A Bird's Eye View of ... Birds

COMBINING TECHNOLOGY AND CITIZEN SCIENCE FOR CONSERVATION

By Susan N. Ellis-Felege, Travis Desell, and Christopher J. Felege

Imagine staring at a computer screen for hours on end as a hen sharp-tailed grouse (*Tympanuchus phasianellus*) sits almost motionless on her nest. Grass blows in front of the screen, insects fly by and, with eyes fatiguing, you patiently watch for the moment something happens. As you watch, you find your mind drifting to contemplate the duality you are faced with: On one hand you hope nothing happens until the eggs hatch and chicks emerge from the nest bowl on the 23rd day of incubation, but on the other hand you hope that anything will happen to break the monotony, even though it may mean the failure of the hen's nest or worse, the loss of her life. Then suddenly it happens—the grouse dips her head, crouches, and out of nowhere a Swainson's hawk (*Buteo swainsoni*) plucks the hen from atop her eggs.

This scenario is what many undergraduate and graduate researchers at the University of North Dakota (UND), studying the ecology and behaviors of nesting birds, experience while reviewing nest camera footage. Increasingly, more of the public is gaining access to experiences like this through streaming videos of cameras placed in urban raptor nests or nest boxes, which provide them with first-hand opportunities to view the daily activities of a nesting bird.

The Data Deluge

Due to affordability and advancements in technology, wildlife research has seen a dramatic increase in camera use to study wildlife patterns and behaviors that would have otherwise been logistically difficult or even impossible to observe in the wild. Miniature surveillance cameras deployed at the nest have become particularly important in understanding aspects of avian ecology such as predation (Pietz and Granfors 2000, Staller et al. 2005), nest defense (Ellison and Ribic 2012, Ellis-Felege et al. 2013), incubation patterns (Burnam et al. 2012), and reproductive responses to management actions (Ellis-Felege et al. 2012). However, rapid improvements in affordable camera technology and data storage systems have resulted in a "data deluge," where scientists are accumulating information faster than it can be filtered and analyzed in order to address critical conservation issues.

Here at UND, in a collaborative partnership between the computer science and biology departments, we have begun pioneering a solution to this problem through an interdisciplinary approach using a combination of citizen science tools and computer vision techniques—methods to process, analyze, and understand video images. Launched in 2012 and recently funded by the National Science Foundation, Wildlife@Home uses a combination of tools to filter through large video datasets collected from sharp-tailed grouse nests in the North Dakota oil fields, as

Credit: Chris Felege

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Credit: Paul Burr

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A researcher installs a miniature surveillance camera attached to a dowel rod as part of the University of North Dakota's Wildlife@Home project. Citizen scientists review the resulting footage, which can range from hours of inactivity in the birds' nests to sudden crises such as this Swainson's hawk (inset) snatching a hen sharp-tailed grouse from her nest in western North Dakota.

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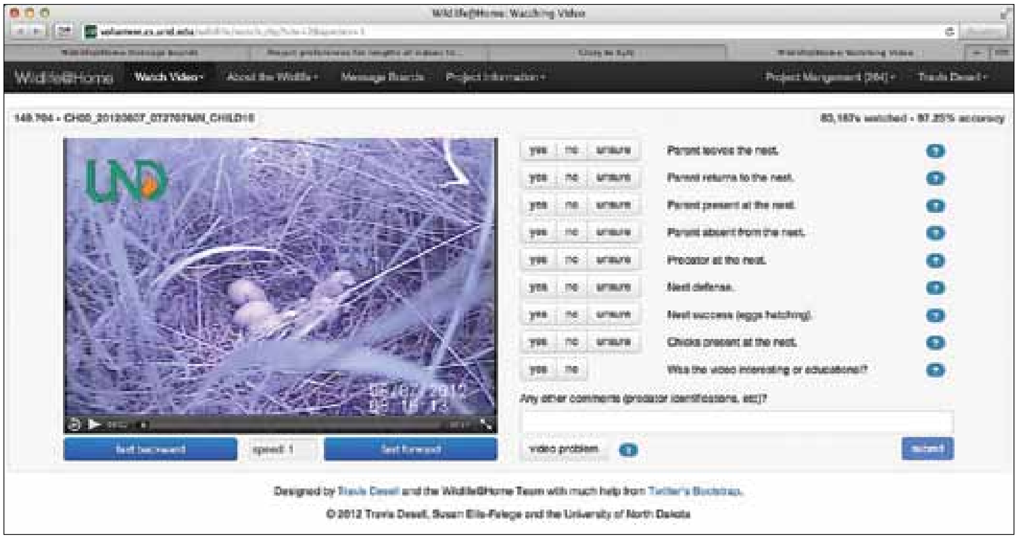

Credit: Travis Desell

This Wildlife@Home webpage allows volunteers to enter observations while viewing nesting videos. Users can provide comments and times of specific behavioral observations, discuss videos in an online forum, and report if they are unsure of any observations.

well as federally listed piping plover (*Charadrius melodus*) and least terns (*Sternula antillarum*) along the Missouri River. As part of the project, we combine crowd-sourcing, where volunteers watch and classify video observations with volunteer computing, where people volunteer their computers to run computer vision algorithms designed to filter the activities of birds at the nest. This interdisciplinary, collaborative approach is (1) seeking solutions for streamlining video analysis to better answer ecological conservation questions in a timely fashion, (2) refining computational methods in computer vision that can have applications beyond wildlife ecology, and (3) investigating methods to improve public understanding of the biology behind the systems and their ecological impact by virtually bringing the public out into the field through streaming video.

Inner Workings of Wildlife@Home

As a result of collaborations with the North Dakota Game and Fish Department and U.S. Geological Survey–Northern Prairie Wildlife Research Center, we have projects deploying nest cameras that have accumulated approximately 100,000 hours of video footage for the three species during the 2012 and 2013 breeding seasons. Continued camera monitoring will occur in 2014 and 2015 for piping plovers and least terns.

As part of these projects, we placed miniature microbullet cameras with infrared light-emitting diodes or LEDs approximately 0.5 meters from sharp-tailed grouse nests in low and high intensity areas of gas and oil development in western North Dakota in order to understand potential influences of gas and oil development on nest predation and grouse nesting behaviors. We placed similar cameras greater than one meter away from nests of piping plovers and least terns and camouflaged them to blend into the surrounding sand substrate. These cameras were then secured to 1.27-cm dowel rods. In both situations, a 25-meter cable connected the camera to a 12-volt, 35-amp battery and a waterproof box housing a DVR, which recorded nesting activities onto an SD memory card. Batteries and SD cards were changed every three to four days, and cameras remained at the nest until the nest hatched or failed.

The video was then uploaded to our server, converted for streaming with a UND logo, and streamed in three-, five-, 10-, or 20-minute clips to volunteers (citizen scientists) who register for a free account through the Wildlife@Home website. Volunteers can access training videos and project background to become familiar with the ecology of the birds and the goals of the research. Next, volunteers and a team of wildlife biologists, including undergraduate and graduate student researchers from UND, classify nesting events to create a database of annotated video. For example, volunteers respond to events such as "parent absent from the nest" or "predator at the nest" with "yes," "no," or "unsure." Video clips are shown to multiple users in order to reach a consensus on activities within each video. Then custom software analyzes the results for discrepancies, which project scientists review and resolve.

Occasionally, volunteers are faced with challenging scenarios of identifying bird presence in the field of view, such as sharp-tailed grouse whose cryptic coloration can be difficult to distinguish from surrounding settings. To further complicate the challenge, video is in color during the day but black and white at night, and completely uncontrolled with varying weather conditions and vegetation. As a result, after viewing a video, volunteers can see other users' responses and flag videos they think have incorrect responses, for project scientists to review.

Researchers use volunteer and expert-generated observations to test and train computer-vision algorithms, which run on computers (that volunteers lend to the project) through the popular Berkeley Open Infrastructure for Network Computing (BOINC) software (Anderson 2004). These computer-vision algorithms are being studied as a way to automatically classify events of biological importance and filter out uninteresting or unimportant video such as grass blowing in front of an almost motionless hen. The goal of these algorithms is to allow the project's users to focus on the biologically relevant, interesting, and challenging videos while automatically classifying less relevant video.

"Wildlife@Home has provided me the opportunity to better understand the ecology of various bird species through watching them in their natural environment," says undergraduate project scientist Leila Mohsenian. The website and database infrastructure at UND also provide a framework for other researchers to collaborate and more efficiently store, filter, and analyze nesting video for similar projects. Eventually, we anticipate hosting other types of wildlife video on the Wildlife@Home website, which will facilitate data and information sharing across animal distributions and foster future collaborative approaches. Further, researchers in computer science will be able to use the video archive and user observations to test other computational algorithms for video analysis. In the future, researchers could also possibly integrate the computer vision techniques developed in this study alongside advances in wireless technology to allow the deployment of multiple-sensor monitoring systems. With such developments, computers could immediately identify an event, turning on other cameras, audio recorders, or temperature and humidity sensors to provide a more complete understanding of ecological systems. This could streamline the study of ecological systems through data fusion.

Education and Outreach

The Wildlife@Home project provides educational opportunities including the ability to communicate with the public on conservation issues and eventually communicate with the academic community for classroom instruction at various levels. Apart from highlighting conservation issues with users across the globe who aren't directly involved in the conservation community, it helps raise awareness of land-use implications such as oil and gas development on wildlife populations.

To do this requires building an online community and learning to engage and educate the public in creative ways. Presently, we have approximately 175 volunteers who have watched more than 14,000 hours of nesting video, which has resulted in 6,000 hours of videos with multiple views that have reached a consensus. To stimulate additional participation and accuracy of this video, we have a badge program that provides incentives for the most amount of video watched and ratings for accuracy. Further, the interdisciplinary nature of this work allows our research team to discuss methods in computer science and wildlife ecology and then communicate data collection and the science behind the videos and computer vision methods to the public via the website.

To encourage such dialogue, we provide discussion boards about conservation issues, computer science methods, news related to the project, and even video observations. For example, when citizen scientists have questions or comments related to a particular video, they can post the video to the video discussion board by selecting a "Discuss this Video" button. "This is a great way for the volunteers and researchers to communicate," says project scientist and UND graduate student Becca Eckroad. "We as researchers can determine what the volunteers find interesting, technical issues they're having, or questions they have about project objectives and methodology." To date, approximately 180 video clips have been posted for community discussion with other volunteers and project scientists.

This project can also benefit students by providing real-life scenarios and discussion opportunities for teachers and students in K-12 schools. As it matures,

University of North Dakota students Julia Johnson and Paul Burr place a radio collar on a hen grouse so they can track and film the bird's activity at its nest. As part of the Wildlife@ Home project, citizen scientists can then view and discuss video footage on a discussion board.

Credit: Susan N. Ellis-Felege

project scientists will be able to provide online modules to facilitate use in the classroom using interesting videos found by the project's volunteers. For example, students could watch videos of least terns feeding chicks and calculate daily feeding rates, or identify predators eating nests, as a way to facilitate discussion about population ecology and limiting factors on population growth. The first series of modules is expected to go live in the fall of 2014. Since students are already extremely familiar with social networking, the Wildlife@Home project can provide hands-on classroom instruction utilizing such technology and communication to meet learning outcome goals. In addition, educating students about conservation issues early on or in metropolitan areas where nature is not easily accessible will help connect students to ecological issues, and has been shown to help make students more environmentally responsible citizens (Bradley 1995, Van Velsor 2004).

Still, the project is not without its challenges. On top of the technical, logistical, and computational hurdles, recruiting and retaining enough citizen scientists to volunteer both their time and computers is critical to the project success. Having enough expert scientists to communicate effectively with the citizen scientists' questions and observations poses a challenge but also an opportunity for other ecologists to become involved in these discussions.

Wildlife@Home is an example of how wildlife biologists, computer scientists, and citizens can work collaboratively on real-world issues such as management of endangered species and impact of gas and oil development on nesting birds to further both research and education. Imagine: You could not only watch a grouse incubate her eggs, but also help scientists better understand the nesting ecology of the species and the impacts humans are having on her behaviors and the fate of her eggs. By working together, volunteers will help us find creative solutions to gather and analyze data fast enough to make meaningful management impacts.

This article has been reviewed by a subject-matter expert.

To assist with Wildlife@Home, go to http://volunteer.cs.und.edu/wildlife/ and register for a free account.

