AI for Earth Grantee Profile

National Audubon Society

Protecting bird populations after hurricanes with AI

Summary

Increasingly intense storms are causing significant erosion and land cover change along US coastlines, resulting in critical habitat loss for birds. The National Audubon Society is using Microsoft cloud and AI tools to improve bird monitoring after weather-related disasters, helping researchers quickly assess disturbance effects and act to preserve endangered coastal birds.

Protecting bird populations after hurricanes with AI-enabled monitoring

Biodiversity is under threat globally from anthropogenic pressures such as habitat loss, fragmentation, and degradation. The World Wildlife Fund for Nature's *Living Planet Report 2016* found that populations of vertebrate animals have declined by 58 percent overall from 1970 to 2012, with freshwater species dropping as much as 81 percent. The National Audubon Society's 2014 *Birds and Climate Change* report studied 588 North American bird species and found that more than half are threatened by habitat loss due to global warming.

> More than 50 percent of 588 bird species studied in North America are threatened by habitat loss due to global warming.

Recent global warming has also been implicated in the increased intensity of hurricanes and tropical storms. NOAA's Geophysical Fluid Dynamics Laboratory concluded in its June 2018 report *Global Warming and Hurricanes: An Overview of Current Research Results* that there is a greater than 66 percent chance of tropical cyclone intensities increasing on average by 1 to 10 percent, while very intense storms are more than 50 percent likely to occur more frequently. Such powerful storms affect birds and other wildlife both directly and through loss or degradation of critical habitat.

Disturbances such as hurricanes cause significant erosion and extensive land cover change, resulting in loss of critical habitats important to breeding, migratory, and wintering birds. Protecting birds (and other wildlife) is worthwhile for their own sake, but beyond that—where birds thrive, people prosper. Barrier islands, coastal marshes, beaches, and other habitats that support diverse and abundant bird communities also provide valuable benefits to people, including storm surge reduction, flood control, support of native marine ecosystems and fisheries, and recreational opportunities.

To conserve coastal birds and other biodiversity, it's essential to quickly and accurately assess disturbance effects and identify areas in critical need of habitat restoration. Quick assessment would also help with disaster management and recovery in general. As well, more accurate methods of counting and identifying bird populations would enable better monitoring of priority and endangered species and better understanding of how major storms affect changes in their populations. Currently, rapid assessment is extremely difficult for two primary reasons: inefficient and costly bird monitoring techniques and the huge scale of the disturbance areas.

Evolving traditional birding

Bird watchers are among the most enthusiastic citizen scientists. For years, the National Audubon Society has relied upon this volunteer community to help count birds. However, in-person bird monitoring is often extremely difficult to do well, particularly for sites that have limited accessibility or can only be surveyed during narrow time windows (such as islands with tide-limited beach access).

In the aftermath of a major storm, damage and debris can make it even more difficult to assess bird colonies and habitats in person. In addition, many productive bird colonies are located in remote areas far from cities, making it difficult to recruit observers trained in bird identification and survey protocols. Large colonies of birds are also difficult to count accurately from the ground, even more so in flat areas such as beaches and barrier islands where many colonial water birds gather, and where sightlines are limited.

Given the challenges of traditional bird counting, Audubon is augmenting in-person monitoring with drones. Using drones to capture high-resolution imagery, bird colonies can be surveyed remotely by anyone, regardless of their bird identification skills, and with greater accuracy due to the direct sightlines and the time available to review images. Drones, however, produce a large amount of data and require extensive computer resources and human labor to process using traditional analytical methods.

In addition, the spatial extent of a hurricane's impacts and damage to critical infrastructure such as roads, bridges, and ports impedes the ability of Audubon to rapidly evaluate storm effects on birds and their habitats and inhibits identification of priority areas for restoration. Currently, Audubon can assess land habitat availability using remotely sensed land cover datasets such as the USGS's National Land Cover Database (NLCD) or NOAA's Coastal Change Analysis Program (C-CAP). However, these datasets are updated infrequently (five- to eight-year intervals), are sampled at relatively coarse resolutions, and have low thematic resolution. To accurately assess land cover change post-disturbance, particularly in narrow linear habitats such as beaches or barrier islands, it is essential to obtain land cover classifications from high-resolution remotely sensed datasets collected more frequently and at thematic resolutions relevant to wildlife.

Scaling up intelligent bird monitoring

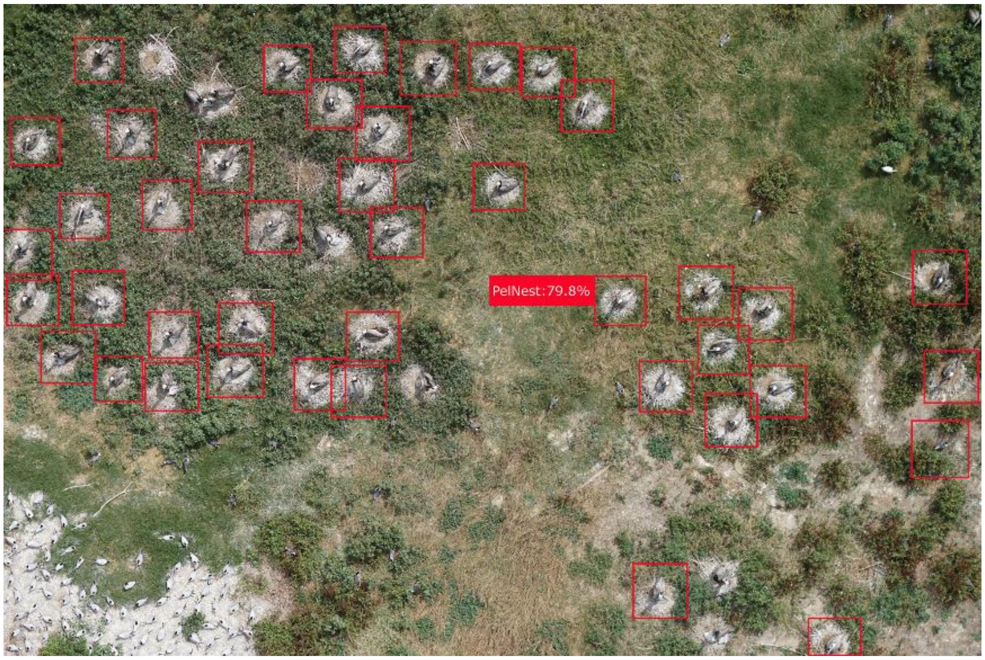
With a grant from the Microsoft AI for Earth program, Audubon launched a new project to advance the rapid evaluation of bird monitoring and habitat assessment. The Audubon project is twofold: documenting changes in bird habitats due to disturbances such as major storms, and more accurately counting the different species of birds living in those habitats.

> Audubon's Azure Custom Vision Service correctly found 78 percent of birds, with 87 percent accuracy—numbers potentially better than human observers.

First, Audubon is developing a robust, accurate land cover classification model that will enable rapid, high-throughput processing of aerial imagery. This model will allow organizations to rapidly assess land cover change following anthropogenic and natural disturbances, from hurricanes to fires, oil spills, forest clearing, and other events. In its initial work, Audubon applied a machine learning algorithm, Random Forest, to classify imagery of sites in Texas before Hurricane Harvey and then conducted a change detection analysis to map post-storm flood extent. The Random Forest algorithm performed well in classifying habitats prior to the storm, with an overall accuracy of 81 percent. This information is critical for identifying species threatened by habitat loss and regions in greatest need of conservation or restoration.

Second, Audubon is developing and training machine learning algorithms to identify and count birds by type or guild (such as shorebird, heron, ibis) and even individual species (such as American Oystercatcher, Great Blue Heron, White Ibis). These algorithms will be applied to large amounts of images captured by drone cameras, which will enable Audubon to perform rapid assessments of disturbance effects following future events, to count populations as part of regular monitoring, and to count birds at colonies that are difficult for human surveyors to access.

Developing machine learning and cognitive algorithms that can rapidly process remotely sensed data to census birds and wildlife and classify land cover will change how Audubon accomplishes its conservation goals. Today, the effects of habitat loss and disturbance are evaluated using count data of limited quantity and quality, and land cover assessments using data of coarse thematic resolution and slow response time post-disturbance. By harnessing the power of big data, machine learning, and cloud computing, Audubon can better organize



The algorithm helps identify just the birds, while ignoring empty nests, in a drone photo of pelicans and terns. Credit: Hank Arnold via National Audubon Society

restoration efforts following disturbance events, thus ensuring the conservation of birds, their habitats, and the ecosystem services they provide.

The Microsoft AI for Earth grant provided several critical tools to enable this project, including access to Esri ArcGIS Pro. High-resolution imagery from drones and aerial surveys, as well as LiDAR elevation data for land cover classification, was loaded into Azure Data Science Virtual Machines for high-throughput processing with Esri ArcGIS Pro. Azure provided cost-effective scalable storage for the large imagery and data files needed for the project. For the bird census, the imagery was processed using Microsoft Azure Computer Vision API in the Cognitive Vision Toolkit to tag images containing birds and filter out images lacking birds. Machine learning algorithms were implemented in Machine Learning Studio using the MicrosoftML package. In both cases, additional tools hosted on Azure, such as the ArcGIS Pro Spatial Analyst Image Classification tool, were used to help train the algorithms.

Once trained, these algorithms enabled Audubon to quickly obtain accurate count and colony size data from remote sites and across large spatial scales that were impractical or impossible to attempt using traditional ground-based surveys.

Counting brown pelicans—an example

Tim Meehan of Audubon conducted trials of the new Microsoft Azure Custom Vision Service. The Custom Vision Service provides a virtual workspace for users to upload a set of images and annotate the objects in the images, then send them to a naïve neural network to train it to see the objects through an iterative process. The service can track how well the neural network model performs through the process and provides tools to improve it through updating or changing annotations and processing more images.

Meehan had two batches of photos taken by drone along the coast of Texas, one from 2017 from a consistent 30-meter height with a 50-mm lens, and a second from 2018 in the same area but not consistently the same height, type of lens, or lighting conditions. The photos included brown pelicans either in nests or on the beach, various sorts of terns on the beach, and black skimmers on the beach. Meehan selected a subset of the photos from 2017 to use for training purposes, and in two iterations determined that the model was much better at picking out the pelicans than the other two types of birds. Choosing to focus on that species, Meehan ran more iterations, and the model correctly found over 78 percent of the birds in the images, with 87 percent accuracy in identification—numbers comparable to, even potentially better than, the counts that human observers on the ground could do.

Following this brief training period, Meehan tested the model by feeding it another small set of photos, some from the same 2017 batch used for training, and some from the 2018 batch. While the model performed well with the 2017 photos, it initially failed to pick out any pelicans in the 2018 photos due to the variability and differences in lighting and distance from the ones used in training. However, by creating a Python script to adjust the size, resolution, and color balance of the 2018 photos to better match the 2017 ones, Meehan was able to get the model to perform similarly well. Meehan also created a script to automate the process of uploading a batch of photos and retrieving a spreadsheet with the results for statistical analysis.

With this successful test of Custom Vision Service, Meehan determined this solution would be suitable for Audubon's needs. The next step would be to create a workflow in which a composite mosaic of a study area, such as an island or coastal section, would be created from a batch of images and geotagged using Esri ArcGIS tools, and then divided into equal parcels. The parceled images would then be processed to normalize the lighting and hues across the set, and with this preprocessing, Custom Vision Service would be able to perform a before-and-after comparison, helping Audubon achieve its goal of assessing the effects of storms.

Going forward

Next for the habitat classification model is to investigate longer-term impacts from storms by comparing images separated by longer periods after the storm. Alternative sensor data, such as radar, can also be used to better distinguish different types of terrain that look similar in visible-light photos. For the bird-counting model, the next step is to scale up by training the model on images with tens of thousands of labeled birds of different species. Additional coding is needed to process the images and model output.

The initial work involved counting birds and classifying habitats on images from around the US Gulf of Mexico. But these solutions could be applied to images taken anywhere across the globe, including wildlife living at remote locations. Audubon plans to transfer its models to other priority coastal locations where it is actively engaged, such as the Carolinas, Long Island Sound, and San Francisco Bay. Audubon not only expects this work to be beneficial within its own organization, but also sees opportunities for its primary partners, federal and state wildlife agencies such as the US Fish & Wildlife Service that are chartered with managing waterbird populations and delivering habitats for conservation.

Audubon published two reports summarizing their findings from this project, one on the pelican counts from drone imagery and one on the habitat evaluation from satellite imagery. The algorithms developed from this project will vastly increase the speed of image processing, identification, and count estimation for future surveys, empowering Audubon to meet the conservation challenges posed by accelerating global change. Moreover, the methods and code developed here will be available for rapid implementation in response to future disturbance events and will be made publicly available through open access (such as GitHub and AI for Earth API) for use by other researchers and organizations. Potential uses include early warning systems such as Global Forest Watch that could identify habitat destruction such as forest clearing in near-real time and alert local people for political action.

About National Audubon Society

Founded in 1905, the National Audubon Society is a nonprofit conservation organization that protects birds and their habitats throughout the Americas using science, advocacy, education, and on-the-ground conservation. The organization operates 23 state programs, 41 Audubon nature centers, and nearly 500 local chapters across the United States that engage members in grassroots conservation action.

Members volunteer to collect vital data through the annual Christmas Bird Count, the Audubon Coastal Bird Survey, and other ecosystem-wide initiatives that focus on protection and restoration of threatened lands across the nation. This data helps generate groundbreaking analyses of the needs of birds and other wildlife. Audubon environmental policy, education, and science experts guide lawmakers, agencies, and its membership in shaping effective conservation plans, actions, and the policies to support them.

Resources

Websites

National Audubon Society
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Press

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