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A Philosophy of Eco-acoustics in the Interdisciplinary Project "Fragments of Extinction"

by David Monacchi

1. Statement and Project Background

I am a human being. I am also an artist, and as such, my work entails an understanding of how to feel and interpret things. The planet on which I was born will radically change within my lifetime, and the decline of the entire biosphere is now unavoidable. Mankind is responsible for the massive changes that are happening, which will affect the survival of the majority of creatures in all of Earth's biomes. This ecocide is progressively damaging the magnificent choirs of natural sound, 'eco-symphonies' we have not even heard, much less recorded. About 15 years ago, I felt compelled to invest my life in a sound-art project, which would promote public awareness on the most silent catastrophe of our times: the *Sixth Mass Extinction*.

According to the Millennium Ecosystem Assessment (signed by some 1360 world scientists and released by the United Nations in 2005), the current global extinction rate is between 100 and 1,000 times higher than it would naturally be. Immediate projections for the future indicated that this rate may reach 12,000 within our lifetime[1]. As a result of the direct human pressure on ecosystems (mostly deforestation and overexploitation) and the effects of human impact on the biosphere (as invasive species-triggering and pollution) an exponentially growing number of the planet's recently estimated 8.7 million living species are going extinct. The rate of 30,000 species per year was already predicted in 1993 by Harvard biologist E.O. Wilson (estimates which order of magnitude has since been revealed correct by most current studies), which equals to some 3 species going extinct every hour. Current estimates do not even include climate change. This is all the more shocking if we consider that, at present, only 1.9 million species have been described, most of which have barely been studied, if at all. Of all known species, one in four mammals, one in eight birds, and 41% of amphibians now appear on the IUCN Red List of threatened species[2]. We are facing the collapse of life itself.

From an ontological point of view, our species is only one among others on Earth's network of interconnected ecosystems. Every single species, the smallest micro-organism and the largest mammals, all thrive and conduct their lives without any external support device to survive and propagate their own genetic heritage. Rare individuals of the same species meet in vast spaces and mate through no force but their own natural communications. I am speechless as to how these coordinated and interdependent mechanisms can happen at every scale of life, within extremely complex processes of natural selection and co-evolution, and how these cycles have slowly refined themselves over the last 65 millions of years.

I wish I could regain the perspective of a guest and in-depth observer of this highly evolved web of life. The time has come to reverse the anthropocentric view of evolution and to envision a new inner space for a deeper understanding of the complex, now vanishing equilibrium of the natural world. To achieve these aims, I have used environmental sound of ecosystems as the object of investigation and conservation, as the model for compositional creation, and as the entity for designing worlds of perception for diverse audiences.

Fig. 1 – Borneo, Brunei, Kuala Belalong - September 2012.
The author recording in remote dipterocarp forest.

It was in the quiet of a December evening in 1999 when I posed myself the question of how could my work as a musician communicate and effectively encourage concern for the ongoing environmental disaster of deforestation and species extinction.

I had to determine how my art could be a platform and forum for environmental awareness, while maintaining a scientific and ecological methodology. I considered the tropics to be the ideal setting in which to record and collect representative data of the oldest and most diverse sonic ecosystems on Earth. It very soon became clear that this was a life's work, which I named *Fragments of Extinction*. *Fragments*, because all the traces we will be able to collect out of the endless and unknown sonic heritage of primary habitats are inevitably small pieces of an entire world, of a now broken organism; *Extinction*, because along with its biodiversity, we are losing the intelligent sound of the natural world.

At that time, I was still working as an electroacoustic composer in a broad range of music, performative arts, cinema, video, installation art, sound design, and sound engineering contexts. All my compositional work was based on personally collected soundscape recordings, which I used to study, process and recompose within narrative or purely documentary perspectives and approaches[3]. A frame of reference was attained at the World Soundscape project in Vancouver in 1998 and nurtured under the direct influence of composers and scholars, such as H. Westerkamp, B. Truax, R. M. Shafer, S. Sciarrino and W. Branchi. The work that I now consider most important was done in the field: thousands of hours of listening activity and

observational speculations conducted during the 1990s in the natural habitats of the central Apennines in Italy and in several trips to natural parks in Africa, South America, Canada, and the United States.
When I first decided to go work in an equatorial area (Amazon – February 2002), the hypothesis I cultivated during those listening fieldworks, that I would find systems of acoustic order in the soundscape of a primary forest, was strongly confirmed. I was witnessing an entire biological community displaying a coordinated behavior, in which every segment emitted sound with several, distinctive levels of pattern arrangement, periodicity, regularity, grouping, and overall interdependence. My first nights recording in the Amazon's flooded forests were actually some of the most powerful aesthetic experiences I have ever had; I was there with my entire body, sensing all the subtle environmental changes (temperature, humidity, wind, light quantity, etc.), realizing they were the exact cues activating all the sounds in the habitat, which my microphones and my ears were experiencing. Similar to an electroacoustic music composition, I was in front of a complex spectrum of sound entities with clear individual identity[4], sometimes aggregating in masses and often times maintaining separation in an extremely efficient tissue of narrow bandwidths. Moreover, this perceived whole system was dynamically changing and balancing over time in an organic sequence of states – exactly what one finds in a good electroacoustic music piece. But all the sounds of this habitat were from living individuals, most of which were tiny insects or amphibians (when not birds and mammals), which were simply unfolding their life and communication functions. Their species *Umwelt*[5] was furthermore dependent on the complex soundscape behavior, forming what I was experiencing as an intelligent sonic ecosystem.

Over time, it has been quite difficult to accept that I was progressively losing my interest in creating traditional musical compositions to instead make space for a new form of personal consciousness of what I then referred to as 'organized soundscape.' This was directly related to my original assumption that the more intact a soundscape is, the more structured and balanced systemic behavior it would display. The reading of Bernie Krause's work[6] about the 'niche hypothesis' in 2004 gave me the definitive signal that I was going in the right direction and that an entirely new field of ecological study and aesthetic thinking had started its course.

The intrinsic question of how a composer can work within such a perfect set of data was a major concern for years and resulted in an entire palette of expressive means and technical devices developed within the long-term project, *Fragments of Extinction*.

Fragments specifically investigates the acoustic biodiversity of untouched tropical forests, communicating to the large public of museums and theatres, how undisturbed nature has shaped its sonic habitats in order to maximize functionality and efficiency within diversity, and how these concepts can be understood through ecological science and experienced through sound-art.

The project, in its final form, concentrates on the three major areas of intact equatorial rainforest that remain: in the Amazon, Africa and Borneo. At least three reasons motivated the selection of the equator[7] (5° North and South, as area of pertinence) as relevant for the project: 1) circadian cycles are regular throughout the year and seasons are minimal, thus time-dependent sonic phenomena can be studied more easily; 2) equatorial forests contain the planet's greatest biodiversity and thus the most complex soundscapes; 3) many of the oldest ecosystems on Earth are found in equatorial forests.

Through extensive fieldwork conducted in these remote areas since 2002, I have collected unique 24-hour sound portraits of rare intact species ensembles recorded for the first time with high-definition space-preservative 3D technologies. These research technologies allowed me to

gather data not only in the time-frequency domain, but also to store the entire spherical spatial information of soundscapes.

The recordings collected[8] are important data for scientific investigation. The newly established field of Eco-acoustics[9] now provides the necessary conceptual framework and analytic tools to investigate the relationship of natural and anthropogenic sounds with the environment, on population and community levels. The evaluation of diversity and complexity of acoustic habitats constitutes a radically different approach from traditional bioacoustics.

The analytical outcomes of soundscape exploration, revealing the intricate co-evolved sonic behaviours of species in primary ecosystems, are also aesthetically relevant. *Fragments of Extinction* aims to present a new paradigm of artistic exploration and integration – a bridge for making these soundscapes accessible to audiences, to ultimately foster concern of the current biodiversity crisis.

Over the last 15 years, *Fragments* has developed in several directions, scientific[10] (conservation biology and intangible heritage preservation, eco-acoustics analytic studies, innovation in space-preservative field recording technologies) and artistic[11] (soundscape composition and acoustic ecology studies, 3D-sound production and post-production methodologies, multichannel and full-periphonic installation practices), maintaining a strong interdisciplinary mission and spirit, while proposing a new way to listen to – and compose with – soundscape.

The critical question that has always directed my work, and which resides at the base of all my pieces is: how to solve the logical contradiction between the perfectly 'organized soundscapes' of these ecosystems, which need to be experienced and displayed as they are, and my own drive for creation? The possible answer generates two more questions as I stated elsewhere[12]: Is it possible to learn from a primary ecosystem and to interplay within the same laws that have shaped these ancient acoustic environments? Is it possible to use compositional tools to reveal and enhance configurations of species, without compromising their intrinsic equilibrium and beauty? The approach I termed 'eco-acoustic composition'[13] tries to respond to these questions.

2. *Fragments*, One Installation/Performance

Since 2002, *Fragments of Extinction* has been publicly presented at a wide array of different installations and performances, in theatres, concert venues, art galleries, outdoor public spaces, museums and research conferences.

To help the reader understand this multifaceted approach – which also offers a new approach to listening to and experiencing soundscape – let us consider a recent sound installation of *Fragments*, presented in Rome in January 2014, at the international festival Visitazioni[14], which was a direct evolution of the first gallery exhibition realized at 3LD – New York, for the 2006 Ear to the Earth Festival, which went on to tour extensively in diverse contexts throughout Europe and North America.

In Visitazioni, *Fragments* (duration: 45 min.) stood as a three-part work, featuring each of the project's different approaches to ecosystem presentation in succession: immersive (pure, unaltered recordings and time-lapses), exploratory (real-time visual analysis of soundscape and ecological interpretation), and creative (eco-acoustic composition and integrative performance).

There, for the first time, the recordings collected in Borneo in 2012 (Ulu Temburong and Gunung Mulu areas) and Africa in 2008 (Dzanga-Sangha's Hokou and Bai Dzanga areas) were presented in complete darkness and reproduced in full periphony. Each performance, unfolding 4 times a day, was introduced by the author. The parallelepipedal black theatre was transformed into a completely neutral venue (both visually and acoustically). The public (a maximum of 10 people at a time) entered an absolutely dark space through a darkened antechamber. Once inside, following a floor system of thin (2-5 mm) semi-fluorescent paths (fig. 2), each visitor was led to a central circular area, where the three-dimensional sound illusion was strongest.

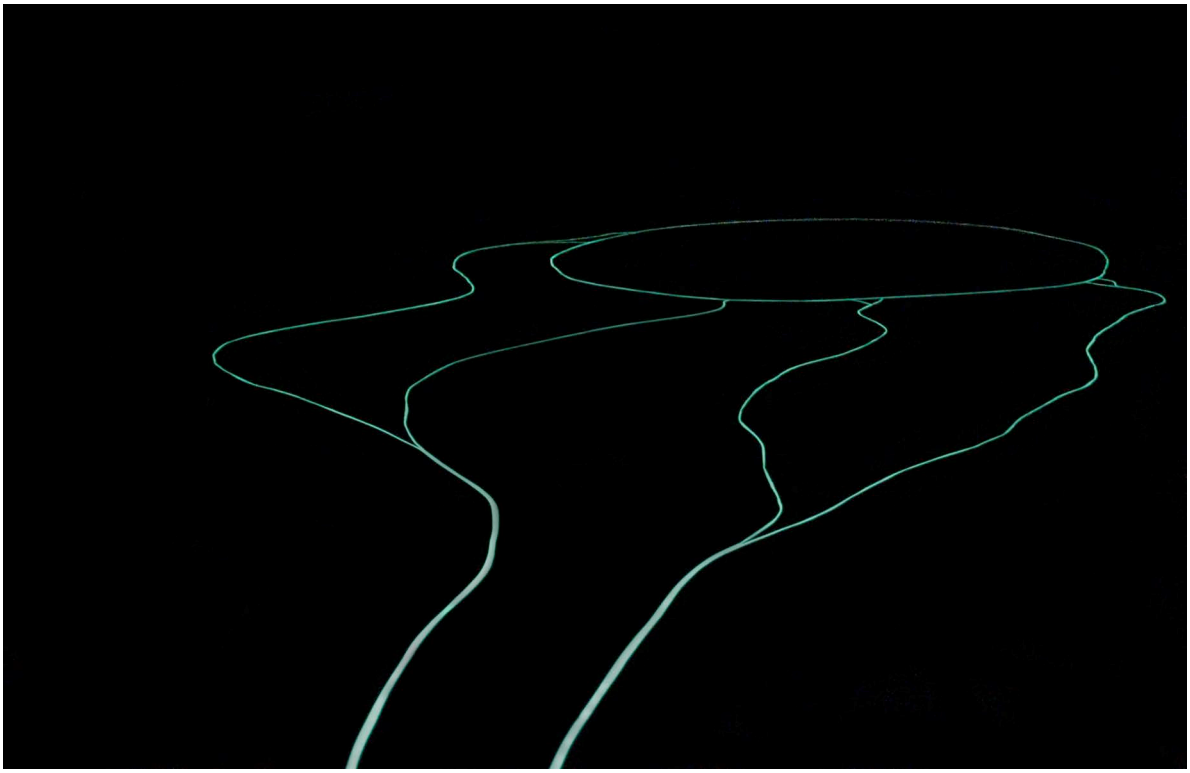

Fig. 2 – Long-exposure photograph of the semi-fluorescent floor paths in the 15 x 4.50 meter venue.

Part I: The Immersive Experience

The audience eventually found itself standing within a circle, silent and invisible witnesses of an exuberant habitat of insects, amphibians, birds and mammals, pulsating from all directions. A dramatic 20-minute time-lapse of a dusk chorus of Borneo primary dipterocarp forest habitat, enveloped the listeners in the increasing density of the species' vocalizations over time, which toward the night-time usually culminates in an impressive wall of sound formed by hundreds of individual insects vocalizing from different territories. Compositionally, 2-minute sections of the unaltered, original 3-hour recording were interwoven imperceptibly in a chronological order, forming a 'compressed' aural reconstruction with phenomena experienced as naturally occurring.

Except for the subtle fluorescent ellipsis connected to the 'streams' on the floor, the space was so dark that keeping one's eyes open or closed created identical experiences. Darkness augmented the sonic immersion achieved through space-preservative recordings and the multichannel periphonic system, not preventing the impression of being present within the enormous, organic space of a rainforest, in a real, living ecosystem, one of the oldest (possibly 140 million years old) and most remote forests on Earth[15]. Audience members spoke of a kind of 'primordial' experience and, surprisingly, about the familiarity of these soundscapes, which no one present could have actually heard before.

Part II: Nature Explained

The work's second part began with the slowly fluctuating light of a real-time, high-definition spectrogram of the acoustic environment being heard. The theatre's interior was revealed, as the immersive darkness of the first act gave way to the low light of shifting projections, instantly transforming visitors' perspective from that of being part of the habitat itself to being a spectator, observing the visual representation of the environment's sound.

Indeed, the smoothly flowing, hi-def visual spectrum of the ecosystem became a medium for moving from the three-dimensional aural experience of an ancient space to a bi-dimensional 'score reading' where each vocalization was displayed as a graphic gesture in time. The precise structure and hidden aesthetics of the network of inter-specific and intra-specific communication was now unveiled.

This objective, physical instrument for acoustic visualization provided an opportunity for the audience to access the organic structure of the sound environment without superimposing any didactic or narrative content, thus constituting a primitive, non-interpreted electroacoustic score of the soundscape[16].

The second stage of the performance now began: a 10-minute time-lapse of a 9-hour continuous recording in Africa composed of 1-min. sections starting from dusk, unfolding in both the acoustic space and in the visualizations on the wall. The recording featured a swamp forest with many species of frogs and insects forming a dense mass of dynamically shifting, narrow frequency niches, as well as a bat species with inaudible, clear echolocation bursts in a bandwidth centred at 25 kHz.

The organized texture of insects and amphibians in this recording also encompassed passages of hornbills flying in the foreground and scattered sound gestures of gorillas' chest beatings in the far background. Suddenly, the trumpeting of a forest elephant (which deep at night during fieldwork started to vocalize exactly below the autonomous microphone system) crossed the spectrogram, while also resonating in the aural space of the theatre. The extremely loud, low-frequency vocalizations of these large mammals (with fundamental frequencies going down to 12 Hz) and the long and diffused reverberation of the forest edges of the Bai make this recording a rare and stunning full-spectrum example of a sonic ecosystem, presented to the audience in its audio-visual form, via selected electroacoustic explorations of the sound spectrum conducted in studio (fig. 3).

Part III: Nature Integrated

The third part of the work began with the entrance of a performer, stepping slowly into the space with a candle. Contrasting with the blue-dominant spectrograms, the warm candlelight, gently illuminating the performer's hands, brought a radically different atmosphere into the theatre. The real-time spectrogram shifted into an analytical/performative canvas on which the performer himself observed the habitat's structure and its niches' configuration. By means of ultrared sensors reading the subtle movements of hands, the three coordinates x-y-z of selected fingers were mapped into two different software programs for digital sound synthesis: the first one[17] generating textural electronic elements which the performer used to build background 'horizons'; the second one[18], based on the prompt analysis and re-synthesis of selected sonic gestures of insects, amphibians and birds from each specific habitat – which the performer used to introduce elements within the unoccupied frequency, temporal niches and the available space in the soundfield scene. With small and very slow hand movements visible to the audience, the

performer (the author, in Rome – fig. 3) inserted compatible, synthetic sounds into the available space present in the visual (thus sonic) network, suggesting a possible form of interplay consistent with a composite ecosystem, without causing any disturbance to it: an ephemeral, virtual form of interspecies coexistence.

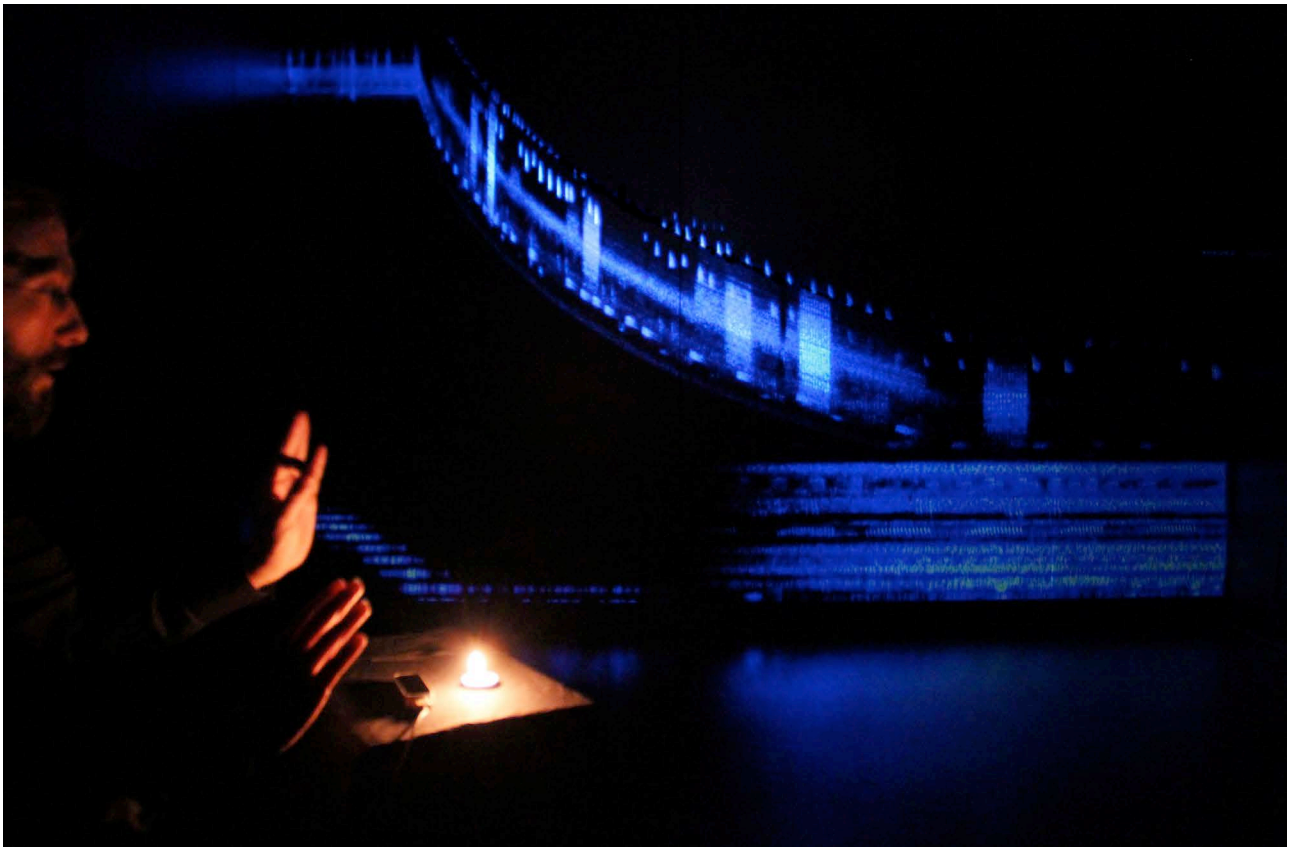

Fig. 3 – Visitazioni 2014. Photo of the moment in which the sensor-driven digital performance begins (opening of part III). The real-time spectrogram analysis displays insects and bats at around 18-25 kHz, progressively shifted in frequency (8-octave, logarithmic). The aim of this process of transformation was to bring the inaudible sound gestures of these animals down to an audible area, thus providing the audience with a tool to hear the inaudible world.
[Spectrogram legend, horizontal axis: time (depicting from right to left – about 3 min. window in the photo); vertical axis: frequency (20-22kHz); colour: acoustic energy from silence (black) to about 70 dB (bright blue)].

3. Conclusions and Current Developments

Visitazioni provided a crucial adaptation of *Fragments of Extinction* to a theatrical space, and represented the ideal circumstance for understanding the dynamics of 'presence'[19] within a virtual ecosystem. Due to the loss of any visual reference point within the installation space (absolute darkness in the first part), the impressions collected revealed that many visitors experienced the opening up of a visceral, instinctual, and deeply emotional perception of the outer 3D soundscapes. In such a space, as in dense tropical forests, the complete lack of visual information makes sound function as the only medium for the perception of distance, perspective, and orientation.

From my experience, working with environmental sound requires imagining the final context and composing its space, even before organizing the sounds. The context is always part of the aesthetic experience[20]. While most approaches in site-specific sound art use context for generating artistic content, by its nature, *Fragments* needs an isolated and 'neutral' space, capable, in the end, of transporting audiences to remote and extremely inaccessible ecosystems. Darkness, acoustic insulation/damping, symmetrical multi-speaker and video setup capabilities are mandatory. These, however, are rarely found in existing, available venues such as galleries,

theatres, museums, and public spaces.

To resolve this issue, and to facilitate full audience participation, I engineered and designed the Eco-acoustic Theatre (also known as the Bio-acoustic Theatre, from its initial conception in 2005) as an ideal device for the immersive listening of ecosystems (fig.4).

This flexible venue[21] offers a radically new experience of nature through sound and visual analyses of sound: a unique context, in which an extremely sophisticated technological experience – collective in form – gives rise to an intimate understanding of something unknown and primordial, while also being profoundly resonant and familiar. Ideally conceived as a 'temple', the theatre simultaneously constitutes a virtual space and a temporal journey back into the oldest ecosystems on Earth. The sound is either a playback of the recordings or streamed in real-time from selected rainforest habitats.

The Eco-acoustic Theatre embraces each of the three different purposes originally envisioned by *Fragments of Extinction*, described above as the immersive, exploratory, and creative compositional approaches. As happened in the installation presented in Visitazioni, the visitor is channelled through different stages of listening, with increasing degrees of intervention by the artist, so that one not only participates perceptually in the wonder of the context, but also learns about its organization and relishes the aesthetic experience, while augmenting one's sense of connectedness with nature. In so doing, the theatre challenges the conventional divides between the different domains of virtual reality, science, and art.

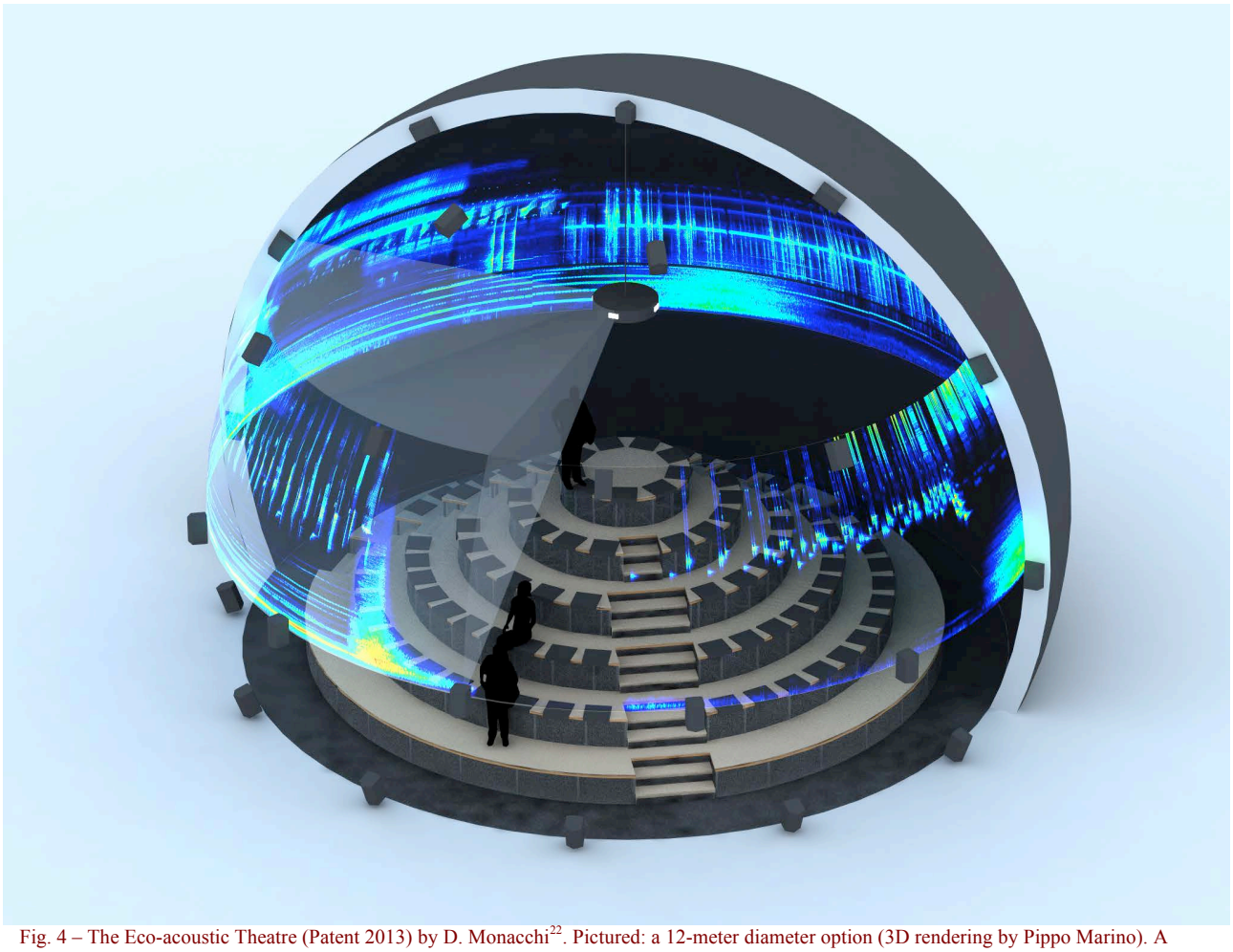

Fig. 4 – The Eco-acoustic Theatre (Patent 2013) by D. Monacchi[22]. Pictured: a 12-meter diameter option (3D rendering by Pippo Marino). A prototype of the Eco-acoustic Theatre, which is also the research and production studio for the project *Fragments of Extinction*, has been built and is fully functional at the Conservatory "G.Rossini" of Pesaro, Italy (www.rossinispace.org).

Coda

Now that humanity will have to engage in a compulsory paradigm shift, from the current utilitarian view of nature to a radical eco-centric perspective, it is time to move beyond approaches which, however helpful and fascinating, incorporate natural phenomena within human-manufactured metaphoric representations, or 'narrative' plots.

Fragments is an attempt toward this end, aimed at maintaining and revealing the complexity, the language and codes, and the self-contained, efficient sonic organization of ecosystems: an approach based on three-dimensional immersive experiences, where high-end research technologies for virtual acoustic reality are used to magnify the perception of the habitats, presented as they are in reality. This may open our minds to a primal aesthetic experience of the natural world, eventually fostering our inner relationship with nature and aural understanding of Earth.

Imagine silent spaces of complete darkness within the urban environment, which people enter just to experience the sounds of remote ecosystems as their 3D sonic imprint is streamed in real-time: would such meditative/cognitive activity help us reconnect with the intangible heritage and vanishing essence of the biosphere?

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[1] For a thorough report see: http://www.millenniumassessment.org/en/index.html

[2] For a thorough report see: http://www.iucn.org/news_homepage/?3460

[3] David Monacchi, *Paesaggi di Libero Ascolto* (Landscapes of Free Listening), a retrospective of compositions from 1990 to 1995 – ANTS Records, Roma 2005, AG11. Compact disc.

[4] *Gestures* and *Textures*. These two terms identify a basic classification of "spectromorphology" (see D. Smalley). I believe sonic ecosystems can be analyzed and interpreted within the same conceptual framework and set of categories used in electroacoustic music analysis.

[5] This is the term is used to describe a separate environment of subjectivity, coined by Jacob Von Uexkull.

[6] Bernie Krause, "The Niche Hypothesis: A virtual symphony of animal sounds; the origins of musical expression and the health of habitats," *The Soundscape Newsletter 06*, June 1993.

[7] Within an area 5° North and South of the equator – pertinent to the project for at least three reasons: circadian cycles are regular throughout the year and seasons are minimal, thus time-dependent sonic phenomena can be studied more easily; equatorial forests contain the planet's greatest biodiversity and thus the most complex soundscapes; many of the oldest ecosystems on Earth are found in equatorial forests.

[8] Since the pilot project, conducted in 2002 in the Amazon (Rio Jauperì area - 1° 8'19.65"S 61°33'40.69"O), several recordings campaigns with cutting edge three-dimensional audio technologies have been carried out in Africa, Borneo and Amazon, forming an archive of several hundreds hours of hi-definition full-spectrum sound data. For extensive information on the filed recording campaigns and ecosystems sound excerpts, see: http://www.fragmentsofextinction.org/listen-to-ecosystems/

[9] Grounded in Bio-acoustics and Acoustic Ecology, the newly founded field 'Eco-acoustics' is "an interdisciplinary science that investigates natural and anthropogenic sounds and their relationship with the environment over a wide range of study scales, both spatial and temporal, including populations and communities," (quoted from the International Society of Ecoacoustics' website: https://sites.google.com/site/ecoacousticssociety/about)

[10] Among the most recent papers and conference presentations related to the project:

- D. Monacchi, U. Grafe, A. Farina, A. di Furia. *A New Recording Approach in Primary Equatorial Forests*. Paper presented at the First International Conference of Eco-acoustics, Muséum National d'Histoire Naturelle, June 16-18 2014.
- D. Monacchi, U. Grafe, A. Farina. *Eco-acoustic Codes of Borneo Primary Forest*. Paper presented at the First International Conference of Code Biology – Universitè Paris Decartes, Paris, 20-24 May 2014.
- Monacchi, "Fragments of Extinction", *A Periphonic Audio-Video Concert on 3D-ambisonics Field Recordings of Primary Rainforest Ecosystems*, Proceedings of the EAA Joint Symposium on Auralization and Ambisonics, Berlin, Germany, 3-5 April 2014

[11] Among the artistic outcomes n. 2 specific audio publications: D. Monacchi, Eco-Acoustic Compositions, CD and booklet, EMF Media, New York (2008) – D. Monacchi, Prima Amazonia, CD and booklet, Wild Sanctuary, California (2007).

[12] "Fragments of Extinction – An Eco-acoustic Music Project on Primary Rainforest Biodiversity", Leonardo Music Journal, Vol. 23, Sound Art, pp.23-25, 2013 ISAST, The MIT Press.

[13] D. Monacchi, "Recording and Representation in Eco-acoustic Composition", in *Soundscape in the Arts*, J. Rudi, ed., (Oslo: NOTAM, 2011) pp. 227–250.

[14] The International Festival of Sound Installation *Visitazioni* (Jan. – Mar. 2014) was organized by G. Antognozzi of Proposte Sonore in collaboration with the Teatro in Scatola, Roma. For more details, see: http://www.propostesonore.org/Programma.html

[15] The recordings were collected by the author in 2012 in Kuala Belalong – Brunei (4°32'44.53"N 115° 9'51.10"E)

[16] The second and third parts of the work for *Visitazioni* are an adaptation from the piece *Integrated Ecosystem – Africa* as part of the "Integrated Ecosystems" series of compositions. The piece has been the subject of analysis by Katharine Norman in her article "Listening Together, Making Place". *Organized Sound*, Vol. 17, No. 3, 257-26, Cambridge University Press (2012).

[17] "STRIA – Multilevel Interactive Sound Synthesizer" (C-Sound based) by Eugenio Giordani.

[18] "INTERPLAY – Sensor-driven Imitative Synthesis" (Super Collider based) by Anthony di Furia and David Monacchi.

[19] R. Ascott, "Is There Love in the Telematic Embrace?" *Art Journal*, Vol. 49, No. 3, *Computers and Art: Issues of Content* (Autumn, 1990), pp. 241-247.
Slater M, Usoh M, Steed A (1994). *Depth of Presence in Immersive Virtual Environments, Presence: Teleoperators and Virtual Environments*, MIT Press 3(2), 130-144.

[20] Walter Branchi. *Canto infinito - Thinking Music Environmentally*, Open Space Publisher, New York, 2012.

[21] D. Monacchi, LMJ 23, MIT-Press – See note n. 12.

[22] A prototype of the Eco-acoustic Theatre, which is also the research and production studio for the project *Fragments of Extinction*, has been built and is fully functional at the Conservatory "G.Rossini" of Pesaro, Italy (www.rossinispace.org).