Building a Global Network for Community Science

Workshop Report

May 24-25, 2021

CONVENED BY

VILLANOVA UNIVERSITY

PERRY WORLD HOUSE
University of Pennsylvania

SCIENCE & SOCIETY
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Building a Global Network for Community Science

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May 24–25, 2021

ORGANIZED BY

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The Scientific Thinking and Representation (STAR) Lab at Villanova University investigates children's and adults' imaginative and scientific reasoning abilities. Through partnerships with the local community, STAR Lab's research contributes to our understanding of what children and adults know about science, how children learn to think scientifically, and how fictional stories impact children's and adults' lives.

Perry World House is a center for scholarly inquiry, teaching, research, international exchange, policy engagement, and public outreach on pressing global issues. Its mission is to bring the academic knowledge of the University of Pennsylvania to bear on some of the world's most pressing global policy challenges, and to foster international policy engagement within and beyond the Penn community.

The Aspen Institute | 2300 N Street, NW | Suite 700 | Washington, DC 20037
Published in the United States of America in 2021 by The Aspen Institute

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Executive Summary

Our world faces climate change, species endangerment, and the destruction of natural resources and Indigenous knowledge systems across the globe. While professional scientists are working in traditional spheres to address these ruptures to the human and natural worlds, community science provides a complementary and novel approach to environmental problems. To find out how community and professional scientists can work together to initiate, carry out, and sustain their research, Villanova University, the University of Pennsylvania & Perry World House, and the Aspen Institute Science & Society Program convened a two-day virtual workshop May 24–25, 2021. These proceedings introduce the workshop, report on the presentations and discussions, and conclude with a summary of common challenges and questions that can unite community science projects in carrying their work forward.

Day One: May 24

The first day opened with a welcome by the organizers and convening words by Youssef Nassef of the United Nations Climate Change Secretariat. Organizer Michael Weisberg introduced definitions of citizen and community science and the vision of shared resources that spurred the workshop's creation. Gwen Ottinger (Drexel University) and Jennifer Pinto-Martin (University of Pennsylvania) set the stage for the panels to follow by highlighting the kinds of problems that community-based science can address, the insights and priorities that community participants bring to localized research, and how professional scientists can best support and communicate with community stakeholders.

Then, the first invited panel brought together case studies from Trinidad and Tobago, New Zealand, and Botswana to discuss the early stages of community science endeavors. Candice Ramkissoon introduced the Caribbean Natural Resources Institute (CANARI)'s use of Information and Communication Technologies (ICTs). Brendan Flack discussed how Indigenous concepts drive mission and engagement for the He Pātaka Wai Ora Project. Lesley McNutt and Hugh Webster told the story of how Coaching Conservation has refined its relationship with children in local communities over thirty years. The panel concluded with an open discussion.

Day Two: May 25

The second day of the workshop presented two more panels, each with three case studies, followed by a wrap-up discussion open to all attendees. The workshop's second invited panel assembled perspectives from Australia, China, and Israel to address the challenges of developing and sustaining community science projects. Gareth Catt spoke on the 10 Deserts Project's capacity-building in Indigenous groups

and the importance of physically assembling people who work together. Lu Zhi discussed the Shan Shui Conservation Center's adoption of local spiritual environmentalism as an engagement strategy. Ayelet Shavit of Town Square Academia emphasized the need to call on local expertise.

The third invited panel presented case studies from the Arctic, India, and Ecuador, and focused on questions of data storage, representation, and ownership. Community empowerment and the positive effect of local control emerged as key themes in all three case studies: Noor Johnson's overview of Indigenous data sovereignty at ELOKA (Exchange for Local Observations and Knowledge of the Arctic), Manu Prakash and Mo Pandirajan's introduction to the accessible design of the pocket-sized Foldscope microscope, and Karen Kovaka and Ernesto Vaca's work with local students at the Galápagos Education and Research Alliance.

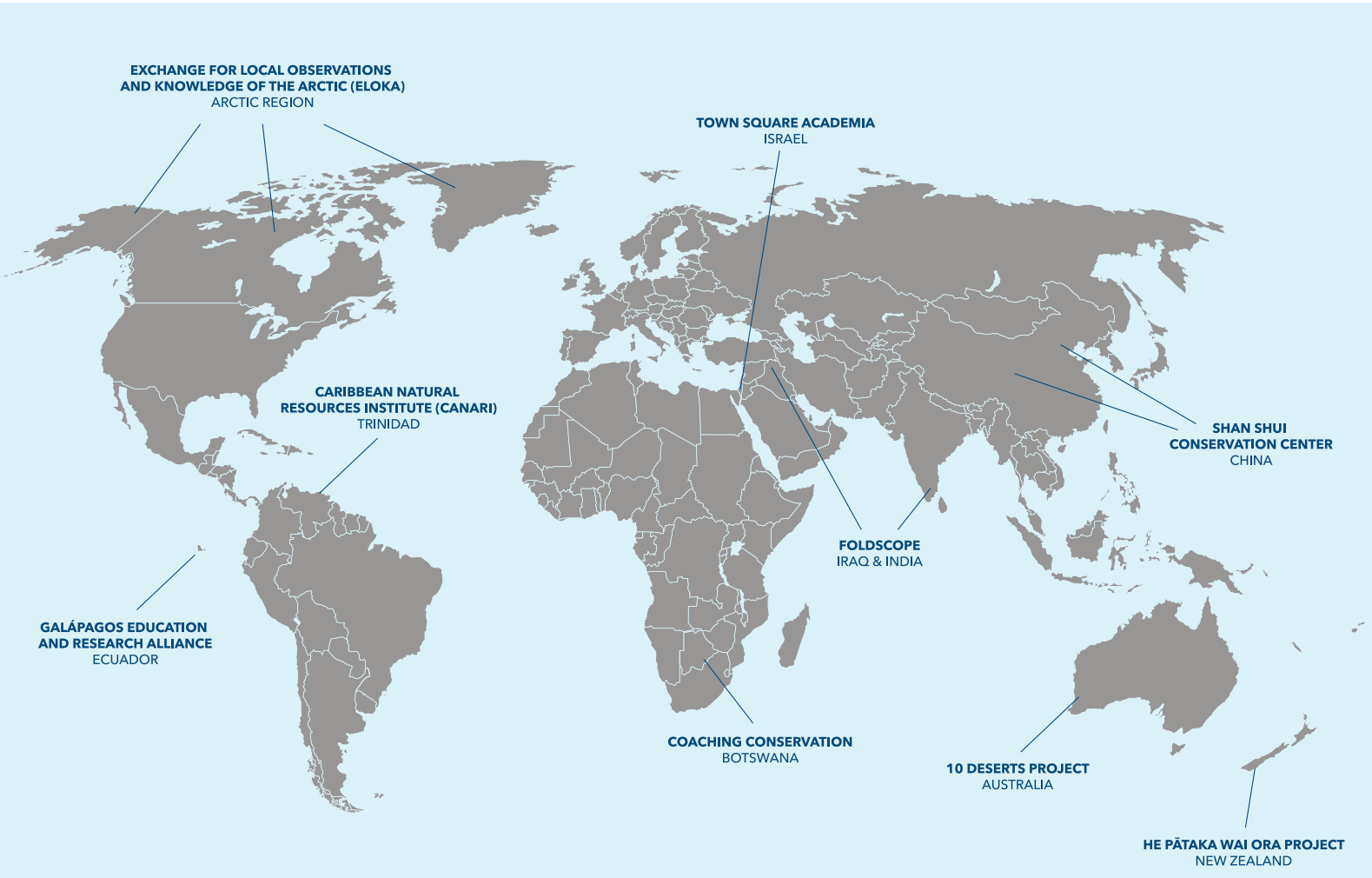
Next Steps

The final section of this report summarizes issues that emerged throughout the workshop in the final discussion, and it addresses potential action areas that the workshop brought to light. Key goals for community science include:

- Law and policy change;
- Recognition by grant-makers and other pathways to sustainable funding;
- Institutional support;
- Standardized assessment tools;
- Standardized tools for communicating with funders;
- Communication among community science initiatives;
- Community scientist agency.

Introduction

The goal of this workshop was to build a vibrant, collaborative, international network of partners committed to devising and conducting civic science through communities. Each of the invited presenters has chosen to pursue research, education, data management, and analysis that is deeply embedded in local communities and that respects local expertise. Drawing on the experience of running diverse projects on all six inhabited continents, the presenters assembled to share the strategies, mindsets, and methods that have succeeded in their work, as well as the challenges they face.



Community science projects address historical and ongoing inequities between scientific professionals and the communities where scientific investigation takes place. The goal of upending traditional hierarchies in scientific research is to empower citizen scientists to initiate and participate in research, analysis, and the implementation of environmental and educational goals. This is a critical moment in human relationships with natural landscapes, resources, habitats, and disasters, in which community-based projects show the potential to change not only how we do science, but the world we live in.

However, there are many impediments to this work. Professional and community scientists may not establish contact easily, may not communicate effectively, or may have conflicting needs surrounding the resulting project. Universities and traditional grantmaking organizations may not acknowledge the types of outcomes measured, making initiatives difficult to sustain. These unique challenges to initiating, funding, sustaining, and reporting on community science highlight the importance of connecting a global network whose members can benefit from one another's experience and from their collective credibility.

To begin this undertaking, the workshop brought together individuals from around the world to discuss how scientific tools can address problems of local interest, particularly ones at the intersection of the human and natural worlds. Nearly 120 attendees registered, including those who presented. Registration for the workshop was free, and all events were open to interested individuals working or aspiring to work in civic science. Organizers conducted the workshop over Zoom, enabling video and chat participation by both presenters and attendees. Two half-hour sessions (not reported on here) divided attendees into breakout groups of three or four people to provide an opportunity for introductions and conversation about each day's case studies.

Monday, May 24

Opening Remarks and Conceptual Frameworks

Organizers' Welcome

Deena Weisberg, Michael Weisberg, and Aaron Mertz began the workshop by welcoming an international gathering of attendees who joined the workshop remotely from 25 countries on all six inhabited continents. The organizers stated their central purpose in convening the workshop: to build better community science projects and a more democratic model of civic science by creating an international network of people who do similar work.

> ***"We are so pleased to have you here this afternoon (in my time), this morning, this evening, from all the different corners of the earth."***
>
> – Deena Weisberg

Michael Weisberg invoked Alexander von Humboldt, whose idea that a global network of observation stations could unite the world in coordinated study stands as a model for civic science today. The organizers hope this workshop will encourage the free sharing of knowledge in scientific communities by enabling research that is not only global in scope, but that is co-developed by professionals and laypeople.

In structuring the workshop, the organizers drew on their collective experience practicing and facilitating community science. Deena Weisberg and Michael Weisberg co-direct the Galápagos Education and Research Alliance with Ernesto Vaca, one of the workshop's presenters, and Aaron Mertz is the Director of the Aspen Institute Science & Society Program, which he founded in 2019 to raise public trust in science and to encourage scientific workers to engage more fully with their societies.

Welcome from the United Nations Climate Change Secretariat

Youssef Nassef, Director of the Adaptation Division of the UN Climate Change Secretariat, spoke on the global problems human beings have designed our way into and of our now urgent need to address them holistically. Citing "symptoms" that have too often been studied in isolation from one another—acid rain, air pollution, climate change, ozone depletion, species extinctions, and even COVID-19—Nassef asked that humanity revise how it conducts science in order to merge these traditionally siloed topics and address them as interacting components of our world.

Assembling quotations from Dennis Gabor, inventor of holography, and biologist and anthropologist Thomas Huxley, Nassef declared that "the best way to predict the future is to create it," and that common sense is the way to do this: "That's where community science comes in, inspiring us to find solutions in the wisdom that

has been created from the bottom up." Experiential knowledge, conventional wisdom, and the aggregation of collective common sense are as necessary to solving problems as is academic scientific research.

> ***"The future cannot be predicted, but futures can be invented."***
>
> – Dennis Gabor, *Inventing the Future* (London: Secker & Warburg, 1963)

> ***"Science is simply common sense at its best."***
>
> –Thomas Huxley, *The Crayfish: An Introduction to the Study of Zoology* (London: C. Kegan Paul & Co., 1880)

Nassef painted an image of a new model for scientific endeavor: science as the meeting place of new technologies, innovative strategies for data collection, Indigenous values, and the wisdom of communities that have stewarded regenerative resources for millennia. This new science stretches beyond academic work and enables a broader scale of data collection by engaging members of diverse communities. Technological tools such as AI (Artificial Intelligence), IUT (Implementation Under Test, a method for analyzing vulnerabilities in systems), and Blockchain (as a decentralized, secure form of data collection) should be adopted where they can serve an expanding population of civic scientists.

The Paris Agreement proposes that individual countries identify measurable goals for stabilizing greenhouse gas concentrations in the atmosphere. Halting or reversing climate change, however, is as much a social, narrative, and cognitive challenge as it is an economic or ecological one. For this reason, as the UN reviews global aims for addressing climate change and incorporates new data into those mobile goals, it is also developing working groups that seek to change not only measurable elements of our physical environments, but the worldviews that determine how we interact with and care for those environments. Scientific work, that is, must encompass communication and value-building endeavors.

UN entities that foster this approach include the Local Communities and Indigenous Peoples Platform (LCIPP), which assembles people and their knowledge systems to inform policy decisions that will build a climate resilient world, particularly in replacing extractive resource destruction with sustainable use practices. The UN also holds an annual research dialogue to incubate new scientific concepts, including from the community level. Finally, the Resilience Frontiers Initiative seeks tools that can support a global transition towards permanent ecological resilience. Nassef voiced his belief that science that merges all possible sources—combining the results of UN platforms with community-based initiatives like those presented at this workshop—is the ideal engine to drive future policy decisions.

Brief Introduction to Citizen Science and Community Science

Michael Weisberg provided definitions for citizen and community science to lay a foundation for the workshop. Many terms exist to describe the work non-professional scientists do in scientific inquiry, including citizen science, community science, civic science, participatory research, and community-based participatory research. In some models, such as the Cornell Lab of Ornithology's bird counts and Galaxy Zoo's crowd-sourced astronomical classification, citizen scientists help professionals gather more data than professionals could gather alone. This workshop aims to consider what laypeople bring to science beyond these kinds of data-collection projects. Their contributions might include changes to how science is funded, framed, valued, learned, and taught, as well as changes to how communities, activists, and scientists achieve their goals.

M. Weisberg introduced multiple frameworks for thinking about the structure of community science initiatives. Social movement-based citizen science, for example, seeks to amplify the power of the disenfranchised, whereas authority-driven community science amplifies the power of professional scientific researchers. A continuum of participants' agency and involvement likewise distinguishes projects imagined by professional scientists and carried out by laypeople from those jointly created by laypeople and professionals. One goal of this workshop is to propel community science organizations toward full partnerships in which citizen and professional scientists truly work together at every stage to identify problems, execute research, analyze data, and disseminate findings.

Attempts to expand community science as a technique pose ethical and philosophical questions: What characterizes expertise, and who is understood to have it? How should scientific communities serve public needs, and when do they exploit citizen collaborators? Could policy makers and the publics they impact better understand each other in a joint language developed through community science? We must also assess community science efforts in order to determine if this is indeed a good way of extending traditional field research. Given the impediments that slow down community science work (time, money, bureaucracy, and differing interests), when is it worth doing and what should it prioritize? Finally, how can community input democratize science, making its findings less elite, more accessible, and more functionally relevant to more people?

Epistemic Injustice and Community Science

Gwen Ottinger, an anthropologist of science and political theorist, has worked with communities located near oil refineries and petrochemical facilities since 2001, and finds that these communities develop independent air monitoring practices to pursue both better air quality and environmental justice. Having seen these community science methods emerge and evolve over twenty years, Ottinger observed that community science can help dismantle unjust knowledge systems and infrastructure. She also warned, though, that community science dominated by professional scientists can continue to harm communities. Ottinger defined this harm as epistemic injustice, or "wrongs done to people in their capacity as knowers." Doing this type of wrong can look like unfairly denigrating someone's credibility or ability to contribute to knowledge, failing to recognize the concepts a person uses to make sense of their experiences of injustice, or excluding that person from deciding what makes knowledge adequate or relevant. Professional scientists have wronged layperson communities in these ways historically and risk continuing to do so. Community science promises three key ways to address these unjust relationships: epistemic recognition, epistemic innovation, and "coming to judgment." While advocating for each of these promising qualities, Ottinger also noted that they risk reintroducing epistemic wrongs and must be approached carefully.

The promise of epistemic recognition is that community science could establish participants as people who make valuable observations and contributions to human knowledge. Grassroots science—such as the system for measuring air quality in real time designed by a California community in the 1990s in response to a refinery's pollutant release—sometimes causes professionals in science, industry, and government to overcome their traditional biases and to see the community members involved as "reasonable people, people who could contribute to knowledge, who [have] epistemic clout." The risk, however, is that scientists may treat community participants as sources of knowledge (mechanical sensors) rather than as subjects of knowledge (agents who give their own insight and opinions on the data they provide), and that scientists may incorporate community findings without respecting their source.

The promise of epistemic innovation is that community science can create new concepts and measures to better represent marginalized experience. Where language or concepts are missing from industry frameworks or professional knowledge systems, community participants can introduce them. The danger, on the other hand, is that participants may be disciplined into replicating preexisting scientific standards, quashing the innovation that made their specific circumstances more visible. The onus here is on professional scientists, not on community members, to close the communication gap. Ottinger encouraged professional scientists to commit to collaborative innovation, to recognizing their own epistemological limitations, and to developing new tools and ways of thinking.

Finally, the promise of coming to judgement is that community science can give participants a place at policy-making tables and empower them introduce their concerns using language that institutions recognize as authoritative. The danger, however, is that communities may remain unable to influence the terms of policy debate. This sometimes happens because the community's ability to collect data produces "a data treadmill"—a demand for infinitely more evidence of the problem before any solution is acted on. This community effort can also become a diversion when political tools, not more data, are the things truly needed to effect change. Community science can do a lot of good, but when science is not the right tool for the job, Ottinger pointed to political mobilization as a necessary complementary method.

Community Based Participatory Research in Public Health

Jennifer Pinto-Martin opened her talk by describing her journey from work in top-down data creation to embracing community-based participatory research (CBPR) as a necessary method for public health research. She defined CBPR as a collaborative and equitable orientation to research that begins by identifying a topic that is important to a given community and that combines knowledge and action to reach social change.

To illustrate why CBPR is necessary, Pinto-Martin presented quotes from community members whose opinions of academic scientific research were critical, jaded, and reluctant. These community members had had poor experiences with professional scientists who gathered local data but never shared their findings, failed to address community priorities or recognize community expertise, assumed partnerships could be established without preliminary relationship-building, or were unable to maintain useful programs once funding streams ended.

Pinto-Martin also shared anecdotes from her own research experience to illustrate how CBPR methods can intervene to improve scientific practices and results. In one case, cultural assumptions about social behavior norms prevented effective international research on autism spectrum disorders, until community partners pointed out the need to revise an indicator checklist with locally relevant metrics. In another case, a community advisory group reframed a research tool by advising the investigators to include questions that would build community trust even if the researchers believed they already had adequate findings on those topics.

> ***"You need to go in with an open mind and include what matters to the community."***
>
> – Jennifer Pinto-Martin, paraphrasing a CDC community advisory board

To repair negative experiences reported by community members and to generate more positive and productive collaboration, Pinto-Martin introduced a series of best practices and core principles for CBPR: to maximize community engagement, professional researchers should build on what the community knows, address locally identified issues, work with community members at all phases, and return research results to the community.

The University of Pennsylvania, for example, has worked to improve community engagement in adjacent Philadelphia neighborhoods since 2009 by holding annual events—Research Readiness Day and Community Driven Research Day (CDRD)—to guide community members into academic-community partnerships on projects that community members identify as significant. The university and its co-sponsors provide funding and instruction on how to frame a community issue in the language researchers use, how to bring a research need to a professional researcher's attention, and how to draw engagement, pitch to funders, and navigate the IRB. These efforts satisfy the final principle of CBPR, to bring knowledge and action together to mutually benefit all parties, because outcomes include items that academic research values (publications, attendees, and presentations) as well as elements communities value (funding, respect, hope, and the ability to make change).

Common Themes

The opening panel introduced community science as a concept and a practice, contextualized it historically, and pointed out the axes of its common variants. Community science emerged as an inspiring potential source for major social and ecological change on a global scale. In our Anthropocene era of environmental alteration, community science may facilitate the intertwined growth of traditional and emerging knowledge bases, opening a way back to Indigenous practices of ecological stewardship and insuring their impact through new technologies.

At the same time, the speakers pointed out challenges that arise at a granular level in the day-to-day work of community science, such as communicating need and intent clearly between professional and community scientists, establishing trust, and choosing research areas and modes of dissemination that benefit the community where research occurs. By presenting these common roadblocks to effective community science, the workshop's convening speakers encouraged attention to procedural and logistical needs within the larger missions of the case study organizations to follow.

Case Studies

Assessing Needs, Identifying Partners, Co-Developing a Project

1. Caribbean Natural Resources Institute (CANARI), Trinidad and Tobago

Candice Ramkissoon

www.canari.org

The Caribbean Natural Resources Institute (CANARI), based since 2001 in Port of Spain, Trinidad, promotes the equitable participation of civil stakeholders in managing natural resources critical to development in the Caribbean islands. Through programs focused on governance, local livelihoods, food and water security, climate change, the green economy, and technological capacity, CANARI fosters actions and partnerships that draw on local knowledge to improve quality of life and conserve natural resources. These actions focus on two main areas: facilitating civil participation in policy development and building local resilience during climate and economic change.

For CANARI, citizen science is "a participatory exercise" that engages communities in building their capacity for resilience. To carry out this mission, the Institute develops ICTs (Information and Communication Technologies) that promote stakeholder participation and draw on local knowledge. Ramkissoon introduced a case study—climate change adaptation (CCA) for fisheries—that used two ICTs: participatory 3D modeling (P3DM) and participatory video (PV) created by local stakeholders. In the first case, CANARI convened fisherfolk, fishery authorities, and dive, hotel, and tour operators—all consumers of natural resources—to build a 3D model of local fishing grounds that incorporated local knowledge of environmental vulnerabilities. In the second, CANARI provided tools to fisherfolk in Montserrat and Anguilla that enabled them to strategically film and collate content that drew attention to the effects of climate change in their lives, work, and environment, and to identify action items for CCA.

By providing tools and clear mission goals, CANARI has developed a regional reputation for bringing local concerns to the attention of policy makers, and now attracts partners who propose needs directly to the institute. ICTs then facilitate project co-development by enabling local stakeholders to participate in gathering, storing, analyzing, and presenting data. Local stakeholders do more than participate—they choose the voices, faces, images, and stories that will communicate their perspectives and the needs they identify for Caribbean stability and sustainability. CANARI also enables collective knowledge-sharing by hosting Knowledge Hubs where individuals and organizations can document and share evidence-based work and local knowledge on social, environmental, and policy topics that inform sustainable development.

Ramkissoon indicated that the technologies used to co-develop projects need not be complex to produce useful results. Simple tools can pave the way for more sophisticated results to follow. In the fisheries initiative, CANARI provided pins and thread for the first versions of the 3D model that it later digitized. To launch the independent video projects, it likewise began with workshops on storyboarding and editing, using only paper and markers. But the results are far from simple: the digitized 3D model, as a Geographic Information System (GIS), can be compared to data gathered by scientists for planning and environmental departments, and the videos can now be shared online to educate and drive policy change.

These creative and accessible tools have proven helpful for collecting and analyzing information while integrating local and scientific knowledge, and for causing change in the region. Local fisheries and the Fisheries Department, for instance, are taking these digital resources into account during fishery management planning, and they are being reviewed to inform climate policies. Ramkissoon closed by highlighting CANARI's ongoing goals and challenges: to build capacity and use it effectively, to use ICTs more and to be sure they can work digitally and remotely, and to continue to create credible spaces for knowledge exchange.

2. He Pātaka Wai Ora Project, New Zealand

Brendan Flack

www.puketeraki.nz/Environment/He+Pataka+Wai+Ora+Project

The He Pātaka Wai Ora Project, overseen by the Kāti Huirapa Rūnaka ki Puketeraki (a sub-tribal Māori council within the Ngāi Tahu tribe of Aotearoa / New Zealand), is now thirty years into a 200-year restoration plan called Wairua (two waters). The Project focuses on identifying the areas of the Waikouaiti River where mahinga kai—natural resources that sustain life—has been most severely compromised by agriculture and other human modifications. The results of the research are being used for restoration projects on and next to the river, in order to assist decision making about how to enhance native fish habitats. Reinstating a protective human connection to the waterway, restoring a "healthy food basket," and communicating with sources of industrial pollution that have damaged the river (such as the gold mine, the largest in the Southern hemisphere, at the headwaters), form key elements of the Project's work.

Flack highlighted He Pātaka Wai Ora initiatives that share a focus on repairing human relationships with nature and restoring resources that traditionally upheld Indigenous quality of life. The Project adopted its standards for effluent reduction and habitat restoration in and around the Waikouaiti River from interviews conducted with tribal elders in 1880. The elders described the 1,500 most important food- and resource-gathering sites in the region and listed the species in those areas according to the tradition of ka

ara tawhito (seasonal harvesting). After Māori chiefs and representatives of the British Crown signed the Treaty of Waitangi in 1840, British settlers divided and fenced the land and excluded Indigenous people from traditional areas. To choose a standard of biodiversity less altered by settler incursions, the Project set its baseline for river health earlier than the interviews, to 1860, and determines local needs based on this historical Indigenous knowledge.

"It may be a small river, but it is our river, so it's important to maintain its health."

—Brendan Flack

Assessments began in 2014 to determine how the region compares to its 1860 standard. These assessments revealed that many traditional food species were extinct or endangered. The Project set about restoring habitats that support these creatures by initiating relationships with current landowners and establishing mutual trust with them. In one instance, a committee formed of Indigenous people and scientists oversaw a community project that placed 500,000 abalone in a taiapure, a "coastal patch" where the New Zealand government has, since 1999, recognized Māori management of a traditional fishery. Another protected area, a freshwater mataitai, has likewise "allowed our people access again" to areas surrounding traditional fisheries that had been inaccessible since the mid- to late nineteenth century.

Flack introduced the He Pātaka Wai Ora Project's goals by highlighting its grounding in Māori terms that orient human life towards other living things. Necessary concepts include kaitiakitaka (inherited stewardship), respect for the methods of tūpuna (ancestors), and the oral passing of knowledge during wānanga, a process that assembles groups to discuss, learn, share, and teach knowledge of mahinga kai. These approaches create ideological consistency so that future generations can sustain stewardship according to its traditional principles, which include reciprocity between the human and natural worlds and a human duty to restrict resource use. Multigenerational investment is key, because environmental partnerships are not all external: some occur within the community, for example, between adults and children. Children have helped move migrating eels to healthier stretches of the river; the Project also organizes trips by traditional canoe for young volunteers who replace exotic and invasive species with native riparian plants.

Flack's case study highlighted the importance of tracing environmental work and community science initiatives to local or Indigenous languages and concepts. Translating across languages, colloquialisms, industries, and regional and national paradigms becomes necessary as efforts to recover traditional habitats and foodways expand. However, local language best conveys the core meanings that motivate change. Using it, moreover, reverses traditional hierarchies by asking that governments, universities, and professional scientists adopt the perspective of people who live closest to an ecological problem and who may already have identified solutions to it.

3. Coaching Conservation, Botswana

Lesley McNutt and Hugh Webster

www.coachingconservation.org

Coaching Conservation (CC), established in 1989 as the Botswana Predator Conservation Trust, uses sports and games to build children's confidence and faith in their futures alongside an increased knowledge of the natural world and empathy for endangered wildlife. Through the "Learning from Wildlife" curriculum, the organization introduces threatened species as exemplars of values like teamwork, communication, independence, and balance, and encourages students to adopt those animals as emotional, social, and behavioral models. A long-running solutions-oriented applied science organization informed by Director Lesley McNutt's expertise in anthropology, Coaching Conservation integrates education, natural science, and community involvement to address issues of human/wildlife conflict.

Coaching Conservation works within a family of charitable organizations under the umbrella Wild Entrust to effect "long-lasting behavioral change" in Botswanan communities dealing with human/wildlife conflict and species endangerment. Coaching Conservation starts its programming with children with a "meet the animal" day that focuses on fun and exciting wildlife facts. The second stage of the program establishes an emotional connection to animals through games and activities where children mimic animals and learn to value their traits. The third stage follows "meet" and "be" with "help": it teaches children about a problem that affects the animal they have imitated and announces an action item that "kids who care" can carry out. The goal is to sustain children's pro-environmental outlook and encourage them to establish the habit of acting on it.

"Science is important to making change, but conservation is about people."

—Lesley McNutt

Over thirty years, Coaching Conservation's leaders have reflected on and changed their methods to better match the needs and interests of local communities. Long before they developed the current curriculum and the partnerships that helped refine it, McNutt recalls attempting to attract community partners by presenting information to local adults at workshops, hoping they would "get on board with our conservation messaging" and adopt environmentally friendly practices. When after ten years this model of knowledge transferal had

not successfully sustained local interest or affected behavior, the organization reviewed its approach. It found that community members without a strong investment in their own futures did not have a foundation for investing in the future of the natural world, and that encouraging empathy with wildlife was easier to begin with children, whose ideas about the future are less established.

As the organization developed its educational program, attention to key areas brought new success in community partnerships. These areas included local values, credibility, play, hiring local staff, and serving needs identified by local people. Teaching children to play soccer drew local approval and interest and hiring local instructors and research assistants embedded Wild Entrust programs in the community, benefitting Coaching Conservation with expertise on local languages and sensitive topics like poaching. Partner organizations also helped to improve the curriculum and to develop a training program for instructors, which has led to interest in expanding the program internationally and through digital tools.

Webster and McNutt emphasized that self-assessment, reconfiguration, and choosing the right community and organizational partners are key to developing an effective community science practice. Their measures of success include not only indicators that child participants retain environmental values and learn to act on them, but also an impetus reversal in CC's relationship with its community: Recently, community members approached the organization to request a partnership to develop a program environmentally friendly beef production, in which disease-free food resources and human/wildlife conflict mitigation productively dovetail. Webster and McNutt also pointed to the importance of recognizing the areas of expertise and influence that one's organization lacks and developing relationships with a broad range of experts and institutions to cover those areas—including marketers, IT specialists, government ministers, and school board members.

Discussion

K.C. Cole moderated a discussion following these case studies. Attendees considered a set of interrelated questions: who belongs to a community, how prolonged engagement with scientists can benefit community science, and how scientist/community relationships change over time.

Tamar Case-Dixon (Southern Trelawny Environmental Agency) asked the Coaching Conservation team about the traditional conservation methods used in the Botswanan communities they work with, and whether they have been integrated into the organization's methods. In reply, McNutt described how responsibility for land and wildlife management has fluctuated between government and community control, resulting in a structure where traditional methods for protecting animals and maintaining food supplies must be supported by protocols that address how the landscape those methods apply to has been altered by fencing, development, and tourism. She noted that her organization's work became more effective at this support the longer it existed. Attendee Pritpal Singh (Villanova University) concurred: "A lot of time investment is needed in local capacity building in order to have a long-term sustainable project." In a discussion the following day, Gareth Catt (10 Deserts Project) also advised that training staff thoroughly and consistently rehiring to avoid gaps in organizational know-how, relationship building, and communication, is crucial to this longevity.

Ayelet Shavit (Tel-Hai College / Town Square Academia) noted that this sustained contact is important not only to develop trust and communication, but so that community knowledge can destabilize "what 'we' [outsider or professional scientists] know." Attendees wondered how often this change in worldview moves effectively from community to professional scientists, with moderator Cole asking how well professional

scientists and academics listen to communities. Ottinger proposed that listening be regarded as an "epistemic and civic virtue," the duty of people who have the power and the resources to cultivate curiosity and open-mindedness. This mindset is especially important to counteract situations where assumptions continue to outweigh curiosity: where data sets launch projects instead of conversations, where advisory boards think of communities as monolithic instead of variable, and where industries prevent their employees from engaging in pro-environmental work because they assume it poses a risk to profits.

Participants agreed that when a scientific organization listens effectively to a community and speaks the language of its concerns, it facilitates change. This is especially true when professional scientists are able to promote better communication between local stakeholders and resource-allocating authorities. Ramkisson noted that governments approach CANARI when they want to integrate local knowledge into policy but don't know how to communicate with local stakeholders and need to be guided by an intermediary. This translation process can be frustrating, however: Flack reflected that although tribal elders knew about abalone endangerment for several years, it was only after researchers with Western science credentials agreed and wrote down the problem that the tribe received help and money. Translation can also strategically capitulate to dominant lexicons, as in communities that learn how environmental regulators think and speak in order to have their problems heard. This approach has pros and cons—it may effect change at the expense of accurately describing the source and nature of a problem.

Finally, attendees wanted to learn more about engaging children and youth in community science and conservation, including how to communicate effectively with young collaborators, how to involve children's families, and whether evidence shows that children's empathy for the natural world affects adult perspectives in their communities. Flack reported that it is effective when young researchers just a little older than child audiences present on how traditional "wisdom knowledge" compares with Western ways of seeing the world. He also mentioned that engaging with educational institutions, as well as offering Indigenous land and knowledge as teaching space and programming, can be a way of sustaining partial funding when other sources dry up.

Three Recommendations for Community Science (Panel 1)

1. **Invest in the historical and current expertise held by local communities.** Provide tools for recording and sharing that expertise, hire or otherwise fully recognize those who have it, and incorporate it into the value systems that support community science projects.

2. **If you are a professional scientist seeking collaboration with community scientists, define your own role and the model of change you are pursuing with input from your community collaborators.** In some cases, that role might be "intermediary," not "investigator," and the work might call more for translating existing community-held data into the language of policy than for collecting new data.

> ***"I think the first responsibility of citizen scientists is to raise awareness in order to include and motivate the public to participate in doing science to solve challenges they face later."***
>
> –Muhamed Abbas

3. **Collaborative relationships and conservation efforts take time to build and may not succeed right away.** Take a long view of goals and resources to keep up morale and promote flexibility.

Case Studies

Executing a Project and Maintaining Enthusiasm

1. 10 Deserts Project, Australia

Gareth Catt
www.10deserts.org

The 10 Deserts Project aims to build the capacity of Indigenous groups to look after the land to achieve a range of economic, social, cultural, and environmental outcomes. The projects within this consortium include fire management, carbon sequestration, tourism, and monitoring feral camels. These projects' key strategies seek to build Indigenous capacities and connectivity, manage threats, and create sustainable jobs and income. The Project covers nearly a third of Australia—the largest connected network of protected areas in the world—and most of the lands members work on are Indigenous Protected Lands (IPA). These semi-arid grasslands in Western Australia, which European settlers and surveyors deemed "the useless country," have been stamped since colonization as unsuitable for agriculture and devoid of natural resources.

Fire mitigation, one focal area for the 10 Deserts Project, addresses the wildfires that have occurred in these deserts for millennia. Many species went extinct around 1964, when local people stopped being able to apply traditional burns to the landscape. Recently, traditional cultural burning techniques have been revived: a person walking with a fire stick creates a fire scar that cuts perpendicularly across areas where fire would naturally spread. The goal is to prevent hot-burning and uncontrollable wildfires by carrying out controlled, cooler burns. While wildfires burn all fuel (vegetation) from its base, the application of cool fire lets vegetation grow back from the top, preserving habitat support for possums and other wildlife, and by the same token, food resources for human residents.

"Deserts are not free of people. They rely on people being in them and part of them."

—Gareth Catt

The 10 Deserts Project relies on volunteer support and wants to give people a meaningful reason to participate in fire mitigation and monitoring. Another goal is for those who own ranches to be able to make informed decisions about their land. Catt pointed out that innovation is not always called for when seeking engagement: the Indigenous Desert Alliance (IDA), one of the 10 Deserts partners, brings people together through practices that have been used for hundreds of years. The biggest key to promoting enthusiasm in the rangers they recruit is to bring people together and make them feel they are part of a meaningful collective effort—an especially important strategy for covering a land mass that ranges from the Great Sandy Desert down through the Great Victoria Desert, and for assembling participants who live in very isolated areas and who have to travel long distances to see other people.

The Project has been effective in reducing large wildfires and improving the health of the desert landscape, with a jump in pyrodiversity (the diversity of fire types in a region) over the past ten to fifteen years. The managed land model they use gets participants invested by presenting a shared task that benefits everyone: The Project trains people to manage fire at multiple sites, working with eight Indigenous land management organizations and building collaboratively with government-funded teams. Catt stressed that productive land management and an enthusiastic workforce depend on connecting people, recognizing their values, and using their ideas rather than imposing ideas from the outside.

Knowledge exchange with Indigenous partners has been key to developing conservation practices, including activities like going out with Indigenous community members to learn about traditional hunting and gathering processes. In turn, these relationships are allowing 10 Deserts to get as close as possible to establishing a traditional wildfire-mitigating burn pattern. Catt emphasized the importance of making sure Project staff understand Indigenous groups' values and needs thoroughly before they start work together, so that they don't unwittingly initiate contentious activities and so that they can collaborate effectively.

2. Shan Shui Conservation Center, China

Lu Zhi

http://en.shanshui.org/

The Shan Shui Conservation Center is an NGO founded in 2007 dedicated to species and ecosystem conservation and to addressing issues in the coexistence of humans and nature. The Conservation Center uses community science approaches to protect habitats and endangered species, including the snow leopard. Lu outlined a number of tools and partnerships that the Center has developed, including China Nature Watch, a program launched in 2014 to collect data from citizen scientists, publish free and accessible datasets, and enable diverse groups to produce reports and policy papers from that data. These data led to a partnership with Peking University to establish a campus conservancy for native wild species. The Center also developed the Biodiversity Impact Assessment tool (BIA) to help residents understand how laws about land use, investment, construction, and the supply chain affect biodiversity, and to better enable those residents to monitor development activity and its impact.

Since 2005, the Center has trained village residents in the Sanjiangyuan region as guards and observers to monitor and protect wildlife. This large area covers approximately one fifth of the Tibetan plateau and is the source of three rivers—the Yellow, Yangtze, and Lancang—whose combined watershed provides for almost a billion people. It has been identified as a priority for conservation efforts and is now the location of China's first national park, which the Center helps to staff. The region has a largely intact ecosystem, with large ungulates and carnivores (including snow leopards and brown bears) and substantial grasslands. In fact, the Tibetan Plateau and Southeast mountains of China have the highest number of large carnivore species in the world. Overgrazing and human use have degraded these habitats, leading to the need for increased conservation that Shan Shui's community science programs are designed to provide.

The area where the Center is working has no permanent residents, but urbanization is expanding nearby towns and villages, so involving village residents is key to conservation success, and the region's culture is an essential component of this community engagement. A syncretic combination of Tibetan Buddhism and older nature worship traditions serve to ground local communities in a respect for mountain, lake, and other nature gods, encouraging kindness to animals and careful, reciprocal relationships with the natural world. A loss of animal life is understood to affect human health; prayer for family wellbeing begins with prayer for the wellbeing of humankind and the natural world. The result is a belief system where feeding wildlife during snowstorms or sitting through boring monitoring sessions are incentivized by social approbation, not by law or money.

"Only when the world is healthy can human families be healthy."

—Lu Zhi, paraphrasing a dominant cultural tenet in the Sanjiangyuan region

Lu recalled being shocked by this prevalent multigenerational attitude when she first began working in the region in the 1990s, because it contradicts research that suggests that people are more able to care for their environments when they are more affluent. In this region, by contrast, the Center's research into cultural values revealed that the richer a culture is, the richer the biodiversity around it. They also found that poorer people care more about treating other species carefully. This combination of cultural foundations provided the Center with direction for staffing the national park with engaged citizen scientists, to which it added the tangible incentive of income. The Center pays 17,000 residents to guard and monitor the area, rewards monitors who report frequently, and recognizes sacred mountains as protectors of wildlife. Increased data collection justified launching an ecotourism structure in which 21 families elected by the community provide homestays and tours. These families split the income they generate between their families, elderly residents' home insurance, and a wildlife conservation fund.

Lu observed that when a community starts to create data, it's not only about helping scientists create more valuable publications, or even about accumulating scientific knowledge—it's about the people's power to participate in conservation. At the same time, she acknowledged that not all regions have historically embedded conservationist value systems, and that even in the Sanjiangyuan region, some challenges are easier to address than others. Since the 1980s, land division and settling have interrupted nomadic life structures and rotational grazing, resulting in grassland degradation. However, while residents want to monitor wildlife, they do not want to return to Indigenous, nomadic systems of land use. This means that engaging herdspeople and managing livestock will call for different strategies.

3. Town Square Academia, Israel

Ayelet Shavit

https://english.telhai.ac.il/initiative/town-square-academia/

Town Square Academia, which began in 2012, makes academic-level courses accessible to the general public in the Upper Galilee region where Tel-Hai College is located. Through dialogue between the community and members of the college, Town Square Academia aims to generate cultural renewal by tapping into the strengths and abilities that exist within the region. Town Square Academia's name comes from the agora, the town square in Athens where Socrates aimed to build knowledge out of critical dialogue. The organization's goal combines education and activism, aiming for multiple academic disciplines to join together to build knowledge that will improve participants' lives and surroundings. Its approach hinges on recognizing the expert knowledge of local residents and on pairing local expert volunteers with academics. This strategy of pairing also brings conflicting perspectives, methods, and people together in one place, such as Jewish and Arab instructors, people with special needs and government officials, farmers and environmentalists, and religious and nonreligious participants. Town Square Academia's vision is to transcend ethnic and religious boundaries and government limitations to ideologically transform the region and ensure adequate resources for those who live there.

Town Square Academia convenes ten courses a year and runs four long-term community science groups that aim to create change through regional cooperation. These partnerships with local experts have led to projects monitoring the local watershed and promoting exchange among individuals with different types of expertise. A project to promote the ecological expertise of Bedouin communities around the village of Tuba drew on local knowledge of ecology and plant life in order to demand government funding and support for local resources, and ultimately to enable a region isolated amid government lands to develop ecotourism and reestablish traditional plant-gathering practices. Town Square Academia's attention grew

the region's reputation as a center of learning, which attracted ethnobotanists and other academics to run studies there. In turn, the academic output made local expertise more legible to the government, reaching the organization's goal of producing recognition, innovation, and political utility in order to convince the government to treat residents as they deserve.

Key to enacting change is recognizing that academics and community members measure success differently. Shavit noted that community members care about what recognition and funding the government can give them and even more about receiving recognition from adjacent communities. If you belong to an oppressed minority group, she observed, you don't want to be recognized just by academics, but by your fellow citizens. For this reason, community members value co-created processes and the people they interact with more than the end result. Even funding is less important than these connections for making a long-term difference to a community. Times of pressure and violence present very real challenges to academic/community relationships, both in terms of physical impediments to gathering and ideological pressure not to innovate or criticize government practices during a crisis. Shavit noted that in such times, even if academics did not maintain a physical presence in the community, the community cared most that academics were critical and self-aware, and that this self-assessment allowed projects to maintain partnerships.

Keeping in mind that scientific evaluation and community evaluation differ, Town Square Academia has created a model that sustains community science by meeting both sets of evaluation criteria. Products include academic grants, publications, and conference papers, but also national prizes awarded to both academic and layperson participants, and a heterogeneous global network of collaborators diverse enough to sustain itself—like an ecosystem. Shavit emphasized that valuing disagreement and accepting failure are important to collaborative work that addresses epistemic injustice. It is also important to bear in mind that the same qualities that attract institutional respect and funding (such as robustness and stability) have the potential to produce conservative, static, or biased findings and to silence the radical criticism of minority perspectives.

Discussion

D. Weisberg moderated the discussion following these presentations. She opened the conversation by noting the biases that scientific institutions often hold favoring formal education and credentials over other forms of learning and knowledge, leading to a question of how professional scientists might address this bias by translating valuable local perspectives to authorities who might not otherwise see their value. The presenters responded by talking about strategies for scientist/funder and scientist/government conversations and by reiterating the need for professional scientists to empower community collaborators to use collectively gathered data to participate in those conversations themselves. For instance, Lu described acting as a liaison between student conservation groups and university leadership at the University of Peking, suggesting that being a "translator" may work best within one's existing workplace or networks.

The question of how to help communities communicate with governments—or "butter them up" (in Case-Dixon's words)—also brought up a range of experiences with NGOs academic institutions. Shavit described the process of bringing a government ecologist to meet with nomadic community members because the two had such different surveying methods that consensus on how to treat local flora had not been reached. Case-Dixon mentioned protest (taking a problem to the government), while Catt described a strategy on the other end of the spectrum: In the "hangover" of colonial genocide and land appropriation, when government frameworks for understanding conservation hinge on concepts like ownership, one could carry

on one's work with Indigenous partners and mostly "avoid the government," showing them "nice photos" only as necessary to request funding. Shavit suggested a middle ground: developing working relationships with individual government representatives who are physically closer to the research than to the seat of authority, and to strategically connect them with community experts who can explain local needs.

All three presenters noted that embodied and structural privilege—being white, being the bearer of data, or having a personal connection in government—both open doors to government approval for a project. They also noted the imperative not to linger in that role, but to make sure activists and community members control their own data so they can direct their own interactions with government authorities.

Attendees returned several times to the idea that scientific research and involving people in that research are two unique undertakings. Engaging people might even be, as Catt said, "the real challenge" of the two, as each community member must be met and treated as an individual. Cheryl Hojnowski (Biosphere Institute of the Bow Valley) asked about how to maintain enthusiasm while perceiving and respecting participants' boundaries, and Shavit noted that this enthusiasm need not be forced but can be asked for in the form of knowledge. To ask for the "gift" of a community expert's knowledge, and to promise to treat that knowledge respectfully, she added, have been effective modes of communicating between academic and community spheres. On the other hand, the gift of knowledge must be returned to the community: Lu recommended not only giving the data back to the people who collect it but showing them how the results are being used by both governments and scientists. And while awards are motivating, not every incentive to participate needs to be positive; constructive criticism also engages participants and shows them they are being taken seriously.

Lynn Chiu (Konrad Lorenz Institute) pointed out that the need to interface with communities may call for social science and perhaps humanities methods, and asked if these case studies could, inversely, inform local research needs in areas like philosophy or history. This comment prompted a number of reflections on interdisciplinary collaboration and general agreement that it is necessary (in Lu's words) "to observe and better understand the attitudes and behavior and the drives behind [community participants]." Later in the workshop, attendees also noted that community science benefits from a mixed use of quantitative and qualitative evaluation tools for community programming, particularly to assess shifts in the values of community participants.

Three Recommendations for Community Science (Panel 2)

1. **Research community values before beginning work on traditional scientific topics and organize the scientific research program to empower participants according to their values.** Incentives to engage in community science must come from within a community and must exist in peer-to-peer relationships as well as in the relationship between a layperson and a professional scientist.

2. **Teach government agencies and representatives how to perceive your work, rather than working fully within existing measures, policies, or provisions.** For professional scientists, this may mean providing and interpreting data, or it might mean using a facet of one's privilege (race, gender, wealth, credentials, etc.) to assist community experts in gaining attention from the government.

3. **Collaborative tasks, human companionship, and peer recognition are motivating social forces in themselves.** Facilitate activities that teach participants about each other as well as about conservation objectives.

Case Studies

Evaluation and Dissemination

1. ELOKA – Exchange for Local Observations and Knowledge of the Arctic

Noor Johnson

http://eloka-arctic.org/welcome

Founded in 2006, ELOKA fosters collaboration between resident Arctic experts and visiting researchers to facilitate the collection, preservation, exchange, and use of local observations and Indigenous knowledge of the Arctic. ELOKA provides data management and user support to Indigenous communities to ensure their data and knowledge are managed, visualized, and shared in an ethical manner to work toward information and data sovereignty for Arctic residents. Indigenous partners initiate projects and determine what data is shared and how.

ELOKA projects map many sorts of data and local knowledge, including topography, weather patterns, local languages, and foraging sites. One partnership, between ELOKA and Alaskan educational nonprofit Calista Education and Culture, has documented place names and local knowledge since 1980. Much of this information had been published in books, but ten years ago elders worried that young people, especially those not living locally, would need to know place names in order to travel safely across the land and would need to learn in a different format. They initiated a partnership with ELOKA, and together they built an online atlas that includes educational modules, photos and videos, and multiple translations of the place names it contains. Other atlas and monitoring projects have documented environmental data such as precipitation and other weather data, snow cover, seasonal sea ice, wildlife, and permafrost integrity, as well as traditional berry collection and hunting sites.

Johnson remarked that research norms have been changing in the Arctic to include co-producing knowledge, community- and Indigenous-led research, recognition of Indigenous data sovereignty, and an emphasis on equity, thanks to "the ten big ideas" initiative by the US National Science Foundation. Following these principles, ELOKA uses a Community Data Management System (CDMS) to co-develop resources like place name atlases, online databases, and websites. Community partners determine how they want their data to be used and shared, and many of ELOKA's partners consider how they will use their data to inform co-management of land and resources with the government, which often needs guidance to understand Indigenous knowledge and techniques. ELOKA's work with partners also focuses on capacity building and education, so that eventually partners can own and manage the technologies that house and communicate their data.

As part of the CDMS, ELOKA develops best practices for data sharing and data stewardship. Indigenous partners then determine how data are evaluated and disseminated based on their needs. The Calista project, for instance, shared its place name atlas with a school district that adopted it as a teaching tool, instructing students in how to use it add place names to it. Some partners publish data publicly and stipulate how they may be used (e.g., crediting the community members who contribute observations and the context in which the observations occur), while others retain password protected access to information like the location of legacy foraging sites, so that only tribal members can access knowledge of vulnerable locations. Like the multilingual place name atlases, a community-established weather station also publishes weather data in two languages, increasing access to community-generated data. Because ELOKA is a network, partners also learn from one another. For example, when the Yup'ik Environmental Project Atlas began to add new types of data to their atlas, the Calista elders did the same, adding climate projection data to be used in partner schools' curricula.

In the next five years, ELOKA will assess how the data sharing applications and products they have co-develop are used. The Exchange will document and evaluate use to determine what needs exits around digital access, technical capacity, and digital literacy. For partners across the Arctic, Internet access is not always reliable, is sometimes very expensive, and may need to be accessed from a shared location like a school or tribal office rather than in a home. ELOKA leaders want to hire and train local technical leads, so that technological capacity exists beyond universities and so that technological infrastructure becomes more accessible. They also have plans to research how partners want to tell stories, how to best capture those stories using digital media, and how partners, including children, can create and contribute multimedia elements to atlases and websites. Working groups are also currently comparing how atlas and observational data projects use digital tools to tell stories and influence policy. The hope is that these efforts will enable new variations on how partners use ELOKA products to log and share knowledge.

2. Foldscope, India and Iraq

Manu Prakash, Mo Pandirajan, and Muhamed Abbas

www.foldscope.com

Manu Prakash, the creator of Foldscope, and Mo Pandirajan, a Foldscope "super user" and community educator, presented on this unique accessible microscope. (A second super user, Muhamed Abbas, was unable to join this day of the workshop to describe his Foldscope Iraq project.) Foldscope was created with a vision to solve an accessibility problem in science. It was invented by Manu Prakash and Jim Cybulski

while Cybulski was a PhD student in Prakash's laboratory at Stanford University. Their inspiration for the Foldscope originated in field visits around the world, where they continually encountered bulky, broken microscopes or a lack of microscopes. As traditional microscopes are often expensive or cumbersome, they realized the universal scale of this problem and the need for a low-cost, revolutionary solution. The result is the flat, pocket-sized Foldscope, a highly portable and inexpensive tool that is bringing new research capacities to well over a million people.

Prakash introduced the Foldscope project as "frugal science" based in the core value that the most important thing for communities to have is independent access to tools and solutions. Foldscope's mission is to develop the scientific curiosity of people everywhere, to engage people in a sense of wonder at the microscopic world, and to facilitate problem-solving in the arenas of health, environment, and education. The folded paper microscope designed to meet this need costs about one US dollar, is waterproof, does not require a power source, and can be used alone or with a cell phone or a projector. The Foldscope inventors set out to share 50,000 of these tools across the world. After achieving that first step towards building a global community, they have now shipped 1.5 million Foldscopes to more than 150 countries.

"We have so few scientists compared to the scale of problems we have. Science needs to be a fabric of our society. Universities are not the only places where science needs to thrive. The role of science is far, far bigger."

–Manu Prakash

Pandirajan, a schoolteacher in rural parts of Madurai, India, then described the work he does as an educator demonstrating and distributing Foldscopes. He travels with an entire portable science lab built of simple tools: a wooden bead on a string as a pendulum, a Foldscope for microscopy, and a tiny telescope. His mission, like the Foldscope mission more broadly, is to share techniques for learning and to inspire curiosity. When he demonstrates scientific tools—on trains and buses, on street corners, at schools and at markets—he noted that he never gives answers, but only asks questions to engage his audience. Where possible, he demonstrates the full process of taking a sample, making observations using a Foldscope, and adding that data to the website before distributing Foldscopes to communities. In only five years, Pandirajan has trained over 95,000 students and 12,000 teachers, encouraging them to implement Foldscopes in their

schools. Foldscope is also a field tool that doctors, milkmen, shopkeepers, and others have adopted to address quotidian community needs. Pandirajan's message is ultimately one of reassurance and practicality, showing new users their capacity for observation and emphasizing the fact that the sphere of science is no different from the locations where they already live and work.

> ***"Science is very simple. Science is approachable. Science is not a large place. It is in your house, in your church. Don't be afraid of scientists, of labs. Science is people."***
>
> —Mo Pandirajan

Foldscope has a two-fold distribution model: the distribution of the tool, followed by the sharing of data collected by Foldscope users. All data is owned by the individuals who capture it and is shared on a central website. Scaling up Foldscope has meant responding to the question: Who finds this tool valuable? The answer has been: Anyone who wants to engage in data collection and who and has a sense of local challenges they want to solve. This democratization of project initiation has led to Foldscope projects that address topics such as education, animal and human health, agricultural science, and science in conflict zones. Pandirajan has also encouraged innovation in his community by working across both English and Tamil, which is the most-used online language after English.

The Foldscope project demonstrates an important "we": the "we" of scientists who are not outside one's community, but who are one's community. It also proposes engagement strategies that stand out because, as Prakash put it, they do not try to convince people to come to science; they put science out in the world and let people stumble upon it in their everyday lives, such as when students hung magnified photos at a rural vegetable stand to begin conversations about the microscopic world. This model successfully spreads interest in and access to community science practices by way of Foldscope adoptees, who gain access to "the a-ha moments" of science and in turn become the science teachers and demonstrators of this technology.

3. Galápagos Education and Research Alliance, Ecuador

Karen Kovaka and Ernesto Vaca

https://web.sas.upenn.edu/galapagos/

Kovaka began the case study by describing the mission and focal areas of the Galápagos Education and Research Alliance (GERA), which aims to support Galápagos communities in protecting biodiversity, building resilience against climate change, and promoting the health of humans and non-humans alike. GERA is a partnership among these communities and faculty at the University of Pennsylvania, Villanova University, and Virginia Tech. Its work focuses on the most pressing issues facing the Galápagos: How can population growth continue while preserving biodiversity? How can these communities prepare for the coming climate emergency? And how can the tools of community science increase civic engagement with these issues and to empower local communities to protect their home? GERA now runs a number of projects under the umbrella LAVA (Laboratorio para Apreciar la Vida y el Ambiente, or Laboratory for Appreciating Life and the Environment): monitoring marine health, studying sea lions, measuring water quality, engaging environmental management, helping to manage invasive species, making astronomical observations, and more.

A sea lion monitoring project in Puerto Baquerizo Moreno demonstrates the GERA's mission and methods. This project asks whether sea lions behave differently at haul-out sites depending on the sites' level of human population. To find out, the Alliance engaged 33 high school students, beginning in 2017, to collect data twice a week over seven months at three to four sites. The project was selected through an initial phase of intensive needs assessment interviews with community members, which revealed a three-part priority structure: education, economic stability, and preservation of endemic species. The project provides high school researchers with school credit, an important incentive for maintaining motivation.

The Journal of Wildlife Biology published the results of this project in 2020, which means the researchers have accomplished their aim of producing and sharing high-quality data that are recognized by the scientific community. GERA also assesses the impact of the research on the researchers, by evaluating the participating students' attitudes about conservation and knowledge of sea lions both before and after the research period. Findings showed that these students increasingly saw people as part of nature and were increasingly internally motivated to engage in conservation. Internal evaluation then, shows positive effects on both the local community and environment and for the academic institutional requirements that sustain the project.

Vaca then spoke about effects the organization has on the dissemination of information and pro-conservation attitudes in the Galápagos. Vaca described a socioeconomic landscape where technological capacity outstripped education and economic development took priority over attention to the history of natural evolution. The purpose of community science, then, is to provide education in what more can be accomplished with technology, to change media messaging to build local confidence, and to promote a local focus on nature. GERA projects address these priorities by promoting teamwork among participants and the message that science can be meaningful work done by community members, to replace the sense that science is a vague activity done by outsiders with no effect on community life.

Going forward, GERA aims to expand the reach of its communication efforts by working with local social groups such as a SCUBA club, engaging residents with coffee chats, and hosting a "cerveza con ciencia" (beer and science) group exclusively for local people. Vaca noted that "when a presentation is pure science, reaction is minimal." However, when they get people talking about social norms and how they interact with nature, then community members begin to propose their own solutions for rebuilding those norms. Through techniques like these, GERA's community science initiatives aim to build an environmentally oriented human population. The most important part of dissemination, in this model, occurs when participants communicate with other locals. This intra-community communication also demands a form of evaluation from within the community. For instance, parents of the high-school researchers report that building and sharing scientific expertise increases their children's confidence. Meanwhile, community members who learn from those researchers come to see science in their daily lives and feel less alienated from it.

Discussion

Cheryl Hojnowski, Executive Director of the Biosphere Institute of the Bow Valley, moderated this last case study discussion. Attendees noted the exciting potential for community science projects to establish a global culture of scientific participation by sharing between projects and asked to what extent community science projects might share evaluating criteria and tools when they exist in distinct local contexts.

Johnson observed that some communities want to share their work while others want to develop tools highly tailored to their contexts. She and proposed that the solution might be to develop frameworks that are broad and flexible enough that they can be adapted too local circumstances. Kovaka agreed that the success of community science projects cannot be measure by whether or not they produce data similar to that a professional scientist would produce in their place—an assumption she noted is still prevalent in publications on community science. She and Vaca both voiced the need for evaluation standards that make sense to and matter to the community.

Prakash, meanwhile, argued that ideally, communities take complete ownership of their own projects, meaning that professional scientists should focus most on locating and supporting community leaders and less on promising narrowly defined projects or outcomes to funders. He advocated for flexibility in how professional scientist collaborators think about documentation style, professional publication venues, and networking, to allow communities to choose how to present their data and to leave them room to develop confidence as producers of scientific knowledge. Johnson added that sometimes, a network is the product of research, hoping that more funders will recognize this in future and support both networks among community groups and structures that enable those groups to propose projects to professional scientists in "bottom up" needs assessment.

Chiu wondered about the feasibility of running pilot studies to figure out where a community project could succeed. Johnson replied that while there is "no real shortcut on relationship building," logistical pilot programs can help to pave the way for larger projects and tend to appeal to traditional funders. Observations followed on the challenges of scaling up and sustaining community science studies, with Prakash exploring ideal visions of a world where every country would support cand sustain community science and public education. M. Weisberg closed the discussion by observing that long-haul projects often demand a two-pronged approach: identifying passionate local leaders while also locating a local park service, government agency, or school that can carry a project long-term, beyond the turnover of individuals.

Three Recommendations for Community Science (Panel 3)

1. **In a community science endeavor, all parties will have different criteria and methods for evaluating success.** If some measures must be shared externally, while others are most meaningful as internal assessments, establish transparency about what all stakeholders prioritize in order to develop suitable evaluation tools.

2. **Ownership of tools, data, technological know-how, and expertise in a research area empower communities to initiate meaningful projects.** To expand reach and enable truly local-driven initiatives, establish the authority of community members over core resources.

3. **To create a world in which all people contribute to science, community/community communication must surpass professional scientist/community communication.** Introduce groups with related concerns and needs to one another and develop simple tools and broad frameworks that each can adapt to their own purposes.

Final Discussion & Next Steps

The workshop's last event was a general discussion about "Next Steps" moderated by Mertz. This concluding section combines the ideas and suggestions made during that discussion with the common themes, questions, challenges, and solutions that emerged over the course of the workshop. The goal expressed in the workshop's title is to build a global network for community science. Here, this report summarizes common challenges and questions that emerged from the workshop's collective knowledge in the hope that they will provide a tool that presenters, attendees, and other community science projects can use in future.

Common Challenges and Questions

What materials should professional scientists provide to community participants?

Items mentioned over the course of the workshop include both the tangible and the emotional. They include string, pins, video cameras, microscopes, digital renderings, control over their data privacy, academic course credit, conversations on how data affects policy, opportunities for creativity, and local social recognition for demonstrating a community value.

What are our common languages?

This question addresses the difference between, say, Māori and English, but also the difference between how laypeople would describe a local problem and how professional scientists would describe it. Most projects will require a degree of translation, or a period dedicated to establishing a shared purpose for language and a shared understanding of key terms. Common languages must also be established with funders, governments, and local industries, meaning that community science projects must develop the capacity to communicate effectively in several specialized topic areas.

What are we assuming?

Residents local to a project site may assume they know what professional scientists know and care about, and what the result of their work will be. By the same token, professional scientists may assume they know what locals know and believe about the object of study, and about scientific work in general. Discovering and correcting these assumptions can improve communication and enable collaboration.

Who are the key players?

Many of the workshop's case studies highlight the different groups that must be taken into account when planning and executing community science: community members, local industries, educational institutions, governing bodies that both scientists and community members must answer to, and leaders and staff of community-based scientific organizations or projects. Each of these key groups may benefit or inhibit the project's development as they interact with one another.

What is the starting point for a community science initiative?

Many participants agreed that it is ideal when a community identifies a need and brings an inquiry or proposal to an organization that has the resources to research and address the need. However, before that can happen, a scientific organization or point person must establish trust and credibility and must make themselves known as a resource for making change. The starting point for truly community-driven science therefore often lies in the lengthy and subjective process of establishing human relationships.

In some cases, initiatives emerge from pro-environment cultural norms, while in other cases, communities' dominant concerns and values focus on areas other than the environment. This contrast emerged, for example, in the case studies from the Sanjiangyuan region of China, from Botswana, and from Ecuador. In closing the workshop, Webster asked how professional scientists can best foster environmental values where they exist and build their presence in places where these values do not tend to drive social and economic behaviors. The Foldscope project's ethos, meanwhile, suggests that curiosity about the natural world exists everywhere, and that communities tend to demonstrate care for their human and natural environments once they have the tools to do so.

"In less reflective citizen science projects, I see people saying, 'We will get the facts right, and then the policy will follow.' People who study policy processes know that's not how change happens. In social movement-based citizen science, the important piece is organizing. In those cases, the process of looking for knowledge becomes part of the process of changing law and policy. I wish the field would stop asking, 'How deeply are people involved?' and instead value the question, 'What model of change are we using to get our results that will cause change?' I want to do that kind of thinking with this group."

—Gwen Ottinger

Who is a member of the community?

Several case studies addressed the fact that some project leads are outsiders to the regions or objects they study, while others are familiar with the area and the study's focus from a lifetime of experience and community identity. When the project lead is an outsider, these case studies suggest that project longevity and commitment over time make a positive difference to collaborative efforts.

What is known? Who knows it?

Case studies brought up the problem of authority over knowledge and the fact that Western science continues to dismiss local, Indigenous, and oral knowledge in the tradition of its colonial and settler roots. When scientific institutions disqualify the authority of the speaker, they can greatly slow the transmission of knowledge. As a result, some community science projects do not fully focus on collecting new knowledge; they also continuously work to share established knowledge with governments and institutions that have more resources and can more effectively address the findings.

"The intergenerational health of the environment is more important than money."

—Brendan Flack

What incentives does community science require?

Especially where funding is scarce or unavailable, alternatives to financial compensation may encourage community volunteers to contribute time, work, and knowledge. These may include materials for doing the work efficiently, physical or social tokens of particular value within their community, companionship, opportunities to voice common convictions, and education in spiritual, emotional, and social aspects of human obligation to the natural world.

How do we assess success?

Speakers touched on numerous ways for measuring success, including wide distribution of tools and knowledge, changes in stakeholder values, habitat restoration, and establishing relationships that endure and enable future initiatives. The challenge of a "currency exchange" between these measures and the metrics of success that funders generally recognize (like publications and graphs) came up often. D. Weisberg described this as the need "to translate the value of our partnerships and work into the languages the funding institutions understand." Ottinger asked how community science can drive change in funding institutions—such as adding standards for engaged research and community-building to tenure requirements—in order to diminish the burden of value translation on individual community science projects.

How are community science projects funded?

While none of the case studies described their funding structures in detail, government, university, and private foundation grants were all mentioned as sources. Multiple attendees asked for more detail on this topic, marking funding as a target area for future conversations. To improve funding prospects, a global network of community science practitioners might succeed through strength in numbers—that is, each project could demonstrate its credibility to funders by association with a list of similar projects meeting similar needs.

How much can we generalize in our recommendations?

Discussions throughout the workshop looked for an effective balance of attention to abstract and widely applicable recommendations with attentive response to hyper-local needs. Attendees debated whether tools like a common licensing system for Indigenous knowledge provides the weight of consistency to multiple communities or risks leaving community needs only partially addressed. One place where standardization could work well, however, is in dealing not with communities, but with funding sources: a standardized set of community science evaluation tools developed by community science practitioners could teach funders how to respond to metrics like quality or length of collaborative relationship in addition to metrics like "number of people reached."

How can community science projects navigate institutional or governmental disapproval or disinterest?

Attendees praised the solidarity that scientists and communities have established in situations when their governments are in conflict or when universities or other authoritative institutions do not support research proposals. One recommendation that surfaced was to remain flexible: to change the location, the success measures, or the scope of a project until it can be done in some form, rather than abandoning it. Another recommendation was that community science practitioners work as a group to articulate why community science methods are key to solving the crises of our times, convening global themes to connect more effectively with individual governments and the UN.

What type of global network do we need?

Attendee Sarah Kirn (Gulf of Maine Research Institute) wrote: "There are a number of international associations supporting citizen science already in existence, with efforts in place to share evaluation strategies, approaches to co-creating projects, practices and supports for environmental justice efforts, etc. What are the unique needs of the international collaborative community that this meeting hopes to launch that are not met by existing groups?" Her question challenges this nascent network to consider what common purposes best define it and to consider the pros and cons of joining or adopting the models of existing citizen science associations. This question also relates to the following one, which asks to what extent citizen science and community science networks would overlap.

What should we call this work?

Terminology drives at defining collaborative science work as precisely as possible but can also be distracting, frustrating, and inconsistent. "Citizen science" may connote projects driven more by professional scientists than communities and, one attendee noted, may offend some communities. "Community science," on the other hand, may represent an ideal middle ground, propelled by activists or community members and by scientific authorities. "Civic science" points to broad engagement with science and evidence to help inform solutions to society's most pressing problems, by building new knowledge and collaborations across many sectors. Discussion produced no consensus on which term precisely fits which projects, but attendees did suggest that a more precise set of definitions could communicate the purpose of collaborative projects more fully.

Looking Ahead

The "Building a Global Network for Community Science" workshop proposed the following methods for achieving some of the attendees' common goals. These methods may serve as action points for community science or as discussion points for further network-building:

- Partnering with social movement activists to change law and policy;
- Increasing the legibility of community science methods to grantmaking institutions;
- Adjusting the parameters for successful outcomes to increase funding and sustainability;
- Transforming institutions that house professional scientists to support careers that prioritize community science;
- Collaborating among community science projects to identify common goals and to standardize assessment tools;
- Associating multiple international projects as a bloc so as to exercise more influence and troubleshoot future challenges;
- Improving collaboration with communities to ensure they are able to drive the direction of inquiry and control the products of their work.

Case Study Organizations

Learn More

10 Deserts Project, Australia
https://10deserts.org/
https://www.youtube.com/watch?v=3rkhORwE88s

Caribbean Natural Resources Institute (CANARI), Trinidad
https://canari.org/
https://bit.ly/CANARI_ICTsforlocalknowledge

Coaching Conservation, Botswana
https://www.coachingconservation.org/
https://youtu.be/ePUaylWNx_Y

ELOKA – Exchange for Local Observations and Knowledge of the Arctic
http://eloka-arctic.org/welcome

Foldscope, Global, Iraq, and India
https://www.foldscope.com/
https://microcosmos.foldscope.com/?tag=foldscope-iraq
https://indiabioscience.org/videos/foldscope-india

Galápagos Education and Research Alliance, Ecuador
https://plus.upenn.edu/galapagos/

He Pātaka Wai Ora Project, New Zealand
http://www.puketeraki.nz/Environment/He+Pataka+Wai+Ora+Project.html
https://vimeo.com/603535186

Shan Shui Conservation Center, China
http://en.shanshui.org/

Town Square Academia, Israel
https://english.telhai.ac.il/initiative/town-square-academia/
https://youtu.be/GuxQMxyVNM4

Presenter & Organizer Bios

Muhamed Abbas is one of the "super users" of Foldscope microscopes, engaging children in Iraq in science activities to spark their curiosity.

Gareth Catt has been working in desert land management for over 10 years. After spending time working with Northern Territory Parks and Wildlife in Central Australia, Gareth worked with Kanyirninpa Jukurrpa (KJ) for seven years. At KJ he worked on establishing the fire program and implementing broad scale burning across the desert with traditional owners and rangers. He maintained a strong focus on cultural and biodiversity conservation in this program. He has built up a strong network with fire management staff and stakeholders across the deserts, which has led to his current position as the 10 Deserts Project's Regional Fire Management Coordinator. He has considerable experienced in developing fire management strategies, prescribed burning programs and fire history mapping.

K.C. Cole is the author of eight non-fiction books, including the national best-seller The Universe and the Teacup: The Mathematics of Truth and Beauty. A long-time writer for the Los Angeles Times, her work has also appeared in Discover, Wired, The New Yorker, Quanta, The New York Times, The Smithsonian, The Columbia Journalism Review, Newsweek, Esquire, Ms., The Washington Post, Slate and many other publications. Professor emerita at USC's Annenberg School of Communication, she is currently scholar in residence at the University of Pennsylvania's Annenberg Public Policy Center. Cole frequently writes on the science of social issues, earning her an EMMA (Exceptional Merit in Media Award) from the National Women's Political Caucus. She has also won the American Institute of Physics science writing award, the Los Angeles Times award for Explanatory Journalism, the Edward R. Murrow Award for "thoughtful coverage of scientific controversies." She is an honorary member of Sigma Xi and a USC Remarkable Woman Faculty Member.

Brendan Flack is the Primary Investigator for an ongoing 'biodiversity stocktake project' on the Waikouaiti River. Led by the Runaka, this initiative is a collaboration with the University of Otago and focuses on identifying the areas of the river where mahinga kai has been most severely compromised by agriculture and other human based modifications over time. The results of the research will be used for restoration projects on and next to the river and will help the He Pātaka Wai Ora Project to make good decisions in how to go about enhancing native fish habitats for mahinga kai. Brendan also maintains the grounds, buildings, urupa, and reserves associated with the Runaka Office that oversees the He Pātaka Wai Ora Project.

Brendan is Kāi Tahu (Kai Te Ruahikihiki) and a Tangata Tiaki for Kāti Huirapa and Chair of the East Otago Taiāpure Committee. He works as a researcher on Te Tiaki Mahinga Kai and leads research within the East Otago Taiāpure as well as supporting the research team in the field when working in other areas. Brendan is leading the He Pataka Wai Ora Project, that monitors the health of the Waikouaiti River, has an important role in the development and testing of the Marine Cultural Health Index (MCHI) tool and is also involved in the Marine Metre squared programme as well as working for Kāti Huirapa Rūnaka ki Puketeraki.

Cheryl Hojnowski is Executive Director of the Biosphere Institute of the Bow Valley. Prior to joining the Biosphere Institute, Cheryl spent six years living and working in eastern Russia. She organized salmon conservation programs on the Kamchatka Peninsula, studied protected area management as a Fulbright Fellow, and worked for the Wildlife Conservation Society as a grant writer and project manager, collaborating with local communities to promote coexistence between people, Amur tigers, and Far Eastern leopards. Cheryl later completed her Ph.D. in Environmental Science, Policy, and Management at the University of California, Berkeley. Her dissertation research brought her to Kananaskis Country, where she studied how grizzly bears and other large mammals adjust their behavior in high recreation areas.

Noor Johnson is the co-PI of ELOKA (Exchange for Local Observations and Knowledge of the Arctic) and a cultural anthropologist whose research focuses on environmental knowledge production and governance in the Arctic. She holds a research scientist appointment at NSIDC at the University of Colorado Boulder. At ELOKA, Johnson's work focuses on data infrastructures and networks for community-based observing and monitoring. From 2015 to 2016, she was an inaugural Fulbright Arctic Initiative Scholar working on offshore and renewable energy.

Karen Kovaka is Associate Director for Community Science at the Galápagos Education and Research Alliance and Assistant Professor of Philosophy at Virginia Tech. Her research areas are philosophy of biology, philosophy of science, and environmental ethics and policy. In philosophy of biology, she is interested in the foundational concepts and processes of evolution, particularly debates about the concepts of inheritance and biological individuality. She also studies the interface between science, science policy, and public understanding of science, including how public opinion about environmental issues such as climate change may be sensitive to widespread misconceptions about the nature of science.

Lesley McNutt, originally from Canada, has a Master's in Development Anthropology from McGill University in Montreal. Her introduction to Africa was in the late 1980s working for World Wildlife Fund in Madagascar and exploring east and southern Africa in a kayak. Captivated, she returned in 1992 and met JW "Tico" McNutt in Botswana. They married in 1996. She and Tico have two boys who were raised in their remote research camp in the Okavango Delta, and Dog Camp remains the familial center of their ever-growing organization, which is now known as Wild Entrust (WE). Formerly the Botswana Predator Conservation Trust, WE is dedicated to the preservation of wildlife and wildlife spaces through research, education and applied conservation initiatives. Lesley's research has focused on human-wildlife conflict and the relationships between people and protected areas. In 2004, she spearheaded the creation of Coaching Conservation (CC) and continues to grow the initiative with a dedicated and amazing team.

Aaron Mertz is a biophysicist, science advocate, and founding Director of the Aspen Institute Science & Society Program, launched in 2019. Through research, outreach, and various convening formats, the Program endeavors to generate greater public appreciation for science as a vital tool to address global challenges and to foster a diverse scientific workforce whose contributions extend beyond the laboratory.

Previously, Dr. Mertz was a National Science Foundation Postdoctoral Research Fellow and Arnold O. Beckman Postdoctoral Fellow in the Laboratory of Mammalian Cell Biology & Development at Rockefeller University, where he researched mechanisms underlying epithelial tissue growth. His publications span biology, physics, engineering, and science policy and have appeared in Nature, Science, Cell, and Physical Review Letters.

Youssef Nassef has led the adaptation workstreams under the UNFCCC since their inception. He possesses over 30 years of experience in diplomacy and international environmental policy and is a seconded diplomat from the Egyptian Foreign Service.

While assuming progressively higher levels of leadership at the UNFCCC, he led UNFCCC support for several initiatives on adaptation. These include the inception and support for National Adaptation Programmes of Action and National Adaptation Plans; the Nairobi Work Programme—an international knowledge hub for impacts, vulnerability and adaptation; and the Warsaw International Mechanism for Loss and Damage. He recently created the Resilience Frontiers initiative which applies foresight for attaining post-2030 resilience.

He holds a PhD in International Technology Policy and Management and a MALD in International Environmental Policy from the Fletcher School of Law and Diplomacy, as well as a MA in Middle East Studies and a BSc in Computer Science and Physics from the American University in Cairo.

Gwen Ottinger, Associate Professor in the Department of Politics at Drexel University, became interested in science and technology studies (STS) as an undergraduate engineering student in Georgia. When her flight performance professor off-handedly mentioned fuel dumping, she immediately wanted to know: Dumping on whom? With what consequences? And who gets to decide whether that's okay?

As a graduate student in an interdisciplinary environmental studies program, Dr. Ottinger pursued questions about the human, political and environmental dimensions of science and technology. That led her to research at the intersection of STS and environmental justice studies, focusing on social inequality in the distribution of environmental hazards and decision-making power.

She came to Drexel in 2014 from the University of Washington-Bothell and teaches classes in Science and Technology Policy, Environmental Politics and Citizen Science. She also advises MS students in the Science, Technology, and Society and Environmental Policy Programs. Her research group, the Fair Tech Collective, welcomes students from all levels and backgrounds who are interested in mobilizing science and technology to empower environmental justice communities. They use an apprenticeship model: students learn by doing alongside more experienced researchers.

Mo Pandirajan is one of the "super users" of Foldscope microscopes and a community educator in India.

Jennifer Pinto-Martin, PhD, MPH, is the Executive Director for the Center for Public Health Initiatives at the University of Pennsylvania and oversees all education, research and action initiatives. She is also the Director of the recently funded Center for Autism and Developmental Disabilities Research and Epidemiology (CADDRE). The University of Pennsylvania Center is one of five such Centers funded by the national Centers for Disease Control and Prevention to work collaboratively to understand the causes of autism and the reasons for its recent increase in prevalence nationwide. The CADDRE is also engaged in research on early screening and identification of ASD, nursing care for families with children newly diagnosed with ASD, sleep disorders in children with ASD, and the psychological health of siblings of children with ASD.

Dr. Pinto-Martin served as the President of the Society for Pediatric Epidemiologic Research and is currently on the Editorial Board for the journal Pediatric and Perinatal Research. She served as a special consultant to the National Institutes of Health on their research initiative on autism during 2001. Dr. Pinto-Martin teaches undergraduate statistics with a focus on the real-world application of statistical knowledge. In addition, she teaches Introduction to the Principles and Methods of Epidemiology, a course that is very popular with researchers who want to learn about the techniques of epidemiologic research.

Manu Prakash is Professor of Bioengineering at Stanford University and is the creator of Foldscope. Foldscope was created with a vision to solve an accessibility problem in science. Foldscope was invented by Manu Prakash and Jim Cybulski while Jim was a PhD student in Manu's laboratory at Stanford University. Their inspiration for the Foldscope originated from field visits around the world, where they continually encountered bulky, broken microscopes, or a lack of microscopes entirely. As traditional microscopes are often expensive or cumbersome, they realized the universal scale of this problem and the need for a low-cost, revolutionary solution.

Candice Ramkissoon is currently a Technical Officer at the Caribbean Natural Resources Institute (CANARI), under their Resilience Programme, which focuses on Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR). She has a diverse science and technology background, offering approximately ten years' practical experience and expertise in DRR and Management, Environmental and Natural Resources Management, and Geographic Information Systems (GIS), collectively.

Candice is extensively involved in development and testing of participatory Information and Communication Technologies (ICTs) as innovative tools to enable capture, management and dissemination of local knowledge, and to facilitate effective input and participation by local communities and other stakeholders in the Caribbean in policy and action to address climate change.

Candice is a trained GIS specialist and P3DM (Participatory 3D Modeling) facilitator. She has been involved in executing several P3DM exercises in small island states in the Caribbean. These include the development of a participatory 3D model of Tobago in 2011 where P3DM was first piloted in the Caribbean, and the recent facilitation of a P3DM workshop in Montserrat in February 2018, for assessing vulnerability to climate change in the fisheries sector. Candice also has experience working with local communities and stakeholders to develop participatory videos to showcase their own stories, as well as technical expertise in development of newer and innovative GIS tools such as GIS story maps.

Ayelet Shavit is professor and head of the Philosophy program at Tel-Hai College in the Galilee region of Israel. She is the founder of Town Square Academia, a project aimed at making academic-level courses accessible to the public. Through dialogue between the community and members of the college, Town Square Academia aims to generate cultural renewal by tapping into the strengths and abilities that exist within the region. These partnerships have led to projects monitoring the local watershed and promoting exchange among individuals with different types of expertise.

Ernesto Vaca co-directs the Galápagos Education and Research Alliance as a Galápagos Naturalist Guide, Level III. Trained in ornithology and evolutionary biology, he has lived in the Galápagos for the last three decades and has over 30 years of experience guiding groups through this fragile ecosystem.

Hugh Webster, from the UK, completed his doctorate at the University of Sussex, studying African Wild Dogs with the Botswana Predator Conservation Trust (BPCT). He then began teaching Biology at a UK secondary school for 6 years, before returning to re-join BPCT to act as research coordinator at the project's field site in Botswana. In 2017, he assumed his current role, developing educational materials for Coaching Conservation. Hugh now oversees all of the research and development of our curricula, training content and new projects. Hugh is passionate about productive conservation activism and is the author of the acclaimed children's book, The Blue Hare.

Deena Weisberg is Assistant Professor in the Department of Psychological and Brain Sciences at Villanova University, where she directs the Scientific Thinking and Representation (STAR) Laboratory and co-directs the Galápagos Education and Research Alliance (GERA). She earned her PhD in Psychology from Yale University and received postdoctoral training at Rutgers University and at Temple University. Her research interests include scientific thinking and reasoning in children and adults, the development of imaginative cognition, and the roles that the imagination plays in learning. Her work has been published in a variety of scholarly journals, including Science and Cognition, and has received funding from the National Science Foundation and the Templeton Foundation.

Michael Weisberg is Professor and Chair of Philosophy, as well as Senior Faculty Fellow and Director of Post-Graduate Programs at Perry World House. He serves as Editor-in-Chief of Biology and Philosophy, is an advisor to the United Nations Framework Convention on Climate Change's Nairobi Work Programme, directs Penn's campus-wide transdisciplinary research in Galápagos, and co-directs the Galápagos Education and Research Alliance. He is the author of Simulation and Similarity: Using Models to Understand the World and Galápagos: Life in Motion, as well as a contributing author to the IPCC's 6th Assessment Report.

Much of Weisberg's research is focused on how highly idealized models and simulations can be used to understand complex systems. He also leads efforts to better understanding the interface between humans and wildlife, between humans and the climate system, and how scientific issues are understood by communities in the Americas and in East Asia. Weisberg received a BS in Chemistry and a BA in Philosophy from the University of California, San Diego, and a PhD in Philosophy from Stanford University.

Lu Zhi is a conservation biologist and an expert on biodiversity. She is a professor at Peking University in China and the Executive Director of the Peking University Center for Nature and Society.