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Innovative soundscape technology could enable automated, rapid, global monitoring of ecosystems

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Human activity is causing global ecosystems to deteriorate at a rapid rate. Monitoring these changes often requires labour-intensive surveys, which may not identify rapid or unexpected environmental change. This study introduces a novel, faster technique — using automated soundscape (acoustic environment) monitoring — to predict habitat quality and provide real-time detection of noises such as chainsaws.

Accelerating global change, from climate change and other anthropogenic activities (such as poaching, fires and logging), necessitates real-time tracking of ecosystem health, to detect and respond to threats. Advances in sensor technology and wireless networks, can enable a scalable, rapid method of monitoring complex systems, such as ecosystems. The researchers suggest traditional ecological field surveys are slow and susceptible to observer bias; whereas automated analysis of an ecosystem's soundscape enables rapid, and scalable monitoring.

The EU Biodiversity Strategy 2030 aims to put Europe on the pathway to protecting and restoring ecosytems – as set out in the UN's Convention on Biological Diversity (CBD). Effective widespread monitoring of ecosystems can support EU Member States in meeting the Biodiversity Strategy's goals of reducing biodiversity loss.

Over a four-year period (2016–2019), the researchers collected over 2 750 hours of acoustic data using a variety of microphones at five sites: temperate forests in Ithaca, New York State, USA, and Abel Tasman National Park, New Zealand; protected lowland rainforest in Sulawesi, Indonesia; protected and logged lowland rainforests in, and surrounding, Nouabalé-Ndoki National Park, Republic of Congo; and lowland rainforests across a gradient of habitat degradation in Sabah, Malaysia.

The audio data was analysed using a neural network (NN) — a brain-inspired, machine learning model, using an artificial NN via an algorithm, to enable the computer to learn. The NN analysis created acoustic 'fingerprints' of soundscapes from the ecosystems sampled. These acoustic

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fingerprints accurately predicted habitat quality and biodiversity across multiple scales and identified anomalous sounds such as gunshots or chainsaws. The researchers then compared the performance of their model with five previously developed eco-acoustic indices (EAI), to see which could most accurately predict the health of an ecosystem over time.

The researchers found that the study model can differentiate between ecosystems, discern changes in habitat quality, and track seasonal/daily changes in biodiversity dynamics more accurately than previous EAI. For example, bird-species diversity in a temperate forest was predicted more accurately — 88% by the NN, compared with only 59% by the EAI. Importantly, the NN bird-diversity predictions do not require species identification, making it less labour intensive. The general acoustic features of the NN gave better predictions of changes that happen over time on a seasonal and daily level. The method was extended to explore large datasets, for automated detection of unusual sounds, such as a gunshot, wood being chopped, or chainsaw use.

Previous eco-acoustic approaches to monitoring habitats, have been site- or time-specific, and not easily applicable to new ecological settings, say the researchers. Progress in implementing an automated ecological eco-acoustic monitoring system, therefore, has been slow. The researchers posit that this study's approach should change this issue, as the technology uses a common set of eco-acoustic features, generalisable across ecosystems, at scale and over time.

Although this approach focuses on temperate and tropical forests, the researchers say it could be applied to other habitats — such as marine, freshwater, grasslands, wetlands — enabling widespread, affordable, ecosystem monitoring, with the potential to detect, in real-time, unwanted behaviour, such as logging or poaching. The researchers suggest their approach could also be used to monitor ecological responses of ecosystems to invasive species or climate change over longer timescales.

The researchers posit that their findings may provide the technological foundation for a global automated, large-scale, ecosystem monitoring and protection system — to better safeguard threatened habitats. They suggest that the technology may enable policymakers to take more responsive conservation measures as a result of more detailed understanding of the changes our ecosystems are experiencing.

1. EU Biodiversity Strategy for 2030 Bringing nature back into our lives COM/2020/380