

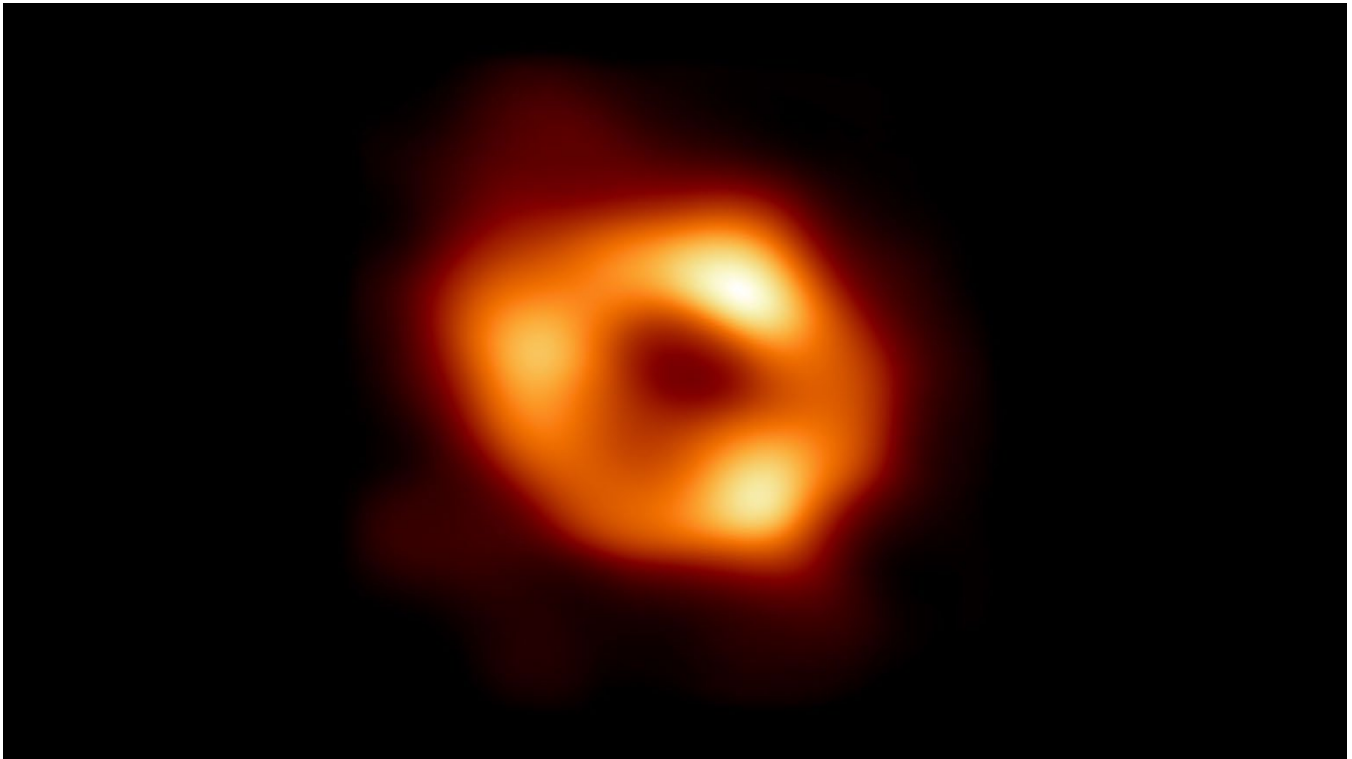


# Smithsonian Institution

## OUR SHARED FUTURE: RESEARCH HIGHLIGHTS JUNE 2022

The following stories highlight Smithsonian research that has helped to shape and champion our strategic pan-Institutional initiatives including **Life on a Sustainable Planet** and **Solving the Mysteries of the Universe**. These highlights also show the collaborative nature of the Institution's research, not only across Smithsonian units but in connection with leading universities, corporations, and research organizations aimed at mitigating the impacts of climate change and other types of human impacts on nature.

## SUPERMASSIVE BLACK HOLE AT THE CENTER OF OUR GALAXY



Astronomers unveiled the first image of the supermassive black hole at the center of the Milky Way galaxy in simultaneous press conferences around the world on May 12, 2022.

The result provides overwhelming evidence that the object at the heart of the galaxy is indeed a black hole, and it yields valuable clues about the workings of such giants, which are thought to reside at the center of most galaxies. The image was produced by a global research team called the Event Horizon Telescope (“EHT”), which includes scientists from the **Center for Astrophysics | Harvard & Smithsonian** (“CfA”), using observations from a worldwide network of radio telescopes.

The image, described in a [special issue](#) of *The Astrophysical Journal Letters*, is a long-anticipated look at the massive object that sits at the very center of the Milky Way. Scientists had previously seen stars orbiting around something invisible, compact and very massive in the galaxy’s core. This strongly suggested that the object—known as Sagittarius A\*, or Sgr A\*—was a black hole; the image provides the first direct visual evidence of it.

“For decades, astronomers have wondered what lies at the heart of our galaxy, pulling stars into tight orbits through its immense gravity,” said CfA astrophysicist Michael Johnson. “With the EHT image, we have zoomed in a thousand times closer than these orbits, where the gravity grows a million times stronger. At this close range, the black hole accelerates matter to close to the speed of light and bends the paths of photons in the warped spacetime.”

The black hole itself is completely dark, yet glowing gas around it reveals a tell-tale signature: a dark central region, called a shadow, surrounded by a bright ring-like structure. This new view shows light bent by the powerful gravity of the black hole, which is 4 million times more massive than the sun.

"We now see that the black hole is swallowing the nearby gas and light, pulling them into a bottomless pit," said Ramesh Narayan, a theoretical astrophysicist at the CfA. "This image confirms decades of theoretical work to understand how black holes eat."

Sgr A\* is about 27,000 light-years away, appearing to those on Earth to have the same size in the sky as a donut on the moon. To image it, the team created the powerful EHT, which linked together eight existing radio observatories across the planet to form a single "Earth-sized" virtual telescope.

Based on the summit of Maunakea in Hawaii, the [Submillimeter Array](#) (SMA), a joint operation between the CfA and Academia Sinica Institute of Astronomy and Astrophysics (ASIAA), was one of the eight instrumental telescopes utilized to capture the image. Together, the telescopes observed Sgr A\* on multiple nights in 2017, collecting data for many hours in a row, similar to using a long exposure time on a camera.

"Over 10 years ago, we linked radio dishes in California and Arizona to the SMA and other telescopes in Hawaii, allowing us to discover features in Sgr A\* that were the size of the black hole shadow," said Sheperd "Shep" Doeleman, founding director of the EHT. "This breakthrough launched the EHT, leading us to the wonderful Sgr A\* image revealed today."

Today's breakthrough follows the EHT collaboration's 2019 release of the first image of a black hole, called M87\*, at the center of the more distant Messier 87 galaxy. The image of Sgr A\*, only the second-ever picture captured of a black hole, shows that black holes look remarkably similar, even though Sgr A\* is more than a thousand times smaller and less massive than M87\*.

## U.S. OCEAN CONSERVATION EFFORTS HAVE MAJOR GAPS

A sweeping new analysis of U.S. Marine Protected Areas ("MPAs") published this month in *Frontiers in Marine Science* identified significant gaps in the country's ocean protections—leaving critical marine systems and the coastal economies that depend on them vulnerable to unprecedented ecological pressures and posing a challenge to meeting conservation goals laid out in the Biden Administration's "America the Beautiful" initiative.

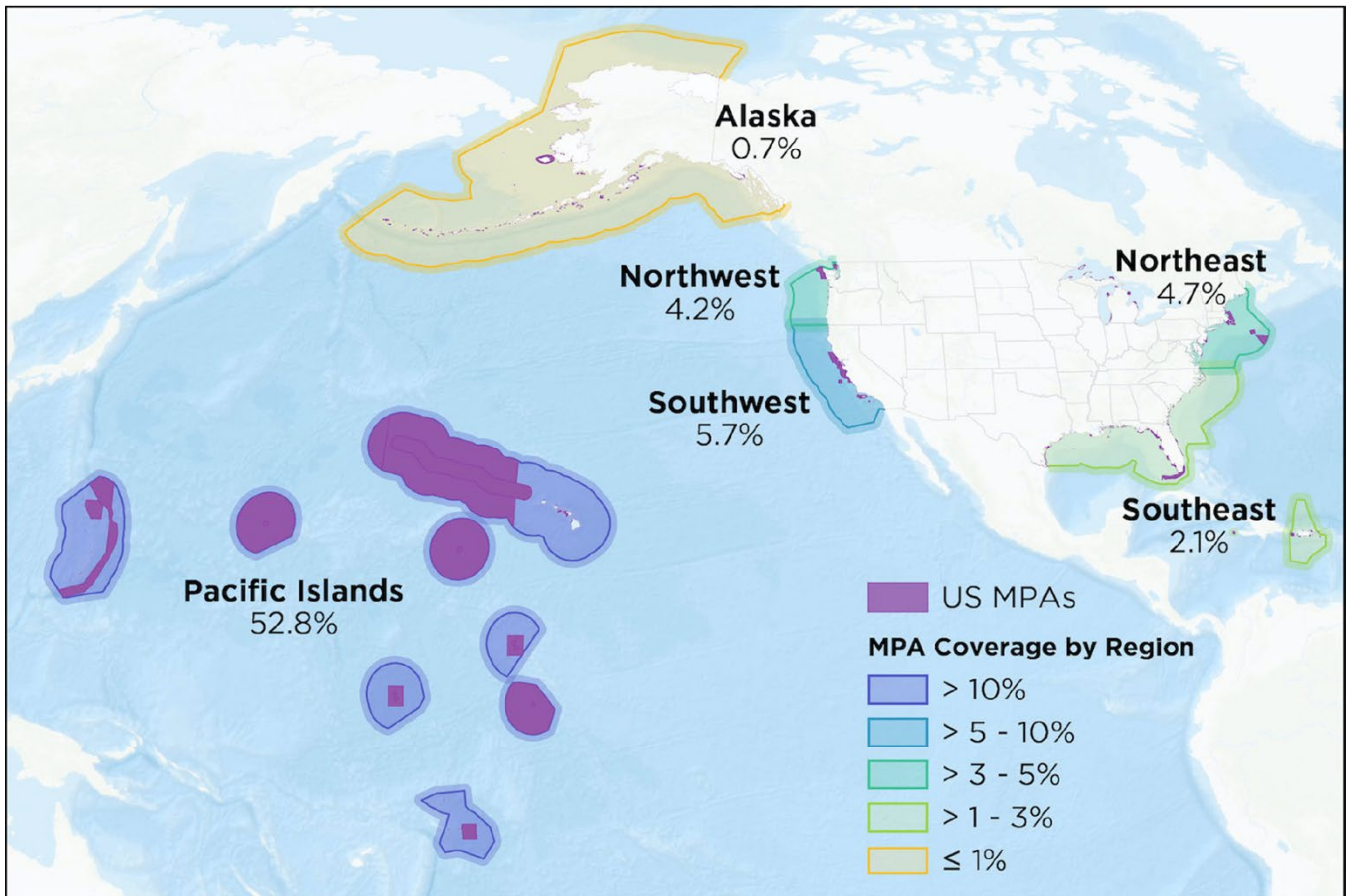
The paper, "[A Scientific Synthesis of Marine Protected Areas in the United States: Status and Recommendations](#)," used the groundbreaking new science-based framework "[The MPA Guide](#)" to evaluate the country's 50 largest MPAs—which make up 99.7% of U.S. MPA coverage. Researchers found that over 96 percent of the total area—and 99 percent of U.S. MPA area that is considered fully or highly protected from extractive and destructive human activities—is located in the central Pacific Ocean. The MPA coverage in other regions is surprisingly sparse. Just 1.9% of the U.S. waters outside the central Pacific benefit from any MPA protections and most of those are only considered lightly or minimally protected.

"These findings highlight an urgent need to improve the quality, quantity, and representativeness of MPA protection across U.S. waters to bring benefits to human and marine communities," said Dr. Jenna Sullivan-Stack, a research associate at Oregon State University and lead author on the paper.

"It is important to recognize that well-managed MPAs, designed with the local context in mind, can deliver benefits that extend beyond marine life to coastal communities that depend on sustainable marine resources for their livelihoods and cultural survival," said Dr. Ana Spalding, Associate Professor of Marine and Coastal Policy at Oregon State University and Research Associate at the **Smithsonian Tropical Research Institute**.

“This work takes a critical step toward understanding not only where, but how well, the U.S. ocean territory is protected,” said J. Emmett Duffy, Director of the **Tennenbaum Marine Observatories Network & MarineGEO** program and one of the authors. “It complements a forthcoming paper, led by Smithsonian **MarineGEO**, that dives deeper by tallying which species and habitats in these areas are best protected and which remain vulnerable. The latter are strategic priorities for new protections.”

The U.S. has set a national target to conserve at least 30% of its ocean by 2030. Achieving this target via marine protected areas that are effectively designed and implemented could be one of the best means to reduce threats to nature and enable ecosystems to meet peoples’ needs through sustainable, equitable use while protecting biodiversity. Although MPAs are not a silver bullet, they are an essential, cornerstone tool to address multiple threats to marine ecosystems and human well-being.



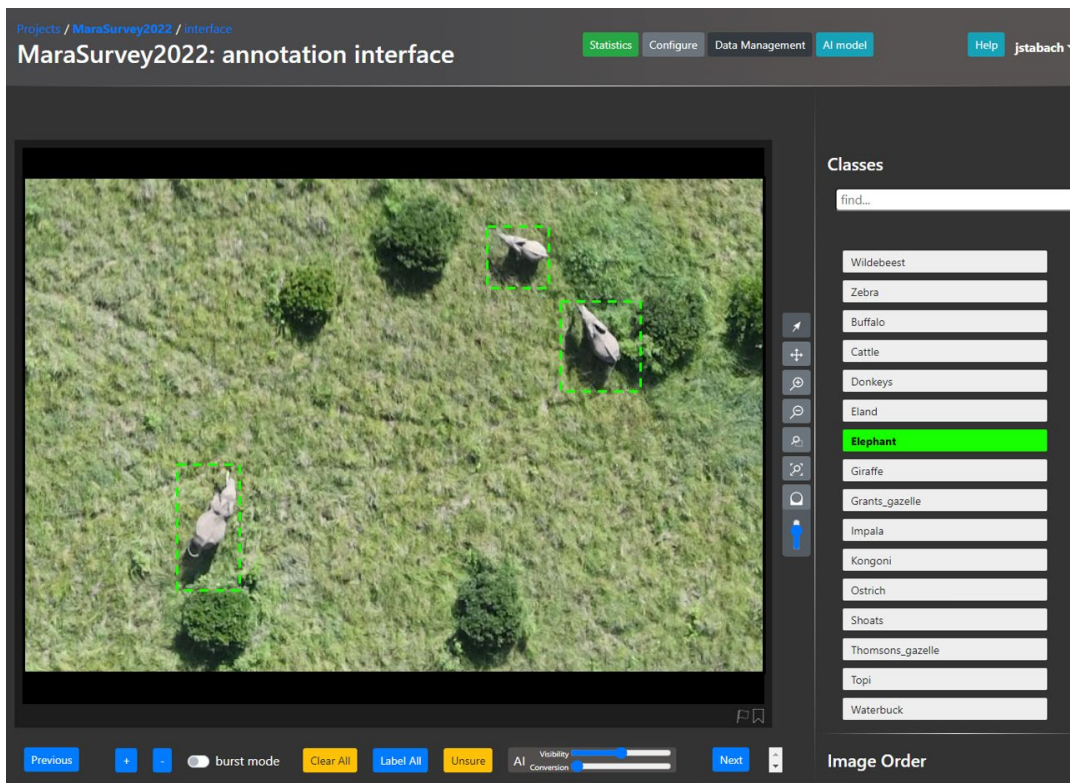
*Percent marine area in any kind of implemented MPA by U.S. Region.*

## CONSERVATION USING ARTIFICIAL INTELLIGENCE (“AI”)

In March 2022, scientists from the Conservation Ecology Center at the **Smithsonian’s National Zoo and Conservation Biology Institute** worked together with multiple international project partners to complete the first-ever joint aerial-satellite survey of the Greater Mara Ecosystem in southern Kenya. Survey aims were to count all large mammals >15 kg across the ecosystem and compare results across three different data collection methods: satellite, aerial, and ground. Over the 4-day aerial survey, the team collected over 11,000 aerial photographs and multiple high-resolution (30 cm), cloud-free satellite images that aligned with the aerial photos in space and time.

Now that the survey is complete, the team is working with Microsoft AI for Good, the University of Glasgow, and the Kenya Wildlife Research Training Institute to train the deep learning algorithm to locate and count multiple species identified in the images (e.g., elephants, giraffe, wildebeest, domestic cows). Results are expected to be provided in fall 2022, inclusive of training opportunities for project partners to learn how to use the open-source monitoring system. This project will provide a critical means to rapidly assess the impact of land-cover change and/or conservation-based activities on wildlife populations in near real-time, reducing the time it takes to go from data collection to results in days or weeks instead of months or years using current methods.

Partners included on the project include the Giraffe Conservation Foundation, Kenya’s Directorate for Resource Surveys and Remote Sensing, Kenya Wildlife Research Training Institute, Kenya Wildlife Service, Kenya Wildlife Trust, Mara Elephant Project, Microsoft AI for Good, One Mara Research Hub, Save Giraffes Now, and the University of Glasgow.



*Annotation Interface for Data-driven Ecology (AIDE) - Developed by Microsoft AI for Good, AIDE allows analysts to train the computer to quickly, efficiently, and more cost-effectively identify objects of interest. Here, three elephants can be clearly identified in the analyst interface. The process is iterative, with the analyst correcting misclassification to refine the computer’s search parameters, improving classification accuracy and results.*

## MITIGATING ARTIFICIAL LIGHT AT NIGHT

Artificial light at night (“ALAN”) is a major factor in global insect decline. In a paper published in *Insect Conservation and Diversity*, **Smithsonian Conservation Biology Institute** (“SCBI”) scientists and partners found that using amber-colored filters to remove the blue spectra of light from “warm white” LED (light-emitting diode) lamps drastically reduces insect attraction to nocturnal lighting in a tropical forest. This is the first study to validate quantitative predictions of how lamp color affects insect attraction and provide clear recommendations to mitigate the negative impacts of ALAN on wildlife in rainforest ecosystems.

“While many people aren’t necessarily fond of ‘bugs,’ their importance in our everyday lives is indisputable,” said Jessica Deichmann, first author and research scientist with the **Smithsonian Conservation Biology Institute and the Smithsonian Conservation Commons’ Working Land and Seascapes Initiative**.

“The essential ecosystem services they provide are endangered by nighttime lighting. We shouldn’t abandon using LED lights—their energy efficiency is second to none. Our research presents an alternative, especially for outdoor settings. If people everywhere take small steps in our homes, neighborhoods and commercial properties, we can reduce the negative impacts of sustainable LED lighting on wildlife.”

In addition to using filtered LEDs that remove the blue light and appear more orange/amber in color, additional ways to support insects include the use of full cutoff fixtures, motion activators and dimmers to ensure light is used only when and where it is needed.

Insects play invaluable roles as pollinators of food plants, regulators of other insect pests, decomposers of waste and sources of food for other animals, like birds. Insects may be directly affected by lights when they suffer mortality from collisions with hot lamps, exhaustion, or increased predation due to the attraction of predators and/or increased visibility. Insects affected by artificial lighting may also become disoriented or inactive, leading to a failure to reproduce, and consequently, a reduction of gene flow in the population.

The study was conducted in lowland rainforest in northern Peru. Scientists set light traps in 12 different locations with three different LED lamps with different spectra and a control (no light) to evaluate the number and composition of insects attracted to lamps during two different time periods at night. Researchers identified 763 unique morphospecies among the greater than 15,000 insects captured across all samples, belonging to 18 different orders. Overall, significantly more morphospecies were captured in the white LED light traps than in either the yellow or amber-filtered traps or the control. Likewise, significantly more individual insects were captured in the white LED traps.

By using amber-filtered LEDs, the number of morphospecies attracted to the light was reduced by 34% and individual insects were reduced by nearly 60% as compared to white LED lamps with reduced blue-light content. In addition, among captured insect families known to contain important vectors of pathogens, bacteria or parasites, 45% of all individuals were captured at white lamps, 41% at yellow lamps and just 13% were found in amber lamp traps. These results provide essential, tangible and actionable information on how to minimize ALAN, an unavoidable consequence of many types of infrastructure development and urbanization. The paper lays out specific management recommendations for new infrastructure projects in tropical forests that can also be applied to urban and rural residential areas.



## TROPICAL TREES DYING OF DEHYDRATION DUE TO CLIMATE CHANGE



*Northeast Australia's relict tropical rainforests, one of the oldest and most isolated rainforests in the world. Credit: Alexander Shenkin*

Tropical trees in Australia's rainforests have been dying at double the previous rate since the 1980s, potentially because of climate change, according to an international study published May 18 in the journal *Nature*. Researchers found the death rates of tropical trees have doubled in the past 35 years as global warming increases the drying power of the atmosphere.

Intact tropical rainforests are major stores of carbon, absorbing around 12% of human-caused carbon dioxide emissions. But their deterioration reduces biomass and carbon storage, making it increasingly difficult to keep global peak temperatures well below the target 2°C required by the Paris Agreement.

"It was a shock to detect such a marked increase in tree mortality, let alone a trend consistent across the diversity of species and sites we studied," said lead author David Bauman, a tropical forest ecologist at the **Smithsonian Environmental Research Center** "(SERC") and the University of Oxford. "A sustained doubling of mortality risk would imply the carbon stored in trees returns twice as fast to the atmosphere."

The study, led by researchers from SERC, the University of Oxford, and the French National Research Institute for Sustainable Development followed the fate of over 8,300 trees over 50 years of data in 24 permanent moist tropical forest plots in Australia. They found that tree death rates had doubled over the past four decades, with trees living around half as long. The pattern held across species and sites across the region. And the impacts could be seen as far back as the 1980s.

“Many decades of data are needed to detect long-term changes in long-lived organisms, and the signal of a change can be overwhelmed by the noise of many processes,” said Sean McMahon, coauthor and senior research scientist at SERC.

“Long-term datasets like this one are very rare and very important for studying forest changes in response to climate change,” said coauthor Susan Laurence, professor of tropical ecology at James Cook University in Australia. “This is because rainforest trees can have such long lives and tree death is not always immediate.” However, the reason for the spiking death rates was unclear. Drought—a drop in the soil’s water supply—did *not* show any link to tree mortality when the team scrutinized the data. The problem was not in the soil, but in the air, through a phenomenon called “atmospheric thirst.” As the atmosphere warms, it draws more moisture from plants, resulting in increased water stress in trees and ultimately increased risk of death. Moreover, the team showed that the loss of biomass from this mortality increase has not been offset by gains from tree growth and recruitment of new trees.

Australia’s tropical trees are not dying alone. Recent studies in Amazonia have also suggested tropical tree death rates are increasing, thus weakening the carbon sink.

The Great Barrier Reef remains Australia’s most famous climate change casualty, as warming waters cause increasingly severe coral bleaching events. But as Oxford professor Yadvinder Malhi, another coauthor, pointed out, the world cannot afford to ignore the impacts happening further inland.

“If you look shoreward from the reef, Australia’s famous rainforests are also changing rapidly,” Malhi said. “Moreover, the likely driving factor we identify, the increasing drying power of the atmosphere caused by global warming, suggests similar increases in tree death rates may be occurring across the world’s tropical forests. If that is the case, tropical forests may soon become carbon sources, and the challenge of limiting global warming well below 2°C becomes both more urgent and more difficult.”