Monitoring Biodiversity Using Acoustic Data in the United States

Pete Beckman[1] Zuzana Burivalova[2] Eyal Frank[3] Rajesh Sankaran[4]

Project Overview: Broad-scale measurements of animal biodiversity are cost-prohibitive and time consuming. As a result, population surveys often focus only on a few species of interest, cover small areas, and are done infrequently. Recent advances in machine learning (ML) and artificial intelligence (AI) have opened up new approaches to rapid biodiversity assessments. Working together, Argonne, Uchicago, and UWisconsin can leverage these new ML/AI techniques to analyze acoustic data and *determine the composition of vocalizing species, and their abundance*. Over the last six years, Argonne has been designing and deploying advanced wireless sensors with edge computing. The Array of Things project and new $9M NSF MSRI Sage project to build cyberinfrastructure for edge computing can be heavily leveraged so that this exploratory project can deploy acoustic recorders *leveraging existing infrastructure* located in areas of interest for biodiversity assessment.

Animals make sounds in order to communicate about their territory, food sources, predators, and mates, amongst others. The multitude of these acoustic signals are a fundamental part of soundscapes, and soundscape ecology is the branch of science that analyzes the data, to understand the relationships between biodiversity, landscapes, and anthropogenic pressures. Fig.1 demonstrates uses of such data.

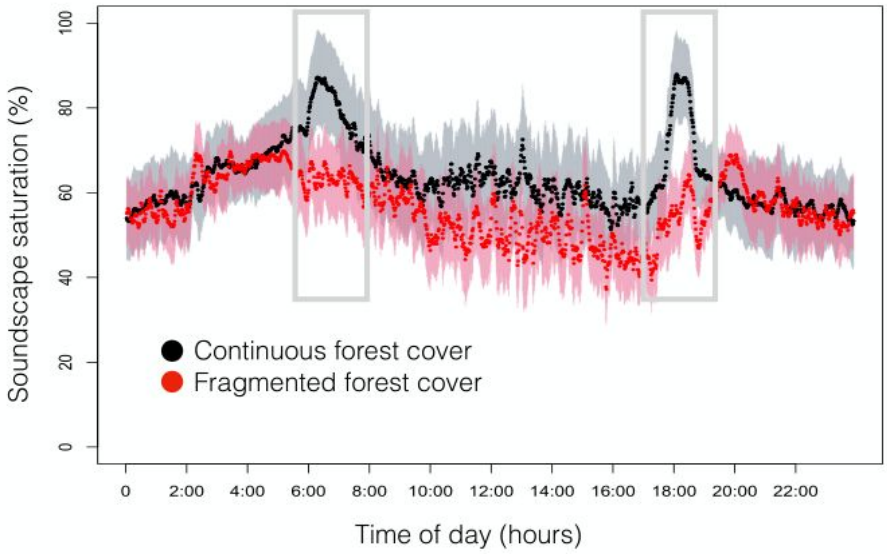

Figure 1. *Saturation of the soundscape in a tropical forest in Papua New Guinea. Fragmented forest is lacking two prominent peaks in saturation that correspond to the dawn and dusk chorus in an undisturbed tropical forest. Points represent estimates, shaded areas represent 95%CI, from 35 sites in the Adelbert Mountains, Papua New Guinea (Burivalova et al. 2018, Cons. Bio).*

In the long-term, using soundscapes as a proxy for biodiversity will allow us to study baseline differences and changes over time in biodiversity. The project we describe here will provide a demonstration for the feasibility of the equipment installation, and the analysis of its output sonic data. Data from our six pilot sites will serve as a proof of concept that will enable us to submit proposals for extramural funding opportunities. The research team brings together expertise in instrumentation for environmental monitoring, policy evaluation, ecology, and bioacoustic data analysis.

[1] Senior Computer Scientist, Argonne
[2] Assistant Professor, Department of Forest & Wildlife Ecology, and The Nelson Institute for Environmental Studies, University of Wisconsin-Madison
[3] Assistant Professor, Harris School of Public Policy, University of Chicago
[4] Experimental Systems Specialist, Mathematics and Computer Science Division, Argonne National Laboratory

Potential Impacts: The United States currently does not have a baseline measurement of biodiversity that covers large areas and multiple taxonomic groups of animals. Such data will allow quantifying differences between protected and non-protected areas, and, over time, estimates of how land-use restrictions create conservation benefits for target and non-target species. Temporal data on changes in biodiversity measures will allow testing if species are migrating or adapting phenology in response to climate change, and to quantify the importance of ecological corridors.

Research Plan and Timeline: We have identified six pilot sites in Illinois where we can deploy the audio recorders, and have quick and immediate access to the data: University of Chicago, Northwestern, DePaul University, Argonne National Laboratory, Morton Arboretum, and Busse Woods (see fig.2). The Chicago land proof of concept installation could be completed by 06/2021 and the preliminary analysis of the data completed by 10/2021. If successful, the work could be deployed on a larger scale -- the SAGE project has a partnership with National Ecological Observatory Network (NEON) and our collaborators have access to Long-Term Ecological Research (LTER) sites.

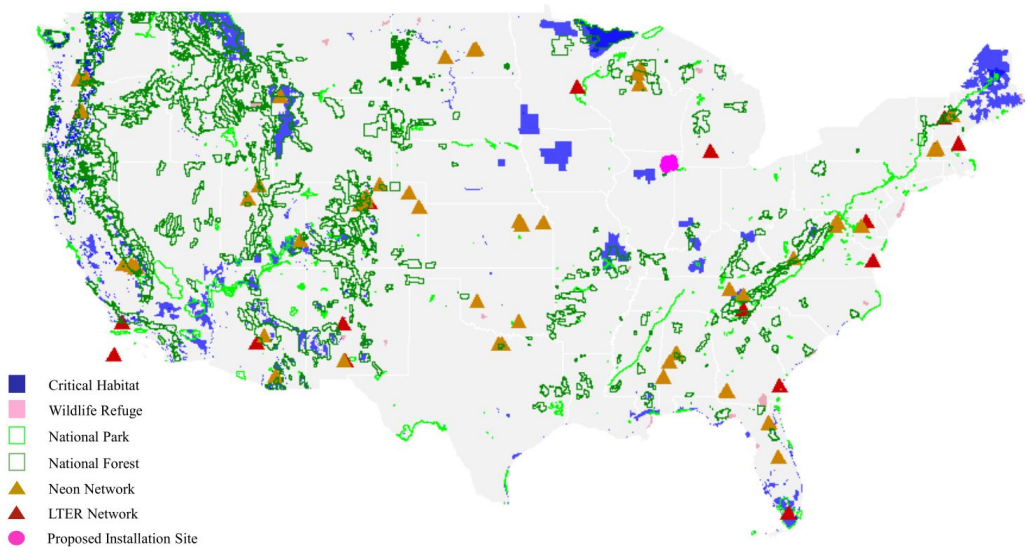

Figure 2. *Planned and Potential Installation Sites. Existing ecological monitoring sites provide opportunities to install new sensors in the vicinity of biodiverse areas of importance.*

Scope for Growth and Additional Funding Opportunities: There is a growing interest in quantifying baseline levels and changes in biodiversity, reflected by the recent UN Summit on Biodiversity that took place on September 30th, 2020, and its call to place 30% of lands under protection by 2030. The National Science Foundation (NSF) has three programs that are a good fit for this work: Systematics and Biodiversity Science Cluster, Instrument Capacity for Biological Research, and Infrastructure Innovation for Biological Research, in addition to NSF's demonstrated interest in biodiversity-related research, expressed in the Advancing Digitization of Biodiversity Collections, and the Dimensions of Biodiversity programs.

Existing infrastructure can be used to install new audio recorders. Relying on towers that are already operating means we can avoid the complicated permitting process involved in establishing new sites. By leveraging NEON and LTER sites, a broader investigation becomes feasible.

Budget and Justification: We request funds to cover the equipment costs, as well as funding a part-time graduate student at the Computer Science Department at the University of Chicago to assist with the data preparation stages. In total, we request graduate student support of $30K for data analysis and $20K in sensors, microphones, and deployment costs. ***Total budget: $50K***