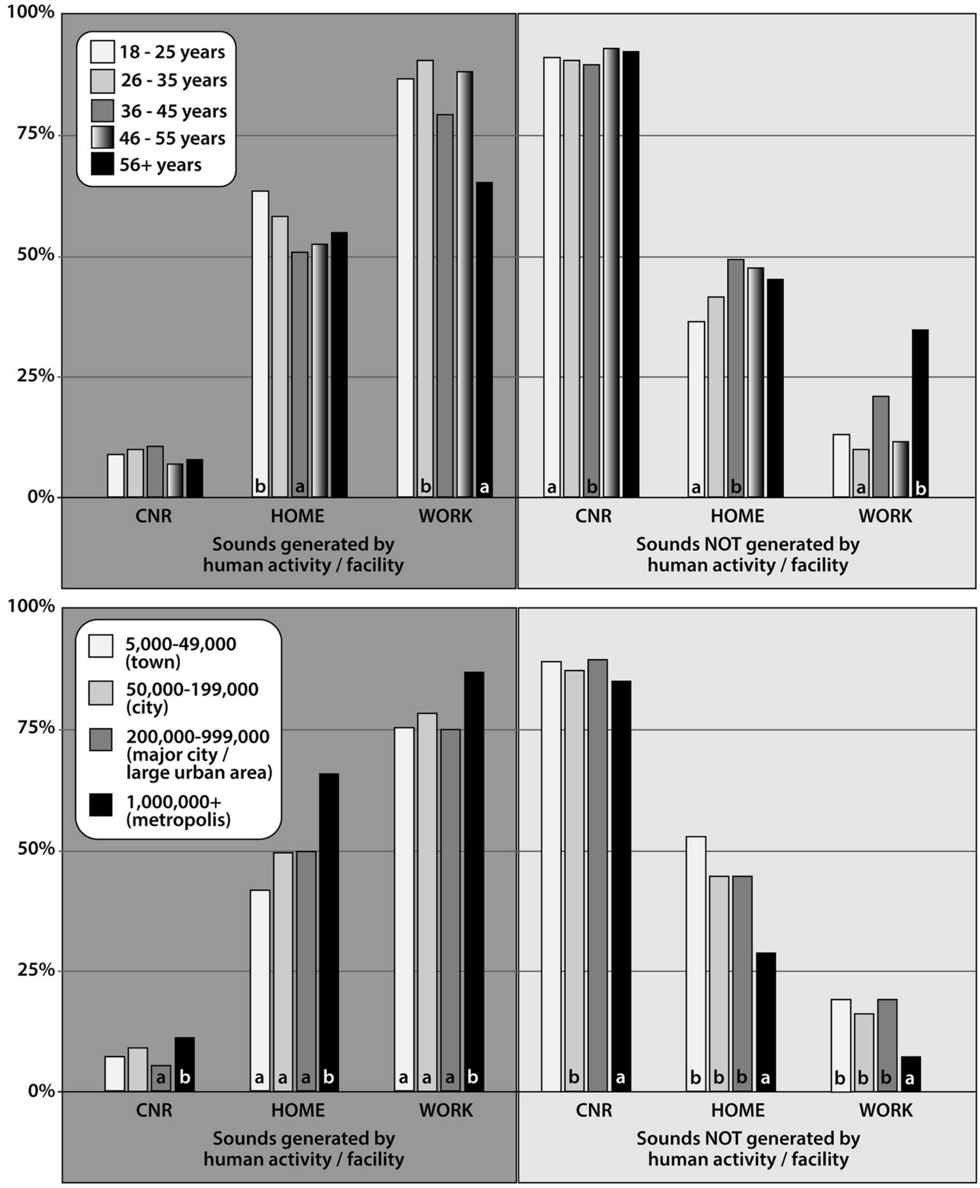

Figure 1. Comparisons of sound types by city size and age across the CNR, home and work contexts.

proportion of "HS" than participants from all other city sizes for home and work, respectively [$X^2(3) = 39.05$, $p < 0.001$, $V = 0.22$; $X^2(3) = 19.04$, $p \leq 0.001$, $V = 0.17$].

Figure 2 employs the ISO/TS taxonomy to compare participant perceptions across the three acoustic contexts. The breakdown between the "Nature" and "Domestic animals" sound types varied across the contexts, where the home context had a much larger percentage of "Domestic animals" (16.9%), while the CNR had virtually none (0.2%). Within the "Nature" sound type, perceptions of *wildlife* and *wind* sound sources were similar at home (11.9% and 10.2%, respectively) and at work (4.1% and 4.8%,

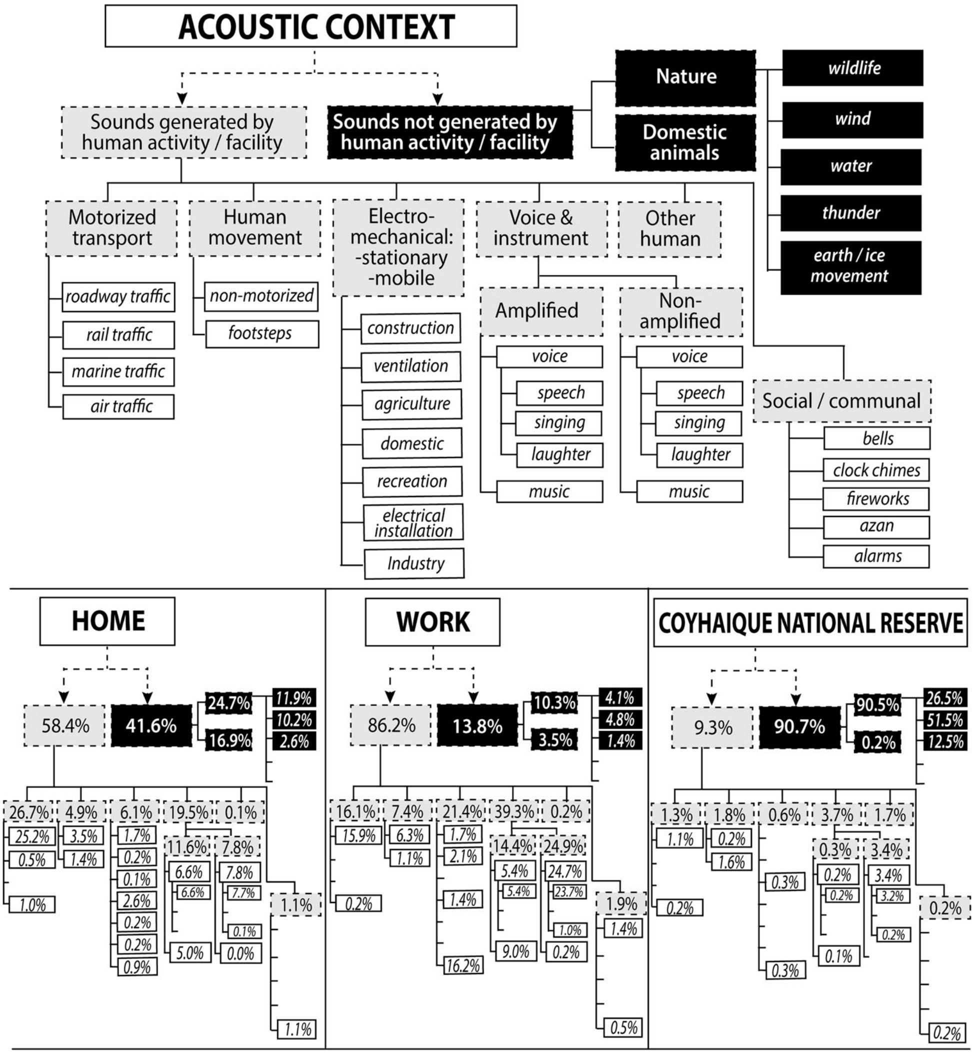

Figure 2. Representation of the ISO/TS 12913-2: 2018 Taxonomy of the Acoustic Environment for Soundscape Studies (top) and analyses of the home, work, and CNR acoustic contexts (bottom).

respectively); while for the CNR, *wind* and *wildlife* sounds comprised the majority of sources (51.5% and 26.5%, respectively). *Water* sound sources were comparatively less represented within all three contexts (CNR 12.5%; home 2.6%; work 1.4%).

"HS" represented the majority of prevalent sounds reported at work (86.2%), over half of prevalent sounds at home (58.4%), and a low percentage at the CNR (9.3%). The majority of work "HS" types were "Voice and instrument" (39.3%), "Electro-mechanical" (21.4%), and "Motorized transport" (16.1%). The majority of home "HS" types were "Motorized transport" (26.7%; *roadway traffic* was the main source), and "Voice and instrument" (19.5%). In contrast, the majority of CNR "HS" types were "Voice and instrument" (3.7%; mainly *non-amplified speech*) and "Human movement" (1.8%), with "Motorized transport" contributing only 1.3%.

RQ2 – How Does the ISO/TS Taxonomy Fit as a Tool to Document the Range of Sounds Representative of a Healthy Natural Soundscape?

The process of open coding sound perceptions within the CNR context identified 28 natural sound sources, as compared to the 5 natural sound sources within the ISO taxonomy. This range of natural sounds is extremely important for PA managers to understand; thus, for the ISO/TS taxonomy to integrate PA soundscape and participant contexts, enhancements seemed warranted. We chose to employ the geophony, biophony, anthrophony structure from soundscape ecology to accomplish this objective.

Moving to an organization of types around geophonic, biophonic, and anthrophonic categories provoked reconsideration of some "NHS" sound types. For example, within the ISO/TS taxonomy, "Domestic animals" were placed within "NHS", separate from other "Nature" sounds. This distinction, and natural soundscape conservation monitoring objectives, prompted us to reclassify "Domestic animals" under "HS"/Anthrophonic types. Domestic animals exist because of human activity/facility, and with respect to PAs, their presence actually counters the purpose of protecting natural soundscapes. Other "HS"/Anthrophonic reclassifications include wind (or rain) hitting clothing or metal roofs within the CNR, and water sounds produced by fountains.

Figure 3 depicts the revised ("NHS") geophony, biophony, anthrophony axial coding. Within the CNR, several geophonic sounds emerged for "Wind" and "Water"; thus, these ISO/TS taxonomy "Nature" sound sources were treated as sound types. "Forest" emerged as a third sound type, which differed from the existing structure of the ISO/TS taxonomy. "Wind" comprised the majority of perceived sounds within the CNR (47.3%), with seven different sound sources reported (e.g., *trees colliding and cracking*; *leaves blowing*; *windgusts over water)*. "Water" comprised 12.5% of prevalent sounds, with seven different sound sources (e.g., *rain*; *moving water [rivers, streams]; waves breaking)*. "Forest" represented a smaller percentage of perceived sounds (4.6%), but still included four sound sources: *forest/trees – general, trees falling (naturally); pinecones and branches falling; leaves falling (naturally)*. Five CNR biophony sound types were identified: "Birds", "Invertebrates", "Mammals", "Fish", and "Amphibians". "Birds" sounds (*general/specific group mentions; vocalizations; movements*) were most prevalent (21.1%), followed by "Insects" (5.1%, dispersed between *insects general/groups; insect vocalizations; insect movements*). The "Mammals", "Fish", and "Amphibians" sound types represented a combined total 0.4% of CNR perceived prevalent sounds. "Nature" geophony sound types at home included "Forest" (0.8%), "Wind" (9.5%), and "Water" (2.7%), and biophony was limited to "Birds" (11.9%). A total of nine sound sources were identified within these types, as compared with the 28 total sound sources for these types within the CNR. The same "Nature" sound types manifested at work, although in all cases to a lesser degree ("Forest" 0.5%; "Wind" 4.3%; "Water" 1.4%; "Birds" 4.1%), with a total of six sound sources.

Figure 4 represents a vision for how the taxonomy may be expanded based on our study results, with a few added examples of common sound sources that were not identified in our study. For example, under the original ISO/TS *earth/ice movement* sound source we have added a range of potential sounds to demonstrate our recommendation that this also be treated as a sound type ("Earth/ice movement"). Considering the

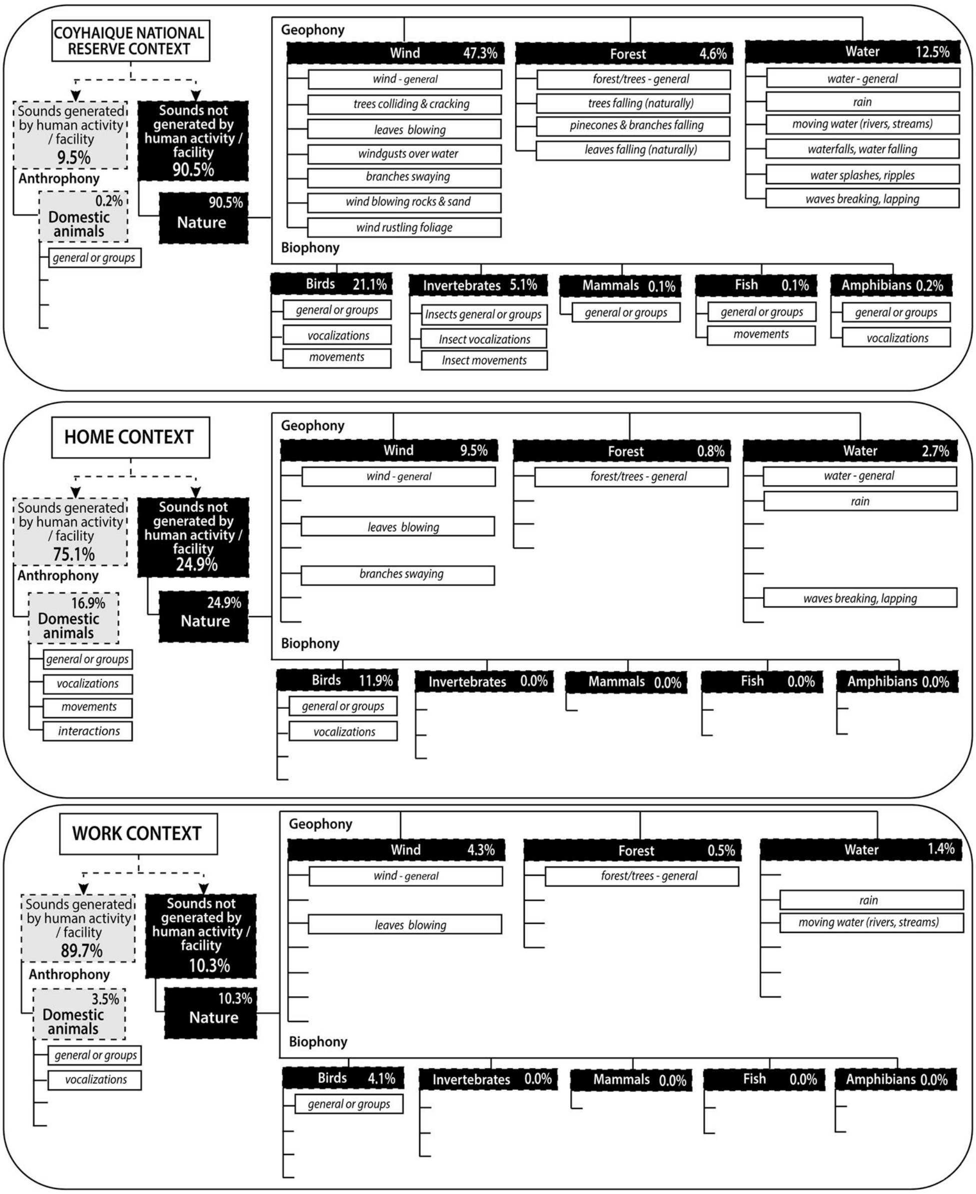

Figure 3. Prevalent "Sounds not generated by human activity" sound types, sound sources, and percentages of total sounds perceived by participants in the home and work contexts.

diversity of soundscapes represented within the World's 265,000+ PAs (UNEP-WCMC 2021), we imagine that future applications of this taxonomy will continue to refine natural sound sources in parallel with future refinements of the anthrophonic sound types and sources.

For example, while we could successfully classify all anthrophonic sound sources within our study; greater methodological clarity is warranted. For example, should people riding bicycles be classified as a *non-motorized* sound source under "Human movement" or as a *recreation* sound source under "Electro-mechanical"? Also, some sound

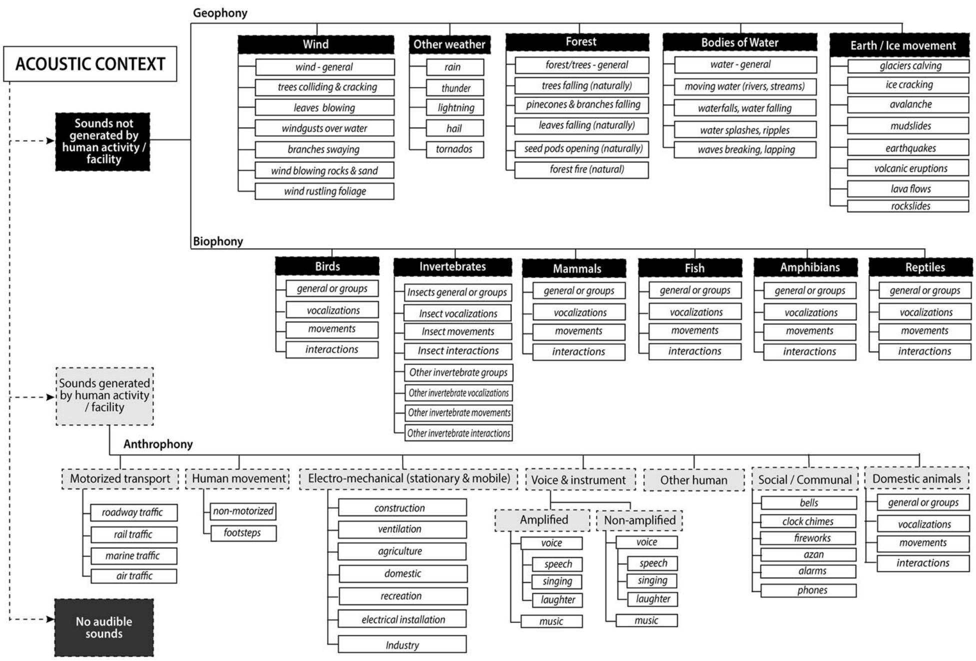

Figure 4. Conceptual taxonomy, with core concepts of the ISO/TS taxonomy and additional natural sound sources and potential clarifications, based on the current study.

sources (e.g., computers and phones) within "Electro-mechanical" may depend on the particular acoustic context. For example, within the home acoustic context, computer and phone sounds were classified as *domestic* sound sources, while within the work acoustic context they were classified as *industrial.* Furthermore, we relied on the *other human* sound type to classify the sounds of a car door shutting, although we felt an *others* sound source within the *motorized transport* sound type would have been clearer.

Discussion and Implications

How a More Robust Taxonomy Will Advance Soundscape Research

Results of this research, including the suggested enhancements to the ISO/TS taxonomy, address the call for integrative approaches to soundscape research that facilitate interdisciplinary advances, aligned with the standards of operation recommended within ISO12913-2 (Aletta et al. 2019; Axelsson, Guastavino, and Payne 2019; Brown, Kang, and Gjestland 2011; Brown et al. 2017; International Organization for Standardization (ISO) 2018). As intended, the ISO/TS taxonomy (Figure 2) provided this research with a common terminology for describing sound sources and types across the three acoustic contexts of home, work, and the CNR, helping to outline the distinctiveness of each, especially in terms of anthrophonic sound types and sources (International Organization for Standardization (ISO) 2018). Comparing the taxonomies across contexts demonstrated anthrophonic sound source similarities and differences. For example, although it was much less frequently listed as a prevalent sound within the CNR, roadway traffic was within the top three prevalent sounds across the home, work, and CNR contexts. Non-amplified voice/speech were among the most prevalent sounds at work and in the CNR, however, amplified voices (e.g., TV, street vendors, neighbors speaking loudly through walls or outside) and amplified music were two of the three most prevalent anthrophonic sound sources at home.

While some of the sound sources that emerged in our study were contextual to the CNR and to Chilean culture in general, results demonstrated the plausibility of enriching the existing ISO/TS taxonomy as a mechanism for extended consideration of natural sound types and sources. While the existing ISO/TS taxonomy was generally effective for axial coding of "HS" sources, the enhanced taxonomy helped us gain perspective about how sounds are perceived within different experienced environments and understand how rich the natural sound experience within the CNR was for visitors.

Home offered the largest variety of anthropogenic sounds; work was concentrated in a much narrower range of anthrophonic sounds (centered on human conversation and industry), and the CNR was almost entirely related with nature. Within the home context, participants in the youngest age category perceived the most human caused sounds, and at work, young professionals (aged 26–35) perceived the most human caused sounds. Given that existing research has suggested nuances in wilderness perceptions and values based on age (Rasch 2018), further research could explore potential implications of generational differences in human-caused sound perceptions on PA management.

Within all three contexts, participants residing in metropolis areas perceived more human sounds as compared with those in smaller city sizes (but even large urban areas). While wind and water sounds were perceived across all three contexts, sound sources manifested with more *richness*, (i.e., sound diversity, variety), in the PA context. The reverse occurred for "HS"; while also perceived across the three settings, sound sources were much broader at home and work. Comparative study across contexts, using the enhanced ISO/TS Taxonomy, helped us surface these tendencies with respect to sound richness, which represent an interesting phenomenon that merits additional research.

Soundscape richness is one of the core descriptors in natural systems acoustic research and the basis for one of the most widely used indices, frequently used to describe levels of acoustic diversity or variety (Borker et al. 2020; Desjonquéres et al. 2015). Nevertheless, richness has rarely been used as a term to characterize human perceptions of soundscapes, and to our knowledge, has not been conceptually defined or examined within the research. It seems likely that this variable is linked with the eventfulness soundscape component identified by Axelsson, Nilsson, and Berglund (2010), in their seminal research on perceived affective quality. High levels of natural sound richness may represent eventful soundscapes for visitors and may influence perceived affective quality for PA soundscapes (Gale, Ednie, and Beeftink 2021b). Perceived soundscape richness may also influence conservation values. A recent study by Jia, Ma, and Kang (2020), that took place in the Chinese city of Tianjin, described richness as one of five dimensions found to be characteristic of urban soundscapes that participants perceived were worthy of preservation. Here, soundscape richness was defined through two semantic pairs of descriptors: simple-varied, and directional-universal, with higher richness scoring for soundscapes characterized by varied, universal sounds. Richness manifested within three types of urban soundscapes found worthy of preservation by study participants: relaxing natural soundscapes (e.g., rustling leaves, river sounds), vibrant natural soundscapes (e.g., birdsong, fountains), and traditional human soundscapes (e.g., traditional cultural street vendors). Future research to understand how richness manifests within natural soundscapes and how it relates with visitors' conservation values, could help move PA soundscape research forward; the conceptual taxonomy, presented in Figure 4, seems a promising tool in this regard.

An enhanced ISO/TS taxonomy may also assist future research by highlighting tendencies across contexts and settings. For example, study participants perceived a wide range of anthrophonic and "Domestic animals" sound sources across their home and work contexts, while in the CNR anthropogenic sounds spanned a more limited range of the taxonomy. Not surprisingly, the reverse was observed with respect to perceptions of "Nature"; however, the extent of this trend did not become visible until we enriched the ISO/TS taxonomy by integrating the additional sources and the geophony, biophony, anthrophony classifications (Figure 3). Of the 28 "Nature" sound sources perceived within the CNR context; only nine were perceived as prevalent at home, and six at work. Both geophonic and biophonic sound variety diminished from CNR to home to work, with differing implications. In terms of geophonic sounds, within the CNR participants perceived a much richer and complex array, noting high levels of detail. Across their home and work contexts, this detail progressively disappeared, and only general geophonic phenomena were perceived. Within the biophony class, sounds were attributed to biodiversity across five animal sound types and a variety of sources within those types. At home and work, biophony was limited only to bird sounds.

Separating out the sounds of "Domesticated animals" as being "NHS" generated by human activity and facility and integrating the soundscape ecology concepts for sound classification (biophony, geophony, anthrophony) with the existing ISO/TS taxonomy, were both useful exercises. They allowed us to more clearly understand the "NHS" that participants experienced, and better clarify the contexts in which they were heard. While "Domesticated animals" comprised relatively small portions of the overall sounds heard at work and within the CNR, they represented almost 17% of the sounds reported at home. Some sounds of domestic pets, especially the barking of dogs, have well documented negative impacts on both humans and wildlife (e.g., Randler 2006; Gaunet, Pari-Perrin, and Bernardin 2014). Focusing classification of these sounds within anthrophony, based on the logic that they are present because of human activities, and further separating the remaining natural sounds according to geophony and biophony, helped to clarify the home context in our study. Reclassifying "Domesticated animals" under "HS"/anthrophony clarified that the levels of biophony related sounds at home were around a third of those heard in the CNR and limited exclusively to birds.

Implications for Healthy Parks and Healthy People

This paper sought to develop a more holistic profile of the sounds and noises urban Chilean dwellers encounter within a range of acoustic environments. A better understanding of these PA visitors and the range of acoustic experiences they encounter can assist PA managers in several ways. First, study results suggest several implications for in-park programming. The richness and variety of natural sounds perceived by visitors in this study reaffirms the important role they play in connecting visitors with nature through sound. HPHP may want to consider infrastructure and programming to help enhance visitor mindfulness and recognition of natural sounds and their abundance in PAs. These could include mindful listening programs (e.g., soundwalks), quiet trails or quiet hours with signage to encourage mindfulness, and educational programs that interpret the richness of the biophonic and geophonic sounds, and inform about natural and human system interrelations via soundscapes (Francis et al. 2017). These types of programs may help citizens restore and regain some of the direct interactions with the natural world that have been lost within their daily lives because of increased urbanization. More research is warranted to guide and support natural sounds programming in PAs, both in terms of their potential to foster nature connectedness and health benefits; as well as their potential to contribute to pro-environmental behavior that can enhance HPHP goals.

Secondly, a holistic understanding of visitors' experiences in their varied environments, including home and work contexts, is important for soundscape management and monitoring practices within PAs. The enhanced ISO/TS taxonomy proposed in this paper would provide a common tool that can assist research in this vein. Since PA soundscape monitoring programs commonly incorporate visitor perceptions data (e.g., Pilcher, Newman, and Manning 2009; Miller et al. 2020), managers should seek to understand how much visitors' experienced environments affect their motivations for visiting PAs, and their soundscape experiences and perceptions within PAs. Recent findings suggest that differing connections to nature and natural sounds may influence the capacity of visitors to provide consistent feedback in perceptions-based monitoring (Ednie and Gale 2021). Thus, the programming initiative mentioned above may play a particularly important role in helping prepare PA visitors to provide useful feedback to soundscape monitoring initiatives within PAs.

Finally, this study suggests both the need and the opportunity to extend the HPHP approach beyond the park through natural sounds. Our study results illuminated the stark contrasts in natural sound richness and variety perceived within the CNR and the home and work settings. Considering the amount of time people spend at home and work, in comparison with time in nature, it seems opportune to consider how PAs might extend the benefits of natural soundscape immersion outside the park boundaries, to home and work settings. Photos have long been used as a visual cue to preserve and enhance memories of being in a place; how about incorporating efforts to enhance the memories of being in a place through sound. What is the auditory equivalent of a photo? Perhaps HPHP programming can use PA natural soundscapes to accomplish this goal. For example, the emergence of 3 D-video, mindfulness apps, and platforms could be enhanced through partnerships with PAs and natural sound content. Spotify, or similar music and podcast outlets, could offer natural sounds playlists, recorded in PAs around the world. Reliving experiences from PA trips through enhanced media may help keep people in a mindful state of the sounds around them, thus, not only providing health benefits to themselves, but also health benefits to parks through increased awareness of impacts and support for protection.

Conclusions

Results support Kogan et al. (2017) arguments about the importance of understanding participants' experienced environments in soundscape perceptions research, and the value in extending approaches beyond their perceptions and observations within a given moment (i.e., a PA visit). The patterns we identified across the three contexts demonstrated the benefits Healthy Parks bring to their visitors, as well as the potential role of PAs in augmenting nature connections that occur outside of their boundaries. Contrasts in the degrees and forms of anthrophonic noise within the different life contexts accentuated the need to conserve and protect natural soundscapes; both to ensure healthy natural systems (Levenhagen et al. 2020), and to provide spaces for humans to escape the anthrophonic noise that fills their home and work contexts (Gale et al. 2021; Ednie et al. 2022). Considering the current urbanization trends within Chile, this is particularly important within PAs like the CNR, that are near cities.

Acknowledgements

The authors would like to thank (1) Andrés Adiego for his technical support with this research, (2) the administrators and park guards of the Coyhaique National Reserve, and (3) the participants in both phases of this research for their valuable assistance.

Funding

This work was supported by Chile's National Research and Development Agency (ANID) under ANID's Regional Program R17A10002; the CIEP R20F0002 project; and CHIC-ANID PIA/BASAL PFB210018.

References

Aletta, F., C. Guattari, L. Evangelisti, F. Asdrubali, T. Oberman, and J. Kang. 2019. Exploring the compatibility of 'Method A' and 'Method B' data collection protocols reported in the ISO/TS 12913-2:2018 for Urban Soundscape via a Soundwalk. *Applied Acoustics* 155:190–203. doi: 10.1016/j.apacoust.2019.05.024.

Aletta, F., J. Kang, and Ö. Axelsson. 2016. Soundscape descriptors and a conceptual framework for developing predictive soundscape models. *Landscape and Urban Planning* 149:65–74. doi: 10.1016/j.landurbplan.2016.02.001.

Alvarez-Berríos, N., M. Campos-Cerqueira, A. Hernández-Serna, C. J. A. Delgado, F. Román-Dañobeytia, and T. M. Aide. 2016. Impacts of small-scale gold mining on birds and anurans near the tambopata natural reserve, peru, assessed using passive acoustic monitoring. *Tropical Conservation Science* 9 (2):832–51. doi: 10.1177/194008291600900216.

Axelsson, Ö., C. Guastavino, and S. R. Payne. 2019. Editorial: Soundscape assessment. *Frontiers in Psychology* 10 (2514):2514–2. doi: 10.3389/fpsyg.2019.02514.

Axelsson, O., M. Nilsson, and B. Berglund. 2010. A principal components model of soundscape perception. *Journal of the Acoustical Society of America* 2010:555–60. doi: 10.1007/978-1-4419-0561-1_48.

Benfield J. A., B. D. Taff, P. Newman, and J. Smyth. 2014. Natural sound facilitates mood recovery. *Ecopsychology* 6 (3):183–8. doi:10.1089/eco.2014.0028.

Benfield J. A., P. A. Bell, L. J. Troup, and N. C. Soderstrom. 2010. Aesthetic and affective effects of vocal and traffic noise on natural landscape assessment. *Journal of Environmental Psychology* 30 (1):103–11. doi: 10.1016/j.jenvp.2009.10.002. Benfield

Borker, A. L., R. T. Buxton, I. L. Jones, H. L. Major, J. C. Williams, B. R. Tershy, and D. A. Croll. 2020. Do soundscape indices predict landscape-scale restoration outcomes? A comparative study of restored seabird island soundscapes. *Restoration Ecology* 28 (1):252–60. doi: 10.1111/rec.13038.

Brown, A. L., J. Kang, and T. Gjestland. 2011. Towards standardization in soundscape preference assessment. *Applied Acoustics* 72 (6):387–92. doi: 10.1016/j.apacoust.2011.01.001.

Brown, A. L., T. Gjestland, and D. Dubois. 2017. Acoustic environments and soundscapes. In *Soundscape and the built environment*, ed. Jian Kang and Brigitte Schulte-Fortkamp, 1st ed., 1–16. Boca Raton: CRC Press. doi: 10.1201/b191452.

Desjonquéres C., F. Rybak, M. Depraetere, A. Gasc, I. Le Viol, S. Pavoine, and J. Sueur. 2015. First description of underwater acoustic diversity in three temperate ponds. *PeerJ* 3 (11): e1393–17. doi: 10.7717/peerj.1393.

Dillman, D. A., J. D. Smyth, and L. M. Christian. 2014. *Internet, phone, mail and mixed-mode surveys: The tailored design method*. 4th ed. Hoboken, N.J, USA: Wiley & Sons.

Ednie, A., and T. Gale. 2021. Soundscapes and protected area conservation: Are noises innature making people complacent? *Nature Conservation* 44:177–95. doi: 10.3897/natureconservation.44.69578.

Ednie, A., T. Gale, K. Beeftink, and A. Adiego. 2022. Connecting protected area visitor experiences, wellness motivations, and soundscape perceptions in Chilean Patagonia. *Journal of Leisure Research* 53 (3):377–403. doi: 10.1080/00222216.2020.1814177.

Elliott, R., and L. Timulak. 2005. Descriptive and interpretive approaches to qualitative research. In *A handbook of research methods for clinical and health psychology*, ed. Jeremy Miles and Paul Gilbert, 147–59. New York: Oxford University Press Inc. doi: 10.1093/med:psych/9780198527565.001.0001.

Farina A., E. Lattanzi, R. Malavasi, N. Pieretti, and L. Piccioli. 2011. Avian soundscapes and cognitive landscapes: Theory, application and ecological perspectives. *Landscape Ecology* 26 (9): 1257–67. doi: 10.1007/s10980-011-9617-z.

Fereday, J., and E. Muir-Cochrane. 2006. Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods* 5 (1):80–92. doi: 10.1177/160940690600500107.

Ferraro, D. M., Z. D. Miller, L. A. Ferguson, B. D. Taff, J. R. Barber, P. Newman, and C. D. Francis. 2020. The phantom chorus: Birdsong boosts human well-being in protected areas. *Proceedings. Biological Sciences* 287 (1941):20201811. doi: 10.1098/rspb.2020.1811.

Francis, C. D., P. Newman, B. D. Taff, C. White, C. A. Monz, M. Levenhagen, A. R. Petrelli, L. C. Abbott, J. Newton, S. Burson, et al. 2017. Acoustic environments matter: Synergistic benefits to humans and ecological communities. *Journal of Environmental Management* 203 (Pt 1): 245–54. doi: 10.1016/j.jenvman.2017.07.041.

Franco, L. S., D. F. Shanahan, and R. A. Fuller. 2017. A review of the benefits of nature experiences: More than meets the eye. *International Journal of Environmental Research and Public Health* 14 (8):29. doi: 10.3390/ijerph14080:864.

Gale, T., A. Ednie, and K. Beeftink. 2021a. Thinking outside the park: Connecting visitors' sound affect in a nature-based tourism setting with perceptions of their urban home and work soundscapes. *Sustainability* 13 (12):6572–19. doi: 10.3390/su13126572.

Gale, T., A. Ednie, and K. Beeftink. 2021b. Acceptability and appeal: How visitors' perceptions of sounds can contribute to shared learning and transdisciplinary protected area governance. *Journal of Outdoor Recreation and Tourism* 35:100414–13. doi: 10.1016/j.jort.2021.100414.

Gale, T., A. Ednie, K. Beeftink, and A. Adiego. 2021. Beyond noise management: Exploring visitors' perceptions of positive emotional soundscape dimensions. *Journal of Leisure Research* 52 (2):129–53. doi: 10.1080/00222216.2020.1749912.

Gale, T., A. Adiego, and A. Ednie. 2018. A 360° approach to the conceptualization of protected area visitor use planning within the Aysén Region of Chilean Patagonia. *Journal of Park and Recreation Administration* 36 (3):22–46. doi: 10.18666/JPRA-2018-V36-I3-8371.
Gaunet, F., E. Pari-Perrin, and G. Bernardin. 2014. Description of dogs and owners in outdoor built-up areas and their more-than-human issues. *Environmental Management* 54 (3):383–401. doi: 10.1007/s00267-014-0297-8.
International Organization for Standardization (ISO). 2014. *Technical Specification ISO/TS 12913-1 Acoustics – Soundscape – Part 1: Definition and Conceptual Framework.* Geneva, Switzerland: International Organization for Standardization.
International Organization for Standardization (ISO). 2018. *Technical Specification ISO/TS 12913-2 Acoustics – Soundscape – Part 2: Data Collection.* Geneva, Switzerland: International Organization for Standardization.
International Organization for Standardization (ISO). 2019. *Technical Specification ISO/TS 12913-3 Acoustics – Soundscape – Part 3: Data Analysis.* Geneva, Switzerland: International Organization for Standardization.
Jia, Y., H. Ma, and J. Kang. 2020. Characteristics and evaluation of urban soundscapes worthy of preservation. *Journal of Environmental Management* 253:109722. doi: 10.1016/j.jenvman.2019.109722.
Joo, W., S. H. Gage, and E. P. Kasten. 2011. Analysis and interpretation of variability in soundscapes along an urban-rural gradient. *Landscape and Urban Planning* 103 (3–4):259–76. doi: 10.1016/j.landurbplan.2011.08.001.
Kogan, P., B. Turra, J. P. Arenas, and M. Hinalaf. 2017. A comprehensive methodology for the multidimensional and synchronic data collecting in soundscape. *Sci Total Environ* 580:1068–77. doi: 10.1016/j.scitotenv.2016.12.061.
Krause, B. 1987. Bio-acoustics: Habitat ambience & ecological balance. *Whole Earth Winter* 1987 (57):14–8.
Krause, B. 2008. Anatomy of the soundscape: Evolving perspectives. *Journal of the Audio Engineering Society* 56 (1/2):73–80. http://www.aes.org/e-lib/browse.cfm?elib=14377.
Levenhagen, M. J., Z. D. Miller, A. R. Petrelli, L. A. Ferguson, Y. -H (J.). Shr, D. G. E. Gomes, B. D. Taff, C. White, K. Fristrup, C. Monz, et al. 2020. Ecosystem services enhanced through soundscape management link people and wildlife. *People and Nature* 3 (1):176–89. no. doi: 10.1002/pan3.10156.
Liu, J., Y. Wang, C. Zimmer, J. Kang, and T. Yu. 2019. Factors associated with soundscape experiences in urban green spaces: A case study in Rostock, Germany. *Urban Forestry & Urban Greening* 37:135–46. doi: 10.1016/j.ufug.2017.11.003.
Miller, Z. D., L. A. Ferguson, P. Newman, M. Ferguson, N. Tipton, V. Sparrow, and B. D. Taff. 2020. Developing visitor thresholds of sound from shale natural gas compressors for motorized and non-motorized recreation users in Pennsylvania State Forests. *Applied Acoustics* 157:107012. doi: 10.1016/j.apacoust.2019.107012.
Pilcher, E. J., P. Newman, and R. E. Manning. 2009. Understanding and managing experiential aspects of soundscapes at muir woods national monument. *Environmental Management* 43 (3):425–35. doi: 10.1007/s00267-008-9224-1.
Rajan, S. C., K. Athira, R. Jaishanker, N. P. Sooraj, and V. Sarojkumar. 2019. Rapid assessment of biodiversity using acoustic indices. *Biodiversity and Conservation* 28 (8–9):2371–83. doi: 10.1007/s10531-018-1673-0.
Randler, C. 2006. Disturbances by dog barking increase vigilance in Coots Fulica Atra. *European Journal of Wildlife Research* 52 (4):265–70. doi: 10.1007/s10344-006-0049-z.
Rasch, R. 2018. An exploration of intergenerational differences in wilderness values. *Population and Environment* 40 (1):72–91. doi: 10.1007/s11111-018-0293-7.
Ren, X., J. Kang, P. Zhu, and S. Wang. 2018. Soundscape expectations of rural tourism: A comparison between chinese and english potential tourists. *The Journal of the Acoustical Society of America* 143 (1):373–7. doi: 10.1121/1.5019466.

Rice, W. L., P. Newman, Z. D. Miller, and B. D. Taff. 2020. Protected areas and noise abatement: A spatial approach. *Landscape and Urban Planning* 194 (February):103701. doi: 10.1016/j.landurbplan.2019.103701.

Taff, B. D., V. Peel, W. L. Rice, G. Lacey, and B. Pan. 2019. Healthy parks healthy people: Evaluating and improving park service efforts to promote tourists health and well-being introduction. In *Travel and Tourism Research Association: Advancing Tourism Research Globally, 7.* Amherst: University of Massachusetts Amherst. https://scholarworks.umass.edu/ttra/2019/research_papers/27.

United Nations Environment Program World Conservation Monitoring Center (UNEP-WCMC). 2021. "Protected Areas Map of the World." www.protectedplanet.net. (accessed July 20, 2021)

Vacha-Haase, T., and B. Thompson. 2004. How to estimate and interpret various effect sizes. *Journal of Counseling Psychology* 51 (4):473–81. doi: 10.1037/0022-0167.51.4.473.

Williams, M., and T. Moser. 2019. The art of coding and thematic exploration in qualitative research. *International Management Review* 15 (1):45–55.