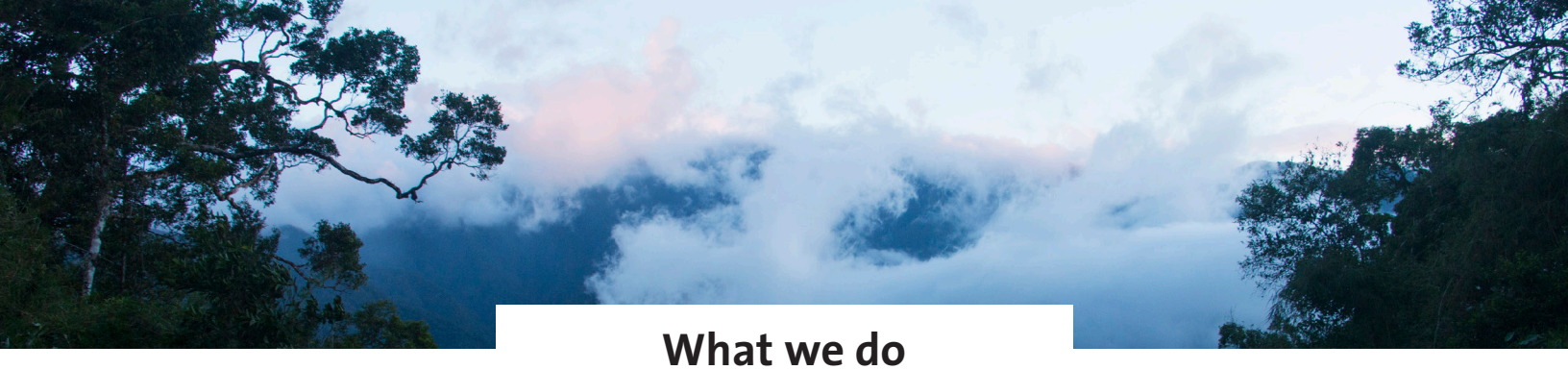
American Museum of Natural History
Center for Biodiversity and Conservation

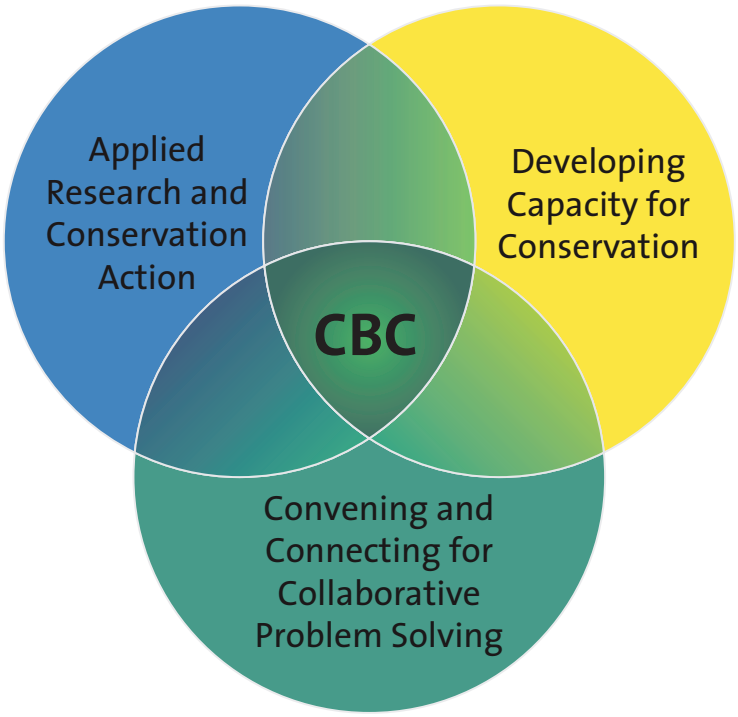
Progress Report

Spring 2019



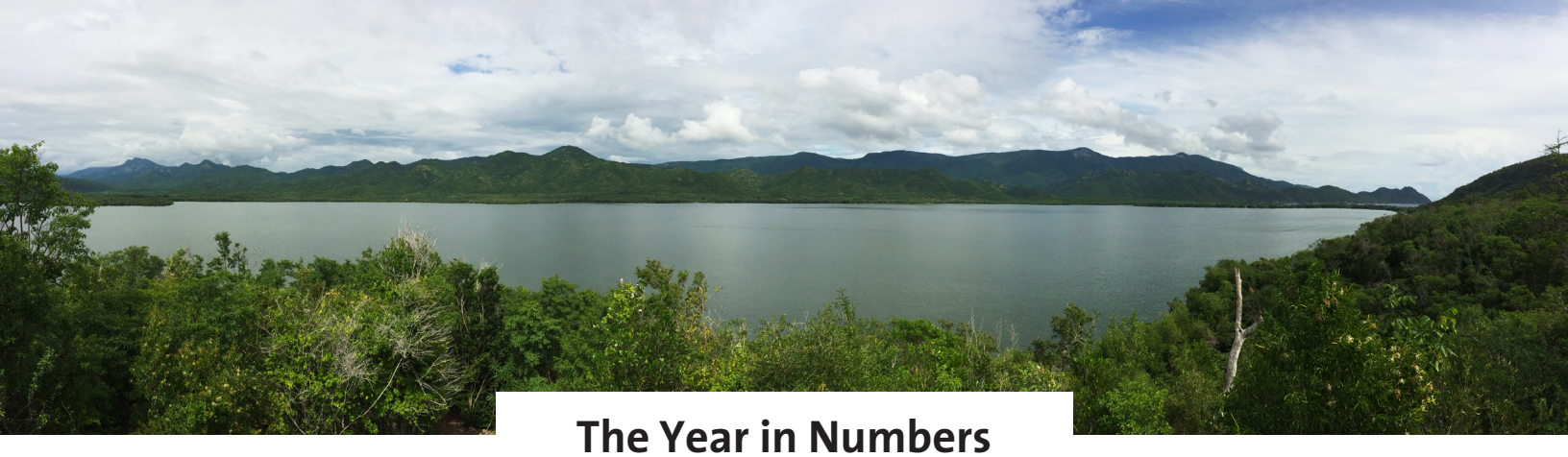
What we do

The Center for Biodiversity and Conservation (CBC) transforms knowledge—from diverse sources and perspectives—into conservation action.



We believe that understanding life on Earth and how to sustain it is the fundamental challenge of our time. The American Museum of Natural History is devoted to understanding our universe, our planet, and our role. Through the CBC, the Museum acts on that understanding and contributes to our collective endeavor of learning how to live with nature in equitable ways.

The challenge is both scientific and social, so we work to connect different strands of knowledge, connect people to knowledge, and connect people to each other, to find innovative and sustainable solutions. This report presents highlights of our most recent accomplishments.



The Year in Numbers

33 Publications
- 24 peer-reviewed
- 21 open access
- 9 with local partners
- 6 with students, interns, and mentees

17 Invited talks

44 Professional conference presentations

23 Funding proposals submitted
- 5 with the Museum
- 15 with external partners

12 New software tools, modules, other resources produced (all open access)

36 Average number of interns, mentees, and trainees per semester

20 Popular articles, media appearances, or media coverage items

32 Museum outreach events

6 Awards and honors

***Jaffe Chief Conservation Scientist* Dr. Eleanor Sterling** received the **2018 Distinguished Alumna Award** from the **Yale School of Forestry and Environmental Studies**, where her introduction lauded her as one of the "world's leading conservationists" who is "a trailblazer in matters of diversity, equity, and inclusion."

She also received an **Honorary Doctor of Science** from **The State University of New York College of Environmental Science and Forestry**.

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Research & Conservation

Conservation Planning and Monitoring

The CBC's biodiversity informatics experts develop new methods, software programs, and training resources to help manage, analyze, and interpret biological and environmental data from expeditions, natural history collections, databases, and remote sensing instruments. We are advancing and promoting the use of **machine learning** for the understanding and conservation of biodiversity.

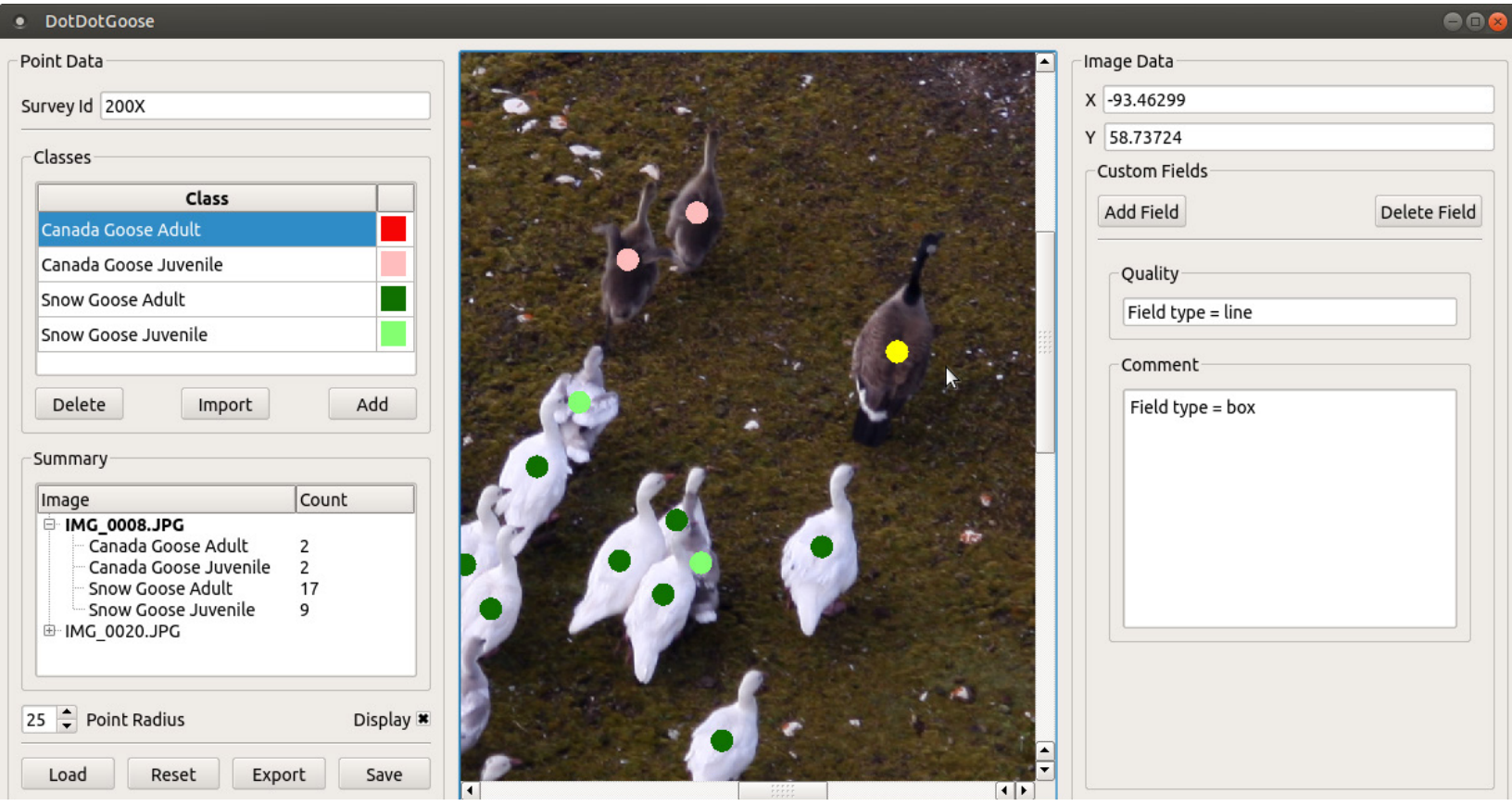
With funding from NASA, *Director for Biodiversity Informatics Research* Dr. Mary Blair and her team led the development of a new software tool that improves estimates of species' ranges named MaskRangeR. This tool enables users to choose among a range of methods to refine the predictions from species distribution models and estimate a species' current range. The new software tool was designed with and for users in Colombia, but can be used globally. Our team engaged in rigorous testing of the software with a range of project partners, potential users, and stakeholders, including with five use cases. One of these use cases is the Olinguito (*Bassaricyon neblina*), a new species of carnivore with strict tolerances for forest cover that lives in Northern Andean cloud forests in Colombia and Ecuador. MaskRangeR applies a data-driven approach to determine a forest cover threshold for the Olinguito. That threshold is then used as a mask to reduce the predicted niche of the species in a way that explicitly considers anthropogenic modification of forest cover, making the range estimate more realistic and more useful to inform conservation efforts.

The next step will be to integrate the new MaskRangeR code into the user-friendly software Wallace. In June, it will be piloted at a workshop in Colombia to consult with users on the next step: calculating biodiversity change over space and time using the species' range estimates. With this project, we aim to overcome the gap between the best practices of state-of-the-art modeling and actual biodiversity conservation decision-making. Further, by co-creating the research and these tools with local partners, we are ensuring that local stakeholders and early-career investigators—such as *Helen Fellow* Cecina Babich Morrow—have an active role in the research and development process to increase the sustainability of our efforts beyond the lifespan of a single project.

We are excited to share that this spring, *CBC Software Developer* Peter Ersts released a new software tool that assists with the manual counting of objects in images. Since photos of flocks of geese were used as the test dataset during development, it has been named "DotDotGoose." While it seems deceptively simple, the tool has broad applications and can used by anyone needing to count objects in an image—from elephants in an aerial photo to coral polyps in a high-resolution picture and cells in a microscope image. Currently, researchers undertaking counting projects have been working with tools that do not produce outputs that can be integrated into subsequent analytical steps. DotDotGoose introduces several key functions: it allows users to identify the objects in the image, to classify them into different categories or types, add custom data fields, and to then export the results for use with statistical software. Most importantly, results are saved in a format that can be fed into machine-assisted identification software. In this way, researchers counting objects in images can do their work knowing that it can be saved for use with advanced methods in the future. We believe this tool will be very popular as it has the potential to transform the work of practitioners in conservation and in many other fields—including the health sciences, urban ecology, and more.

Together with *Director of Applied Bioinformatics* Ned Horning, Mr. Ersts is also working on the continued development of the Animal Detection Network, which will provide software and standardized datasets for the automatic detection and labeling of animals in trail camera (camera trap) archives, and Nenetic, a new approach to land cover classification, designed specifically for use with high-resolution, low-altitude images collected with popular instruments including drones. All products are released with open-access licenses so students, educators, researchers, practitioners, and the general public can freely use them.

Our team's leadership in the field is increasingly recognized and Mr. Ersts was recently interviewed by the journal *Nature* for a feature on the use of machine learning and other technology for the understanding and conservation of biodiversity.



Research & Conservation

Resilient Biocultural Landscapes: Supporting Effective Reef Management Locally and Globally

The CBC continues to illuminate the fundamental connections between people, their culture, and their environment in the Pacific, fostering more robust natural resource management in areas of high cultural and biological diversity. The research team led by *Jaffe Chief Conservation Scientist* Dr. Eleanor Sterling in collaboration with several partners—now in its fifth year—has produced valuable new data on the importance of biodiversity to food security and climate change adaptation, and developed new indicators that the participating communities can use to track progress in these areas.

As part of this project, through an ongoing collaboration with the Wildlife Conservation Society in the Solomon Islands, we have been carrying out social and ecological surveys of coral and reef fish ecosystems. We are pleased to report these have now been conducted across four focal communities. We found that survey respondents were very aware of human impacts on marine systems; more than 85 percent of respondents affirmed that humans affect the marine environment in their community. The CBC and partners have developed a suite of key indicators that the communities can track through time. These indicators include reef habitat and fish biomass status, market access, knowledge of human impacts on reef systems and on management regulations, and indicators of subjective wellbeing in relation to reef systems. The suite of indicators was well-received and was included in a Global Monitoring Report produced for the MacArthur Foundation's 10-Year Coastal and Marine Strategy—indicating the impact of our work on global coverage of wellbeing indicators.

As the project in the Solomon Islands matures, we are exploring new opportunities to collaborate and broaden the application of biocultural approaches to conservation in new contexts. Dr. Alex Moore, who joined us and the Museum's Education Department in 2018 as *Postdoctoral Conservation Research and Teaching Fellow*, continues to explore approaches for incorporating cultural links into restoration and conservation outcomes in wetland ecosystems. Dr. Moore published research results showing that different crab species have varied and unexpected roles in New England wetlands, with important implications for restoration. She recently traveled to Kuala Lumpur and Borneo (Malaysia) to meet with potential research collaborators and investigate research sites there. While there, she gave a brief lab presentation on her work, met with several members of the National University of Malaysia (UKM) community, and visited a peat swamp forest conservation center to determine research potential. Dr. Moore also attended the He Au Honua Indigenous Research Conference in Hawai'i in order learn about Indigenous approaches to research and how to incorporate these viewpoints into her own research.

Also in Hawai'i, *CBC Biodiversity Scientist* Pua'ala Pascua has been spearheading exchanges with the He'eia National Estuarine Research Reserve and other sites to advance health and climate solutions by synthesizing evidence for what a healthy community looks like when considering linked human and ecological sustainability. We are seeking to launch projects to identify a range of health determinants, especially linked environmental, social, and cultural measures, that impact human wellbeing. Our vision is that this work will inform ways these concepts can be woven into into environmental sustainability planning, policy, and management actions locally, and inform comparable resource management efforts in communities across the United States and beyond.

Research & Conservation

Wildlife Trade in Southeast Asia

Dr. Mary Blair continues to collaborate with partners in Southeast Asia on genetics and wildlife trade mitigation to inform the conservation of Southeast Asian Primates. Together with colleagues in Malaysia, they have confirmed via genetic analysis that the slow lorises on Langkawi Island are Bengal slow lorises, *Nycticebus bengalensis*. Previously, only the Sunda slow loris *N. coucang* had been found in the Malay Peninsula, although *N. bengalensis* had been hypothesized to exist in the Northern part. This study presents the first evidence to confirm the presence of *N. bengalensis* in Malaysia. This work is a part of a larger project where Dr. Blair's team of collaborators are amassing a genetic database of reference DNA sequences based on slow loris museum specimens across Southeast Asia. The goal of the database is to enable forensic identification of animals confiscated in illegal wildlife trade to track trade patterns, inform enforcement efforts, and guide releases of healthy animals to appropriate habitats.

She was also invited to provide an update on slow loris conservation status to Vietnam's National Primate Conservation Action Plan in January, as they continue to roll out its implementation.

Research & Conservation

Sea Turtles in the Pacific

The CBC continues to analyze data and publish results from our sea turtle research and conservation program at the Palmyra Atoll National Wildlife Refuge in the Central Pacific, including a manuscript on the residency patterns of Palmyra's turtles. In this study, CBC scientists and collaborators reported on the tagging and tracking of 18 turtles with satellite transmitters and their movements for approximately 21 months. We found that the turtles for the most part had small home ranges, and remained very close to the atoll, with the exception of one turtle that traveled in a roughly 5,600-km loop to the east of the atoll, swimming by the island of Tabuaeran where there are turtle rookeries. The extended time spent around Palmyra indicates that it is high-quality habitat. This study highlights the importance of this protected area, which harbors regionally endangered turtles whose movements over several years are almost entirely encompassed within its established boundaries.

Research & Conservation

Flamingos in the Americas

In February 2019, *CBC Associate Director* Dr. Felicity Arengo co-led a multi-disciplinary expedition to the wetlands of the Andean altiplano in Argentina to study hydrology and limnology, and monitor flamingo and other waterbird populations. This research is generating data on the hydrology of the region for the first time, and that is critical for assessing the impact of extractive activity on critical water resources.

While unusually rainy weather affected roads and access to sites, the team was able to reconfigure the itinerary and visit most of the planned sites. The multidisciplinary team included ecologists, hydrologists, limnologists, and social scientists. They took water samples to begin studying the interconnectivity of wetland basins, water residency times, and recharge rates, variables that are necessary to determine water budgets under different levels of use. The area has seen an increase in lithium mining, prospecting, and exploration in the past 18 months, which can have impacts of unprecedented scale on wetland resources on which human livelihoods and biodiversity depend. Flamingo numbers were lower than in previous counts, likely because water levels were higher than normal, excluding birds from several sites. The team also visited several mining camps, gathering information that will be critical for understanding the impacts of mining activity on wetland resources. These research results will form the basis for any science-based management actions, and our continued presence in the field and professional relationships with government agencies are necessary to advance conservation and sustainable approaches to resource use.

Welcoming Dr. Samantha Cheng

We are delighted to announce that Dr. Samantha Cheng joined us as *CBC Biodiversity Scientist* in February.

Dr. Cheng is a population geneticist and conservation scientist working to design effective conservation approaches for nature and people. Her research interests are rooted in two areas: using population genetics and genomics to inform fisheries management and conservation, and investigating the impact of conservation actions on nature and people. She has both experience in the field, working in tropical coral reefs, cephalopod fisheries, and seafood sustainability, and experience in the policy sphere, engaging with diverse stakeholders in organizations, governments, and academic institutions to develop evidence-based solutions for conservation and human wellbeing outcomes. To advance this work, she blends the biological, social, and computer sciences to devise tools and determine pathways to achieving shared benefits between nature and human wellbeing. Her latest publication in *Environmental Evidence*, for example, asks: "what evidence exists on how forests can help the poor?" By reviewing the evidence available and its quality, Dr. Cheng and coauthors illuminate research gaps and priorities.

Dr. Cheng was previously at Arizona State University, where she was Assistant Research Professor at the School of Life Sciences and Associate Director for Conservation Evidence at the Center for Biodiversity Outcomes. She obtained her Ph.D. in biology from University of California, Los Angeles. A "Bostonian at heart," she will be dividing her time between New York City and Phoenix, Arizona. We anticipate many CBC and Museum projects will have synergies with Dr. Cheng's diverse interests and skills, and we are thrilled she has decided to join our team!

Building Capacity for Conservation Through Education: The What, How, Why, & Who of the Network of Conservation Educators and Practitioners

Kimberley Landrigan
Network of Conservation Educators and Practitioners, Center for Biodiversity and Conservation, American Museum of Natural History, New York, NY, USA

Sufficient conservation capacity—the ability to set and achieve conservation goals—is critical to meeting the environmental challenges we face globally as individuals, organizations, and societies (e.g., see Fox et al. 2017, Gill et al. 2017). The Network of Conservation Educators and Practitioners (NCEP) seeks to build that capacity for conservation through evidence-based higher education and professional development. By thinking about *what* is taught and *how*, *why* is it effective, as well as *who* is included at the table and in the classroom, we work to improve the teaching and learning of conservation in universities and other professional settings. The works presented in this

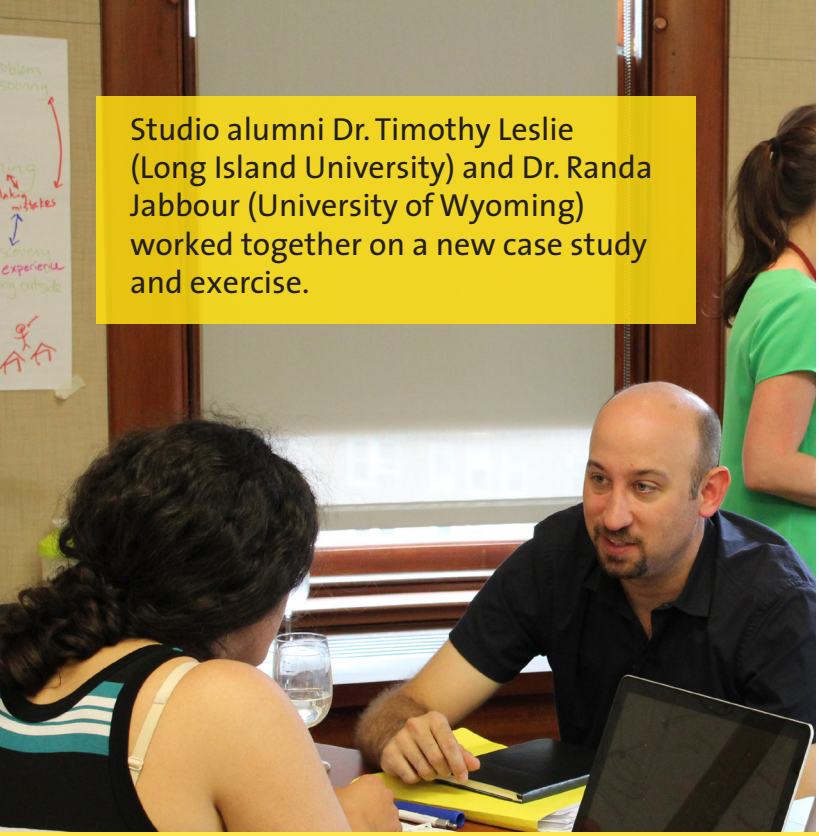
What We Teach: The Beginnings of the Network

In the early 1990s, as a doctoral student studying a nocturnal lemur (the aye-aye) in Madagascar, Center for Biodiversity and Conservation (CBC) Jaffe Chief Conservation Scientist Dr. Eleanor Sterling was inspired to learn about how environmental science was taught in the country. Madagascar was and is a widely recognized global hotspot for biodiversity and she was curious about how the next generation of conservation actors was being trained. What she found was that Malagasy educators were limited by a scarcity of resources such as textbooks, and that (when available) these were

Capacity Development

Network of Conservation Educators and Practitioners

Our signature program dedicated to developing capacity for conservation, the Network of Conservation Educators and Practitioners (NCEP) continues to support teaching and lead training to improve conservation. In January 2019, NCEP published its 9th volume of *Lessons in Conservation* (LinC). This issue featured a collection of case studies and exercises developed by past participants from NCEP *Conservation Teaching and Learning Studios*. The issue's contents span bird conservation, tools to explore biogeography in a changing world, and the challenges in decision-making regarding payments for ecosystems in tropical forests as well as genetically modified organisms.



Studio alumni Dr. Timothy Leslie (Long Island University) and Dr. Randa Jabbour (University of Wyoming) worked together on a new case study and exercise.

This is the pair's first formal collaboration with each other on research and writing. Dr. Leslie shared with us that while he and Dr. Jabbour teach similar topics, they do so in very different parts of the United States (in terms of climate, ecosystems, student familiarity with agriculture, and more) and in different university settings; for this reason, he found this opportunity to collaborate and discuss pedagogy especially valuable. Their exercise is titled *Genetically Modified Crops and Biological Conservation on Farmlands*.

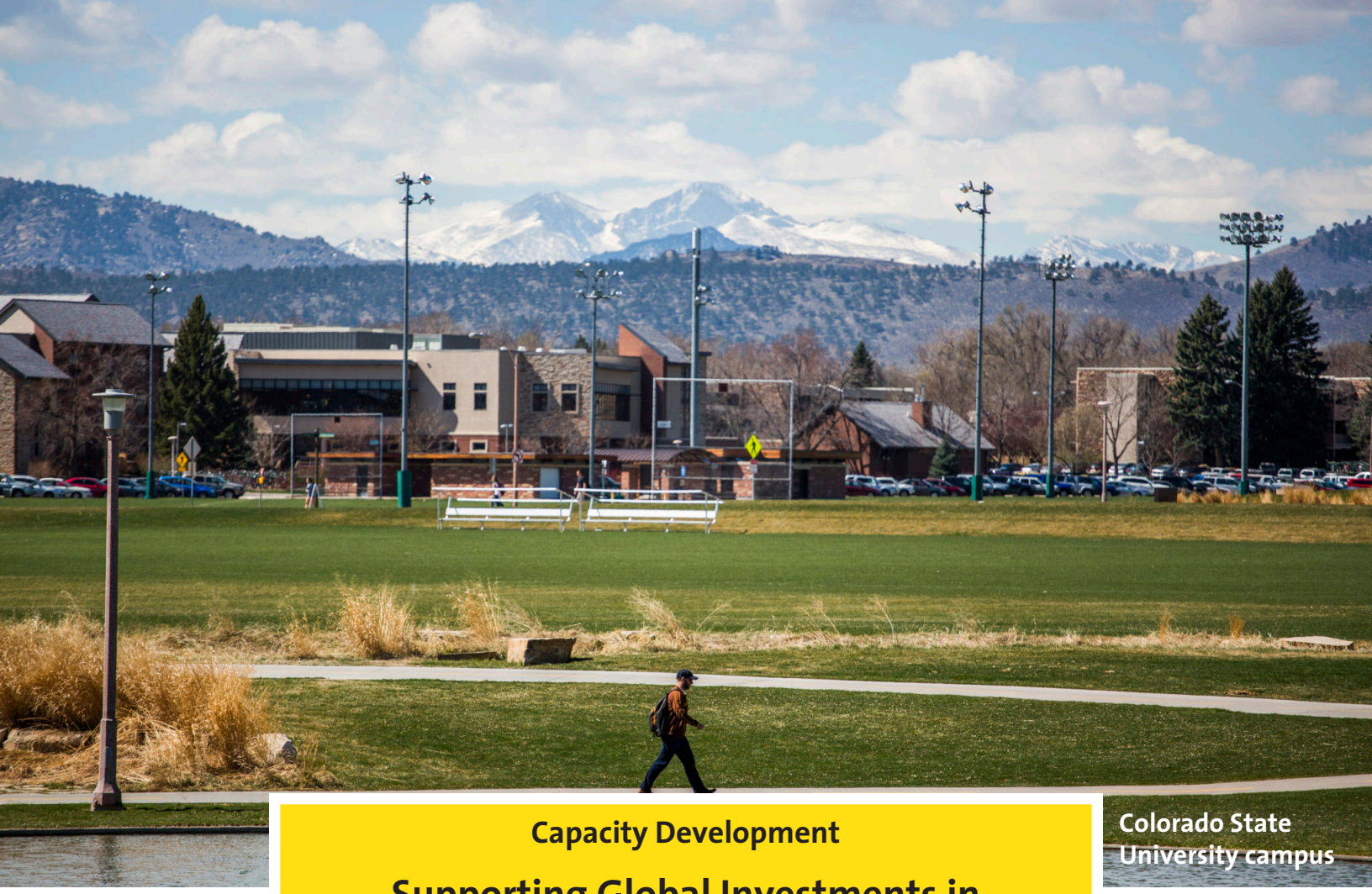
The new issue's educational materials all share one feature: they are designed to promote active learning and develop critical thinking skills through interactive games, conservation decision-making exercises, real-world case studies, and research projects. Specifically, they encourage students to grapple with the realities of "tradeoffs"—a frequent feature of real-world conservation decision-making.

Our next NCEP *Conservation Teaching and Learning Studio* will take place at the Museum in June. Over 45 applications have been received for 24 placements and we are in the process of selecting the next cohort of participants.

The publication of the LinC journal complements our new website, where modifiable and adaptable resources are available for educators and practitioners from around the world. Visitation and use of the updated NCEP website, which was launched in 2017, continues to grow. The website has welcomed more than 5,000 users and over 27,000 pageviews since its debut, and the number of registered users—which exceeds 600—is growing by more than 25 percent quarterly. Traffic is equally divided among users from the United States and other countries; after the United States, the top 10 countries are the United Kingdom, Canada, Peru, France, India, Madagascar, Mexico, Brazil, and China.

In keeping with our efforts to broaden the resource collection with a focus on 21st century challenges, we are developing new materials on topics including climate change impacts on biodiversity, systems thinking for conservation, food systems, biocultural approaches, wildlife trade, and technology in conservation. In order to continue to update and improve existing materials, NCEP has entered into a new type of collaboration with Columbia University's Ecology, Evolution, and Environmental Biology Department's Master of Science program. Throughout the spring as part of Dr. Sara Kross's (Director, Master's program in Ecology, Evolution and Conservation Biology at Columbia University) conservation biology course, three teams of students will be exploring, researching, and updating some of our most popular NCEP materials that were written early in the program's history. Students will get the opportunity to learn in-depth about threats to biodiversity, ecosystem loss and fragmentation, and marine conservation policy through our materials, while also thinking strategically about how to incorporate new information from research that has been generated over the last 15 years. This unique partnership will help students foster skills related to academic and scientific writing, critical thinking regarding assessing literature, and working collaboratively through the editorial process, while NCEP will receive up-to-date materials, recommendations for other open educational resources that can support our materials, and the possibility of continued relationships with students who are interesting in becoming NCEP authors.

NCEP staff members and Columbia University students after the students presented their proposals for updating NCEP materials.



Colorado State University campus

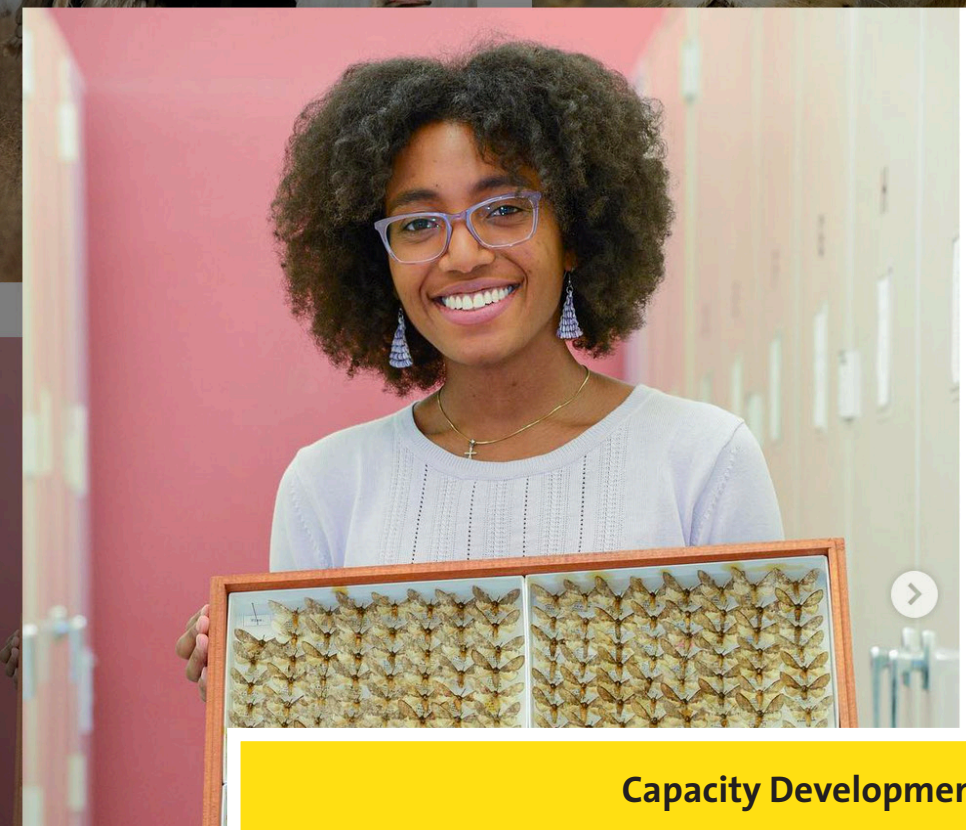
Capacity Development

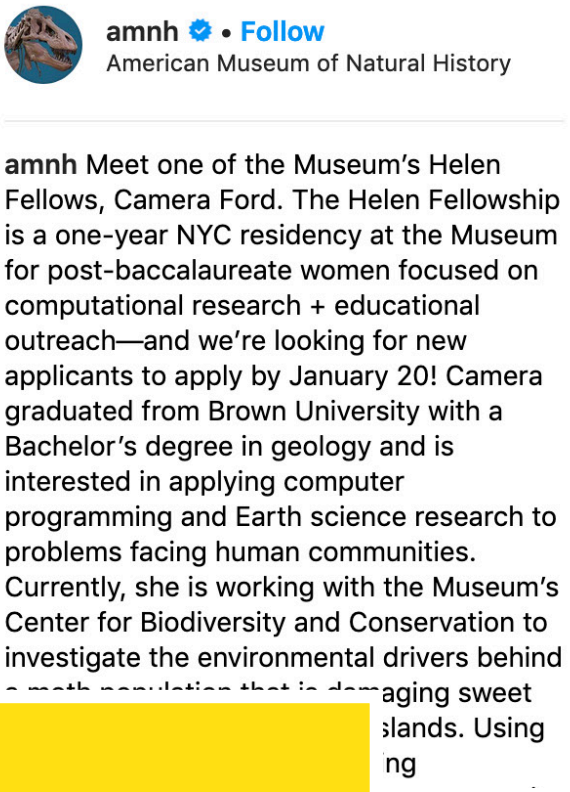
Supporting Global Investments in Conservation Capacity

We also continue to leverage partnerships to advance and improve the strategic evaluation of capacity development efforts. As part of her leadership role in a World Commission on Protected Areas (WCPA) Working Group on this theme, Dr. Sterling is spearheading a collaboration with Colorado State University, which saw the successful completion of a fall-semester graduate-level course developed around assessing and coding the literature on capacity development evaluation. The class was so successful that the majority of students signed on again for the one-credit class in the current spring term. The students have expressed an interest in continuing to collaborate on the project going forward, and we are exploring ways to facilitate their ongoing involvement. The results of this work will help build a directory highlighting capacity development evaluation case studies and tools, and will inform a literature review on the topic.

"[This collaboration] provided a fantastic opportunity for students to critically engage with the literature in a very meaningful way."

Dr. Jennifer Solomon
Course professor





Capacity Development

Strengthening the Future of Conservation Science

To encourage excellence, diversity, and inclusion in conservation, the CBC is devoted to promoting the recruitment, achievement, and success of students and early-career professionals from groups historically underrepresented in the field. We lead a number of activities to advance these goals, under our Inclusive Conservation Community Initiative (ICON). We are currently training or mentoring 20 youth and early-career conservationists through our activities!

Our mentoring efforts continue to inspire success in our trainees; *Helen Fellow* Camera Ford was awarded a Fulbright Scholar Award to pursue a Master's degree in science communication, geoscience, and remote sensing. She also publicly presented her research to engaged youth at one of the Museum's Teen SciCafes. Former intern Elora Lopez was awarded research support from the Explorer's Club and National Geographic. Former Postdoc Dr. Rae Wynn-Grant is now an American Association for the Advancement of Science "If/Then She Can" Ambassador, working to highlight positive and successful female role models in STEM to inspire young girls to explore STEM careers. PBS's American Spring LIVE will be featuring her research on how humans can influence carnivore behavior and ecology, and specifically grizzly bears. A preview, in the form of a Facebook live video, can be found on the program's website.

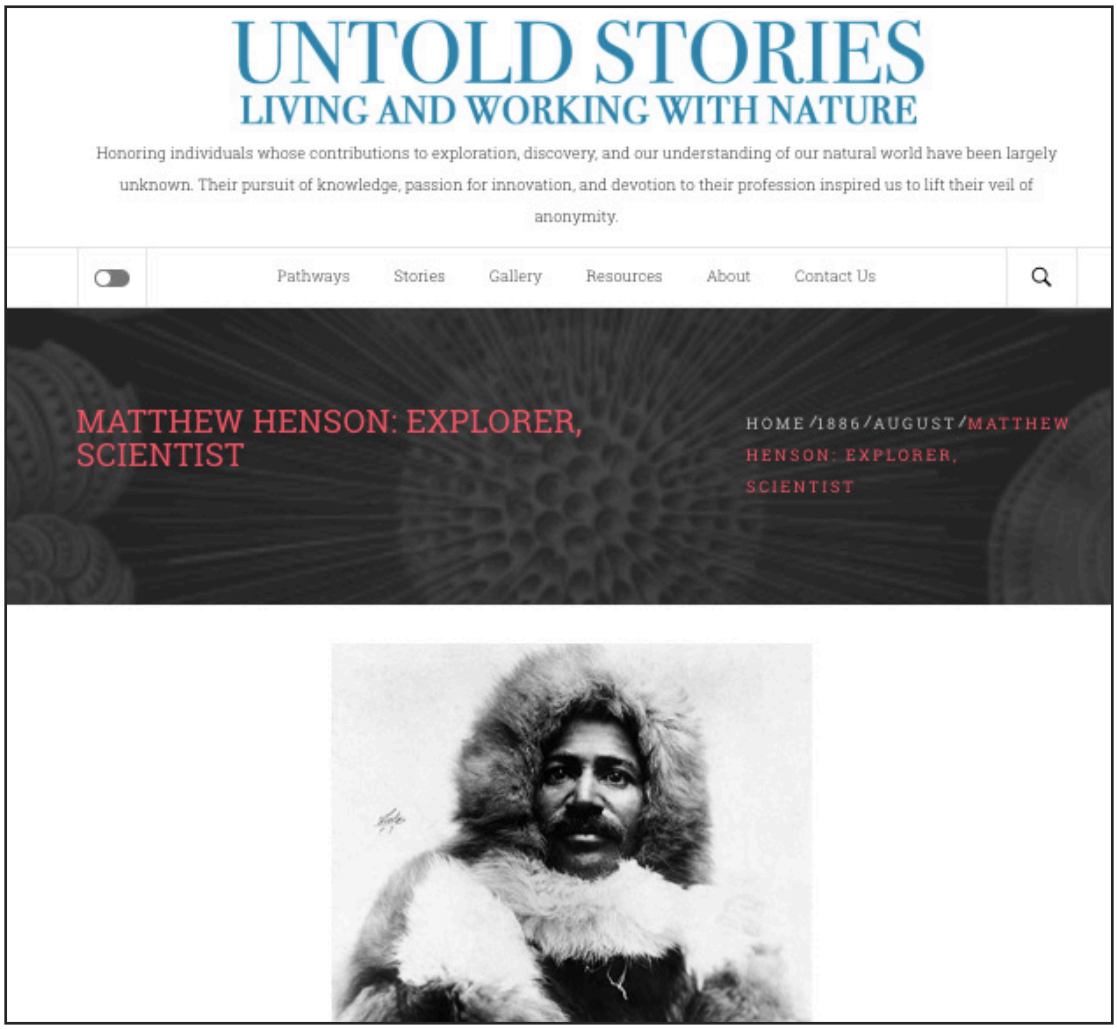
The staff of the CBC continues to be seen as leaders in advancing equity, inclusion, and diversity in the field of conservation, and to participate in and catalyze important conversations. *Director* Dr. Ana Porzecanski was an invited workshop leader at the 6th annual Empowered Young Environmentalist's Summit held at the Urban Assembly School for Green Careers, New York City in March, and Dr. Sterling and Dr. Moore were invited to lead a careers workshop at the Doris Duke Conservation Scholars Program Alumni Homecoming in Washington State in April. Titled "What Am I Doing With My Life? Career Planning for Conservation Researchers and Practitioners," the workshop aimed to introduce conservation career paths to the participants who were largely individuals of color in various educational and career stages, including undergraduate and graduate students, social justice activists, and early career practitioners.

Capacity Development

Untold Stories in Conservation and Natural History

Our collaboration with members of the Women in Natural Sciences Chapter of the Association for Women in Science, led by Dr. Sterling, experienced several notable milestones in recent months. This initiative aims to raise awareness of previously unknown change makers in conservation and museum-based natural sciences. *Untold Stories: Living and Working with Nature* will work to link partners with the Museum and other institutions around the world to foreground stories to serve as inspirations to current and future generations of conservationists.

The initiative has publicly soft-launched a website featuring diverse stories through time and space, currently highlighting profiles of 23 changemakers authored by different project collaborators (http://untoldstories.net). Some highlighted individuals include the naturalist sisters Harriet and Helena Scott, two of the best natural history painters in colonial New South Wales, Australia. Another highlighted individual is Matthew Henson, the Black Arctic explorer. Henson was a co-discoverer of the North Pole and played an integral role in retrieving meteorites on display here at the Museum; the team has been in consultation with the Exhibitions Department to ensure that his accomplishments will soon be recognized here once renovations to the Arthur Ross Hall of Meteorites are complete, anticipated in Summer 2019.



Convening & Connecting

Indicators Gathering

Building on the success of our 2018 gathering of Indigenous experts, this spring we convened a smaller, in-depth gathering at the Museum. The April 2019 Indicator Practitioner Gathering engaged 18 Indigenous Peoples and Local Community (IPLC) representatives who work on indicators that demonstrate the connections between and across people and place. The gathering provided a key opportunity to share and learn together with individuals who have developed and applied indicators on the connections between people and place, and those who are actively exploring ways to demonstrate the importance of this type of indicator within the management and policy arena.

The CBC's convening work continues to have impact long after the events, by transforming careers and projects over time. A participant who joined one of our Symposia over a decade ago recently shared:

> *"The symposium was the first international meeting where Hungarian ecologists and emerging ethnecologists joined the international research community who study biocultural heritage and traditional ecological knowledge... The conference has changed our minds about research and science and encouraged us to do research and participate also in education programs about biocultural diversity. Since that time research on traditional ecological knowledge and biocultural heritage have been accepted by the Hungarian Academy of Sciences as 'doing science,' and we were invited to establish a research group at the Centre for Ecological Research of the Hungarian Academy of Sciences in 2013."*
>
> Zsolt Molnár, researcher at the Hungarian Academy of Sciences
>
> Participant in the CBC's 2008 Symposium "Sustaining Cultural and Biological Diversity in a Rapidly Changing World: Lessons for Global Policy"

Convening & Connecting

Guiding Global Policy

As we work to advance conservation action and bridge local and global scales in conservation, we continue to connect with the international arena and share lessons from our work with global initiatives. Dr. Sterling has been leading these efforts, which recently included co-hosting a session at the 14th meeting of the Conference of the Parties to the Convention on Biological Diversity, in Sharm El-Sheikh, Egypt in November. During the session, titled "Connecting people and place: an exchange on biocultural indicators," participants explored, shared, and contrasted indicators that reflect the connections between people and place, and between nature and culture. Drawing from the session's key messages, Dr. Sterling helped craft text for the final declaration of the Conference of the Parties Nature and Culture Summit. This final declaration emphasized the importance of ensuring that a biocultural approach to indicators informs and contributes to the Convention on Biological Diversity's future nature- and culture-related work, its post-2020 program of work, and a proposed international alliance on nature and culture.

As part of a Working Group supported by the Science for Nature and People Partnership, Dr. Sterling is developing an assessment of the gaps and overlaps between global indicators and local wellbeing priorities to foster equitable approaches and outcomes for sustainability that will be submitted to *Science Advances* in the coming months. The Working Group is also developing a set of national and multilateral outreach materials for the Convention on Biological Diversity, to help guide its plans for the next decade. With regional partners in the Pacific, we will develop and pilot a set of guides for national-level reporting agencies and regional funding bodies. These policy briefs are intended to support organizations interested in developing culturally-relevant monitoring and reporting indicators. By engaging with the Convention's next program of work we aim to ensure that biocultural concepts are included in global sustainability commitments and goals for the next decade.

Convening & Connecting

Events, Exhibitions, and Outreach

Dr. Porzecanski has had an active role in Museum programming and outreach this past season, helping to catalyze innovative public programming on the topics of species extinction and climate change. Last fall she led a CBC team that informed a public festival celebrating Día de Muertos (Day of the Dead), organized by the Museum's Education Department. The CBC contributed expertise for innovative exhibits on endangered species that took the shape of traditional Oaxacan flower altars, and generated research about each of the species included. The result was a stunning and compelling array of flower altars that were displayed to the public from November 1-3 in the Hall of Biodiversity. The Festival also included artistic performances and informational tables, one of which was about the CBC's conservation work. More than 10,000 people attended Day of the Dead programming during the weekend festival.

Dr. Porzecanski is also collaborating closely with the Museum's Public Programs team to develop integrated programming on climate change. This spring, they co-hosted a special edition of the New Science New Solutions public event series, on the topic of "Leadership, Economics, and Governance Under Climate Change." The panel convened a diversity of voices to explore this topic ranging from finance and policy experts to youth activists, and an engaged and diverse audience.

Last but not least, building on the CBC's expertise on food systems, *CBC Biodiversity Scientist* Erin Betley and Dr. Porzecanski participated as advisors on this season's Earth Day informational video, which focused on food waste and its environmental implications.