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Editorial: Advances in ecoacoustics

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Editorial on the Research Topic
Advances in ecoacoustics

The global decline of biodiversity in the wake of expanding human development (United Nations, 2019a), resource depletion (United Nations, 2019b), and climate change (IPCC, 2021) motivates research in basic and applied ecological science. The new scientific discipline of ecoacoustics (Sueur and Farina, 2015) creates an epistemological bridge between ecology, acoustics, animal behavior, biotremology, and semiotics, providing fresh perspectives to study ecosystem function and new tools for ecological monitoring in terrestrial and aquatic ecosystems. Advances in affordable hardware (Pavan et al., 2022) mean that we can now passively, remotely and continuously record acoustic environments; advances in machine learning provide potential methods to digest the big data generated, but many theoretical and practical issues remain. We are pleased to introduce this special issue on Advances in Ecoacoustics that makes important contributions to the development of the semantic, conceptual and theoretical foundations, analysis methods and infrastructures necessary for ecoacoustics to advance as a scientific discipline that is equipped to tackle the urgent environmental issues we face today.

Four articles address core definitions, concepts, and theoretical principles in ecoacoustics. A primary focus of the field is the investigation of the ecological role of soundscape. However, the term "soundscape" encompasses diverse concepts, including objective physical phenomena and subjective perceptions (ISO 12913-1, 2014). With the aim of operationalising the concept of soundscape in conservation, Grinfeder et al. propose three new functional categories to clarify soundscape definitions: distal, proximal, and perceptual.

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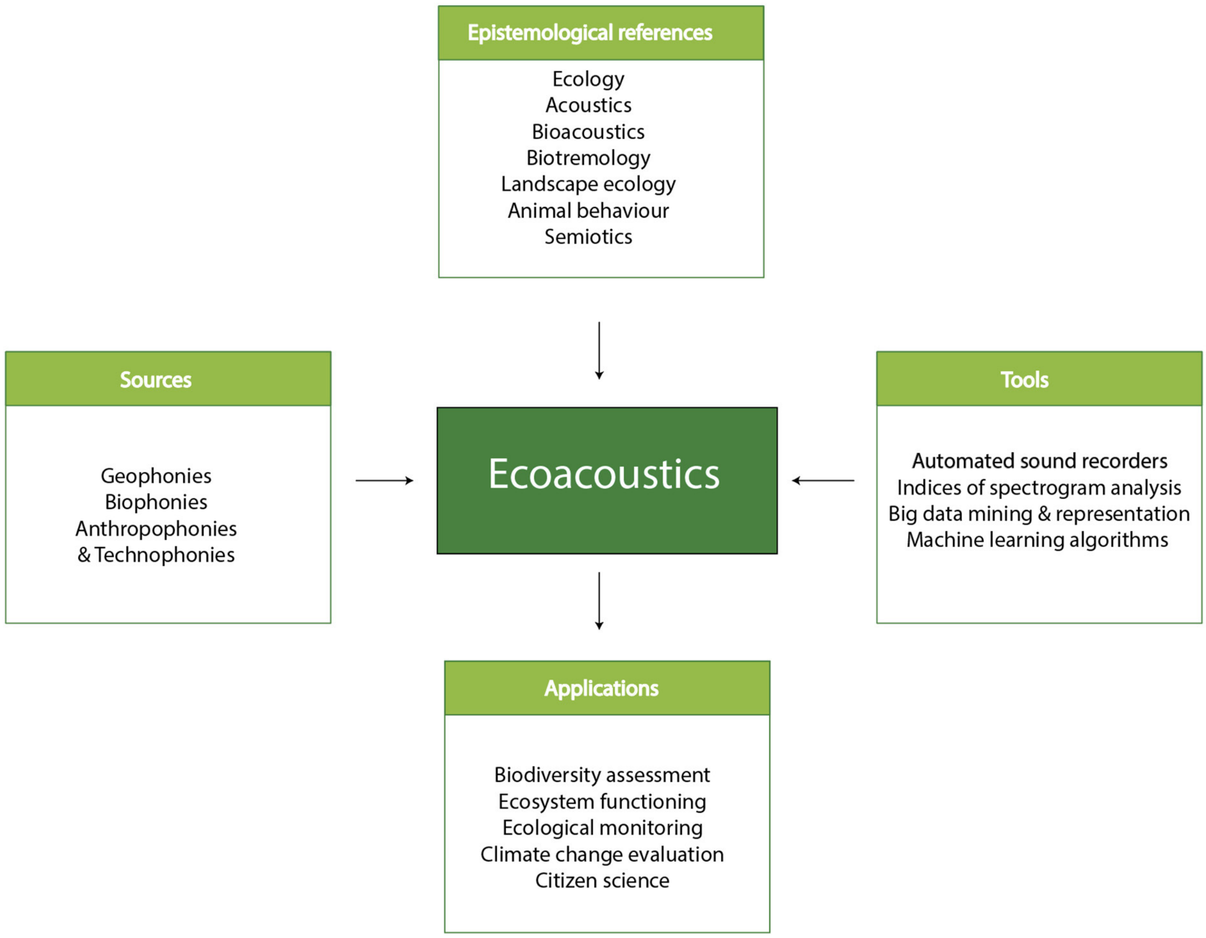

FIGURE 1
Ecoacoustics epistemological domain and competencies.

Ecoacoustics has traditionally focused on air-borne sounds in the range of human hearing [soundscape definition given by (ISO 12913-1, 2014)]; but now includes infrasounds and ultrasounds used by animals for communication and echolocation. In addition, recent research suggests that substrate-born vibrations are important sources of environmental information (Hill et al., 2019), as studied by the new discipline of Biotremology. Šturm et al. introduce the concept of *vibroscape* as the substrate-borne analogy of the soundscape and *ecotremology* as the study of its ecological significance. Ecotremology expands the paradigm of ecocoustics to new registers and opens fresh possibilities for non-invasive monitoring of arthropod species that are essential for ecosystem functioning.

The conceptual framework of ecoacoustics describes the components of the soundscape according to their sources: biological (biophony), geophysical (geophony), and human-produced (anthropophony and technophony) sounds. However, it is common in applied ecoacoustics to focus on biophony, disregarding anthropophony and geophony as noise (Figure 1). Farina et al. emphasize the importance of geophonies as key drivers of adaptation and habitat selection and highlight the value of including geophonies in ecocoustic analyses, especially when monitoring climatic changes and their ecological consequences. Following classical niche theory (Hutchinson, 1957), the acoustic niche hypothesis (ANH) (Krause, 1987), posits that species' acoustic repertoires tend to be partitioned in acoustic space to avoid interference and signal masking. In contrast, the clustering hypothesis (Tobias et al., 2014) predicts that convergent acoustic features may be beneficial to reinforce acoustic communities. By observing signal overlap between montane tropical wet forest bird communities in Costa Rica and Hawai'I, Hart et al. tested these hypotheses and found evidence of temporal partitioning but not of clustering, lending support to the ANH.

Two articles address the theory and application of ecoacoustics in land-management. Human impact on natural systems is typically considered in terms of physical aspects of habitat degradation. Sánchez et al. investigated the impact of vegetation structure versus industrial anthropophony on the Lincoln sparrow (*Melospiza lincolnii*) occupancy at three sites in Northern Alberta, Canada. Their results demonstrate the importance of species-specific *acoustic habitat* and promote further research on the ecological consequences of human impact on soundscapes as well as physical habitats. The need for cost-effective tools to guide decision-making in sustainable forest management has never been more pressing and there is growing evidence that forest diversity is related to acoustic diversity. Using simple soundscape features to analyse the acoustic environment of Panamian forests, Müller et al. report that relative to monoculture forests, polycultures increased orthopteran acoustic activity at night in tropical forests. These results bolster growing evidence for the value of ecoacoustics as a cost-effective monitoring tool in land-management.

Three articles focus on new computational methods for ecoacoustic monitoring using both global soundscape indices and automated species identification. Acoustic indices provide simple statistical summaries of the spectral and/or temporal distribution of energy in an acoustic recording. Single indices may capture intensity or spectral distribution but are insufficient to capture the complex patterns emerging from soundscapes. Scarpelli et al. integrate compound indices with time series classification and machine learning to provide a semi-automated classification method for terrestrial soundscapes.

Fully automated species detection remains a challenge. Traditional methods require an extensive, manually labeled call library for training data, which is often obviated by time, funding or data availability. Eichinski et al. describe the successful application of active learning methods (a semi-supervised machine learning approach using unlabelled data) to predict multiple avian species in a novel habitat. Brodie et al. similarly address the inherent challenges of working with vast data sets. False-color spectrograms (Towsey et al., 2018a), generated from an open-source analysis tool (Towsey et al., 2018b), are used to visualize and detect chorusing of multiple species of frogs in large acoustic data sets, creating an efficient manual ecoacoustic analysis workflow that complements automated approaches.

The final two articles address the critical issues of ensuring ecoacoustics is founded on open-access principles to ensure sustainable, scalable and open practices. Parsons et al. sound the call for a global library of underwater biological sounds and stress the value of an open-access reference library, data repository, training platform, and citizen science application to support aquatic ecoacoustics. Vella et al. report the results of an Australia-wide workshop to identify key issues in realizing open ecoacoustic monitoring in Australia. This is an important exercise that would be valuable to carry out globally.

At a time of unprecedented biodiversity decline, ecoacoustics has the potential to become a key ecological discipline to support cost-effective, long-term monitoring of ecosystems and provide a scalable paradigm for ecological research. The articles in this special issue contribute to the important tasks of developing the language, concepts, theoretical foundations, research tools, methods, and open infrastructures necessary to advance the field in order to address some of the pressing environmental issues of our time through open and equitable science.

Author contributions

AF, SF, and GP: concepts. AE: concepts and revision. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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