Microsoft

AI for Earth Grantee Profile

Soundscapes to Landscapes

Mapping biodiversity by classifying bird calls with AI

Summary

As a global phenomenon, climate change affects biodiversity at scales that are difficult to monitor. The Soundscapes to Landscapes (S2L) project in Sonoma County, California, is developing a new methodology to measure these changes in bird communities. Citizen scientists distribute audio sensors around the county and help identify bird calls in the recordings through an online system. From these data and satellite imagery, the S2L team uses species distribution modeling to create biodiversity maps that provide a better understanding of the impact of climate change on bird diversity and help conservation planning efforts. This method generates massive amounts of sound data that requires an automated approach to analysis. Through a Microsoft AI for Earth grant, S2L team members Professor Shawn Newsam and PhD student Shrishail Baligar at the University of California, Merced, are developing and training AI deep learning models to identify and annotate the bird calls. Not only will the data be analyzed quickly, but also the process can be scaled up to large landscapes on a global level. Additionally, providing these models through an Azure API will enable other scientists to benefit from this work.

Mapping biodiversity through bird calls and AI

In 2019, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) released its latest Global Assessment Report, in which it estimates that as many as 1 million species, plant and animal, face extinction in the near term. Such a loss of biodiversity would have a profound impact throughout the world, destabilizing ecosystems and disrupting various natural systems essential to humans as well as other life, from food production to freshwater supply, medicinal resources, and disease control, among others. Already, biodiversity has suffered in recent decades, both in outright loss of some species and in population decline in many others. This harm to biodiversity can be directly attributed to human activities—expansion of land use for agriculture and human settlements for the most part, but increasingly due to climate change induced by carbon release as well.

Biodiversity loss and climate change are both global phenomena, occurring at a scale that is difficult to adequately monitor, analyze, and manage. Improving our knowledge of those changes is vital to making better decisions for conservation. Satellite imagery provides a ready source of data to analyze changes in the landscape due to climate change. However, collecting data on biodiversity loss is a greater challenge, as it

requires taking samples of species in many different locations, many times over; aerial photography alone would be inadequate. Overcoming this challenge is a key task of Soundscapes to Landscapes (S2L).

Tracking biodiversity with bird calls

Soundscapes to Landscapes is a project to collect species presence data through sound recordings and correlate that with satellite sensor data to better understand how climate change and other human pressures are affecting biodiversity. Started in 2017 through funding from the NASA Citizen Science for Earth Systems program, S2L is a partnership of several organizations including Sonoma State University, Point Blue

> "If we don't understand how these changes are happening, we cannot prepare well for them."—Dr. Leo Salas, Soundscapes to Landscapes (S2L)

Conservation Science, and the University of California (UC) Merced, among others. Speaking of the importance of S2L's work, Dr. Leo Salas, a quantitative ecologist with Point Blue Conservation Science and part of the S2L team, says, "There is no way to efficiently sample what's happening in the landscape with the technologies that we have now. If we don't understand how these changes are happening, we cannot prepare well for them."

The audio recordings are acquired by deploying small AudioMoth recorders in the field in Sonoma County. (Photo credit: Brennan Spark)

To attain the wide coverage needed for audio data collection, S2L works with volunteers from the general public as citizen scientists, sending them out to place inexpensive recording devices in many outdoor locations, from rural to urban. These recorders capture one-minute samples of the ambient sounds every ten minutes over the course of a few days. After the recorders are collected, the data are uploaded to a web-based system through which the citizen scientists help identify the animal sounds—bird calls for now—in the recordings.

Birds are used as a proxy for overall biodiversity because they are prevalent in every terrestrial ecosystem, they can be detected by their calls even when they can't be directly observed, and their calls are well documented and readily identifiable. Tracking the probability of presence of different bird species over time provides an indication of the overall health of the ecosystem. When mapped to satellite imagery showing the changes in vegetation over time, this method can show the effects of climate change on biodiversity.

An AutoMoth deployment team. (Photo credit: Brennan Spark)

As a pilot project, S2L is focused on Sonoma County, California, but the methods and technology it's developing are meant to scale to much larger areas as well as produce new maps annually. "We're trying to build this so it could eventually be global in scope," says Dr. Matthew Clark, a professor at Sonoma State University and the principal investigator for S2L. "We'll be able to produce new maps every year because the satellite data will change over time, and the bird data will change over time, so we can basically use this modeling approach to look at biodiversity change over a really broad scale." But that will involve vast amounts of data—S2L already has over 350,000 minutes of bird calls from about 600 locations around Sonoma County, with another 200,000 recordings being added every year. Automated methods using AI deep-learning models are needed to process so much data efficiently and effectively. For that, S2L turned to Microsoft AI for Earth.

Calculating species presence with machine learning

Through a Microsoft AI for Earth grant, S2L team members Professor Shawn Newsam and Ph.D. student Shrishail Baligar at UC Merced are developing and training AI deep learning models to identify and annotate the bird calls. "The grant will allow us to develop artificial intelligence deep learning models that, in the simplest way of thinking of it, are able to indicate the probability of a bird having made a call in a given one-minute recording," Dr. Newsam says. "The Microsoft Azure resources will allow us later on, once the models are developed, to apply them to these large numbers of recordings, processing all this data at scale."

S2L currently uses the ARBIMON bioacoustics analysis platform, which uses the common Random Forests machine learning algorithm to predict species presence, but its results need manual review to weed out false positives, preventing it from being a scalable solution. However, the ongoing work by citizen scientists to review those results does have an incidental benefit, explains Dr. Clark. "We need a lot of these labeled bird call data that will feed into [Dr. Newsam's] work. The data recordings and the training data for these deep learning models to identify bird calls are coming from citizen scientists."

> "Microsoft Azure will allow us, once the models are developed, to process all these audio recordings at scale."—Dr. Shawn Newsam, S2L

"I've been working in Dr. Newsam's lab for the past two years, developing deep learning models for the audio domain, especially dealing with analysis of the raw waveform," says Baligar. Under Dr. Newsam's guidance and with support from the AI for Earth grant, Baligar is developing the deep-learning models that will distinguish the calls of 30 different species of birds, picking them out from the other sounds captured in the recordings. Because the training dataset includes background noise from human activities and other natural sources, the resulting algorithms will be more robust. The models will calculate the probability that each processed audio sample contains the call of a particular species, which then can be used to indicate its relative presence where the audio was recorded—and, collectively for all the species, the overall biodiversity of birds in the area.

Enabling better conservation decisions

Dr. Salas refers to the extraordinary wildfires that ravaged Australia for months starting in 2019, and the past three years of severe seasonal wildfires in California where the S2L team is based, as recent examples when speaking of the need for this work. "These are things that didn't use to be the norm. They were rare events. They're happening now more often, and they're changing very large swaths of the land. We don't know how those changes are going to affect the biodiversity on the ground. That's what we want to understand." But

more than understand; S2L sees these models as tools to help inform other research and help guide efforts to manage and preserve biodiversity. Dr. Newsam says, "One outcome would be for our models, our recognition techniques, to be deployed on the Microsoft AI for Earth API for other scientists to use." That would allow the models to be extended to recognize other animal calls as well, and to develop a fuller view of the biodiversity where this method is deployed.

"The broader goal," says Dr. Salas, "is to help people make better decisions about managing resources towards a climate-smart future. If we are able to predict which pieces of the landscape will host the largest biodiversity into the future, given what we understand now is happening, then we can plan for protecting those areas, for example." Although the plan is to scale this methodology and technology up to global use, it also comes back to local action, helping private and public decision makers—landowners and governments—take steps to preserve the life of the land for today and the future.

AutoMoth deployed in a Sonoma County wetland. (Photo credit: Rose Snyder)

About the Soundscapes to Landscapes team

Dr. Shawn Newsam is an associate professor of Electrical Engineering and Computer Science in the School of Engineering at the University of California, Merced. He joined UC Merced as a founding faculty member in 2005, just a few months before the campus opened. Prior to joining UC Merced, Dr. Newsam was a post-doctoral researcher with the Center for Applied Scientific Computing at Lawrence Livermore National Laboratory. He received his Ph.D. in Electrical and Computer Engineering from the University of California,

Santa Barbara, his M.S. in Electrical and Computer Engineering from the University of California, Davis, and his B.S. in Electrical Engineering and Computer Science from the University of California, Berkeley. Dr. Newsam is the recipient of a U.S. Department of Energy Early Career Scientist and Engineer Award, a U.S. National Science Foundation Faculty Early Career Development (CAREER) Award, and a U.S. Office of Science and Technology Policy Presidential Early Career Award for Scientists and Engineers (PECASE). Dr. Newsam's research interests include image processing, computer vision, and machine learning particularly as applied to scientific data in interdisciplinary settings.

Dr. Matthew Clark is a professor in the Geography, Environment, and Planning department at Sonoma State University, and the principal investigator for Soundscapes to Landscapes. He has a PhD in Geography from University of California, Santa Barbara and a M.Sc in Conservation and Ecosystem Analysis from University of Washington. He teaches classes in geographic information systems (GIS) and remote sensing. His research is focused on using novel forms of remote sensing, including satellites, airplane sensors, and drones, for monitoring biodiversity, assessing land change, and helping conservation and land management.

Dr. Leonardo (Leo) Salas is a senior quantitative ecologist at Point Blue Conservation Science. Originally from Venezuela, where he obtained his Bachelor's degree in Biology, Dr. Salas attended graduate school at the University of Massachusetts (Masters and Ph.D.). He has studied several organisms and ecosystems: tropical forests, Andean bears, lowland tapirs, biodiversity in Borneo, arboreal marsupials in New Guinea, seals and food webs in Antarctica, landbirds and secretive marshbird in the western U.S., among other things. His passion is to apply statistical tools to describe these systems and organisms in open, transparent, and repeatable applications, always centered on data-driven management objectives for conservation. Dr. Salas joined Point Blue 13 years ago to work on the most pressing issue of our time: climate change impacts. He currently collaborates with a variety of incredible and passionate colleagues on projects that aim to guide management decisions that account for possible future climates and changing habitats.

Shrishail (Shree) Baligar is a third-year Ph.D. student in Dr. Shawn Newsam's lab in Electrical Engineering and Computer Science (EECS) at UC Merced. Prior to that, he received his B.E. (Bachelor of Engineering) in Information Technology from MIT College of Engineering, India. His area of research includes developing deep learning algorithms for audio data analysis which involves tasks like recognition, classification, and segmentation of audio features. The source of audio data can range from bird-sounds, musical instruments, to human speech. Currently he is developing deep learning models based on anthrophonic, geophonic, and biophonic audio data for biodiversity analysis, in collaboration with the NASA-funded Soundscapes to Landscapes project. His work will be funded by the Microsoft AI for Earth grant for the year 2020.

Resources

Websites

Soundscapes to Landscapes home site

Publications

Clark, M. L. (2020). Comparison of multi-seasonal Landsat 8, Sentinel-2 and hyperspectral images for mapping forest alliances in Northern California. ISPRS Journal of Photogrammetry and Remote Sensing, 119, 228-245.

Documentation

Global Assessment Report on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). 2019. https://ipbes.net/global-assessment

Andy Purvis. "A million threatened species? Thirteen questions and answers." IPBES. Accessed February 26, 2020. https://ipbes.net/news/million-threatened-species-thirteen-questions-answers

Thalif Deen. "As Planet Burns, One Million Species in World's Eco-System in Danger of Extinction." Inter Press Service. February 18, 2020. http://www.ipsnews.net/2020/02/planet-burns-one-million-species-worlds-eco-system-danger-extinction/

"Biodiversity". World Health Organization. Accessed February 26, 2020. https://www.who.int/globalchange/ecosystems/biodiversity/en/

Adam Wernick. "Biodiversity loss has an enormous impact on humans, according to a UN report." *Living on Earth*. Public Radio International (PRI). April 21, 2018. https://www.pri.org/stories/2018-04-21/biodiversity-loss-has-enormous-impact-humans-according-un-report