The Soundlapse Project

Exploring Spatiotemporal Features of Wetland Soundscapes

FELIPE OTONDO AND **ANDRÉ RABELLO-MESTRE**

ABSTRACT

This article discusses an interdisciplinary project aimed at highlighting the acoustical heritage of wetlands by means of field recordings and a novel time-lapse montage method. The authors discuss a site-specific sound installation that was designed using original wetlands field recordings, live processing and spatial audio multichannel reproduction. The discussion focuses on spatial and temporal features of different types of recorded wetlands soundscapes. Future developments of this project will consider the implementation of a standalone spatiotemporal application, to be used in the context of virtual reality applications, game audio and interactive dance performance.

Soundscape research has increased exponentially in recent decades, mainly due to the availability of affordable portable recording technology and a growing public interest in acoustic ecology [1–4]. Following this trend, artists and researchers from diverse fields such as audio, cultural studies, game design, music technology, landscape ecology and urban planning are using field recordings as a regular practice [5–8]. Inspired by the pioneering work of the composer R. Murray Schafer, and concerned by the increasing levels of noise pollution across the globe, various kinds of artistic and research projects have been developed over the past decade that investigate sonic environments using a holistic approach [9–13]. These developments motivated the International Organization for Standardization (ISO) to form a working group with the goal of developing the first international standard on soundscapes [14–16]. The resulting three-part standard includes information on conceptual definitions, reporting requirements and data analysis and makes suggestions for the use of Ambisonics and binaural microphone techniques. Another interesting emerging field of research in which field recordings play an important role is soundscape ecology [17]. This area of research involves the use of multiple passive acoustic recorders to study sonic environments as a combination of three types of sound sources: anthrophonies, biophonies and geophonies [18]. By carefully analyzing the acoustic attributes of simultaneous field recordings carried out at different monitoring stations, researchers are able to build sonic maps that allow them to assess the impact of human activity on landscapes [19].

Inspired by these developments, we carried out a series of 24-hour continuous field recordings in urban wetlands in the city of Valdivia, Chile. The aim was to study and highlight the natural and cultural heritage of the wetlands. In this article, we describe how we used these soundscape recordings to design and implement a sound installation. The process was based on an original time-lapse method that has the potential to be further developed for various kinds of artistic and research applications.

WETLAND SOUNDSCAPES

Wetlands are important sources of biodiversity, playing a significant role in the supply of fresh water and the survival of varied species of plants and animals [20]. Research by artists and scientists has shown that field recordings carried out in these natural areas can provide useful data on wetlands wildlife activity and help in assessing the impact of anthropogenic noise [21,22]. In line with these developments, there is an increased awareness in Chile surrounding land use and the degradation of ecosystems. The city of Valdivia is no exception. A considerable portion of the city's urban landscape is framed by an extensive network of wetlands, originated in 1960 by one of the strongest earthquakes on record. Figure 1 shows a map with Valdivia's urban wetlands (in shaded areas), as showcased in a recent study by Paulina Ibieta. Over the past few decades, citizens and community-based organizations have become increasingly concerned about the environmental impact of housing demands and illegal dumping on these natural habitats [23]. A pilot research project aimed to investigate this issue from an acoustic perspective. Twenty-four-hour continuous field recordings were made by

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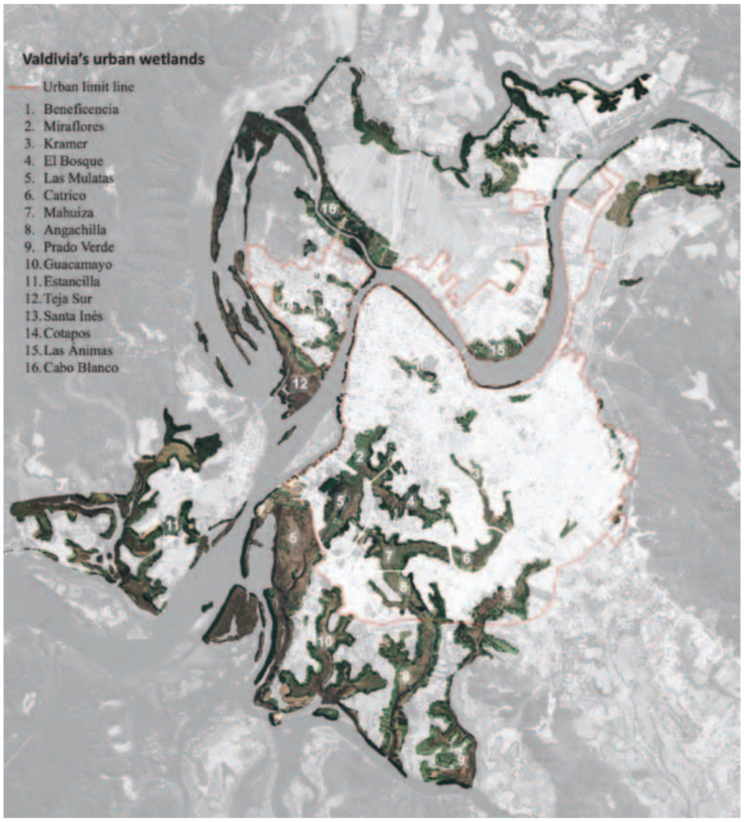

Fig. 1. Map of Valdivia's urban wetlands. (© Paulina Ibieta)

soundscape researchers as a means to assess the impact of anthropogenic noise on the sonic landscape of two wetlands in Valdivia [24]. Results of this research showed that continuous recordings can be an effective means for monitoring wetland wildlife activity and the impact of noise pollution. While this pilot project provided an interesting insight into the diversity of anthropogenic noise in wetlands and its impact on wildlife, its outcomes were seriously constrained by two main problems: (1) unpredictable performance of the semiprofessional audio recording equipment, operated in low temperatures and under difficult weather conditions, and (2) the inadequacy of most audio software for handling and editing very long audio files. With these issues in mind, an improved recording setup and an innovative montage method were designed and implemented, as described below.

FIELD RECORDINGS AND TIME-LAPSE MONTAGE METHOD

We selected three urban wetlands of the city of Valdivia as main locations for a new series of field recordings. The chosen sites were the Miraflores, El Bosque and Angachilla wetlands (numbers 2, 4 and 8 in Fig. 1). Each of these wetlands provides a unique soundscape, where biophonic, geophonic and anthrophonic sound sources are combined in unique ways. In order to capture the sonic environment of the three wetlands, two main field recording methods were implemented. The first method involved the use of short, periodic stereo recordings carried out at specific locations on the borders of the three wetlands over a long period of time. For this purpose, three Songmeter SM4 Wildlifeacoustics recording units were installed on the edges of the wetlands. These monitoring stations were spatially and temporally synchronized using a GPS accessory and programmed to carry out 5-minute stereo recordings each hour of each day over a period of 365 days. We used a 44.1 kHz sampling frequency and 16-bit quantization. The main goal of this recording methodology was to obtain a comprehensive database of short, discrete audio samples, chronologically arranged to be used as the basis for the time-lapse montage method described below. The second recording method was aimed at obtaining high-definition audio material in various spatial formats, recorded continuously for periods of between 1 and 2 hours. An 8-channel microphone array was installed at the El Bosque wetland. The array included a Neumann KU100 binaural dummy head, a DPA 4060 stereo spaced pair and an AMBEO VR Sennheiser microphone. Color Plate D shows pictures of the two recording setups described above.

We designed a sonic time-lapse montage method using both types of recordings as source material. For both types of recordings, the same type of signal processing described below was carried out independently on each recorded channel. This montage method was adopted as a way of generating short audio files that could retain the more significant acoustical features of the recorded soundscapes. An early version of the method involved deliberate inspection of the spectrograms of 24-hour recordings in order to manually select short samples from each recorded hour. We later modified this approach in order to (1) achieve greater methodological efficiency, opening up the possibility of automatically obtaining audio samples with comparable results and (2) avoid 24-hour recordings that, on top of being data heavy, are informationally redundant for the purpose of this project. Between samples, crossfade dynamic parameters between recorded samples were carefully adjusted in order to create an audio montage that could summarize the main spectromorphological attributes of the original 24-hour continuous recordings [25]. Figure 2

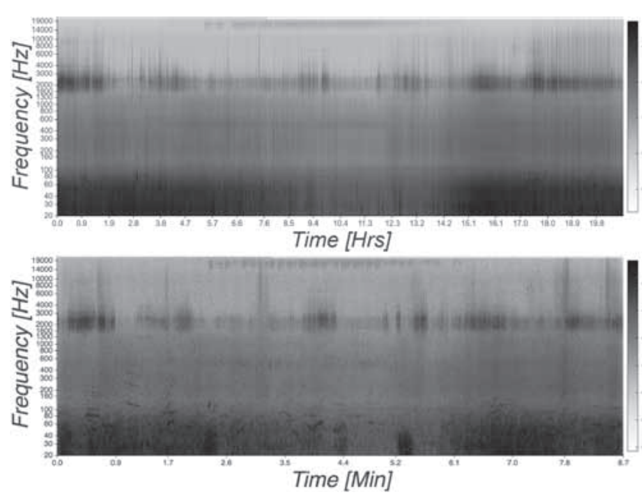

Fig. 2. Comparison between spectrograms of 24-hour continuous recording (top) and 9-minute generated time-lapse montage audio file (bottom). (© Felipe Otondo)

exemplifies the outcome of the time-lapse montage method, using a 24-hour wetland recording as source material (top spectrogram), resulting in a 9-minute time-lapse–generated audio file (lower spectrogram). As can be observed by comparing both parts of the figure, there is an overall resemblance between the two spectrogram representations—with some minor dynamic and temporal inaccuracies. While differences can be observed in the low and high frequencies, one should remember that the two parts of the figure have very different timescales. The recording shown at the top of the figure is 160 times longer than the short audio montage of the bottom of the figure. The presence of anthropogenic noise can be clearly observed in the lower spectrogram, most prominently low-frequency harmonic variations that can be linked to vehicle and airborne traffic.

SOUND INSTALLATION

Taking as a point of departure the collection of field recordings obtained, and the time-lapse methodology described above, we designed an immersive and site-specific sound installation. The aim was to take as a starting point some of the timbral and spatial attributes of these wetland soundscapes to design a space whose sonic architecture could be constantly determined by the spatial features of the recordings and its adjustable parameters—particularly sample and crossfade sizes. By means of live sound processing and spatialization techniques, we designed an immersive listening environment using short excerpts of field recordings as source materials. Various time-lapse montage techniques were applied. This idea stems from Anne Ring Petersen's model, which emphasizes that installations should activate both space and context: They should have a phenomenological focus on the viewer's bodily and subjective experience [26]. The location chosen for the implementation of the work was the multimedia museum "El Centro de Interpretación Patrimonial de Todas Las Aguas del Mundo" in Valdivia [27]. This venue was envisaged as a dynamic multimedia space, aimed at generating a link between local history and the city of Valdivia. The museum is housed in a two-floor, 112-square-meter underground space. It includes an audiovisual mapping system that allows short films to be projected on walls and floors and has interactive tactile platforms where visitors can access information about the various shows on display. Figure 3 shows a layout of the museum's spaces.

The sound reproduction setup constructed for the installation involved the use of a laptop computer. This ran an application—designed using the Max/MSP programming environment—to handle audio live processing and multichannel sound diffusion in the two floors of the hall. Figure 4 shows a diagram of the installation setup and the position of loudspeakers on the top and bottom floors of the museum. The first step in the program routine involved a chronological selection of samples from a database of 8,760 5-minute field recordings (24 samples × 365 days) carried out over the course of a year at the El Bosque wetland in Valdivia (number 4 in Fig. 1). We adapted 12-second audio samples from each recording using crossfade dynamic processing in order to allow gradual transitions between samples to overlap to create the time-lapse montage file. By means of spectral processing techniques, we created two separate montage mixes (for the top and bottom floors, respectively). The first audio mix was conceived to fit the larger space on the top floor. It was designed using sound-lapse stereo audio files, reproduced through a quadraphonic system with a variable time delay between pairs of loudspeakers. We used longer crossfade transitions in this case to create an immersive spatial design. Subtle timbral variations were mapped to images projected on the front wall. The second audio mix was envisioned for the smaller space on the bottom floor. It deployed the Ambisonic recordings with a more dramatic and less realistic approach. The goal was to create an intimate sonic environ-

Fig. 3. Layout of the De Todas las Aguas del Mundo museum in the city of Valdivia, southern Chile. Architect Robert Martínez, Roberto Benavente Arquitectos (rvenabenter@gmail.com) and Amercanda (pabloc@amercanda.com). Project commissioned by Contraloría General de la República. (© De Todas Las Aguas Del Mundo museum)

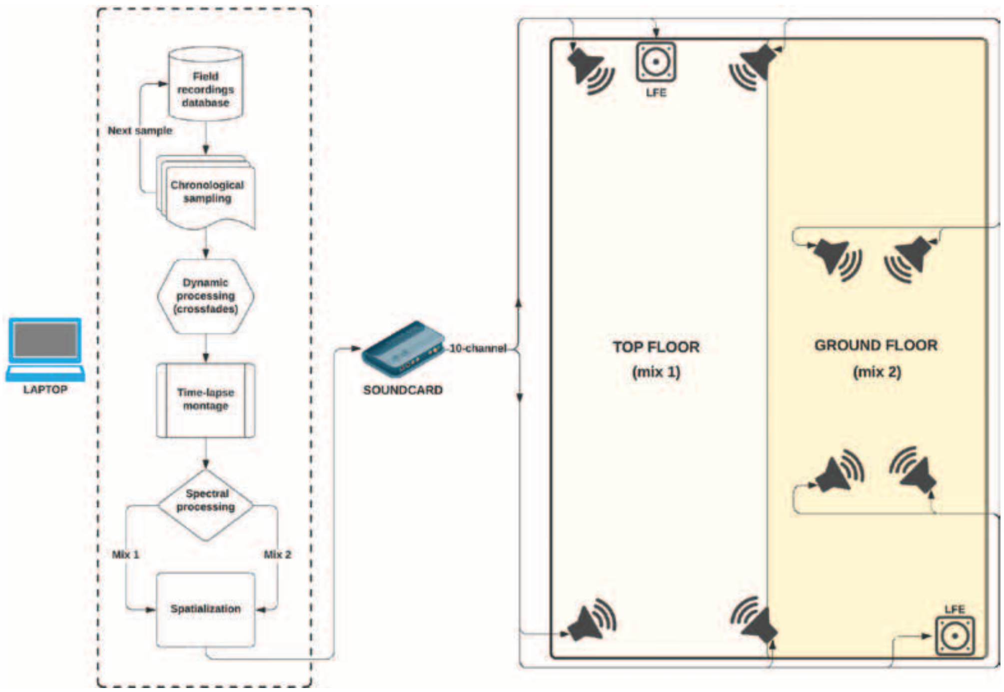

Fig. 4. Time-lapse algorithm routine and audio setup for the 10-channel sound installation at the De Todas las Aguas del Mundo museum in Valdivia. (© Felipe Otondo)

ment, one that would allow visitors to explore connections between the show on display and the projections on the floor. The filtering and spatial processing employed in both mixes was aimed at emphasizing contrasts between spaces. We also designed it to encourage people to move from the first to the second floor and vice versa.

CONCLUSIONS AND FURTHER WORK

One significant outcome of this project was the creation of an innovative spatiotemporal environment that encourages active listening as a tool for a better understanding of how natural heritage and urban presence overlap in the Valdivian wetlands. Through the use of field recordings in various spatial formats as an input to the time-lapse algorithm discussed above, the project provides an original framework for highlighting significant spatial and temporal features of wildlife sonic environments. Stereo, Ambisonics and binaural field recordings proved to be rich and versatile source materials but difficult to implement in challenging weather conditions in wildlife settings. Future developments of the project will explore the use of higher-order Ambisonics recording applied to virtual reality. We also plan to conduct cognitive assessment of this research by means of controlled listening tests.

The time-lapse montage method presented here allowed for the generation of short audio files of various spatial and temporal qualities. These are suitable for use in different kinds of artistic and educational contexts. The main current limitation of the method lies in the fact that the sampling process in the source field recording is done arbitrarily, at specific times to be determined by the user. A new version of the algorithm could integrate machine learning techniques in order to allow a selective sampling process, one that could be informed by the acoustic content of the field recordings employed.

A standalone spatiotemporal application for artistic and educational use would be a natural development of this project. A first potential area of development is immersive multimedia installations for museums or art galleries, where enhanced aural awareness has the potential to effectively strengthen the audience's relationship to space and time [28].

Results of the project show that field recordings can provide a fruitful framework for rich listening experiences in education, cultural and aesthetic contexts. The model is flexible enough to be accommodated in a range of various acoustic environments by means of loudspeaker positioning and equalization. Game audio could also benefit from the implementation of an integrated spatiotemporal audio engine, which could enhance narrative and realistic elements of interactive sound design [29]. In line with Mark Grimshaw's first-person shooter acoustic ecology model, an enriched game engine could integrate the time-lapse montage method to generate varied and engaging sound materials based on acoustic and perceptual features of environmental recordings [30]. A further potential area of development of the application could be music and dance performance. An interactive version of the algorithm used for the installation could be adapted to integrate spatiotemporal features of sounds and performers' movements. Previous research of ours showed that spatial sound can be used as an effective tool to engage dance and music audiences, with shared creative attributes of composition and choreography [31]. By means of sensors or tracking devices, the movements of performers could be mapped to parameters of the spatiotemporal engine (such as duration of samples, spectral transformations and duration of crossfades, as well as depth and positioning of sound sources in a particular sound field).

Overall, we believe that the project presented here provides an original and flexible framework for the development of tools that respond to growing social and ecological demand. This research responds to this demand by helping users to engage with natural soundscapes in creative and innovative ways.

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COLOR PLATE D: **THE SOUNDLAPSE PROJECT: EXPLORING SPATIOTEMPORAL FEATURES OF WETLAND SOUNDSCAPES**

Field recording setups used to generate raw material for the time-lapse montage method. Stereo recording system for discrete recordings (left) and 8-channel microphone setup for continuous recordings in various spatial audio formats (right). (See the article in this issue by Felipe Otondo and André Rabello-Mestre. © Felipe Otondo.)