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Soundscapes as Conservation Tools: Integrating Visitor Engagement in Biodiversity Strategies

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Abstract: This study investigates visitor soundscape perceptions in Queulat National Park (QNP), Chile, to inform biodiversity conservation strategies amid rising anthropogenic pressures. By analyzing responses at two sites—Lagoon and Overlook—during peak tourist periods, this research examines how visitor experiences align with protected area management goals. A one-minute listening exercise was followed up by a survey to gather data on perceived sounds and their appeal. The results highlight the importance of involving visitors in monitoring acoustic environments, providing managers with insights into visitor-perceived soundscape dynamics. Unique QNP ecosystem characteristics emerged, with visitors identifying anthrophonic sounds as problematic, especially at the Lagoon site. Perceptions aligned with management concerns about noise impacts from congestion, showing visitors can discern when soundscapes diverge from protected area objectives. These findings underscore the need to integrate visitor engagement into acoustic monitoring to enhance biodiversity conservation. This study advocates ongoing sound level monitoring, protective policies, and tools derived from visitor input. It promotes protected areas as educational venues in order to deepen connections with local environments through sound recognition and calls for signage to inform visitors about noise impacts. Future research should continue to explore these strategies and the potential of visitor soundscape perceptions to reshape conservation strategies and support biodiversity preservation.

Keywords: soundscape perceptions; anthropogenic pressures; acoustic monitoring; participatory governance; conservation strategies; Convention on Biological Diversity (CBD); visitor perceptions

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Academic Editors: Minja Bolesnikov, Tamara Gajić and Aleksandar Erceg

Received: 10 January 2025
Revised: 24 January 2025
Accepted: 29 January 2025
Published: 4 February 2025

Citation: Gale, T.; Ednie, A.; Beeftink, K.; Báez Montenegro, A. Soundscapes as Conservation Tools: Integrating Visitor Engagement in Biodiversity Strategies. *Sustainability* **2025**, *17*, 1236. https://doi.org/10.3390/su17031236

1. Introduction

The Convention on Biological Diversity (CBD) is a landmark agreement in international environmental governance that emerged from the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro. Ratified by 196 countries, the CBD addresses challenges in biodiversity conservation and sustainable development, guiding efforts to protect the Earth's biodiversity and foster equitable human–nature relationships [1]. It establishes specific goals, targets, and principles for conservation and sustainable use, requiring signatory nations to create national biodiversity strategies, report progress, and implement its provisions. While the effectiveness of these measures has been scrutinized, evolving compliance mechanisms aim to ensure countries meet their treaty obligations [1–3].

Protected terrestrial and marine areas (PAs) have been pivotal in regional and national biodiversity strategies since the ratification of the CBD and remain essential for achieving the 2030 Global Biodiversity Framework (GBF) targets [2]. Over the next two decades, the GBF aims to transform traditional PAs into more effective and ecologically representative conservation areas [4,5]. This transformation focuses on enhancing PA management effectiveness through capacity building, improved outcome monitoring, and the development of transdisciplinary participatory governance frameworks [6–8].

Despite the growth of PA coverage over the past two decades, ongoing environmental degradation and increasing pressures on natural resources highlight the need to expand biodiversity conservation strategies beyond traditional PA frameworks [3,9–11]. The GBF emphasizes establishing new areas and mechanisms to enhance biodiversity conservation beyond conventional PAs. Examples include nature-based solutions (NbSs), other effective conservation measures (OECM)s, area-based conservation, buffer zones around PAs, urban greenspace conservation, and biological corridors [12,13]. These initiatives extend biodiversity protection into residential areas, neighborhoods, and cities, integrating nature-friendly approaches into everyday life and the community fabric. Researchers argue that the success of these measures will depend on “mainstreaming” policies across societal sectors to achieve regenerative and sustainable development that aligns with conservation principles [5,9,10,14–16]. This vision of broad-scale, regenerative development relies on aligning societal values and behaviors to foster health in biodiversity, humans, and their shared environments [9,11,17–19]. Understanding how people experience and relate to nature can further inform these efforts.

Another key success factor for the GBF is the commitment and capacity at regional and national levels to develop and implement biodiversity strategies that enhance existing PAs. Chile exemplifies this, being an active CBD member engaged with GBF and UNESCO PA policies [20–22]. However, it ranks among the lowest in global funding for biodiversity conservation, limiting its financial support for PAs [20–22]. The IUCN has aided Chilean ministries in developing legislation for the National Biodiversity Protection Service, transitioning management of public PAs from CONAF to this new service. This will also involve private PAs and OECMs [20,23]. Chile’s national biodiversity strategy emphasizes improving management in 120 terrestrial public PAs and integrating sustainable development and biodiversity-friendly practices across sectors [24].

GBF targets aim to protect ecosystem integrity, connectivity, and resilience; promote sustainable biodiversity use; ensure fair benefit distribution; and enhance ecosystem functions for the mutual benefit of humanity and nature [2]. Mainstreaming national biodiversity strategies for regenerative and sustainable development requires a better understanding of how people perceive nature and human behavior in relation to it. This paper explores visitor perceptions of PA sound environments (soundscapes) to inform GBF strategies, focusing on a popular national park in Aysén, Chilean Patagonia. The findings could enhance PA management strategies, inform policy and practice across societal sectors, and promote new pathways for valuing and engaging in regenerative and sustainable behaviors.

2. Literature Review

2.1. Soundscapes and Visitor Experiences in PAs

Natural soundscapes provide benefits for both biodiversity and humans [25–27] and are incorporated into management plans for protected area systems like the U.S. National Park Service (USNPS). Experiencing the sounds of nature or natural quiet is often cited as a motivating factor for visitors in national parks and other protected areas [28]. In recent years, researchers have sought a better understanding of visitors' experiences with soundscapes in protected areas [28–40].

PAs need practical tools to evaluate the impacts of direct and indirect drivers of natural system change. Acoustic monitoring plays a key role in some PA systems worldwide [41,42]. In U.S. National Parks, which mandate the protection of natural sounds, monitoring variables include (a) decibel levels (dB), (b) frequency analysis to distinguish natural sounds from anthropogenic noise, (c) sound duration measurements of noise events affecting wildlife and visitor experiences, (d) noise levels tracked at different times to understand human activity and wildlife behavior, and (e) sound source identification to assess impacts from vehicular traffic, aircraft, and recreational activities [41,42]. These studies may also include acoustic diversity indices [43] and location-specific monitoring to understand spatial variations in noise levels. Together, these variables enable park managers to evaluate noise pollution's effects on wildlife, visitor experiences, and overall ecosystem health.

While useful within the U.S. protected area legal system, these practices have limitations in gauging human perceptions and reactions to specific sounds and noises, including their appeal to visitors. Current monitoring practices lack the specificity needed to provide rich context about soundscape experiences, which is vital for biodiversity monitoring and enhancing visitor experiences. For instance, Ferguson et al. [28] noted that the sound level does not indicate the sound source. It was not a significant predictor of soundscape pleasantness in previous studies.

Examining human perceptions of soundscapes helps managers to understand the impacts of growing visitation and anthropogenic development on visitor experiences, allowing for more informed PA monitoring to meet management goals. Research on visitor social norms—"shared beliefs about the acceptability of an action or situation" [44], p. 650—has aided managers in developing indicators, thresholds, triggers, and quality standards [30,32–38,40] to monitor soundscape conditions and identify necessary interventions. Visitor perception data have also been used to establish zoning areas within national parks to cater to diverse motivations for natural quiet [30] and to evaluate educational strategies for reducing visitor-created noise [45]. Some strategies have been successfully implemented in national parks like Muir Woods, and Ferguson et al. [28] emphasized the need to expand such noise-reduction strategies to urban parks.

2.2. Sound Observation and Perception Data

Visitor soundscape studies in PAs examine various perceptual variables, typically beginning with observation data, i.e., what individual sounds visitors heard during a designated listening period. Sounds are categorized based on their origin into three primary types, identified by Kraus and colleagues [46,47]: biophony (animal sounds), geophony (sounds from earth processes), and anthrophony (human-created sounds, including voice and mechanical noises). Efforts to standardize soundscape research taxonomy began with the International Organization for Standardization [48], and recently, Gale et al. [49] refined the biophony and geophony categories to better suit the needs of soundscape research into natural protected areas.

Recently, researchers [32] have collected more detailed observation data to capture visitor soundscape experiences more comprehensively. This includes recording the duration of individual sounds and their placement (i.e., whether they are in the foreground or background). These measures aim to contextualize how individual sounds contribute to the overall soundscape. For example, do visitors notice that certain sounds dominate the soundscape due to their placement (e.g., in the foreground), duration (e.g., persisting throughout the listening period), or both?

Visitor observation data often include measures to assess perceptions of sounds in the environment. Commonly studied aspects include the overall appeal of the soundscape [36,50,51] and the appropriateness of specific sounds. Appeal gauges how pleasing a sound is to visitors, while appropriateness relates to whether a sound fits its location and is deemed acceptable. These measures can diverge; visitors might find a sound unpleasant yet still acceptable, recognizing it as part of the natural world [36,37,39,52] or necessary for environmental maintenance. An improved understanding of how these measures manifest in the perceptions of different visitor groups may improve the applicability of perceptual data, permitting managers to calibrate perceptions with their own understanding.

It is important for managers to understand visitor perceptions of appeal and appropriateness, as research shows the existence of a disconnect between visitor and manager views on environmental impacts [53,54]. This misalignment can affect what visitors and managers deem appropriate concerning the conservation goals of protected areas [54]. Such discrepancies have implications for the goals of the GBF, particularly in terms of mainstreaming policies and practices. If visitor perceptions diverge from the broader objectives of the CBD, this highlights the need for educational initiatives to better align visitors with these goals and emphasize their significance in ecosystem conservation.

2.3. Research Purpose

This research examined visitors' perceptions of soundscape experiences in Queulat National Park (QNP) in Chilean Patagonia, located in the remote Aysén del General Carlos Ibáñez del Campo region. We aimed to understand the sounds and noises visitors encountered and their perceptions of them. We were particularly interested in obtaining a better understanding of visitors' perceptions of extent (duration and placement), appeal, and appropriateness, treating these as perceptual measures that could help managers to identify potential areas for empirical research and monitoring and as opportunities for environmental education and participative governance. By gaining insights into how different visitor groups experience and respond to natural sounds and anthropogenic noise, this research sought to help inform biodiversity policy and programming, both within Chile's protected areas and in adjacent private lands [2,11]. This led to three specific research questions:

- RQ1: How did sound observations vary between the two sites?
- RQ2: How did soundscape appeal and appropriateness differ between the sites?
- RQ3: Did the appeal and appropriateness of the soundscapes relate to the dominance (placement and duration) of anthrophonic sounds at each site?

3. Materials and Methods

3.1. Study Area

Founded in October 1983, QNP spans approximately 1541 square kilometers and features a hyper-humid to ultra-hyper-humid climate, with high humidity levels that often exceed 80% (Figure 1). The park's elevation varies from glacial peaks at 1000 to 1500 m to valleys and rivers near sea level (200 m). QNP is marked by diverse, interconnected ecosystems that support rich biodiversity and ecological health [55–58]. These ecosystems provide essential services such as carbon sequestration, water regulation, soil stabilization, and water purification, which are crucial for maintaining ecological balance and supporting local biodiversity. The Andean temperate deciduous shrubland, found at elevations of 700 to 1300 m, hosts unique flora like lenga and ñirre, alongside diverse wildlife, including over 70 bird species. Above 500 m, the Andean temperate grassland features low herbaceous formations that support high-altitude fauna, such as Andean condors and pumas.

The temperate evergreen forest, covering nearly 20% of the park, is primarily dominated by coigüe de Magallanes and is home to various amphibians, birds, and unique species like the Monito del monte (*Dromiciops gliroides*). The deciduous forest, ranging from 200 to 1200 m, supports various mammals and birds while integrating non-vegetated areas that enhance ecological diversity. Aquatic habitats, including glacial lakes and rivers, are vital for nutrient cycling and habitat support, further enriching the park's ecosystems [55–58]. Overall, QNP is crucial for biodiversity conservation and provides significant ecosystem services, highlighting the need for ongoing management efforts to protect its unique environments and the local communities that depend on them.

Figure 1. Photography of Queulat National Park visitor areas taken during the study.

3.2. *Anthropogenic Pressures Affecting the Queulat National Park and Surrounding Areas*

The QNP and its surrounding area are experiencing increasing anthropogenic pressures. Modern settlement began here less than a century ago during the 1930s. This initial colonization focused on timber harvesting, small-scale agriculture, and the production of hand-woven wool rugs. Regional connectivity between Puyuhuapi, QNP, and the rest of

Chile improved in the 1990s. In 2000, the park recorded 8500 visitors, a number that is managed well by existing infrastructure. However, following the Chilean government's new National Tourism Strategy (2012–2020), which aimed for aggressive market growth [59], visitation surged from 2012 to 2017, challenging existing management (Figure 2). Despite the increase in visitors, staffing and infrastructure did not keep pace, leading to overcrowding, conflict, environmental damage, and infrastructure failures during peak summer seasons. In parallel, a broader conservation strategy emerged, involving a historic agreement between the Chilean government and Tompkins Conservation to expand national parks and protected areas. This included the Route of the Parks of Patagonia, aiming to enhance nature-based tourism [60–63]. After facing management challenges in 2017, new policies were implemented in 2018 to mitigate ecological pressures and resource overloads, including visitor restrictions. These measures faced resistance from the tourism sector, limiting the Chilean National Forestry Corporation's (CONAF) ability to enforce management policies between 2017 and 2019. Consequently, visitation numbers increased again in 2019 before declining due to COVID-19 closures in 2020 and 2021. As of 2019, the nearest urban center, Puyuhuapi, had approximately 319 homes and 855 residents [64]. Recently, the area has seen accelerated subdivision for second homes and tourism accommodations [65].

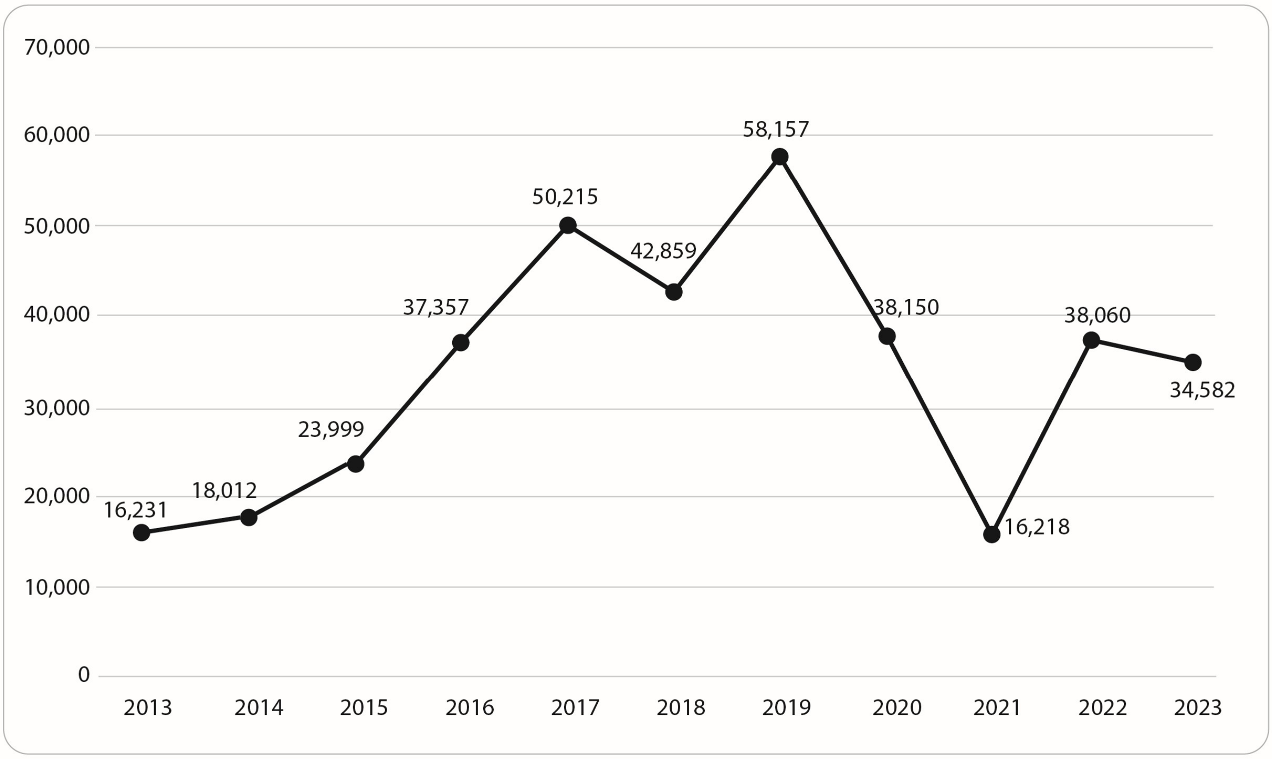

Figure 2. Queulat National Park—visitors by year.

3.3. Study Sites

Two sites within the QNP were chosen for this study in order to allow us to understand a range of soundscape perceptions (Figure 3). The Lagoon site was located near the loading dock for boat tours on the Tempanos Lagoon, viewing the Queulat Glacier. This site is at the far end of the 0.6 km trail, which is relatively flat and easy to walk. Surveys were either conducted on the dock or in a small clearing near a boat tour ticketing shed. At the Lagoon site, where crowding and lengthy wait times for a boat tour were both problematic, managers were concerned about visitor behavior and its impact. The Overlook site was located at a scenic overlook along the 3.3 km trail up the mountain, leading to a close-up view of the Queulat Glacier. This survey site consisted of a wooden viewing platform with an eastward view of a river winding through a valley, the distant fiords of the Pacific Ocean, and dense forest coverage on the surrounding mountains.

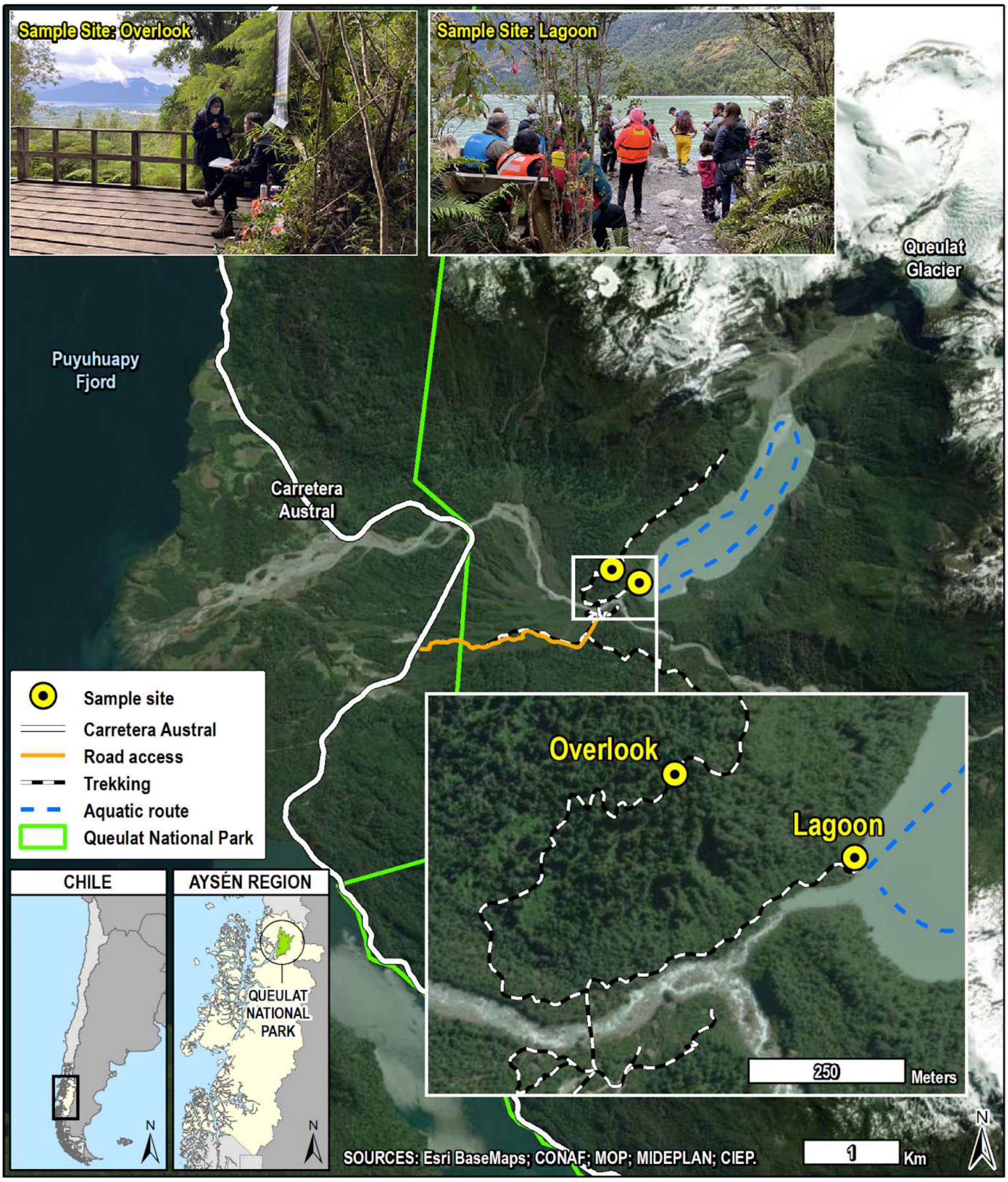

Figure 3. Study area layout and intercept sites.

3.4. Survey Design

This study aimed to assess anthropogenic noise levels in visitor areas during peak tourist periods. The QNP protocol involved a 1 min listening exercise followed by a brief survey of soundscape perceptions. Participants were instructed to relax and listen for one minute, after which they named the sounds heard. Surveyors recorded sounds using Gale et al.'s [49] adaptation of the ISO/TS soundscape taxonomy [48] (Figure 4). Participants then specified each sound's duration (using a five-point scale: pulse; ¼ time; ½ time; ¾ time; entire time) and placement (foreground, background, or both). They rated the sounds' appeal and appropriateness for the PA setting on a nine-point scale from −4 (very unappealing/inappropriate) to +4 (very appealing/appropriate), with 0 as neutral. This was consistent with previous PA research [36,39]. Lastly, participants rated overall soundscape aspects, including appeal and naturalness, using similar nine-point scales.

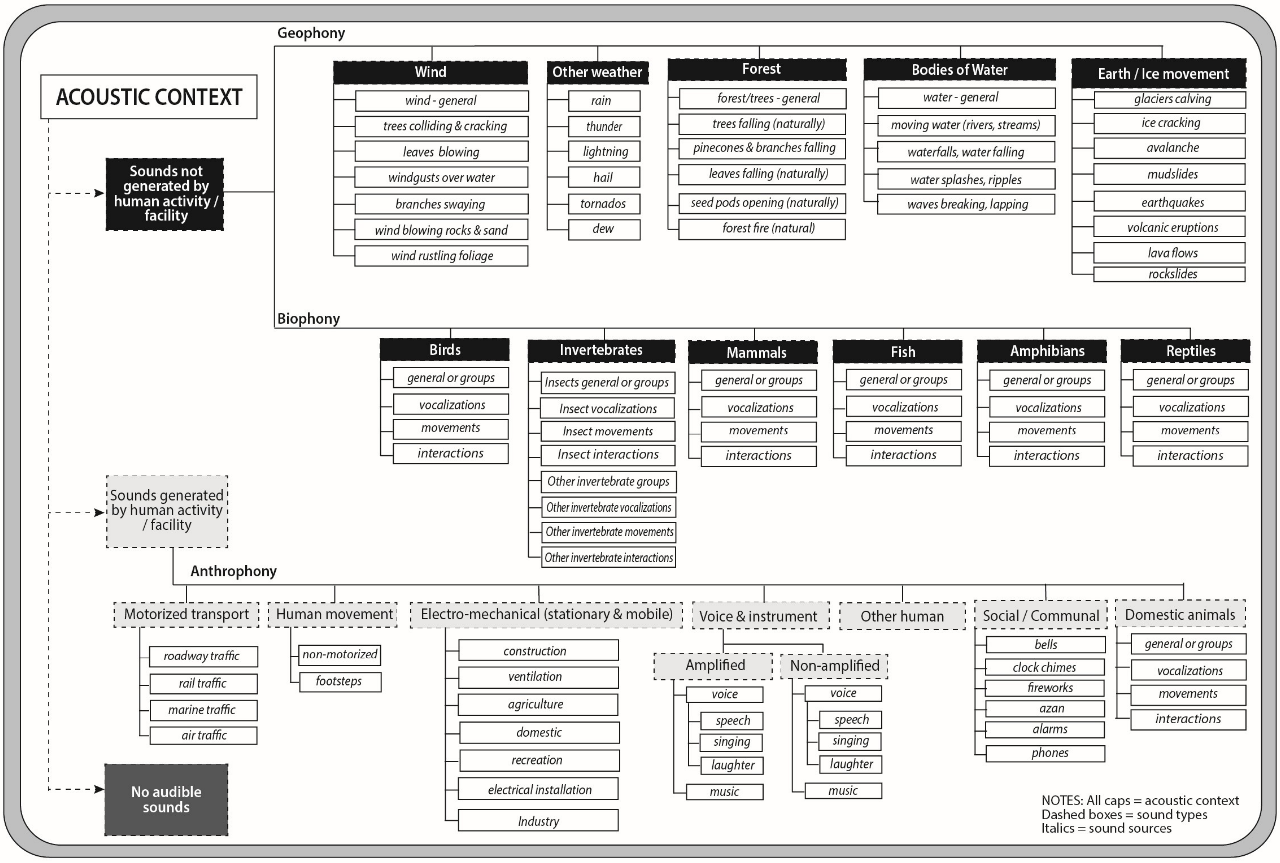

Figure 4. Gale et al.'s [49] adaptation of the ISO/TS soundscape taxonomy [48].

3.5. Data Collection

After receiving project approval from CONAF, the agency overseeing Chile's National System of Natural Protected Areas, Institutional Review Board (IRB) approval was obtained from the University of Wisconsin-Whitewater (IRB Protocol Number: IRB-FY2021-2022-63). Data collection, management, and reporting adhered to IRB-approved protocols. Data collection occurred over five days, from 22 to 26 February 2022, during the peak tourism season for Chilean nationals. Visitor surveys, conducted with informed consent, took place at the two sampling sites within QNP (Figure 3). Visitors were approached, provided with a brief explanation of the study, and invited to participate. Interviewers were present at both sites during the PAs' eight daily visitation hours and aimed to intercept as many participants (18 or older) as possible. Interviewers recorded refusals, along with the sampling site and date.

3.6. Data Analysis

Descriptive statistics for continuous variables are presented as means with standard deviations (*SD*), while categorical variables are shown as percentages (%) with counts (n). The frequency distributions of the sound category (biophony, geophony, anthrophony), duration, and placement data for each site were used to plot and contrast the two study sites. All quantitative analyses were conducted using SPSS version 29 (2023), with p-values (p) below 0.05 considered statistically significant. Non-parametric statistical tests were used for analyses relating the sound observation data (from the taxonomy outlined in Figure 4) to the sound placement and duration data. These were performed using the nominal sound placement and ordinal sound duration data. Chi-square tests and *Z*-values, along with Cramer's *V* tests for effect size, were employed to assess differences in sound observations between the two study sites. Mann–Whitney *U* tests compared the sound duration of biophonic, geophonic, and anthrophonic sounds across sites. Parametric tests were used for analyses involving the sound appeal and appropriateness variables since the evaluation of the data indicated that assumptions of normality, homogeneity of variance, and linearity were met. Independent samples *t*-tests with Cohen's *D* tests for effect size were implemented to evaluate mean differences in sound appeal and appropriateness between sites. One-way ANOVA tests with eta-squared (η^2) assessed differences in soundscape appeal and appropriateness ratings based on the observation of anthrophonic sounds in the foreground, background, or both. In consideration of the ordinal sound duration data, a non-parametric correlation analysis (Spearman) was used to identify relationships between sound type duration, soundscape appeal, and soundscape appropriateness ratings.

4. Results

According to CONAF official records, the QNP had 2230 visitors during the five days of sampling. Among this population, 364 (16.3%) were from the Aysén Region, 1736 (77.6%) were from other regions of Chile, and 130 (5.8%) were from other countries. Gender identification included 45.6% male, 52.7% female, and 1.5% unspecified. Of the total visitors, 749 were intercepted and invited to participate (33.6% response rate), with 99 (13.2%) declining, resulting in a final response rate of 650 (86.6%). This paper presents data from 2 of the 3 intercept locations in the larger study, comprising a total sample of 422.

4.1. Study Sample

Among the 422 participants, a majority (88.6%) were Chilean and from outside the Aysén Region (Table 1). Slightly over half identified as female (53.3%), and more than half (51.6%) were aged between 25 and 44 years. Participants were intercepted fairly evenly at the two sites, with 48–51% found at each location.

Table 1. Summary of sample characteristics, $n = 422$.

Variable	Category	% (*n*)
Residence	Aysén	7.6% (32)
	Chile—outside Aysén	88.6% (374)
	International visitor	3.8% (16)
City density	DG1 = ≤3999 ppl/km^2	51.4% (217)
	DG2 = 4000–5999 ppl/km^2	19.5% (82)
	DG3 = ≥6000 ppl/km^2	29.1% (123)
Gender	Female	53.3% (225)
	Male	42.9% (181)
	Nonbinary/third gender	0.9% (4)
	Prefer not to specify	2.8% (12)
Age	18–24 years	25.8% (109)
	25–34 years	37.9% (160)
	35–44 years	13.7% (58)
	45–54 years	9.2% (39)
	55–64 years	9.7% (41)
	65+ years	3.6% (15)
Survey site	Lagoon	51.4% (217)
	Overlook	48.6% (205)

4.2. RQ1: How Did Sound Observations Vary Between the Two Sites?

Participants observed a similar number of sounds at the two sites, with 844 sounds detected at the Overlook site and 882 detected at the Lagoon site. However, there were notable differences in the prevalence and dominance of anthrophony. Participants at the Overlook site reported a higher proportion of natural sounds (72%) compared to those at the Lagoon site (59%). Figure 5 chi-square test revealed significant differences in geophonic, biophonic, and anthrophonic sounds between the sites ($X^2(2) = 31.42$, $p < 0.001$, V = 0.14, Table 2). At the Lagoon site, biophonic and geophonic sounds constituted smaller proportions, while anthrophonic sounds were more prevalent compared to the Overlook site.

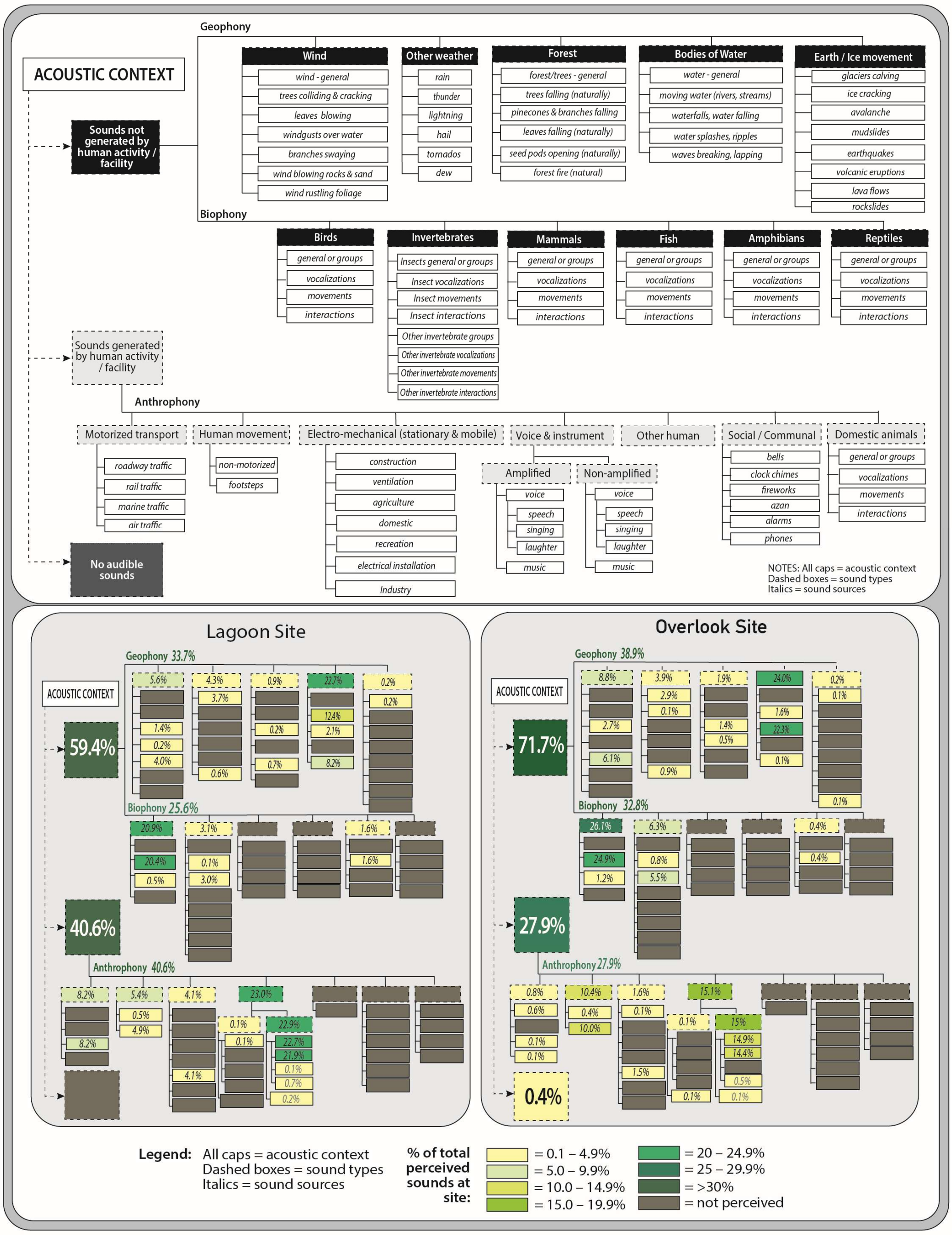

Figure 5. Gale et al.'s [49] adaptation of the ISO/TS soundscape taxonomy [48] for the Lagoon site and the Overlook site, including the percent of total sounds/site perceived for acoustic contexts and sound types.

Table 2. The proportion of geophonic, biophonic, and anthrophonic sounds between the two study sites (X^2).

Sound Type	% (*n*)	
	Lagoon	Overlook
Geophonic sounds	33.75% (299) a	39.06% (332) b
Biophonic sounds	25.62% (227) a	32.94% (280) b
Anthrophonic sounds	40.63% (360) b	28.00% (238) a
Total sounds	100% (886)	100% (850)

Note: different letters within a row indicate a significant difference between sites.

The taxonomies in Figure 5 visually compare the prominence of specific sound observations at the two sites. Geophonic sounds made up a similar proportion at both sites (39% at the Overlook and 34% at the Lagoon), with bodies of water being the most prominent geophonic sounds (24% at the Overlook and 23% at the Lagoon). Wind-related sounds were minimal, accounting for 9% of sounds at the Overlook and 6% of sounds at the Lagoon. Biophonic sounds constituted nearly a third of sounds at the Overlook (33%), while they comprised closer to a quarter at the Lagoon (26%). This was primarily due to bird vocalizations and movement sounds (26% and 21%, respectively). A greater proportion of anthrophonic sounds was observed at the Lagoon site (41%) compared to the Overlook (28%). Most anthrophonic sounds were linked to recreation, particularly human movement and non-amplified voices and instruments. Non-amplified voices were the most common, representing 15% of sounds at the Overlook and 23% at the Lagoon. Footsteps were also prevalent at the Overlook (10%), but less so at the Lagoon (5%). In terms of unique sound sources, both sites observed similar numbers, with 10–12 human-caused sounds and 16–17 natural sounds. Although infrequently heard, sounds from roadways, marine and air traffic, and construction were noted at the Overlook, but not at the Lagoon. The only motorized transport sound at the Lagoon was from the zodiac tour boat to the nearby hanging glacier.

The analysis of sound duration at each site revealed distinct acoustic environments at QNP. Mann–Whitney *U* tests showed significant differences in biophonic and anthrophonic sound durations between the two sites (Table 3). Biophonic sounds had longer durations at the Overlook site (median score of 4, ¾ of the listening minute) compared to the Lagoon (median score of 2, ¼ of the listening minute). Conversely, anthrophonic sounds were longer at the Lagoon (median score of 5, constant) than at the Overlook (median score of 2, ¼ of the listening minute).

Table 3. Observed duration of the different sound types across the three sample sites.

	Lagoon Median	Overlook Median	*U*	*p*
Biophonic sound duration	2	4	42,133	<0.001 **
Geophonic sound duration	5	5	48,313.5	0.601 ns
Anthrophonic sound duration	5	2	23,743.5	<0.001 **

Note: ** signifies that the differences are significant at the 0.01 level; "ns" signifies that the differences are not significant.

Figure 6 synthesizes the prominence (placement and duration) of geophonic, biophonic, and anthrophonic sounds, which are color-coded by type. Row height indicates the proportion of each sound type at each site, while the width of the shaded areas within each row represents the proportions of sounds observed in foreground only, foreground and background (both), and background only. Musical note sizes reflect the duration of sounds, from pulse (very brief) to constant. Placement was similar for geophonic sounds but varied for biophonic and anthrophonic sounds at the two sites. At the Lagoon site, 52% of biophonic sounds were in the background, while 70% at the Overlook were in the foreground or both. For anthrophonic sounds, 73% were in the foreground or both at the Lagoon, compared to 62% at the Overlook. Sound duration dynamics are notable. At the Lagoon, anthrophonic sounds were longer-lasting: 62% were constant in the foreground, and 71% were constant in both planes. At the Overlook, anthrophonic sounds tended to be shorter in both planes. Conversely, biophonic sounds were shorter at the Lagoon but more constant at the Overlook. Geophonic sounds were consistently heard at both sites, and were mixed with constant anthrophonic sounds at the Lagoon and more biophonic sounds at the Overlook.

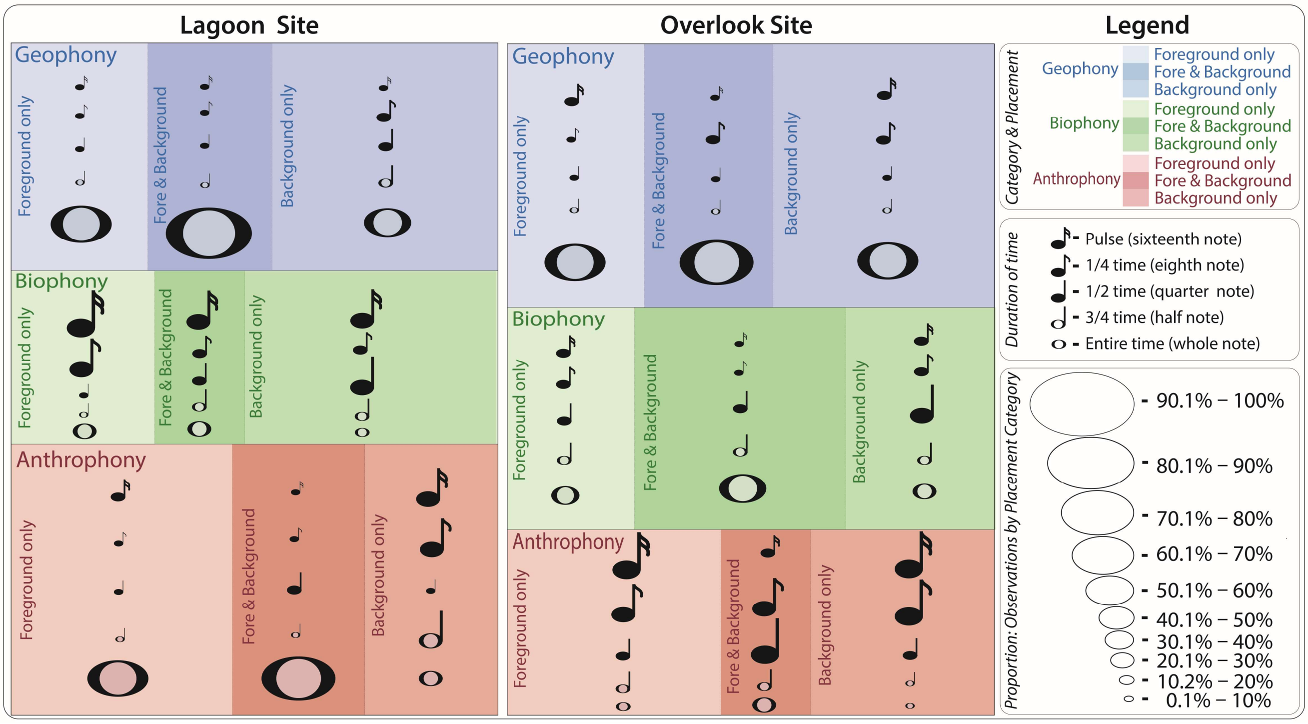

Figure 6. A dashboard contrasting observed sound type prevalence, placement, and duration at the two study sites.

4.3. RQ2: How Did Appeal and Appropriateness Differ Between the Sites?

Soundscape appeal and appropriateness ratings were generally positive, with mean appeal at 2.66 (*SD* = 1.86) and appropriateness at 2.52 (*SD* = 2.09). However, significant differences emerged between the two study sites. Participants at the Lagoon site rated both appeal and appropriateness near the midpoint between neutral and very appealing/appropriate, with values notably lower than those at the Overlook, whose mean scores approached very appealing/appropriate (Table 4).

Table 4. Independent samples *t*-tests for mean differences in soundscape appeal and appropriateness between the study sites.

Measure	Lagoon		Overlook		T (419)	p	D
	M	SD	M	SD			
Soundscape appeal	2.06	2.15	3.30	1.23	−7.24	<0.001 **	0.71
Soundscape appropriateness	1.78	2.40	3.31	1.29	−8.08	<0.001 **	0.79

Note: ** signifies that the differences are significant at the 0.01 level. Scale: −4, −3, −2, −1 (very unappealing/inappropriate); 0 (neutral); 1, 2, 3, 4 (very appealing/appropriate).

4.4. RQ3: Did the Appeal and Appropriateness of the Soundscapes Relate to Dominance (Placement and Duration) of Anthrophonic Sounds at Each Site?

At both sites, soundscape appeal and appropriateness ratings were significantly higher when anthrophonic sounds were solely observed in the background compared to when they were detected in both planes (Table 5). However, ratings did not significantly differ when anthrophonic sounds were only in the foreground versus when they were present both planes. Notably, at the Overlook site, appeal ratings were lower when anthrophonic sounds were present only in the foreground or in both planes compared to when they were solely present in the background.

Table 5. Mean differences in soundscape appeal and appropriateness ratings based on placement of anthrophonic sounds at each site.

	Foreground		Background		Both		*F*	*p*	η^2
	M	*SD*	*M*	*SD*	*M*	*SD*			
Lagoon site									
Soundscape appeal	2.07^{ab}	2.17	3.04^{b}	1.28	1.70^{a}	2.26	4.19	0.017 *	0.039
Soundscape appropriateness	1.70^{ab}	2.65	2.85^{b}	1.49	1.42^{a}	2.37	3.79	0.024 *	0.036
Overlook site									
Soundscape appeal	2.94^{a}	1.40	3.61^{b}	0.91	2.75^{a}	1.55	6.35	0.002 **	0.077
Soundscape appropriateness	3.06^{ab}	1.48	3.61^{b}	0.95	2.56^{a}	1.62	7.64	<0.001 **	0.091

Note: **—signifies that the differences are significant at the 0.01 level; *—signifies differences are significant at the 0.05 level. Unique letters indicate a significant difference between groups.

Spearman correlation analyses revealed significant negative relationships, at $p < 0.01$, between the duration of anthrophonic sounds and soundscape appeal and appropriateness ratings at both sites (Tables 6 and 7). At the Lagoon site, these negative correlations were contrasted by significant positive correlations at $p < 0.01$ between the durations of geophonic and biophonic sounds and soundscape appeal and appropriateness. At the Overlook site, correlations between natural sound duration and soundscape ratings were less clear, with a notable positive relationship observed only between geophonic sound duration and soundscape appropriateness.

Table 6. Lagoon site correlation matrix, relating sound type duration with visitor perception variables.

	M	*SD*	1.	2.	3.	4.	5.
1. Geophonic sound duration	4.364	1.431	1	0.180 **	−0.053	0.272 **	0.250 **
2. Biophonic sound duration	2.447	1.774		1	−0.169 *	0.333 **	0.298 **
3. Anthrophonic sound duration	4.223	1.469			1	−0.406 **	−0.379 **
4. Soundscape appeal	2.056	2.147				1	0.767 **
5. Soundscape appropriateness	1.778	2.403					1

Note: ** signifies correlation is significant at the 0.01 level (2-tailed), * signifies correlation is significant at the 0.05 level (2-tailed).

Table 7. Overlook site correlation matrix relating sound type duration with visitor perception variables.

	M	*SD*	1	2	3	4	5
1. Geophonic sound duration	4.853	0.641	1	−0.018	−0.066	0.113	0.250 **
2. Biophonic sound duration	3.824	1.468		1	−0.039	0.097	0.057
3. Anthrophonic sound duration	2.181	1.741			1	−0.455 **	−0.448 **
4. Soundscape appeal	3.298	1.226				1	0.775 **
5. Soundscape appropriateness	3.307	1.290					1

Note: ** signifies correlation is significant at the 0.01 level (2-tailed).

5. Discussion

PNQ managers aimed to understand visitor perspectives of noise from rising anthropogenic pressures in key visitor areas of the park, considering the increasing evidence of noise's cyclic effect on visitor experiences and behaviors [11,25,28].

5.1. Sounds and Noise Prevalence Observed in Queulat National Park Settings

The richness of data obtained in this study demonstrates the potential to involve visitors in acoustic environment monitoring in the QNP, providing managers with simple dashboards (Figures 5 and 6) representative of the visitor-perceived soundscape dynamics within our two study sites. The taxonomies in Figure 5 provide a graphic comparison of the sounds and a visual contrast of the differences between the sites in terms of sounds generated, or not generated, by human activity and facility. Participant sound observations made using the expanded taxonomy [49] demonstrate the context gained from the addition of more detailed biophonic and geophonic sound sources to the ISO technical soundscape research specifications [48]. The ISO specifies five categories of sound sources associated with nature—wildlife, wind, water, thunder, and earth/ice movement. Using the expanded taxonomy of sound sources, participants observed 16 sound sources at the Lagoon site and 17 sound sources at the Overlook site, in addition to the 10–12 human-caused sounds observed.

Many of the unique characteristics of the QNP ecosystems were reflected in the acoustic characterization of the participants in the study; yet, anthrophonic sounds were prevalent, comprising 40.6% at the Lagoon site and 27.9% at the Overlook site. The taxonomies provide managers with a general understanding of the typical characteristics of those sounds (amplified sounds, voices & laughter, recreation equipment sounds, footsteps, etc.). Geophonic sounds, particularly moving and falling water, as well as lapping waves, dominated both sites, enhancing visitors' connection to the moisture-rich environment crucial for biodiversity (Figure 5). Wind also played a significant role in the soundscape, primarily allowing visitors to "hear" the sounds of the QNP forests through its interactions with the trees. The taxonomy of Gale et al. [49] revealed additional natural sound sources that distinguished the sites and provided context. Notably, there was a limited variety of biophonic sounds, as many mammals in the park, such as the South American gray fox (*Lycalopex griseus*), the Patagonian hog-nosed skunk (*Conepatus humboldtii*), the Chilean bat (*Myotis chiloensis*), the pudú (*Pudu puda*), and the puma (*Puma concolor*)—amongst others—are relatively "quiet" [55–58]. In contrast, more than 70 bird varieties inhabit the QNP; for example, some of the avian fauna common to this ecosystem include the Austral parakeet (*Enicognathus ferrugineus*), the Patagonian flicker (*Colaptes pitius*), the thorn-tailed rayadito (*Aphrastura spinicauda*), the white-crested elaenia (*Elaenia albiceps*), the Patagonian sierra finch (*Phrygilus patagonicus*), the black-chinned siskin (*Spinus barbatus*), the hummingbird (*Sephanoides galeritus*), the chucao tapaculo (*Scelorchilus rubecula*) and the black-throated huet-huet (*Pteroptochos tarnii*) [55–58]. The vocalizations of QNP's abundant birdlife, along with amphibians and insects, offered visitors a diverse range of biophonic stimuli in both settings (Figure 5).

Marketing efforts for QNP highlight wildlife observation as a key attraction, yet only five biophonic sounds were recorded, making up 25.6% and 32.8% of the soundscape at the Lagoon and Overlook sites, respectively. This indicates that much of the park's biodiversity goes unheard by visitors. Managers should consider emphasizing audible biophonic sounds in visitor education programs to help them recognize and appreciate the biodiversity that attracts them to the park. In this way, the QNP can serve as a living laboratory, training visitors to identify subtle biophonic sounds and fostering connections with the natural environments they encounter in their daily lives.

5.2. Enriching Context Through Perceptions of Dominance (Duration and Placement)

Despite the general similarity in sounds at each site, the layering of dominance—assessed through visitor perceptions of sound duration and placement—enhances the understanding of different soundscapes and experiences. At the Overlook site, with less anthropogenic noise, the placement and duration of biophonic sounds differed significantly from that at the Lagoon site (Figure 6). Participants at the Overlook site experienced a listening environment where they felt "surrounded" by foreground biophonic sounds, primarily from birds. In contrast, at the Lagoon, biophonic sounds were mostly background noise, overshadowed by anthropogenic sounds.

Figure 6 integrates the prevalence of observed sounds with the context on dominance, highlighting how different sound combinations characterize various park locations and reflect overall park characteristics. Notably, anthrophonic sounds were more prevalent in the foreground at the Lagoon, with 73% of observations noting them in the foreground or both planes, compared to 62% at the Overlook. Moreover, at the Lagoon, 62% of anthropogenic sounds were perceived as constant in the foreground, and 71% were detected along both planes. In contrast, biophonic sounds at the Lagoon were primarily heard in the background and for shorter durations.

Visitor noise was less concerning at the Overlook; although a significant proportion of sounds were anthrophonic, they were typically short in duration and characterized by brief pulses, lasting about a quarter of the time compared to foreground sounds at the Lagoon site. Few anthrophonic sounds were constant at the Overlook. In contrast, visitors predominantly experienced biophony in "surround sound", with many reporting sounds in both the foreground and background, often lasting throughout their visit. The greater number and longer durations of biophonic sounds at the Overlook suggest that visitor noise may have a reduced impact on wildlife communication compared to the Lagoon.

Collecting dominance data also aids in identifying anthrophonic disturbances from external sources in natural settings. At the Lagoon, high levels of anthropogenic noise dominated the acoustic experience, with a significantly larger percentage of motorized sounds due to a departing boat tour (8.2% compared to 0.8% at the Overlook), and no outside anthropogenic noises were perceived. Conversely, at the Overlook, where anthropogenic noise was less dominant and primarily heard in short bursts, a small but relevant number of external noises (e.g., construction, marine, road noise, airplanes) were observed.

Noises coming from developments near the QNP, though rare in this study, underscored the need for monitoring as external pressures grew. Anthrophony from outside the QNP affects visitor areas like the Overlook site, diminishing the natural experience. Monitoring these trends and advocating for biodiversity-friendly policies that incorporate acoustic considerations in construction is crucial for protecting both habitats and visitor experiences. Future research should assess the impacts of external anthropogenic noise on visitor experiences and QNP ecosystem services [25,66,67]. Management planning may need to extend beyond park boundaries, necessitating research and policies for acoustic protection across sectors.

5.3. Visitor Reactions to the Queulat National Park Soundscape

The central focus of this research was understanding visitors' alignment with PA missions through their perceptions of soundscapes. Visitors identified anthrophonic sounds as prominent and problematic, particularly at the Lagoon, QNP's most accessible site. This aligns with management concerns regarding noise impacts from visitor congestion, indicating that visitors can discern when soundscapes deviate from the PA ideals. Additionally, soundscapes at the Lagoon were rated as less appealing than those at the Overlook, highlighting the value visitors place on natural soundscapes. This awareness suggests that involving visitors in monitoring could enhance their connection to experiences and satisfaction. Further research is needed to explore these dynamics. Practically, management measures to reduce anthropogenic noise at the Lagoon to levels below river sounds could improve visitor perceptions of the soundscape.

It is encouraging that visitors could perceive and record various soundscape attributes within a minute of observation and without prior training. Their insights are valuable for managers in identifying potential issues. In the QNP, the loud, constant sounds of the river illustrate the need for context beyond dBA, incorporating factors such as duration and dominance. While the river is the loudest sound in the park, visitor perceptions suggest it is appealing and appropriate, unlike the disruptive sounds from visitors, particularly at the Lagoon site.

This research highlights the potential for enhancing visitor interpretation programs by emphasizing soundscapes, particularly given the promising data on visitors' ability to identify acoustic-related problems as both unappealing and inappropriate for the setting. Implementing initiatives such as a soundscape-based interpretative trail could serve as an effective tool to improve awareness and perception skills among visitors. By fostering a deeper understanding of soundscapes, these programs could enrich the visitor experience, promote mindfulness of natural sounds, and encourage greater appreciation for the QNP's acoustic environment. Ultimately, such efforts could lead to more harmonious interactions between visitors and the park's natural soundscapes, aligning visitors' perceptions with the park's mission.

6. Conclusions

Visitor soundscape perception monitoring has the potential to inform new pathways for valuing biodiversity and promoting regenerative, sustainable behaviors. By incorporating mindful listening, visitor education, and visitor soundscape perceptions into broader conservation strategies, meaningful dialogue can emerge around biodiversity preservation and sustainable tourism in ecologically sensitive areas. Encouraging visitors to stop, listen, and reflect on the sounds they encounter in nature may influence their attitudes toward anthropogenic noises and their impact on natural systems. Future research should test interventions (e.g., interpretative trails, guided soundwalks, etc.) in order to better understand this potential and the most effective levers to employ.

PAs can serve as natural laboratories for exploring human–nature relationships and developing GBF strategies. The QNP, for instance, allowed us to engage with numerous national visitors from diverse acoustic backgrounds (Table 1). Understanding how different demographic groups perceive natural soundscapes within PAs like the QNP may help to inform strategies for mainstreaming biodiversity-friendly acoustic practices across various societal sectors. Extending soundscape research to urban areas and comparing visitor perceptions across settings could yield valuable insights for the potential to extend GBF strategies outside of PA boundaries. Both of these areas deserve additional research attention.

While managing external sounds is challenging, creating opportunities for visitors to consciously "notice" these noises may yield effective "teachable moments". Research indicates that interpretative educational materials, such as signage to explain the impacts of noise on biodiversity and the benefits of natural sounds, can enhance visitor experiences [45,68,69]. This approach may address indirect drivers of natural system change and help to shift underlying values and behaviors toward pro-biodiversity perspectives. Further research is needed to evaluate acoustic interpretive materials in Chilean PAs and beyond, with implications for educational initiatives at the interface with private lands [2,11].

Utilizing synthesized graphical dashboards (Figures 4 and 5) to analyze visitor perception data provided insights into the acoustic dynamics of the QNP, revealing its unique characteristics in comparison to other acoustic contexts. Greater use of tools like the taxonomy and dashboards across various settings—from urban to wilderness environments—could promote a more holistic understanding of sounds and noise, facilitating the mainstreaming of acoustic policy and educational efforts. Enhancing the nuance in the taxonomy regarding natural sounds (geophony and biophony) will draw attention to both observed and unobserved sounds that warrant consideration [70]. Integrating objective sound level data at the zip code level could further enrich these approaches [28].

The IPBES 2019 global assessment on biodiversity and ecosystem services stressed the need for transformative change in how we engage with biodiversity [11]. It called for innovative environmental governance that emphasizes justice and inclusion in conservation. Our findings within the context of the QNP suggest that involving visitors in acoustic monitoring may enhance the potential for participatory forms of governance, aligning with the leverage points outlined by Brondizio et al. and the GBF [2,11]. As perception-based acoustic monitoring evolves, validating its potential to foster pro-biodiversity values and behaviors, alongside its role in mainstreaming policy and practice across societal sectors, will be essential.

The results also suggest the importance of extending biodiversity protection beyond PA limits, especially along the private land/PA interface, as development noise carries into PA ecosystems and habitats, affecting both biodiversity and visitor experiences [25,66,67]. Even within the remote setting and context of the QNP, outside development noise could be observed, reinforcing the importance of mainstreaming conservation policy to effectively integrate biodiversity conservation within the areas and biological corridors surrounding PAs [12,13]. Additional place-based research is important as GBF strategies should be rooted in the context of their countries and regions. These projects will not only extend biodiversity protection but also illustrate how nature-friendly practices can be integrated into daily life.

This research is limited by its focus on only two sites within QNP, which may not fully capture the diversity of soundscape perceptions across the entire park or other protected areas. Additionally, the study's reliance on visitor self-reports for soundscape perceptions may introduce bias, as individual experiences and interpretations of sound can vary widely. However, despite these limitations, this study provides valuable insights into visitor perceptions that can inform management practices and conservation strategies, within and beyond the borders of PAs. By highlighting the nuances of soundscape experiences, this research contributes to the growing body of knowledge on acoustic environments in biodiversity rich settings, offering a foundation for future studies to explore soundscapes more comprehensively across diverse settings. Such findings can aid researchers and managers in developing targeted interventions to enhance visitor experiences and biodiversity conservation efforts, helping to inform integrative biodiversity conservation strategies and governance.

Author Contributions: Conceptualization, T.G. and A.E.; methodology, T.G., A.E. and A.B.M.; software, T.G. and A.E.; validation, T.G., A.E. and A.B.M.; formal analysis, T.G., A.E. and A.B.M.; investigation, T.G., A.E. and A.B.M.; resources, T.G.; data curation, T.G., A.E. and A.B.M.; writing—original draft preparation, T.G., A.E., K.B. and A.B.M.; writing—review and editing, T.G., A.E., K.B. and A.B.M.; visualization, T.G. and A.E.; supervision, T.G.; project administration, T.G.; funding acquisition, T.G. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by Chile's National Research and Development Agency (ANID) under the ANID's Regional Program R17A10002; the CIEP R20F0002 project; and the CHIC-ANID PIA/BASAL PFB210018, and FONDECYT 1230020.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved in by the Institutional Review Board of University of Wisconsin-Whitewater (IRB Protocol Number: IRB-FY2021-2022-63; Date: 4 February 2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Please note that the original data presented in the study are openly available in the Mendeley data repository: Gale, Trace; Ednie, Andrea; Báez Montenegro, Andrea (2023), "Soundscape Citizen Science Potential in Chilean Patagonia's Queulat National Park", Mendeley Data, V1, doi: 10.17632/62yrz7bv7c.1 [71].

Acknowledgments: The authors would like to thank: (1) Andrés Adiego for his technical support with this research, including fieldwork and the development of the map (Figure 3); (2) the administrators and staff of the Queulat National Park and Aysén's Department of Wild Protected Areas (DASP) of the Chilean National Forestry Corporation (CONAF); and (3) the participants in this research for their valuable perspectives.

Conflicts of Interest: The authors declare no conflicts of interest.

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