



ORIGINAL ARTICLE

The soundscape ecology: A new frontier of landscape research and its application to islands and coastal systems

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Abstract Islands and mainland coastal ranges are fragile systems rich in biological endemisms and ecological peculiarities. In these environments, the cultural heritage that represents an important component of the overall ecological complexity is under attack from human pressures (urban sprawl, logistics, fish farming and mass tourism).

Among the most valuable resources pertaining to these environments, the overall emerging sounds (the soundscape) play a relevant role with respect to the maintenance of the sense of a place and its cultural value.

The study of the soundscape requires an epistemology based mainly on the cognitive landscape perspective, and within this theoretical framework, the General Theory of Resources, the Eco-field hypothesis and the soundtope model are also important components.

Among the methods used in soundscape ecology, the analysis of the frequency bins of the acoustic spectrogram can provide proxies for understanding and interpreting acoustic patterns and processes in action across a landscape.

The description of a case-study from a Tyrrhenian coastal system of Northern Italy, via the use of dedicated software and metrics, briefly illustrates the potential of soundscape ecology, which is entirely suitable for achieving a better understanding of the dynamics of island and mainland coastal systems.

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Introduction

Islands and coastal systems are bounded regions in which the role of human intervention is particularly intense (Hassan et al., 2005). Indeed, these areas are major draws for tourism, fish farming, transportation facilities and shipping logistics (harbors, lighthouses, etc.). Both systems are also ecosystems that are under human 'attack', and immediate surveys and long-term monitoring schemes are urgently required to prevent further damage and conserve nature and its environmental and cultural value for future generations.

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Islands associated with mainland coastal systems represent frontiers for several ecological, biological and sociological processes, such as migration, population spreading and human demographic concentration. In particular, islands are fragile ecosystems in which endemic biodiversity is often dismantled by the explosive intrusion of alien species (Brockie et al., 1987; Lodge, 1993; Mooney et al., 2005). Islands remain the cradle within which to study speciations and endemisms, and have represented a source of epistemic-theoretical inspiration for generations of ecologists (MacArthur and Wilson, 1967).

Among the different perspectives with which is possible to explore, describe and manage the ecological complexity of such environments, the soundscape may be an excellent proxy for both short- and long-term scientific investigations. The soundscape can be defined as every sound produced by any abiotic and biological component of an ecosystem (geophonies and biophonies, respectively) together with anthropogenic sounds (Anthrophonies) (Pijanowski et al., 2011). It is thus the result of the energy released by both natural processes and human technologies.

The sounds of a landscape are the acoustic context produced and, in turn, perceived in different ways by both animals and humans. In particular, the quality of a soundscape represents an important component among the factors that contribute to creating and preserving the individual and the social wellbeing of resident people (Evans et al., 1995; Evans and Maxwell, 1997; Dumyahn and Pijanowski, 2011). Accordingly, a Hi-Fi acoustic context, which refers to an environment where all sounds may be heard clearly without being crowded or masked by other sounds and noise (Truax, 1999, 2001 p.65), contributes to the overall attraction of a living space for human beings (O'Connor, 2008).

Considering that most islands and coastal systems (at least in the temperate and tropical regions) are chosen by people for recreation and tourism purposes, and that the amenity of these areas is an essential feature for such activities, the acoustic patterns become important indicators of these processes. Consequently, the soundscape approach appears to be an obligatory step for achieving and maintaining their integrity.

The aim of this paper is to illustrate and discuss the potential applications of soundscape ecology in these critical environments. A brief description of the theoretical basis of soundscape ecology, together with its applied methodologies, is also provided. Finally, a case-study from a Mediterranean coastal system is put forward as a practical example of a soundscape assessment.

The epistemological basis of soundscape ecology

The soundscape approach does not simply correspond to the analysis of a collection of sounds, but also pertains to a complex system of identification of sounds and the interpretation thereof. The description of soundscape patterns is an indispensable, but not sufficient, way of studying (ecologically) this matter; a biosemiotic approach is also required to understand and interpret the uses and functions of sounds (Farina, 2012).

The significance of the soundscape largely depends on the individual status of a species and its life traits that intersect acoustic cues.

For this reason, it is imperative to introduce the individually-based perspective of the environment (see f.i. Allen and

Hoekstra, 1992, p. 159), and the associated concept of *Umwelt* as a subjectively perceived surrounding (von Uexküll, 1982, 1992). This concept, which was long ignored by ecologists, is a fundamental point when it comes to understanding environmental complexity. In fact, *Umwelt* means a self-centered world in which each species or individual has a semiotic world with which to interact.

In order to better understand the role and importance of the soundscape approach, it is also crucial to consider the cognitive dimension of a landscape.

The landscape can be defined in several ways according to the epistemological basis adopted and the discipline; geographic, ecological and economic are just some of the adjectives that can be associated with the notion of "landscape".

Recently, Farina (2008) defined the landscape as a semiotic interface between organisms and resources, and this essay has been expanded on by the introduction of the concept of the *eco-field* (Farina and Belgrano, 2003, 2006), which is defined as every spatial configuration carrier of meaning that is necessary to track resources.

As argued in the General Theory of Resources recently developed by Farina (2011, 2012), resources may have a dual nature: material, such as food, water and refuge; or immaterial, like safety and cultural heritage. The soundscape can be regarded from a biosemiotic point of view as a collection of acoustic eco-fields that are used by species to track specific resources. For instance, in the world of birds, when an eavesdropping female intercepts the contemporary song of different males, these cues are a spatial configuration carrier of meaning used by this female to identify where the best territory is located. Indeed, song is considered to be an honest signal, and the quality and quantity thereof when uttered by a male is an indication that this individual is the owner and active defender of a place where there are abundant resources, such as food and nesting places. The same process occurs when alarm calls are emitted by a group of individuals; again, their position is an indicator of enemies that are invisible to the eavesdropping subject.

Humans adopt the same strategy; for instance, the siren of an ambulance signals an emergency, while the different tolling of bells may indicate special days or the passing of the hours.

Specifically, sounds from nature are used by animals and humans in different ways according to the function performed at a particular time. In the animal world, the use of acoustic cues to communicate (like in frogs or songbirds) and explore the surroundings (like in bats and dolphins) is extremely diffuse, but only humans have developed a complex and highly plastic language that has differentiated a huge number of regional variants. Moreover, humans produce extra-body sounds, like noises connected to transportation (trains, cars, airplanes and boats), factory activities, and social events (sport, concerts, religious ceremonies, etc.), all of which become part of the soundscape processes.

Relationships between landscape and soundscape

The structure of a landscape and the soundscape sphere are strictly connected, since aspect, morphology, vegetation patterns, human infrastructures and settlements, and animal distribution all correspond with the production of sounds and their propagation. For instance, an attempt to couple

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