ZOONIVERSE

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With the advent of automated data collection that uses high resolution imaging and other refined instrumentation, scientists are dealing with huge volumes of data. And these volumes are increasing exponentially with each new generation of instrumentation. In astronomy, some instruments collect up to 2.5 terabytes (TB) of data each night. A terabyte is a unit of digital information equal to one million, million (10^{12}) bytes. (More accurately it is 2^{40} bytes.) Some future instrumentation will be able to collect 15 to 30 TB of data per night. One TB can hold about 310,000 photographs, or the text of more than 132,000 large books.

All of this data requires analysis (otherwise why collect it at all?). Individual scientists could spend their entire lifetime working around the clock and would only be able to sort through a tiny fraction of this volume. After all, how many large books have you read?

What's more, for much of this data, computers are of little help. Computers can organize the data, but it takes a human being to perform the analysis itself. It turns out that humans are more adept at picking out patterns than any computer algorithm yet devised. Computer programs easily get confused and often miss significant factors.

This is where Zooniverse comes in. Zooniverse was founded in 2007, as a collaboration among the Alder Planetarium, the University of Oxford, and the Citizen Science Alliance. Zooniverse started as an astronomy project that called on volunteers to classify galaxies in digital images from the Sloan Digital Sky Survey. It has since grown to more than 125 completed and current projects.

The Zooniverse website connects people with professional researchers to promote collaboration and discovery using large data sets. Zooniverse enables citizen scientists to take part in cutting-edge research with nothing more than an internet connection. And participants do not need specialized training. Each project describes the procedures and provides help and instruction to perform the required tasks. Each project also has on-line discussion boards for the exchange of information and ideas.

When the first project started, within a day, the site was receiving nearly 70,000 classifications per hour. Within a year, more than 50 million classifications had been submitted by more than 150,000 participants. The more volunteers who look at an image, the more likely the resulting classification is to be correct.

Rainforest Flowers

Reading Nature's Library

Now its diverse project categories include biology, history, climate science, the arts, medicine, ecology, and the social sciences. Participants can switch among projects. If you get tired of counting Weddell seals in Antarctica's Ross Sea (Weddell Seal Count: *www.zooniverse.org/projects/slg0808/weddell-seal-count*), you can sort through fragments of Middle Eastern and Mediterranean texts from the 10th to 13th centuries (Scribes of the Cairo Geniza: *www.zooniverse.org/projects/judaicadh/scribes-of-the-cairo-geniza*).

Obviously, this system benefits researchers by having others sort through the data to identify areas for further study and to cull out less significant information. But it also benefits the volunteers by enabling them to become part of a community involved in exploration and scientific advancement.

The names of volunteers are listed with those of the project leaders on discovery publications and dozens of volunteers have been co-authors on articles and scientific papers. Zooniverse puts the power of science in your hands and gives volunteers a first-hand look at how science progresses from raw data to analyzed results.

Currently, Zooniverse has 88 active projects. Below is a listing of the 46 current Zooniverse projects related to biology and ecology. There is something here to interest everyone. (*www.zooniverse.org/projects*)

Beluga Bits: Examine underwater photos of wild beluga whales and help identify the age, sex, and group size. Also need a keen eye to look for identifying marks to recognize beluga that return to this location year after year.

Snapshot Hoge Veluwe: Classify the wildlife in the pictures and contribute to important ecological research in the Netherlands.

South Sudan DiversityCam: South Sudan, the newest nation in the world, is extraordinarily biodiverse. Help conserve wildlife in this special and under-studied region by identifying animals in camera trap photos.

Rainforest Flowers: Help tag the Field Museum's photos of tropical flowers.

London Bird Records: Help recover 20th century bird observations collected by the London Natural History Society.

Penguin Watch: Tag penguins in remote regions to help researchers understand their lives and environment.

Candid Camera: Identify New York wildlife to create thriving forests.

eMammal: Help classify camera trap photos of different animals.

Invader ID: Help researchers track changes in coastal environments by identifying marine invertebrates.

HumBug: Discover mosquitoes from their buzz.

Manatee Chat: Identification and classification of manatee calls.

Grouse Grooves: Our lab is studying Greater Sage-grouse conservation, help us protect this important species.

Orangutan Nest Watch: Search drone images of Bornean rainforest for orangutan nests and fig trees.

Interior Least Tern and Piping Plover Predators: Help researchers identify predators of threatened and endangered species that nest within the Central Platte River Basin in Nebraska.

Reading Nature's Library: Help Manchester Museum discover the treasures in its collection.

Snapshot Grumeti: Check out photos of wildlife living in Grumeti, home of the ancient annual wildebeest migration, which drives the dynamics of this unique ecosystem.

Snapshot Serengeti: Help researchers explore the secret life of the Serengeti. Our cameras track the movement of thousands upon thousands of animals migrating with and following the wildebeest migration.

Snapshot Ruaha: Help researchers mitigate human-wildlife conflict by classifying photos that are used to assess communities' contributions to conservation efforts.

Project Plumage: Help researchers explore bird color with museum specimens.

Floating Forests: Help researchers uncover the history of Giant Kelp forests around the globe.

The Community Seagrass Initiative – Seagrass Explorer: The UK's most important marine habitat is in decline, help researchers understand why and find out more about the animals that live there.

Cheetahs of Central Namibia: The Cheetah Conservation Fund needs your assistance: Help us research the predator and prey species of central Namibia, home to the largest population of wild cheetah.

Parasite Safari: Do watering holes concentrate wildlife and their parasites? Help researchers to measure how different species balance the need for water with the risks of parasitism and predation.

Treeversity: Tag our trees. Help researchers identify plant features while learning about botany and exploring the Arnold Arboretum's Living Collection.

Seabirdwatch: The world's seabirds are in rapid decline. Help monitor them and change conservation worldwide.

Leaf Targeting: Help us understand how plants grow by marking leaves in plant images.

Wildwatch Kenya: We need your help to count, identify, and track the giraffes and other wildlife living in our field conservation sites in northern Kenya.

Weddell Seal Count: Are Antarctic Weddell seals threatened by fishing? By climate change? Help us find out.

Colorado Corridors Project: Let's build an overpass for wildlife. Help us identify animals that need a safe place to cross the road.

Fossil Atmospheres: Count cells of modern & fossil leaves. Help researchers track climate change over millions of years

Serengeti Wildebeest Count: Count the Serengeti wildebeest.

Michigan ZoomIN: Help researchers investigate wildlife in Michigan.

Western Montana Wildlife: Help process the thousands of creatures captured on camera.

Etch a Cell: Help researchers learn more about the structures that make up cells.

Steller Watch: Help researchers find out why the endangered Steller sea lion continues to decline in the Aleutian Islands.

Chicago Wildlife Watch: Help researchers understand how animals—from coyotes to chipmunks—share this great city with humans.

Arizona BatWatch: Help scientists learn about endangered Lesser Long-nosed Bats.

Mapping Change: Help researchers use over a century's worth of specimens to map the distribution of animals, plants, and fungi. Your data will let us know where species have been and predict where they may end up in the future.

Camera CATalogue: Analyze wildlife photos to help Panthera protect big cats.

Notes from Nature: Transcribe museum records from several groups including plants and insects.

Snapshot Wisconsin: Discover wildlife by classifying images captured on trail cameras.

Whales as Individuals: Help researchers identify individual Humpback Whales by clueing our computer algorithms in to patterns on their tails.

Chimp & See: Welcome to Africa—home of the chimpanzee. Our cameras have taken thousands of videos of these and other animals. Now we need your help to study, explore, and learn from them.

Science Gossip: In the Victorian period, scientists and members of the public worked together to further scientific discovery. Before computers and cameras they had to draw what they saw. Their drawings are locked away in the pages of Victorian periodicals, such as *Science Gossip*, *Recreative Science*, and *The Intellectual Observer*. Help us to classify their drawings and map the origins of citizen science.

Condor Watch: The California Condor is a critically endangered species and the population is suffering from the effects of lead poisoning. By tracking the location and social behavior of the animals we can better detect early warning signs of the illness.

Plankton Portal: Understanding where and when plankton occur at different depths in the ocean allows scientists to get a global understanding of the function and health of the ocean from small to global scales.

Reference: Klesman, Alison. "Zooniverse: A Citizen Science Success Story." *Astronomy*. October 2018. pp. 26–35.