"FRAGMENTS OF EXTINCTION" A PERIPHONIC AUDIO-VIDEO CONCERT BASED ON 3D-AMBISONICS FIELD RECORDINGS OF PRIMARY RAINFOREST ECOSYSTEMS

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ABSTRACT

Following the extensive data collection carried out with space-preservative recording methodologies during the last field recording trips to the remote equatorial primary rainforests of Brunei and Sarawak (Borneo), and Dzanga-Sangha, Ndoki (Central Africa), the audio-video concert proposed a sequence of sonic experiences where pure unaltered recordings, were explored and then complemented with subtle digital sound synthesis. The spatial complexity and inter-species ecoacoustic order within the different sonic habitats (primary lowland dipterocarp forest, alluvial forest, pond and riverbank forest in Borneo, and dense forest and saline habitats in Africa), manifesting the balanced interplay among hundreds of biophonies, have been recorded with the highest 3D-Ambisonics definition possible in those remote environment, and presented with periphonic playback systems. Compositionally, different levels of time-lapse, explorations of audible and inaudible sonic languages, and a real-time spectrogram video projection, allowed the audience to understand the ecosystems' internal configurations. Subtle sensor-driven live musical integrations ideally build then a powerful metaphor of our species collaborating with these extraordinary composite ecosystems.

1. INTRODUCTION

Crossing boundaries between bioacoustics, acoustic ecology, electroacoustic technology, music composition and installation art, the long-term project Fragments of Extinction aims to portray and reveal the ordered structures of primary ecosystems, define a possible model of compositional integration and make the outcome accessible to audiences to foster awareness of the current "sixth mass extinction." [1]
Natural soundscape has always provided unconscious imitative models for music creation. Western music tradition has deliberately turned to natural soundscape as a source of inspiration, and, with the increasing availability of recording tools and electroacoustic techniques, nature sounds have entered music as compositional elements. In recent times, few musicians have started to work and interact with bio-acoustic sources, generating different practices within 'environmental sound art'.
Studying ecosystem diversity from the music perspective, helps to reveal hidden structures of equilibrium and an aesthetic order (particularly noticeable in primary forests) which can be fully integrated in eco-acoustic composition [2]. Recording, reproduction and design of immersive sound installations can constitute an effective strategy to raise awareness within an ecological/environmental perspective.
The progressive decline of diversity and the consequential degradation of soundscape's balanced structures represents an immeasurable loss both for science (which will be denied the opportunity to study the sonic imprints of original ecosystems), and for artistic creation, since the fragile beauty of these possible models of sound organization will be lost forever. The aim of the international long-term project Fragments of Extinction is to bring the current biodiversity crisis to broad public attention, through spatial audio ecosystems' reconstruction (Fig.1).

Figure 1: *The author during the presentation of his project Fragments of Extinction, before the concert into the 25-speaker periphonic array at the EAA Symphosium, Berlin, April 4th 2014. (Photo: M. Kronlachner)*

2. FIELD WORK METHODOLOGIES

2.1. General Considerations

The project's research vision relies on the acknowledgment that natural habitats are highly organized systems: according to the niche hypothesis [3], species seem to follow niche separation, both in time and frequency domains, thus arranging their vocalizations very efficiently in the collective sonic space. In order to deepen the study of this hypothesis and its public artistic rendering, I have been focusing on the most ancient and complex eco-

systems on Earth – primary equatorial rainforests – where biodiversity is utmost, and these phenomena appear more traceable and clear. Furthermore, equatorial areas present stationary circadian cycles (equal duration of day and night all year through), thus species are evolutionarily tuned to this uniformity, resulting in more predictable sonic niches.
Bio-acoustic studies have focused on single species' sonic languages and behaviour both in terrestrial and marine habitats [4], and have employed Shannon-like and dissimilarity indices (H and D indices) [5] and complexity indices (ACI) [6] as methodological tools to assess biodiversity through entropy and information calculation. These approaches imply the use of high numbers of autonomous low-quality recording systems in the field, useful for ample data collection and quantitative analysis but not suitable for qualitative rendering of auditory and aesthetic properties of the soundscape.
The three-dimensional space-preservative [2] recording strategies I adopted seem to reveal appropriate both for conducting detailed analysis of biodiversity and for the scope of reproducing sound portraits of multifactorial natural soundscapes for artistic fruition.

2.2. Field Recording

The recording techniques I used call, thus, for a broader ecological perspective, involving the collection of as many components as possible of a complex soundscape. Within this approach, the spatial information of a given acoustic environment becomes a key element in understanding the complexity of its organization and making it available to audiences. Unlike other habitats, in such high canopy forests, sounds come from every direction, including above (e.g., birds and monkeys) and below (e.g., amphibians and insects) the listening position. This three-dimensional information is detected in its entirety by the human brain through several sub-parameters that agree with our composite natural perception of: 1) direction – the angle, in the 360° spherical domain, from where the various sound sources reach the listening position, the microphone; 2) perspective – how distant the sound sources are from the listening position and to each other; 3) dimension – how large their are. In order to effectively record these spatial attributes in the field, "space-inclusive" and "space-preservative" mic techniques have been largely employed to pick-up and retain the entire sonic space of these ecosystems for their reproduction over three-dimensional playback systems.

Figure 2: *Testing the recording system for a 24-hour continuous 8-channel recording in the saline of Dzanga Bai, Africa, 2008. (Photo: D. Monacchi)*

The investigation of long temporal sections of 24-hour+ continuous recording (Fig.2) in such remote and dangerous habitats forced me to develop in the past pioneering recording strategies suitable to the extreme conditions of: a) humidity percentage varying from 60 to 99%; b) absence of electric current, obliging very slow solar charges of multiple batteries; c) need of autonomous systems capable of recording during hazardous moments, e.g. night hours in Africa; d) need of hanging up the systems for protection from mammals (Fig. 3). Taking into account all these

Figure 3: *Displacement of an authonomous hi-def microphone system in Bai-Hokou, Dzanga-Sangha, Africa, 2008. (Photo: D. Monacchi)*

concerns while making the most out of cutting-edge technology – such as: mic capsules with 83dBA S/N ratio, studio-grade pre-amplification and A-D conversion, high sample rates of 96/192Khz for recording inaudible insects and bats species (Fig. 4), experimental multichannel 3D formats – was a process of years of empirical research. The result is the most vivid sound portraits of this endangered biological heritage, now available for posterity.
The recording campaigns I have carried out since 1992 used incresingly advanced methods for two-channel and multichannel field recording, always aiming to reach the cutting edge of the available technology. Dozens of different techniques have been employed, from classic music methodologies to broadcast and cinema standards to experimental self-built arrays. For the mentioned target and the several problems that always are encountered in the field, I have selected few of them. First Order Ambisonics microphone techniques (Core Sound TetraMic, Soundfield ST350 and Soundfield ST450 systems) are the most practical and useful systems in such extreme environmental conditions, to store, within the space-preservative approach, the whole spatial information. In addition, I always parallely use binaural recordings in the field, based on self-weared miniature pressure microphones (among which, Sennheiser mke2002 and DPA 4060) to retain a personal binaural stream and to allow for explorations of the forest habitats through convenient soundwalks. Furthermore, a quasi-binaural microphone (an experimental self-built spherical baffle with Schoeps CCM-2S pressure microphones) is employed to reach the best S/N ratio, allowing for the extension of the overall perceived perspective and clear distance sensitivity of far away biophonies.
I am currently experimenting in the field with microphone arrays and High Order Ambisonics approaches. This might constitute an advancement both for the application of these technologies to

outdoor field work and for standardising new methods for eco-systems heritage recording.

Figure 4: *Ambisonic and ultrasound recordings at a bat cave in the montane primary forest at Kinabalu – Sabah, Borneo 2012. (Photo: M. Fatigante)*

3. CONCERT OUTCOMES

Since the project's beginning, its concert outcomes have been adapted to extremely different contexts, venues and playback formats to render the multifaceted soundscapes of these diverse ecosystems. Over the years, I have been achieving the best results with 3D-ambisonic systems[1]. 2D systems can occasionally be employed but in this case the overall immersivity and a considerable part of directional information (the many species vocalizing from the elevation plane) is, of course, lost.

When I proposed to the Symposium organizing committee to install a periphonic system in Berlin for presenting my latest Africa and Borneo 3D field recordings, I immediately found enthusiastic response from Franz Zotter and the Graz group. A 25.2 loudspeaker array was prepared and installed in an hemisperical configuration in a nicely damped and irregular room, thus providing a quite suitable venue for my intended delicate ecosystem reconstructions. The speakers (Genelec 8020C + 7050B) were arranged in five rings of 8+8+4+4+1 in an ellipsoidal dome + 2 opposite floor subwoofers.

My 3rd order ambisonic materials were first converted from Fu-Ma to ACN-SN3D format and then decoded with an *Ambix Decoder* configuration previously optimized and tested in the venue. In some cases 1st order materials were upsampled to 3rd order using Harpex method [7]. *Mirror* and *Warping* algorithms [8] were employed in few sections before the decoding, to adjust the full-periphony of my soundscape materials to the hemispherical setup of the venue.

The program (Table 1) comprised a series of habitat reconstructions and eco-acoustic compositions[2].

Table 1: *Concert program.*

Composition	Type	Dur.
Dusk Chorus in Dipterocarp Forest	Time-lapse of unaltered recordings	13.56
A Path into Rainforest	Eco-acoustic composition	05.49
Intermission - Audience change		
Circadian Cycle Collection	Unaltered recordings sequence	06:00
Integrated Ecosystem n.1	Eco-acoustic composition	14:50

The first and last piece were complemented with real-time spectrogram analysis projections. These visuals allowed the audience to enter the structure of the ecosystems, to reveal: the cycles and sound signatures in the macro-temporal domain; the interspecies niche segregation dynamics; the microcosm of the sublte sound gestures and narrow frequency textures of insects (Fig.5).

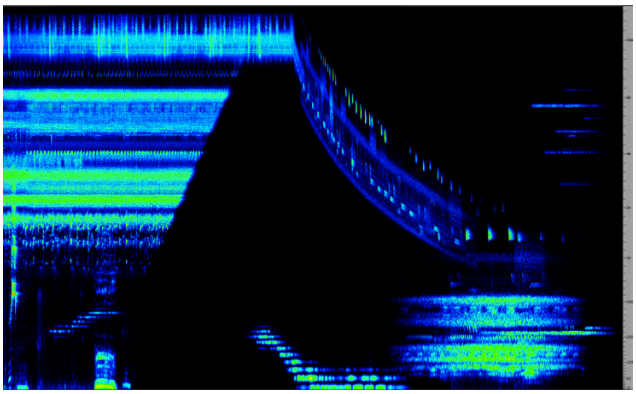

Figure 5: *Spectrogram analysis of the composition Integrated Ecosystem. Horizontal axis. At the beginning (shown in the left side) are the species' frequency niches of the unaltered dense habitat. The original recording is then progressively filtered out starting from low frequencies, with the exception of insects (at around 16-22Khz) and inaudible bats. Around the center, after a descending real-time synthesis, a logarithmic frequency shift of the highest bandwidth brings the inaudible sound gestures of bats (gradually appearing as the highest green dots descending on the right) down to a perceivable area of the spectrum. Then the integration with various transformed and generated materials follows. (© David Monacchi)*

The rest of the program was proposed in complete darkness, allowing the public to experience an immersive listening of the richness and beauty of these ancient primary soundscapes, with no interference from other sensorial stimulations.

The second and fourth compositions contained few supplementary creative levels, i.e. sonic exploration of audible and inaudible areas of the spectrum, and subtle integration of the ecosystems through computer generated sound.

[1] From year 2008, through various phases, functional and dimensional options, I engineered the Bio-acoustic Theatre (B.A.T.), a specific periphonic device optimized for soundscape reproduction and visualization. The control room for the B.A.T. and for the post-production of *Fragments of Extinction*'s recordings has been built at the Conservatorio "G.Rossini" of Pesaro, Italy (see: www.rossinispace.org)

[2] For listening to the result of this compositional approach see the author's CD: *Eco-acoustic Compositions*, EMF-Media / Earth Ear, New York (NY), 2008 (http://earthear.com/ecoacoustic.html).

Despite the public had to be divided in two groups, the program was designed to deliver to each group a complete experience made of immersive, educational and artistic elements in sequence (Fig.6).

Figure 6: *The hemispherical loudspeaker array during the concert. (Photo: M. Kronlachner)*

Due to time shortage, in Berlin, I only performed few of the collaborative actions which are usually in the program, using invisible infrared sensors to detect my hands' movements to feed the parameters of a C-Sound based synthesizer[3]. In these interventions the performer enters the soundscape structure interplaying strictly within available temporal and frequency niches left open by that habitat. The project questions whether or not it is possible to compose in a deferent way, by using compositional tools that preserve unaltered and amplify, at the same time, existing configurations of species.

But why do we - as humans - need to supplement ecosystems which are already the most organized soundscapes on Earth? In other words, may the aesthetic vision of these supplemental digital sound sysnthesis, performed on top of an ecosystems, be something philosophically contradictory?

The answer resides perhaps on the fact that always audiences seem to find, in these subtle integrations, a semantic cue to better understand the sound of life, and metaphorically reposition our species within a natural order.

4. ACKNOWLEDGMENTS

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