PARTNERS IN SCIENCE

The people who should benefit from research are increasingly shaping how it is done.

BY CASSANDRA WILLYARD, MEGAN SCUDELLARI AND LINDA NORDLING

Valarie Blue Bird Jernigan knew she had to tweak some standard scientific practices when she started her latest research project. One of the first things to go was the usual concept of a control group — people who would not receive interventions to encourage healthy eating. That wouldn't be fair to the people of the Osage Nation, a Native American people in northeastern Oklahoma.

Another concept to ditch was the idea that she was studying a group at all. Jernigan, a public-health researcher, who is Native American herself, has treated the Osage people as equal partners from the first day of the project. It took two years and seemingly endless rounds of community discussions to get the study off the ground, but Jernigan wouldn't have had it any other way. This kind of research "isn't just about proving your hypothesis", she says. It's more about improving people's lives and, at the same time, helping them gain the skills to do science.

Jernigan's approach, often referred to as community-based participatory research, has been gaining traction for the past two decades. It has become particularly important for research that involves indigenous and other populations who have been mistreated by scientists in the past. The Havasupai tribe in Arizona, for example, waged a lengthy legal battle with Arizona State University in Phoenix over researchers' misuse of blood samples that the tribe had provided for a diabetes study in the 1990s. The samples were eventually returned as part of a settlement two decades later. The lessons learnt from the event have set the tone for how best to do research involving Native Americans.

Community participation has become the norm. "In minority communities, it's probably the primary research methodology," says public-health researcher Alexandra Adams, director of the Center for American Indian and Rural Health Equity at Montana State University in Bozeman. "It reduces mistrust, it improves dissemination and it improves cooperation." The goal of such efforts is the co-production of research, in which the stakeholders who are supposed to benefit from a strand of research become active partners in conducting it. Scientists from disciplines as varied as archaeology, public health and climate change have embraced the approach, working with community members on many different aspects, from formulating study questions and design, to doing experiments and analysing and reporting results.

Nature talked to three groups that have built successful co-produced projects. Their experiences reveal the challenges and rewards that come with the open and collaborative exchange of ideas. The work veers away from the standard outputs of science, such as talks and papers, and expands the idea of what it means to be a scientist and a collaborator.

GARTH CRIPPS

A PLACE AT THE TABLE

Jernigan's latest project with the Osage people wasn't wholly her idea. It started with Raymond Red Corn. As a child growing up in the Osage Nation, Red Corn helped his parents to harvest the dusky red ears of maize (corn) and process them into corn soup and hominy, a food made from soaking kernels in lye or wood ash until they go puffy. Taking the maize from seed to soup is something the Osage have done for centuries. But that tradition has nearly disappeared. "I couldn't hardly find anyone younger than me that had ever done it, even in the most traditional families," he says.

Four years ago, Red Corn was elected assistant chief of the Osage Nation. Right away, he started looking for a spot to plant traditional maize and other crops. Fresh fruit and vegetables are hard to come by in Osage County. Since the 1970s, the Osage people have increasingly relied on canned and processed foods that are high in salt, fat and sugar.

Red Corn wants to see the community take

Researchers excavate an ancient cattle pen for the Morombe Archaeological Project.

"YOU NEVER ASK SOMETHING OF SOMEONE WITHOUT GIVING THEM SOMETHING BACK."

back control of its food supply. By restoring their connection to the land and its lost food traditions, he thinks, they just might be able to rewind to a healthier lifestyle. The efforts might even help to tackle the high rates of obesity and diabetes in Native Americans in the area. In the Osage Nation, "everything we do revolves around food", Red Corn says. "You can't heal the community unless you heal the food system."

Red Corn and other tribal leaders hoped that providing locally grown fresh foods would yield obvious health benefits, but they weren't equipped to measure those benefits themselves. So, they reached out to Jernigan at the University of Oklahoma Health Sciences Center, who is a member of the Choctaw Nation. Jernigan has spent the bulk of her career testing strategies to improve the food environment on reservations as a way to enhance health. She has another project with two other Native American communities in Oklahoma to get healthier foods into their convenience stores.

Research on marginalized groups can be fraught, and working with tribal communities is especially complicated. A history of research abuses has left many Native Americans mistrustful of the scientific enterprise. In the past, investigators have used tribal members as unwitting participants in unethical and dangerous experiments. And, as in the Havasupai case, scientists have at times withheld information from the communities they have studied and largely ignored tribal concerns.

When Native Americans think of health studies, they often think of "helicopter researchers", Jernigan says — scientists who fly in, collect data and blood samples, and then leave. "And they never see one benefit." What's more, working with indigenous communities means dealing with sovereign governments, some of which have their own institutional review boards. "You have to go through all these extra layers of protections," Jernigan says. These days, collaboration and co-production aren't just ethical, they are mandatory. "There's almost no other way of doing it," she says.

As a first step, Jernigan proposed launching a pilot study to work out what the community actually wanted. The team surveyed everyone from community members to leadership, and found that people seemed most interested in the idea of community gardening. They wanted to use locally grown crops to help supply some of the tribally run programmes for children and older people.

But boosting the supply of fresh fruit and vegetables is only half the battle; people also wanted to increase the desire for healthy foods. So Jernigan worked with the Osage to design a community programme aimed at getting young children and their families to eat more fruit and vegetables. The trial, called Food Resource Equity and Sustainability for Health, or FRESH, launched in January. The team came up with new, healthier menus for a programme that provides care for children aged 3–5 from low-income backgrounds. The researchers also provided the schools with demonstration gardens. Each week, the teachers spend 90 minutes telling stories about food, working with the children in the garden, and conducting a simple cooking lesson. On Fridays, the children take home a healthy meal kit to prepare with their families. Meanwhile, their parents take part in a 15-week online workshop.

The cultural elements are important. Parents are encouraged to attend a monthly family night, where they talk about foods they remember eating when they were young, what they eat now, where it comes from and why they choose certain foods. Jernigan's team has given video cameras to families to record their own food stories. "There's a lot of realization about ▶

▶ the connections between language, identity and indigeneity," she says. "Those are the kinds of things that typical health-science interventions don't address." And "those are the kinds of things that offer really our best hope for health".

The FRESH study will look at whether the interventions actually increase children's consumption of fruit and vegetables, and their willingness to try them. The researchers will also look at health measures, such as body mass index and blood pressure, in the families.

Collaborative research isn't always easy. Jernigan often has to strike a balance between scientific best practice and the community's needs and desires. For example, the ideal way to test an intervention is often through a randomized trial. But with FRESH, the researchers couldn't use a true control group. It wouldn't be ethical to deny some of the participants the resources that the study provides. Instead, the team adopted a 'wait-list control' design. In the first phase of the project, two communities receive the intervention and two serve as the controls. When the 15-week intervention is complete, the control communities join the experimental arm. "That was a way to have a control group, but then to be able to tell the community that everybody gets the intervention," Jernigan says.

Despite the challenges, Jernigan has no regrets. "I had seen traditional research in my training, and to me that seemed so myopic," she says. And she was never interested in generating knowledge for its own sake. In traditional Native American culture, "you never ask something of someone without giving them something back".

VALUE IN THE PAST

Kristina Douglass remembers sitting around a fire after dinner in Madagascar, listening to the conversations of women who spent their lives gathering shellfish among the sand and rocks of the Velondriake Marine Protected Area, a network of 25 fishing communities along the country's southwest coast. The women were discussing a new variety of bivalve shellfish they had identified. "I couldn't see the difference, but they insisted," recalls Douglass, an archaeologist at Pennsylvania State University in University Park, who has been studying the fossilized remains of shellfish and other animals found in early human settlements in the area. Their conviction and their experience with the organisms suggest to her that they are probably correct.

Douglass directs the Morombe Archaeological Project (MAP), which is reconstructing the impact of human settlement on the Velondriake area, a biodiversity hotspot where pygmy hippopotamuses and giant tortoises once roamed. Since 2012, the project team has been conducting drone-assisted surveys, excavating fossils and preserving DNA. Team members have also been recording the oral histories of local elders, to explore the migration of clans in the area and preserve their histories.

Douglass is the only person on the team with a PhD. The others are members of the region's five ancestral clans, and hail from three local communities: Vezo fishers, Masikoro farmers and herders, and Mikea foragers. Few have completed secondary school, and many cannot read or write. Yet Douglass considers them the experts, "and great field researchers", she says.

Raymond Red Corn (centre) of the Osage Nation studies the impact of food sovereignty on his community.

RED CORN: NICK OXFORD FOR *NATURE*; MADAGASCAR: GARTH CRIPPS

Including locals in research was a priority for Douglass, even before MAP started. "I came to archaeology with a vivid sense of the absurdity," she says. Relatively large sums of money, resources and time were going into studying people of the past while their descendants gained little from the findings. If the research didn't have relevance for people living today, there wasn't a point, she decided.

A region's citizens can and should have a choice about how their area is represented and what research is valuable to them, says Eréndira Quintana Morales, an archaeologist at Rice University in Houston, Texas, and a collaborator with Douglass. In June she visited Andavadoaka, the fishing community where MAP is based, to teach a workshop on preparing and cataloguing the bones from contemporary fish to create a local reference collection. The intensive, co-production research effort exemplified by MAP also makes for better science, she says. "We go in with our own biases when we're not open to learning from community members."

The Velondriake women, for example, have local ways of describing taxonomic relationships between animals, such as referring to shellfish from different families as male and female versions of one another. Prompted by that knowledge, MAP now includes a project exploring how the classification system affects

A local historian in Madagascar describes live drone footage of an archaeological site.

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the ways in which locals choose to harvest species or leave them alone.

Leading the daily operations for many of the MAP projects is George 'Bic' Manahira, one of Douglass's first full-time team members. Manahira, who is from Morombe and speaks five languages, began participating in MAP as a volunteer in 2012. He joined the staff a year later as the field manager. "I was curious how they do stuff," says Manahira. "And I wanted to know my story."

Thanks to the team's efforts, that story is now being told. In a paper published this year, Douglass and the MAP team collected and analysed animal fossils from coastline rock shelters in the area (K. Douglass *et al. Quat. Int.* **471**, 111–131; 2018). From roughly 1,400 years ago to the start of the twentieth century, settlers in the region harvested only certain marine species while leaving others untouched, and the team found no evidence linking humans to the extinction of many large fauna, such as the giant tortoise. The finding challenges the assumption that rural communities are blanket consumers of the resources around them, which has implications for contemporary conservation efforts.

With the MAP team, Douglass asks members to participate in almost every aspect of research: experimental design, fieldwork, sorting and analysing material, interpretation and presentation. "Everybody has to go through every different activity to get a full understanding of how we do it and why," says Douglass.

Yet there's one area in which team members have yet to be involved: co-authorship and publication. Manahira, for example, has never had his name on a paper, although he would like to. Douglass has published four papers based on the project; although several acknowledge team members and their unique experience, they do not list them as co-authors.

"It can be a bit of a minefield," says Sarah Buckley of the Sea-Fisheries Protection Authority in Ireland. She leads a species-management project with fishers along the coast of Kenya, and has listed non-scientists on papers. "There are certain people that I would like to make an author, but, according to criteria for a journal, I shouldn't put them on."

Douglass is planning several papers for the coming year in which she hopes to include the whole team as co-authors. "For me, it's the next step in building this collaboration." But it isn't easy. Team members do not have regular Internet access, and Douglass lacks the funds to fly them to Pennsylvania to work in person. And such funds would be hard to obtain. Funders have already baulked at her level of spending in Madagascar, with grant reviewers commenting that Douglass's project budget for paying locals — about US$200 per month, a living wage in the area — was unreasonably high.

Co-production research remains peripheral in archaeology, says Douglass. For the field to wholly embrace it, archaeologists will have to start questioning how they run their projects, she says. "There's such a long and entrenched history of practising archaeology in a way that enforces certain power dynamics," says Douglass. "It would make a lot of people uncomfortable to have to sit down and think about how you really collaborate."

Plus, it takes time and effort, says Buckley. "It's not just a science project. You need to approach people at their level and go back again and again and again."

TEACHABLE MOMENTS

By September 2016, the residents of Zambia's capital city, Lusaka, were getting desperate. The city of around 2 million people was withering in a drought. Maize harvests had dropped by about 20% from the year before, driving up food costs. And reduced water flow through the country's main hydroelectric dam had triggered rolling blackouts in the region.

That month, Lusaka held its first 'learning lab', a gathering of city planners, policymakers and climate scientists intended to improve climate-related decision-making in the country. As the meeting got under way, people were looking to the researchers for answers. Chief among their concerns: when was it going to rain again?

But the scientists were not there to give answers. They were there to listen as part of the Future Resilience for African Cities and Lands (FRACTAL) programme, a co-production effort designed to improve the alignment of research and policymaking in nine southern African cities. ▶

Maputo in Mozambique is participating in the climate-resilience research project, FRACTAL.

JAMES OATWAY/PANOS

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Sub-Saharan Africa's urban population is projected to double in the next 25 years. And climate change is expected to hit the continent particularly hard. But although most African governments are aware of climate change, many efforts to inject climate science into city planning have had limited success. Partly, that is because many initiatives assume that the main reason why cities fail to make their development plans climate-proof is a lack of knowledge. If they could just get more accurate information, they could better prepare for what lies ahead. But solving climate-related challenges in developing countries requires more than just climate predictions, says Chris Jack, a climate modeller at the University of Cape Town in South Africa and one of the programme's lead scientists. "The focus on providing information has distracted from the need to co-produce solutions," he says.

FRACTAL tries to address this by setting out to understand what cities actually need — and then working with city planners and local scientists to co-produce the missing knowledge.

The learning labs are one of the main ways in which the project explores this shared knowledge. FRACTAL hosts the labs in each city every six months, and has produced a list of burning issues that residents of each area are most concerned about. In Lusaka, these include flooding and the unregulated use of groundwater, as well as poor sanitation and erratic water supplies. FRACTAL also studies how decisions are made in the cities. This doesn't happen in the way that most scientists think, says Jack. "We imagine that you bring the data together, you integrate it and you make a decision. In reality, it's much messier than that."

One major realization, he says, was that decisions that influence cities' climate resilience often fall outside the remit of local legislators. Investments in large infrastructure projects in Africa, such as power stations and water pipelines, are sometimes made by development banks and global agencies, meaning that city authorities have limited involvement.

So FRACTAL stakeholders have produced climate-risk narratives for each of the cities, based on different climate-change scenarios described by international models. Many of these deliver different, and sometimes contradictory, predictions. The Lusaka scenarios all involve a warmer city, but the rainfall varies: in one scenario it is drier than now; in another, the rainfall is unchanged; and in a third, there is greater variability in rainfall, with prolonged periods of drought and heavier downpours.

Each scenario describes what will happen to important variables such as water supplies, flooding and sanitation. They are particularly useful in helping stakeholders to visualize the futures they need to prepare for, says Mununga Mungalu, a senior engineer at Lusaka Water and Sewerage. He says that the narratives have helped to guide his company's corporate plans and disaster preparedness. "It has changed the culture," he says.

And the FRACTAL programme has helped people around the region to share knowledge and experience, Mungalu adds. "Most of our institutions plan in silos, and FRACTAL has let us have a voice across these institutions."

Everyone is on a learning journey, says socio-economic planner Brenda Mwalukanga, FRACTAL's embedded researcher in Lusaka. All involved accept that they have something to learn from each other, and things are changing, she says. "I have seen scientists engage more with civil society about city governance, and non-science stakeholders request training in climate science."

The difficulty, then, lies in finding ways to capture and communicate the knowledge being produced by the project. There are different outcomes in each city, involving various groups of stakeholders. "The end product of co-production done well is almost in the intangible," says Jack. "It's in the fact that you have connected people and started those discussions." ■

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