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editor's note

Cover art **Norzin Norbhu**

We are thrilled to bring you a new issue of *Current Conservation*.

From the mountains and steppes of Central Asia, where over half of all known species of wild tulips are found, to grey wolves in the US and the secret lives of endangered Asiatic wild dogs amidst human-dominated landscapes in India, this issue showcases a wide geographic spread of species and conservation issues.

While most of the media attention is on elephant and rhino poaching in southern Africa, the poaching of succulents is a lucrative yet illegal industry that's growing at an alarming rate. Within this larger context, read an endearing field note about Helen Burton's search for Cape grey mongoose scat, which led to her stumbling upon a rare succulent species in Namibia. Then, zoom out with Jared Margulies and Frankie Moorman to examine the role of illegal trade within the cactus and succulent collector community, highlighting missed opportunities for conservation.

Through Thomas Daum and colleagues' feature article, learn how food production and biodiversity conservation are inextricably linked and why 'biodiversity-smart agriculture'— which is biodiversity-friendly and requires little labour, while also providing high yields—is the need of the hour.

A wealth of ecological knowledge is often encoded in regional names for species. In the cover story of this issue, Manya Kotera and Andrea D. Phillott discuss the information that can be gained from understanding local names and consider the implications of the compounded loss of linguistic diversity along with biodiversity.

— Devathi Parashuram

Author **Helen Burton** | Illustrator **Upasana Chadha**

At first glance you'd think we were auditioning as extras for a zombie film, the way we were shuffling around, hunched over, staring at our feet. I will even admit to the occasional groan, as my back arched uncomfortably and the hot sun beat down on my neck. But we were not looking for succulent brains, rather for tiny succulent plants, almost invisible against the stony ground.

I was studying the diet of the Cape grey mongoose at a conservancy in southern Namibia, when a team of botanists from the National Botanical Research Unit of the Ministry of Environment, Forestry and Tourism arrived. Dr. Sonja Loots and her team were in the area to look for and count lithops, or living stones as they are sometimes known. True to their name, these small succulent plants look remarkably like stones, and finding them against the quartz-strewn outcrops they inhabit is a challenge. I had spent the last two months staring across the arid and seemingly barren landscape looking for isolated mongoose scats, so when they asked for help, I was more than happy to have a change of focus!

This region of southern Namibia is subject to extreme fluctuations in temperatures as well as low, unpredictable rainfall. Yet, its location at the intersection of three biomes—the Succulent Karoo, Nama Karoo, and Namib Desert—means that the area is incredibly biodiverse and home to many unique succulents.

These fleshy plants are well adapted to the arid landscape, with extensive shallow root systems that can quickly absorb the infrequent rain, and waxy leaves that can resist desiccation in the dry desert air. Many species are highly restricted in geographic range, with populations often found exclusively in areas measuring just metres across.

This was our first stumbling block. The core area of this conservancy is 50,000 hectares! Despite identifying several potential quartz grounds, it took over a day before we found a hill, or koppie, with a good density of the target species. On our second afternoon of preliminary searches, I found a delicate little plant, like a patch of feathers coming up out of the ground. Even my definitely-not-a-plant-expert eyes could tell it was not the lithops they were looking for, but equally it wasn't anything we had previously seen. I called Sonja over, who after looking at it wondrously, said it was one of the rarer species of *Avonia*, and despite being barely 6 cm in diameter, this individual could be up to 85 years old and, thus, would be considered a collector's item.

A growing threat in a vulnerable habitat

This was why we were out here in the hot desert sun. Elephant and rhino poaching get all the media attention, but succulent poaching in Southern Africa is a huge and growing problem. The popularity of these plants with collectors combined with the difficulty of propagating them outside of their preferred habitats, means that the poaching and illegal trade of the larger specimens and rarer species from the wild is big business. The scale of the problem is growing. In 2019, 15,000 specimens of a single *Conophytum* species were confiscated from poachers in South Africa. A large haul can have a street value of thousands of dollars. The plants themselves often do not survive translocation, and even if recovered, it is almost impossible to replant them without knowing exactly where they came from. For species restricted to such small areas, poachers can easily wipe out a population in just one day.

One of the major issues for these plants in Namibia is that very little is known about where they are found. This survey effort was part of a big push to get location data so that more areas can be protected. Only five percent of Nama Karoo in Namibia is in state protected reserves, with another 17 percent under some form of conservation management, making it the least protected biome in the country.

As we painstakingly searched each 'pie slice' of the circular survey area, we counted dozens of *Conophytum* and *Avonia* species, often clustered together in the less densely vegetated areas or sometimes snuggled against a larger piece of quartz. This area is currently under the conservancy's protection, in addition to being difficult to access, which means that these populations are likely safe for now.

Historically, the greatest threat in this region has been overgrazing, with high stocking densities leading to land degradation and scrub encroachment. Up on the quartz koppies, where other vegetation is sparse, these succulents have escaped the worst of the damage. I pause to consider the life of my tiny plant—85 years of drought and intermittent desert rain, growing slowly in this one spot in the middle of nowhere, surviving while all around it sheep and goats overgraze the arid grasslands until little more than dust remains.

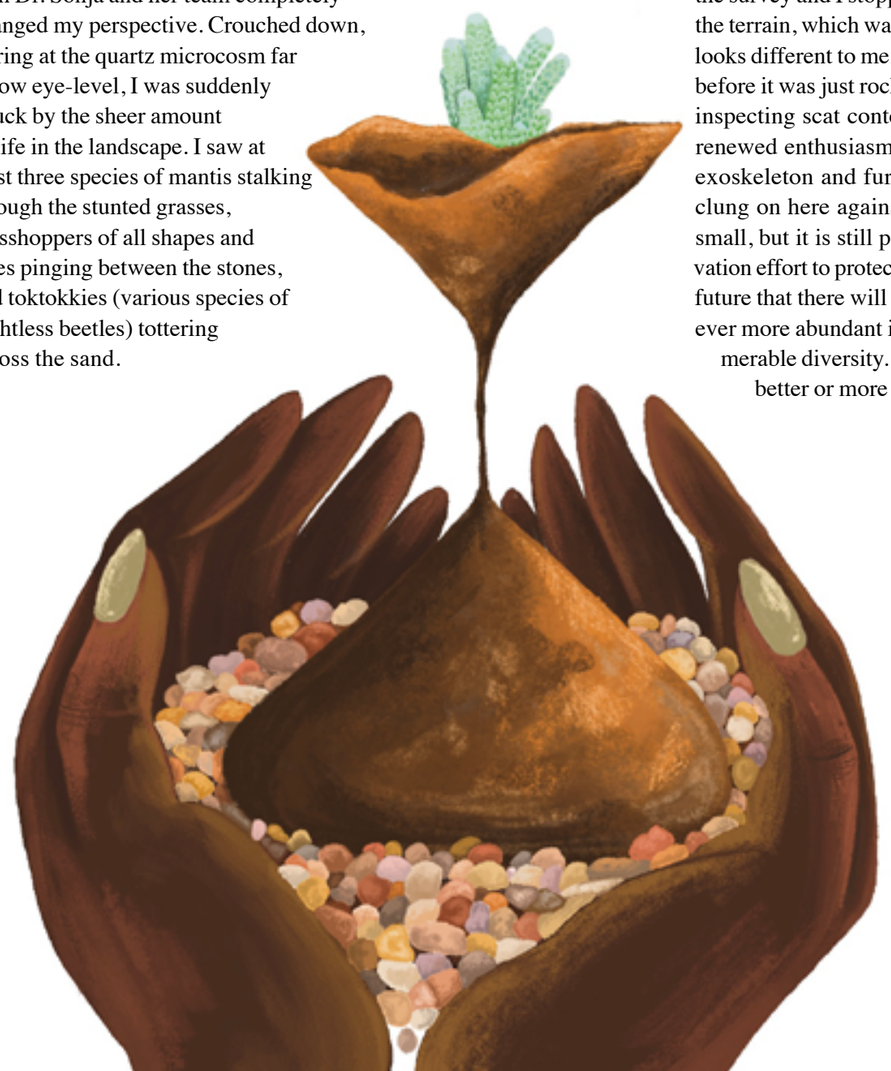
Between the bare rocky ground and lack of charismatic megafauna that attract tourists and make other African biomes so famous, you'd be forgiven for thinking the Nama Karoo was an empty, desolate place. However, that wasn't always the case. In the past, this area was home to some of the largest springbok herds ever known, as they migrated from the summer rainfall regions of southwest Namibia to the winter rainfall regions on the South African coast. This phenomenon, known as the 'trekbokken', saw millions of springbok in enormous migratory herds that took days to pass by. Now those herds are small and scattered, and the land is divided up by fences enclosing farms with sheep, goats, and cattle. After years of drought in the area, many of those farms have since been abandoned, leaving behind an ecological vacuum.

New ways of seeing

There are large animals, such as oryx and brown hyenas, in the conservancy, but they are shy, and sightings are few and far between. The largest species I had seen was the klipspringer, a small antelope. To be more precise, I saw the backsides of a group of klipspringers as they ran away from me! I had also spotted my study species, the Cape grey mongoose—which is very common and found almost everywhere in Southern Africa—only once.

Lacking the budget for a car, my mongoose project had been confined to a 10 km radius around the farmhouse. If I was really honest, things had started to feel 'samey' after two months. I walked the same transects each week, saw the same rubble-strewn mountains, the same common birds, rodents, and invertebrates. I do love these small things but, lacking the 'wow factor', perhaps it was the sort of dutiful love that you tend to take for granted. Sifting through endless grasshopper and beetle legs and drifts of four-striped mouse fur in mongoose scats, I felt like I wasn't finding anything worthwhile, and began to question the value of my work.

However, the time I spent looking for lithops with Dr. Sonja and her team completely changed my perspective. Crouched down, staring at the quartz microcosm far below eye-level, I was suddenly struck by the sheer amount of life in the landscape. I saw at least three species of mantis stalking through the stunted grasses, grasshoppers of all shapes and sizes pinging between the stones, and toktokkies (various species of flightless beetles) tottering across the sand.



The creatures I saw living in this miniature ecoscape were the same things I had been routinely finding in my mongoose scats. They are present in suchnumbers thanks to the resilience of the tiny, specialist plants that underpin this habitat. They have managed to survive despite the numerous threats, thus preserving the diversity of this unique ecosystem. It will take time, but with the surrounding vegetation protected and allowed to recover, the invertebrates will creep back, followed by the birds and the small mammals, the larger herbivores, and the carnivores, until this whole corner of the Nama Karoo thrums with life again.

As the final afternoon drew to a close, we finished off the survey and I stopped to take in the subtle beauty of the terrain, which was glowing in the afternoon sun. It looks different to me now—a living landscape, where before it was just rocks. The following day, I resumed inspecting scat contents under the microscope with renewed enthusiasm, joyfully taking the remains of exoskeleton and fur as more evidence that life has clung on here against the odds. My project may be small, but it is still part of the vast and varied conservation effort to protect this unique habitat. I hope in the future that there will be more mongooses here, eating ever more abundant invertebrates and rodents of innumerable diversity. Bigger doesn't necessarily mean better or more valuable for conservation.

Further Reading

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Helen Burton *is a conservationist and wildlife photographer. She is just returned from a research trip in Namibia looking at whether mongoose diet can be used to monitor habitat recovery.*

Upasana Chadha *is an illustrator and visual artist who loves creating for the fantastical world of children's books. She enjoys translating the world around her in her sketchbook.*

Sleuths on a dog hunt

Author & Photographer **Sabiya Sheikh**

Asiatic wild dogs (dholes) are group-living carnivores found in the forests of South and Southeast Asia. They are generally shy, elusive, and very sensitive to human disturbance. But in the Valparai plateau of India's Western Ghats, they live alongside people in human-modified habitats such as tea and coffee plantations. How do dholes live in such areas? Are they not scared of humans? Have they changed their behaviours and habits to adapt? In a quest to answer these and many other questions, I travelled to Valparai earlier this year to understand the secret lives of dholes in this unique landscape.

Within a week of my arrival in Valparai, I had seen a lot of wild animals including Nilgiri langurs, lion-tailed macaques, gaurs and even elephants living alongside people in tea and coffee plantations. I found myself constantly amazed at the incredible adaptability of these large animals that were living in 'human spaces'. I started interacting and engaging with the local residents who lived or worked within tea and coffee estates, almost incessantly enquiring about their last dhole sighting or their knowledge about the dholes' movements and whereabouts.

The contrasting accounts left me rather surprised. One person reported seeing dholes 13-14 times in a year, while their neighbour had never seen a dhole in the 10 years they had lived in that area. People's accounts of dhole sightings and their enthusiasm in sharing information about the species was heartening. Most were amazed at how well co-ordinated a dhole pack was and how well they communicated with each other to bring down large prey such as sambar deer.

Often overshadowed by other charismatic species they co-occur with, dholes have largely been overlooked in terms of research and conservation. This was also evident in my conversations with the people of Valparai. At the end of each conversation, they would almost invariably ask me if I also wanted information about leopards or elephants. When I told them that I was only looking for information on dholes, I would get puzzled looks; they would even ask, "Why do you want information on dholes when there are so many leopards and elephants here?" Some would admit that they have only ever had researchers ask them about leopards and elephants, but this is the first time someone is asking them about wild dogs.

Dholes are listed as 'Endangered' by the IUCN and their populations have experienced significant declines across their range. Their largest population occurs in India, and so far, most research on dholes here has focused on populations inside protected areas.

Based on the information I gathered from the local residents, I started looking for signs of dhole movement (scat and tracks) in areas where they frequented. Initially my instincts told me to look for signs in locations closer to forest fragments because there was no way that dholes would venture too close to places where humans lived or worked. Subsequently, I started combing the plantations—tea bushes, swampy areas with small streams adjacent to forest fragments and grounds that had been cleared for annual football tournaments.

I found dhole scats in all these locations, as well as along the roads of tea estates that were heavily used by plantation workers. Despite having heard of high dhole activity in these areas, I was still very surprised at what I was seeing. Apart from dhole scats, I also found signs of leopards, sloth bears, elephants, and gaurs on these same paths. The people in Valparai were sharing space with big carnivores and mega-herbivores on a daily basis.

It had been almost three weeks since I had arrived in Valparai. I had seen a lot of dhole signs all over the landscape, but the dholes themselves continued to elude me. I connected with local naturalists who took me to more locations where they had frequent dhole sightings. Again, I found an abundance of indirect signs but no dholes.

One morning in the last week of January, we were in the eastern part of the plateau where the dholes had killed a sambar around two weeks earlier. As I meticulously inspected the skull of the sambar, I felt a bit restive, wondering if I would see any dholes in Valparai at all. At that very moment, my field associate received a phone call about a sighting of a pack feeding on an ungulate inside a dam around 20km away. It would take us 40 minutes to get there, and the dholes would have probably finished their meal and moved on by then. But that was a risk we were willing to take; we were desperate.

As expected, yet to our disappointment, we missed seeing the dholes by the time we reached. Upon inspecting the kill site, we found the damp soil covered in fresh tracks of several dholes and a sambar. We suspected that there had been a chase before the hunt in that location. As we followed the tracks, our suspicions were confirmed when we found the extremely well-camouflaged carcass of the sambar that the dholes had been feeding on. Luckily, there was some meat still left on the carcass, which meant that the pack would likely come back to finish it off.

Dholes are diurnal animals, with peak activity at crepuscular hours (i.e., dawn and dusk). It was presently getting hot with the sun looming high, roasting up the open, dry reservoir bed. We decided to return to the site at around 4pm. Later that day, stationed on an elevated path that overlooked the dam, we eagerly waited. An hour passed and the sun started to set. The air around us cooled down but there was no sign of the pack. Minutes later, I felt a tap on my shoulder and my field associate excitedly pointed at the path below. A single dhole went trotting towards the sambar kill. Within seconds, seven more dholes followed. We watched in fascination for 20 minutes, as they tore into every last bit of meat from the carcass. Once they finished their meal, they headed back to the tea bushes where they had emerged from. And with that, I had seen my first ever dhole pack in Valparai.

A mere five minutes after the dholes had disappeared, a tea estate worker walked down the same path, completely unaware that they were treading the same path that a pack of carnivores did, just moments ago. Agroforests like coffee and tea plantations have been predicted to play an important role in maintaining connectivity between source populations of dholes in the protected areas of the Western Ghats. In Valparai, these habitats are doing more than just maintaining connectivity; they are providing space for dholes to live, hunt, rest and reproduce. The sighting left me feeling excited about finding out the myriad ways in which wild dogs are adapting and cohabiting the landscape with the wonderful people of Valparai.

This project is part of Wildlife Conservation Society-India and The Dhole Project's efforts to conserve dhole populations in India.

Sabiya Shiekh *is a wildlife biologist at Wildlife Conservation Society-India. She is studying the behavioural ecology of dholes in a human-dominated landscape in the Western Ghats.*

Addressing agricultural labour issues is key to biodiversity-smart farming

Authors **Thomas Daum, Frédéric Baudron, Regina Birner, Matin Qaim & Ingo Grass**
Illustrator **Swati Addanki**

Once an integral part of her daily routine, it now has been weeks since she last wielded her hoe. "Things have changed since I hired a tractor and a neighbour sprays my fields with herbicides," says Precious Banda, a farmer in Zambia. "Farming used to break my back, taking hundreds of hours, but life is easy now," she adds. But she has also noticed changes around her farm. Most concerning for her: it has become difficult to find wild caterpillars and Bondwe (Amaranth leaves), which used to make her a delightful dish. Precious Banda's story illustrates the situation of millions of farmers in the Global South.

Agricultural development is a top priority in much of the Global South. In Africa, for example, governments have ambitious goals for agricultural growth as part of the Comprehensive African Agricultural Development Programme (CAADP), with the aim to reduce poverty and hunger, which particularly affects farmers. But while agricultural development is necessary for improving livelihoods, it often clashes with biodiversity, which is rapidly declining worldwide. The Living Planet Index, representing over 20,000 populations of 4,392 species, shows an average decline in population size of 68 percent between 1970 and 2016. Scientists talk about a sixth mass extinction.

Losing the world's remaining biodiversity could have dramatic effects on food security as it undermines ecosystem services such as pollination, soil formation, nutrient cycling, climate regulation, maintenance of water supplies, and pest and disease control. Biodiversity loss can also undermine farmers' access to wild meat, honey, vegetables, fruits, tubers and nuts. In the case of Precious Banda, it is the loss of wild caterpillars and Bondwe that make her dishes less nutritious.

Agriculture affects biodiversity through both land expansion and intensification

Agriculture affects biodiversity via two pathways: agricultural land expansion and intensification. In Africa, 75 percent of agricultural growth comes from the conversion of forests and savannahs into farmland, as a study in *Science* showed in 2021. Similar trends have been observed in other regions of the world. The loss and fragmentation of habitats threaten species that rely on large contiguous habitats for survival.

Intensification allows growing more food on existing land, sparing land for "wild" nature. As part of the Green Revolution, India tripled cereal production since the 1960s, while increasing farmland area by only six percent. In Africa, farmers still achieve only around 25 percent of their yield potential, according to a study by Wageningen University. However, intensification is often associated with greater use of agrochemicals such as pesticides and landscape simplification to ease the use of machinery.

The need to reconcile agriculture and biodiversity is gradually more recognised by researchers, policymakers, and farmers, among others. However, discussions on biodiversity-friendly agriculture focus mainly on conservation objectives and—to some degree—on reducing trade-offs with land productivity, which is important as low yields undermine land sparing. In contrast, the role of agricultural labour is often neglected. In a new paper in *Biological Conservation*, we argue that this is problematic given the heavy toil of agriculture for the world's 550 million family farms, as exemplified by the story of Precious Banda. Ultimately, neglecting labour needs is not only bad for livelihoods but may also undermine the success of biodiversity conservation efforts. We, therefore, call for biodiversity-smart agriculture, which reconciles biodiversity conservation with not only land productivity but also labour needs.

Farmers strive to reduce the heavy burden of agriculture

Addressing agricultural labour issues is key to achieving the Sustainable Development Goals. Raising agricultural labour productivity can help to increase farmers' income, thereby reducing poverty. Moreover, manual agriculture is burdensome. Cultivating one hectare of maize takes smallholder farmers close to 1200 hours, much of which is spent working with simple hand hoes in extreme heat and humidity (climate change will make this even worse).

"I can still feel it," says Precious Banda as she recalls her farming experiences without tractors and herbicides. "I often felt bad but could not have done it without my children, sometimes they could not go to school," she adds. The International Labour Organisation of the United Nations estimates that 70 percent of all child labour is in agriculture, affecting 112 million children. Furthermore, despite the prevailing notion of labour being abundant in the Global South, agricultural labour shortages have become increasingly common in many regions due to ageing, outmigration and structural transformation.

For many farmers, labour-saving technologies such as mechanisation and herbicides are therefore very appealing. In Zambia, farmers like Precious Banda, using tractors for land preparation need only 10 hours per ha—as compared to 226 for non-mechanised farmers, as a recent study in *Food Policy* has shown. In Mali, a study by Steven Haggblade and co-authors from Michigan State University shows that herbicides reduce weeding workloads by up to 90 percent. In Burkina Faso, William Moseley from Macalester College and Eliza Pessereau from the University of Wisconsin-Madison found that herbicides are often referred to as "mothers' little helpers". It is not surprising that the adoption of such technologies has accelerated rapidly across the Global South. Steven Haggblade and co-authors speak about a "herbicide revolution".

Labour-saving technologies can negatively affect biodiversity

But while appealing and beneficial to farmers, such technologies can negatively affect biodiversity. The case study in Zambia suggests that tractors allow farmers to cultivate more land, which is good for them but bad for the African savannah. A comparative study in Benin, Kenya, Nigeria and Mali published in *Agronomy for Sustainable Development* suggests that mechanisation can lead to the removal of on-farm trees and hedges and the altering of plot sizes and shapes, leading to a loss of farm diversity and landscape mosaics.

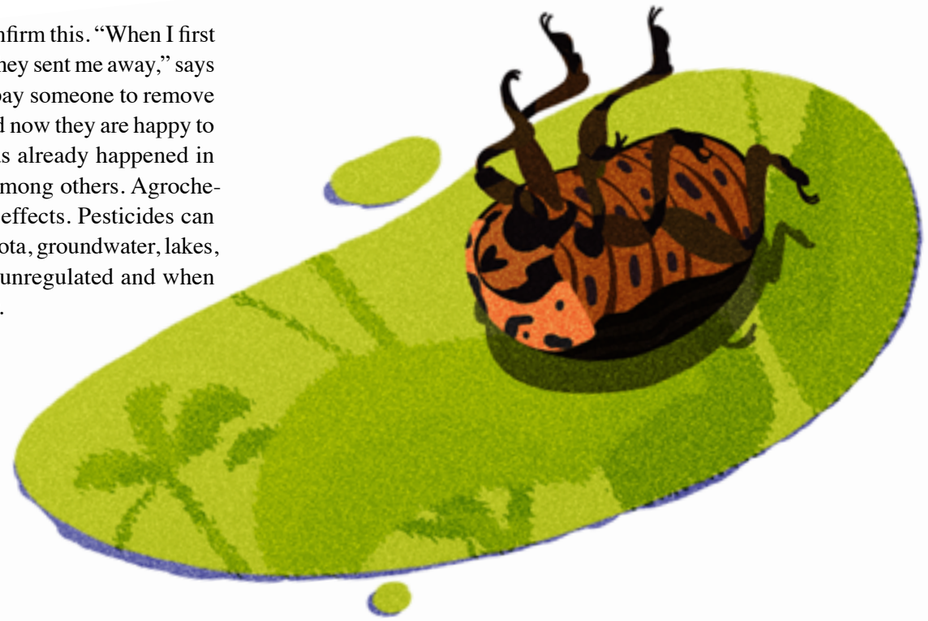
Precious Banda experiences confirm this. "When I first approached the tractor owners, they sent me away," says the Zambian farmer, "I had to pay someone to remove a couple of trees and stumps and now they are happy to serve my fields." The same has already happened in much of Europe and the US, among others. Agrochemicals can also have negative effects. Pesticides can affect insect populations, soil biota, groundwater, lakes, and rivers, in particular when unregulated and when management practices are poor.

... and biodiversity-friendly practices can increase labour burdens

At the same time, many solutions to make agriculture more biodiversity-friendly are often met with resistance from farmers. Many organic or agroecological farming practices that would be good for local biodiversity are not adopted by farmers because they come with a high labour burden.

In China, intercropping is said to suffer from a "slow death" due to labour shortages. In a meta-analysis led by Sigrun Dahlin from the Swedish University of Agricultural Sciences, planting basins were found to increase agricultural labour for land preparation by an astonishing 700 percent. A study in Zimbabwe by Leonard Rusinamhodzi, now with the International Institute of Tropical Agriculture (IITA), equates such solutions to "tinkering on the periphery", as they create more problems than solutions for farmers. The increased labour burden of such technologies can be particularly pronounced for women.

Given these labour dynamics, it is not surprising that farmers typically adopt technologies and practices that ultimately lead them to a low-labour/low-biodiversity situation. This pattern has been observed across the world, first in the Global North but now increasingly in the Global South. In Indonesia, for example, our paper shows that farming systems have evolved toward oil palm monocultures with broadcast mechanical and chemical weed, pest and nutrient management, which are characterised by low labour intensity and high yields—but which are bad for biodiversity.



Biodiversity-smart solutions are good for nature and people

To successfully reconcile food production and biodiversity conservation, we need biodiversity-smart agriculture, which is high-yielding, requires little labour, and is biodiversity friendly. At the farm level, this requires efforts to reduce the biodiversity trade-offs associated with labour-saving technologies such as mechanisation and pesticides, and to reduce the labour trade-offs associated with biodiversity-friendly farming practices.

In parts of the Global North, one solution could be fleets of small agricultural robots, which help to overcome the yield penalties and labour requirements associated with agroecological farming, potentially leading to an ecological utopia as a recent article in *Trends in Ecology and Evolution* suggests.

In the Global South, less expensive solutions are needed. One potential solution is scale-appropriate mechanisation, where machines are adapted to farm size and not the other way around. This is because two-wheel and small four-wheel tractors are better suited to manoeuvre around trees and hedges and other landscape features. In Arsi-Negele (Ethiopia), our paper shows that farming systems have evolved toward the low labour, low biodiversity, and high productivity scenario until the mid-1980s. But since then, they started to move to the low

labour, high biodiversity, and high productivity scenario, through labour-saving technologies compatible with high biodiversity, as well as reforestation efforts.

With regard to pesticides, integrated pest management, which aims to reduce pesticide use with biological (e.g., crop rotations) and mechanical (e.g., precision sprayer) solutions could help to reduce trade-offs between yields, labour and biodiversity. In contrast, simply refraining from pesticides, would not be ideal as it decreases yields and therefore undermines land sparing. A recent review in the *Annual Review of Resource Economics* led by Eva-Marie Meemken, now at ETH Zürich, indicates that crop yields in organic farming are 19–25 percent lower than in conventional agriculture. Avoiding pesticides such as herbicides also comes with great labour needs, much of which is shouldered by women as discussed above.

Next to reducing the trade-offs of labour-saving technologies, such as mechanisation and pesticides, biodiversity-friendly measures are needed, including both production-integrated measures (e.g., patch cropping, intercropping) and set-aside measures (e.g., trees, hedges, flower strips). A recent study in *Nature* shows that tree islands can improve biodiversity in oil palm plantations in Indonesia, without compromising yields. But more research is needed to understand how such measures can be designed to minimise trade-offs regarding agricultural land and labour productivity.

In many cases, labour-saving technologies could help to increase the uptake of measures toward biodiversity conservation. For example, studies suggest that labour-saving mechanisation may be a missing link to a more widespread adoption of Conservation Agriculture, which is good for soil health and biodiversity. Similarly, smart mechanisation solutions could facilitate strip intercropping systems, which are labour-intensive in their manual form, and the management of hedges and flower strips.

Biodiversity-smart agricultural solutions reduce the trade-offs between socio-economic goals and biodiversity conservation for individual farmers, increasing the chances of adoption. This is key in the Global South, where many governments have few resources to otherwise compensate farmers for biodiversity-friendly farming. However, innovative certification or payments for ecosystem services schemes may still be needed where biodiversity conservation comes with more costs than benefits for individual farmers.

Ideally, such schemes should be designed to reward farmers for actual sustainability outcomes and not the practices pursued, and to take into account not only local but also global effects. Such farm-level solutions have to be accompanied by efforts at the landscape level, for example, land-use management to preserve biodiversity hotspots, habitat mosaics and patch connectivity. The case study from Ethiopia shows that multifunctional landscapes can be planned to "work for biodiversity and people".

More efforts needed to scale up

Developing biodiversity-smart agricultural development requires paradigm shifts in both policymaking and research and development. For example, conservation ecologists must pay more attention to economic and social sustainability. Without explicitly accounting for labour issues, conservation efforts can hardly be successful. At the same time, agricultural scientists have to embrace multiple goals beyond yields.

Our paper shows that many solutions for biodiversity-smart agricultural development already exist. If they can be scaled, they can help us to feed the growing population, improve the livelihoods of millions, and protect the world's remaining biodiversity conservation before it is too late. And for Precious Banda, the farmer in Zambia, they would allow her to continue her "easy life" as well as have her delightful dish with caterpillars and Bondwe.

Further Reading

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Swati Addanki *is an illustrator and animator from Mumbai. She loves to take walks and talk about them.*

WHAT'S IN A NAME?

Changes in local names can reflect shifts in biodiversity and culture

Authors **Manya Kotera and Andrea D. Phillott** | *Illustrator* **Norzin Norbhu**

Western science emphasises standard, universally agreed upon nomenclature for the natural world based primarily on morphology. In comparison, indigenous or tribal names are often based on animal or plant habitats, kinship systems, uses, relationships with humans and non-human species and/or mythology or taboos. For example, the local name given to the nectar-rich *Justicia californica* plant by the Comcáac (Seri) tribe—*Noj oopis*—translates to "hummingbird's suckings" and the O'odham tribe name for the same plant—*Vipismal je:j*—translates to "hummingbird's mother".

If regional names reflect the unique culture and local environment in which they are used and encode valuable knowledge about human societies and their interactions with biodiversity, then why might names change over time? Interviews with coastal fishers in the Sindhudurg district of Maharashtra conducted by Aditya Kakodkar found that the local names used for sea turtles in 2006 were different to those shared in a later study conducted by Andrea Phillott and Paloma Chandrachud in 2018.

Earlier, *Kurma* was used for the giant leatherback turtles, *Tupalo* for the common olive ridley turtles, and *Kasai* in reference to all other species. Twelve years later, the names *Kaasav, Kasho, Kodam* and *Kachua* were used interchangeably for all sea turtle species. The names have different origins: *Kasai* is of the regional dialect Konkani, *Kaasav* means turtles in the state language of Marathi, *Kachua* is from the northern Indic language Hindi, and *Kurma* is from the ancient and classical Indian language Sanskrit. *Kasho, Kodam,* and *Tupalo* as names for turtles are of unknown origin.

The 2018 study proposes four possible reasons for the changes in local names over time: a) the species of sea turtles encountered by fishers in local waters changed over time, b) the cultural significance of sea turtle species to fishers shifted in the period between the two studies, c) change in language over time, and/or d) the language in which the interview was conducted influenced fishers' responses. Each of these reasons is of concern to people who value the local names for biodiversity.

Change in species presence or numbers

Knowledge encoded in local names for biodiversity is based on a large timescale and focused on a narrow and specific geographic area and therefore provides valuable, in-depth information about localised environments. Sometimes, these names convey knowledge of past phenomena that are no longer observed. Such a case is the name in the language

Tosni

Ghiquet

&

Kasaz

Kacho

Cassava

Vpismal je:j

Cmiique Iitom used by the Seri People to refer to an island in the middle of the Gulf of California – *Tosni Iti Ihiiquet*, which translates to "where pelicans have their offspring". Breeding pelicans in the area have declined and don't use the island in current times but historical records from a naturalist's journal corroborate the accuracy of the Seri name.

Biodiversity has been declining at an alarming rate worldwide, with the current situation being labelled "the sixth mass extinction". The major causes of this extinction event are anthropogenic—including pollution, habitat loss, hunting, overexploitation of natural resources, climate change, and introduction of invasive species. However, it is not only biodiversity that will be lost as more and more species become extinct; linguistic extinction will also occur.

This loss is already being recognised: declining specialised knowledge and vocabulary related to plants and animals among the Solega tribe of Karnataka is attributed in part to the introduction of the invasive plant *Lantana camara* that now dominates the landscape with its dense woody thickets, driving many shorter plants to local extinction. Culturally important herbs and shrubs have become rare and then absent from the immediate environment of the community and are, therefore, spoken about less. This disrupts the transmission of traditional knowledge to younger generations and results in a cultural loss of local names.

Shift in cultural significance of species and language

Cultural knowledge and names can diffuse—meaning items such as language, food and clothing, spread out and merge with pieces from different cultures—and erode—where core cultural elements are lost when replaced with other elements—due to environmental and social change. For instance, the root vegetable cassava had an integral role in the culture of the Amuesha tribe of the Central Peruvian Andes, featuring in their songs, myths and traditions, and being collected, cultivated and traded by the community. The value of cassava was reflected in the vast number of local names assigned to the different cultivated varieties of cassava.

Over time, however, there has been a shift in the cultural significance of cassava, with the younger generation focusing on market-viability and increasing cassava productivity using select varieties over maintaining the diverse range that was traditionally cultivated. Older generations attribute this attitude to the loss of traditional knowledge and language, within which the cultural value of cassava is encoded, through modern schooling. Indeed, there has been a shift in the dominant language used by cassava cultivators in the Peruvian region. Before 2000, cassava varieties were referred to by the indigenous names. In 2022, the names were primarily in Spanish or a combination of Spanish and the indigenous language.

Another case of shifting cultural significance of an indigenous language is evidenced by the Solegas described above. The word *tho:pu* to older Solegas refers to the tree dominated high-altitude forests that the Solega traditionally live in, while younger Solegas use the word to refer to groves or small clumps of trees. The latter is based on the word for "grove" in the state language Kannada, indicating attrition of their tribal language after increasing contact with mainstream Indian society and institutional pressures.

Similarly, the Amuesha describe displacement of traditional knowledge and indigenous language among younger people with increasing acculturation and assimilation with Spanish culture and modern schooling. There is an imminent risk of the disappearance of many of the world's languages as well as the wealth of knowledge they carry with increasing migration, acculturation, and integration of linguistic minorities. Sadly, linguists have predicted the extinction of 50–90 percent of world languages by the end of this century. The loss of language will come with a great cost to our knowledge systems about biodiversity.

Influence of research language and method

Among the researchers conducting interviews in the 2018 study of fishers' names for sea turtles, some spoke Marathi, the state language, and/or Hindi, the common northern Indic language. A few Marathi speakers also knew the regional dialect of Konkani and all were fluent in English. Fishers—who can also be multilingual—were given the choice of which language they wanted to speak during the interview. These conversations in multiple languages in their vicinity could have shaped the way fishers thought about the researchers (and their questions!) and shaped fishers' cultural mindset when responding. We don't know which language/s were used in the 2006 interviews, but a difference could also have contributed to the difference in local names used by fishers for sea turtles over time. Similarly, the demographics of fishers interviewed and the wording of the questions asked in the 2006 and 2018 studies may also have been different, resulting in the variation in names over time.

Conclusion

The knowledge that can be gained from understanding local names and the insights into cultural and ecological changes that can be inferred by examining changes in local vocabularies mean that conservationists need to be concerned about more than just threats to biological diversity. Loss of linguistic diversity will result in the loss of indigenous and tribal knowledge systems that are valuable for understanding the natural environment.

To understand, and prevent the loss of, ecological knowledge encoded in regional languages, academics from different fields—such as linguistics, ethnobiology, and ecology—must collaborate and form partnerships with local communities. In the case of the change in local names for sea turtles at Sagareshwar beach in Maharashtra, such collaboration could provide valuable perspectives on if and why the names changed and what this could imply. If the difference over time is the result of encountering fewer, or different species of, sea turtles changing cultural significance or research method, then understanding the cause of the change could determine whether conservation action is needed.

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A romp in the city

Author **Mike Mesterton-Gibbons**
Illustrator **P I Megha Vinod**

A once polluted isle where trees were few

Reforested and minimized its rate

Of bay pollution. Greater green and blue

Made Singapore the garden city state.

Pollution meant no otter romps. Today,

In Singapore, they roam the city streets.

No fishpond's safe if owners are away:

The otter is not coy—koi's what it eats!

Home owners losing koi may be displeased.

Ecologists, however, are beguiled:

Concern for wildlife would be greatly eased

If city life could coexist with wild …

To keep your koi from otters isn't hard—

You just erect high walls around your yard!

Mike Mesterton-Gibbons *is a Professor Emeritus of Mathematics at Florida State University who builds game-theoretic models of animal behaviour. His acrostic sonnets have appeared in Light, Lighten Up Online and several other journals.*

P I Megha Vinod *is a biotechnologist and an illustrator with a soft spot for creatures. She's probably chasing butterflies somewhere, but you can find her at pimeghavinod@gmail.com.*

What can we do about illegal trade within the cactus and succulent collector community?

Authors **Jared Margulies & Frankie Moorman** | *Photographs* **Jared Margulies**

It seems today that cactus and succulent plants are everywhere. Yet, despite their global popularity, many succulents face pressing conservation concerns. A 2015 study published in *Nature Plants* assessed that 31 percent of all cactus species are threatened with extinction based on IUCN Red List categories, and 47 percent of all cacti are harvested for horticultural and ornamental collection, much of which is for the international illegal trade. Many conservationists reckon that obsessive collectors are driving this trade. But why would people who are seemingly most passionate about these plants, engage in activities that harm them? And, how prevalent is such illegal behaviour among cactus and succulent collectors?

This research emerged through interdisciplinary conversations on how to analyse and assess the role of cactus and succulent collectors in potentially facilitating as well as hindering conservation efforts. Our research survey asked members of cactus and succulent societies about their familiarity and perspectives on current CITES trade regulations (i.e. the Convention on International Trade in Endangered Species of Wild Fauna and Flora). Barring a few exceptions, the entire cactus family is listed in CITES Appendix II. This means that nearly all cactus plants require export paperwork for legal international trade, while trade in some species is almost entirely banned (Appendix I). The survey also asked direct and indirect questions about illegal behaviour, including directly transporting, purchasing, or shipping CITES-listed plants or seeds without appropriate export and/or import permits.

Our results suggest that around 12 percent of the 441 surveyed participants engaged in some form of illegal trade in cactus and other succulent species. While a minority of survey participants engaged in forms of illegal wildlife trade, it is important to note that those engaging in active rule-breaking tended to do so knowingly, and some *justified* their behaviour as beneficial for plant conservation. Of course, this will strike many as strange. How could someone argue for participating in illegal wildlife trade as a benefit to species conservation? Further, why does such behaviour persist when 75 percent of respondents—including 62 percent of those who directly acknowledged engaging in illicit behaviour—said illegal collection of cacti and succulents represents a "very serious problem" and two-thirds of respondents stated that wild succulent plant collection was on a rise?

Our results suggest that many within the cactus and succulent collecting hobby believe that the CITES trade restrictions make it harder for collectors to legally gain access to seeds and plant material which in turn drives illegal trade. This opinion appears widespread within the collector-hobbyist community. Further, because the likelihood of detection in many forms of illegal trade in cacti and succulents is generally low, and the repercussions for being caught are often minimal, the risks that collectors face by engaging in illegal behaviours are also perceived to be low. Our survey results also indicate that cactus and succulent collectors see themselves as playing an important role in conservation efforts. To this end, we conclude that despite the persistence of illegal behaviours, there are missed opportunities to develop deeper engagement between collector and conservation communities.

A key takeaway from our study is a need for parties to CITES to engage in more meaningful stakeholder consultation to avoid potentially sidelining would-be conservation allies. Most of our survey respondents show concern about species conservation, and many formal cactus and succulent organisations are actively invested in funding conservation efforts. From a practical perspective, the professional conservation community risks alienating this group of stakeholders by not taking into greater consideration the lasting demand many plant species hold within international collector communities. To put it simply, prohibition of trades may not further long-term species conservation goals.

Ensuring that legally-acquired, and sustainably-sourced cultivated plant material is available within international markets may prove a far more practical—if still controversial—approach to protecting wild cactus and succulent species than trade prohibition. We hope the results of this study can further productive discussions about how to best ensure that these much beloved wild species can thrive in perpetuity.

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Jared Margulies *is an assistant professor in the Department of Geography at the University of Alabama.*

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Wild tulips fight to survive in their ancestral home

Author **Brett Wilson** *Illustrator* **Jisha Unnikrishnan**

Tulips are one of the world's most well-known spring flowers. Like all other garden plants, they have natural ancestors, and surprisingly these do not grow in the Netherlands—the country that exports the majority of horticultural tulips. In fact, most wild tulips can be found in the steppes, semi-deserts, and mountains of Central Asia, where over half of all known species of wild tulip grow. The number of wild tulips is dwarfed by the tens of thousands of horticultural varieties, yet the large number of species found in Central Asia makes this region a diversity hotspot for this plant group.

These wild tulip species harbour genetic resources that may be crucial for future breeding efforts, especially with respect to disease resistance and tolerance to climate change. They also act as indicators of overall ecosystem health, i.e. they provide an important signal if their habitat is being damaged. The flowers provide important resources and homes for insects, most notably supporting the insect populations that may also pollinate crop plants. Furthermore, wild tulips hold significant cultural value in this region, with local communities often possessing knowledge about where they occur close to their settlements. Therefore, they are a valuable asset, especially to local communities. However, limited understanding of natural diversity, the impact of climate change, and the effects of environmental disturbance have made it challenging to develop a solid conservation plan for these plants.

Since 2018, a team led by Fauna & Flora International has been proactively working on solving some of these issues. Specifically, I—Brett Wilson, a PhD student at the University of Cambridge and Dr. Sam Brockington the Curator of Cambridge University Botanic Garden—have been part of a research team that focuses on using technical knowledge and local expertise shared across organisations, to tackle these challenges. Sam and I have been working most closely with Bioresurs—a Kyrgyz conservation NGO, the National Academy of Sciences of the Kyrgyz Republic, and the Gareev Botanical Garden in Bishkek, Kyrgyzstan. Additionally, we have also developed collaborations across the region, including in Uzbekistan, Tajikistan, and Kazakhstan. This includes a range of botanic gardens where we have actively expanded tulip collections, not only for public

viewing but also for both scientific and conservation purposes—an often-overlooked role of global botanic garden plant collections.

The first task for our team was to improve our knowledge of tulip taxonomy. Without this fundamental information, conservationists struggle to appropriately target and obtain funding as well as carry out mitigation and management. In recent decades, it has become easier and cheaper to sequence DNA, and to use this information to infer whether the target plants are distinct species, and how these species are related to one another. Simultaneously, there has also been an increase in sources of tulip material, especially across the global botanic garden network.

Over the past four years, our team has collected and sequenced DNA from leaf material sourced from: an array of wild tulip populations in Central Asia, the living collections of several botanic gardens, and herbarium material—some of which was collected nearly a century ago. This allowed us to survey over 86 percent of all currently recognised species, as well as many plants collected under old names that are no longer recognised as species. Through this huge effort, we discovered the existence of a new subgenus, and reorganised many sections to simplify these groupings. Based on the data, we were able to reinstate several species, declassify some that are no longer considered separate species, and we also discovered a new species which we formally described in the summer of 2022.[1]

Genetic data can be used to explore the evolutionary history of a plant group across millions of years. Understanding the history of tulips is important as it can allow us to identify the geographic origin of this plant, as well as begin to understand where, when, and why it diversified. In turn, this can help us pinpoint the areas of distribution that are most important for conservation as well as specify which species are the most genetically unique. We were able to show that wild tulips originated in the broader Central Asia region with the most recent common ancestor estimated to have existed here around 23 million years ago. In addition, we discovered that this part of the world was crucial for the diversification of wild tulips throughout their history. The explosion of different tulip species in Central Asia could be linked to aridification, development of large mountain ranges, and global cooling. Strikingly, we were also able to show that tulips most likely moved out of the region through the Kazakh and Russian steppes into the Caucasus, from where they spread into the Middle East, Mediterranean, eastern Europe, and Iran. Very few species seem to have made it south out of Central Asia due to historical barriers such as deserts and seas. Crucially, all this work demonstrated that Central Asia is both historically and currently important for tulips, emphasising the need to conserve these flowers and their habitats in the region.

Central Asia has seen several decades of instability, with the collapse of the Soviet Union leading to economic issues, border disagreements, and political uncertainty. Thus, Central Asian countries often struggle to collaborate on policy and management approaches. This is a major problem for biodiversity, which doesn't abide by borders or nationality. Although individual countries (e.g., Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan) have undertaken national assessments of tulip diversity, few studies have looked at the region as a whole.

It is important to work at a larger scale in order to predict and protect wild tulips from the effects of global threats such as climate change. We used a large dataset comprising the location points of tulip populations to predict the impact of different climate change scenarios. Our findings pointed to vast reductions of suitable tulip habitat by 2050, including inside designated reserves. Our study predicted that most

species would only survive at higher altitudes. Overall, not only did this work highlight the threat of climate change to biodiversity in the region, but it also provided important information to help policymakers and conservationists take action to protect tulip diversity. This will hopefully act as a rallying call for greater regional collaboration on this and other conservation efforts—especially those related to large-scale threats, such as climate change.

We felt that a good starting point to promote regional cooperation would be making use of the IUCN Red List. The online resource aids in raising awareness and catalysing action by indicating the conservation status of specific species. In order to add wild tulips to the Red List, we created a network of experts from across Central Asia. This ensured better communication, sharing of data, and collaboration—linking up a wealth of country-specific information—so that researchers could conduct a more cohesive, border-spanning assessment of tulip populations. This process took place in several stages: writing initial draft reports for each species, obtaining inputs from regional experts (at a workshop held in Bishkek, Kyrgyzstan), asking an expert to review the reports, and finally, ensuring the reports met IUCN's standard. These efforts led to collated information about the species' population sizes, locations, threats, habitat, and required conservation action.

After around two years of hard work, we were able to ensure that reports for 53 species of wild tulips from Central Asia were published in December 2022. The reports showed that approximately 51 percent of all assessed Central Asian species are Threatened: six are Critically Endangered, six are Endangered, and 15 are Vulnerable species, with 14 other species considered Near Threatened. They highlight the precarious situation of wild tulips in Central Asia, especially as a result of livestock

[1]https://www.botanic.cam.ac.uk/dna-techniques-reveal-new-tulip-species/

overgrazing and climate change. It is clear that urgent conservation attention is required, but we hope that the collaborations to date have brought together the people and information which will be fundamental in stopping the decline of these species.

At the moment, wild tulips continue to bloom in the Central Asian landscape every spring, yet our work shows that this may not always be the case. Although new species continue to be found in this mountainous haven, we may still be losing tulip diversity overall, potentially including many undescribed species. A stable taxonomic framework has now been established, which can hopefully underpin a wave of more effective research and conservation. Our partners have simultaneously been working on expanding botanic garden collections of wild tulips and promoting better management of pastures where they grow. We hope that our work will help preserve this beautiful flower in its native home, so that when spring rolls around once again, we will see the meadows, grasslands, and deserts alive with the colours of flowering tulips.

Brett Wilson *is a conservationist and researcher specialising in Central Asian flora particularly wild tulips, a topic he wrote his PhD thesis on and has published several articles about.*

Jisha Unnikrishnan *is an illustrator and print designer based in Ahmedabad. She considers her illustration work as a constant form of study—of nature, people and culture and believes in art as a powerful tool to understand and communicate.*

Wolves deserve our best science, not vilification

Authors **Peter Kareiva** *&* **Elishebah Tate-Pulliam** | *Illustrator* **Bhavya K. Magdziarz**

In the last several years, the hunting and trapping of grey wolves has increased dramatically in the "lower 48" states of the United States. A recently published paper (see Further Reading section at the end) authored by several of the nation's leading biologists and wildlife advocates, found that there is a lack of data to justify this recent wave of lethal wolf management. This is the first peer-reviewed research of its kind since wolves were removed from the Endangered Species List in the Northern Rockies in 2020.

Below is an interview with authors Dr. Peter Kareiva, a member of the National Academy of Sciences and President and CEO of the Aquarium of the Pacific, and Elishebah Tate-Pulliam, a research assistant at the Aquarium of the Pacific and a previous recipient of the Aquarium's African American Scholars award.

Q: Stepping back a bit, why did you personally get involved with the wolf issue? Running the Aquarium of the Pacific in Long Beach, California, what led you to author a peer-reviewed analysis on an issue that is most central to the Northern Rocky Mountain States?

Peter: I joined the Aquarium of the Pacific because I love animals, am committed to conservation, and believe that our planet will thrive only if the public better understands and appreciates wild nature. Our current wolf management conundrum is a trenchant example of three factors: poor treatment of animals, poor conservation, and poor information. Of course I got involved—I used to call my beloved family dog "little wolf" as a puppy. And then there is the science. In 1997, I served on a National Academy Committee that examined the hunting of wolves in Alaska. What we found in Alaska foreshadows what is happening now in Montana, Idaho, and Wyoming—the Alaskan wolves were being unfairly blamed for doing much more damage to moose populations than the actual data revealed. Conservation, compassion, and a commitment to data drew me to the #RelistWolves Campaign—a grassroots coalition of conservationists, environmental nonprofit organisations, wildlife advocates, Native American tribes, and scientists. The campaign and its members have dedicated themselves to enhancing public understanding of wolves and ensuring their survival by advocating for one common goal: to restore the grey wolf to the Endangered Species List.

Elishebah: My undergraduate and graduate work included nothing about wolves or terrestrial conservation, but I did conduct research on ecosystem restoration in marine coastal systems. The reintroduction of wolves to western North

America is one of the greatest successes of species reintroduction and ecosystem recovery. That caught my attention. So, when Dr. Kareiva invited me to join the wolf team, I couldn't say yes fast enough. Like many people, I had my own view of wolves, but as a scientist, I wanted to learn more about their ecology and interaction with humans. In some way, wolves remind me of great white sharks, which I think of as wolves of the ocean—feared and vilified, yet magnificent animals.

Q: What are some of the benefits of wolves? Why are wolves so vital for our society and for nature?

Elishebah: As a keystone species, grey wolves are critical for maintaining healthy, resilient ecosystems and preserving biodiversity. We depend on these amazing animals to serve as ecosystem guardians. For example, wolves help keep herbivore populations, like deer and elk in check. Without predators, elk and deer can become so abundant that they overgraze, which in turn exacerbates soil erosion and produces heavy loads of sediment in streams.

Peter: Elishebah is exactly right. The best documented case study comes from Yellowstone National Park, where wolves were reintroduced in 1995. The return of wolves changed elk behaviour, keeping them on the move, which in turn allowed young willow and aspen plants to survive when previously they would have been browsed by elk. The return of these plants then helped beaver populations recover, and helped reduce sediments in streams. A less commonly appreciated benefit of wolves is their prudent predation of sick and diseased animals.

For example, chronic wasting disease has been spreading among elk and deer populations in the Greater Yellowstone Ecosystem, and wildlife biologists hypothesise that wolves could play a valuable role in removing sick and infectious animals, thereby slowing the spread of this deadly brain disease.

Q: What is wrong with current wolf management policies?

Peter: Extreme wolf hunts in states like Idaho, Montana, and Wisconsin have shocked many wildlife

Keystone species

The concept of "keystone species" can be traced to R.T. Paine, who introduced the idea after conducting field experiments in which the removal of starfish from rocky intertidal communities in Washington State, USA, led to a transformed intertidal zone—blanketed with mussels, whereas in the presence of starfish intertidal rocks were covered with barnacles, sea palms, mussels, anemones, and other "space-holders". "Keystone" is a metaphor for a species that holds the ecosystem together, much like the keystone at the top of a stone arch. Some species are more equal than others, and keystone species are those organisms which, if deleted from an ecosystem, the ecosystem shifts to a totally different state with a cascade of impacts that dramatically alter the abundances of other species. Without its "keystone", a stone arch collapses into rubble. The elimination of these species in nature can prompt surprising and far-reaching changes or collapses in the local environment. Examples of keystone species include sea otters, elephants, sharks, certain diseases, and of course humans! Unfortunately, human activities have tended to deplete and in some cases locally extinguish keystone species throughout the world, largely because keystone species are most often predators at the top of food chains and are thus viewed by humans as dangerous or as competition.

biologists because of how many wolves were killed in such a short period of time. In only six months of the 2021–2022 hunting season in Montana, at least 25 wolves from Yellowstone were killed when they wandered outside the park boundary—a number that represents one-fifth of the federally protected Yellowstone wolf population. Even more dramatic is the killing spree in early 2021 of at least 216 wolves in Wisconsin over a three-day period. The zeal with which hunters killed wolves clearly overwhelmed Wisconsin's Department of Natural Resources. By the time the hunt was shut down, at least 97 more wolves had been killed than the state-mandated quota of 119 wolves. More generally, we found that data surrounding the benefits of wolves typically has not been incorporated into state-level wolf management decisions. Also, when state agencies formulate their wolf policies, it does not appear that they gave much weight to the collateral damage associated with rampant trapping and hunting of wolves.

Elishebah: Creating effective management policies for wolves is complicated. Firstly, wolves are predators and there's no denying that wolves kill both wild and domesticated animals as they go about their business of being a wolf. That said, data indicate wolves much prefer wild prey to domesticated cattle and sheep. Human societies have a long history of treating predators like wolves as vermin. Before the arrival of European colonists, wild nature thrived in harmony with Native Americans, and wolves were abundant throughout North America. That all changed as western colonists spread across the continent hunting, trapping, and poisoning wolves to near extinction. But now as wolves make a comeback, they encounter a landscape filled with human activities. This renews opportunities for wolf-human conflict and in turn has created the threat of a second round of persecution and wolf slaughter.

Unfortunately, our protest of the wolf slaughter is seen by some as an attack on hunters. It is not an attack on hunters. We know that hunters are often great conservationists. We also recognise that hunting is a cultural legacy for many westerners, and any ban on hunting might be interpreted as an infringement on the rights of hunters. I certainly agree that hunters have rights. But animals also have rights. Ethical hunters respect animal rights when they embrace the principle of fair chase. However, no one would call baiting, trapping, running wolves down with packs of dogs and ATVs, and night-vision hunting a fair chase.

Q: You have mentioned poor information—what did you mean by that?

Peter: That's a great question. First, there is huge uncertainty about how many wolves there are, how many have been killed in the recent hunting spree, and how frequently wolves have preyed on livestock. We think there are around 6,000 wolves left in the lower 48 states as of last year, but credible analyses of the uncertainty of this estimate have not appeared in the scientific literature. We are not even sure how many wolves have been killed over the last two years—we think it is around 1200. However, because of poor data transparency, under-reporting, and poaching, we worry the 1200 number is an underestimate. Finally, when we attempted to quantify wolf impact on livestock, we ran into difficulties. We examined the US Department of Agriculture's data on livestock killings in our analysis and found that it's only published about every five years and includes livestock deaths that are only presumed wolf kills, not necessarily confirmed wolf kills. The bottom line is this: the current justification for wolf hunts is based on data that is inconsistent and unevenly reported. It is my strong belief that given the precarious status of wolves, no hunting should be allowed until we have more transparent and accurate data. In the absence of such data, prudence tells us to be cautious before we sanction such widespread slaughter of wolves.

Q: What do you say to the tens of thousands of farmers and ranchers throughout the US who claim that they must kill wolves, In certain instances, to protect the well-being of themselves and their livestock?

Elishebah: Firstly, I understand the desire to protect one's livelihood. Ranching is a tough business: droughts, fires, diseases, extreme temperatures, and predators can cause a rancher to lose income. At a more personal level, I am sure ranchers are upset whenever one of their cattle or sheep are killed. For this reason, ranchers should have their concerns heard and addressed—and they are. I wonder, however, if the ranching community has an accurate view of the deaths caused by wolves in the context of all the undesired deaths that their livestock suffer? To provide some context regarding this concern: the number of sheep and cattle killed by wolves never exceeded 0.21 percent and 0.05 percent of unwanted deaths in Idaho, Wyoming, Montana, and Wisconsin, according to the 2020 USDA report on sheep and 2015 report on cattle. Causes other than wolves made up the vast majority of unwanted livestock deaths. Why are we vilifying wolves for their attacks on livestock, when in fact theirpredation on livestock is minor compared to all the other factors?

Peter: We understand the challenge that independent ranchers have, which is why we advocate for conflict reduction (which has proven effective) and reimbursement programs. Our point is simply that killing wolves should be a last resort, not the first option.

Q: You mentioned conflict reduction, what can this look like in practice?

Peter: There are a wide variety of effective non-lethal wolf management techniques. Ancient techniques like fladry, which entails creating a perimeter of colourful flags around livestock, combined with contemporary techniques like strobe lights and loud noises have proven effective at deterring wolves. In addition to these tried and true methods, some recent non-lethal innovations promise even greater success going forward. I just learned about this idea of infusing carcasses of cattle with cocktails of nauseating chemicals. When the wolf eats this cattle carcass, it feels sick and develops a learned aversion to cattle. That clever innovation is exemplary of the creative ideas we should be exploring in order to avoid primitive lethal approaches.

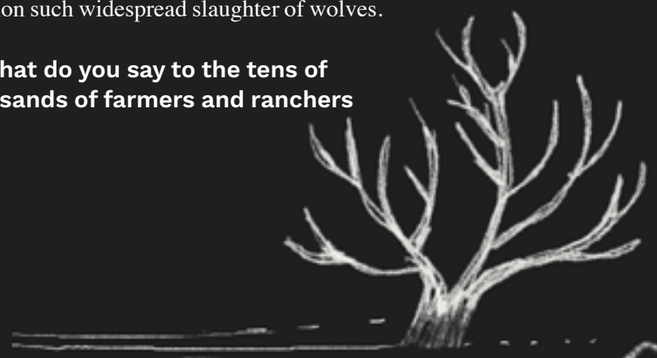
Elishebah: One idea is establishing programs that reward ranchers who invest in conflict reduction. This can complement programs that compensate ranchers who have lost livestock to wolves.

Q: Does the killing of wolves ever evolve into the killing of other, non-targeted species so to speak? If so, can you explain?

Elishebah: Attempts to deplete wolf populations often result in wolf hunters and trappers accidentally shooting and trapping dogs and other "non-target" species. Nearly one non-target animal was accidentally trapped for every wolf trapped in Idaho from 2012 to 2019, including threatened and endangered species. In Montana during the hunting seasons of 2018–2020, half of all non-target species accidentally caught in traps were domestic dogs.

Q: Is there anything being done to advocate for wolf protection? What can readers do to get involved?

Peter: The Biden Administration is conducting a status review with the chance to restore federal protections to ALL grey wolves. Relisting wolves is the only way to stop brutal state-led hunts before it is too late. In the long term, we need to pursue coexistence with wolves, as well as coexistence with the many other "dangerous" animals that were once endangered but are now recovering. We have learned how to save and restore wildlife—now we need to learn how to live with wildlife. Write



your congressional representatives and encourage them to pay attention and care. Support organisations that strive to protect wolves and other wildlife.

Elishebah: Dr. Kareiva mentions what amounts to advocacy. As a recently graduated student, I think education and communication are key. We need to escape the tyranny of an "us versus wolves" mentality to an "us and wolves" mindset. Moving toward this change in mentality is what we are working towards with the #RelistWolves Campaign. I'd encourage folks to visit RelistWolves.org for more information on the campaign and how they can take action.

Peter Kareiva *is President and CEO of the Aquarium of the Pacific and a research professor at the University of California, Los Angeles, where he was previously the director of the Institute of the Environment and Sustainability. He is the chief scientist for relistwolves.org, and was elected to the National Academy of Sciences in 2011.*

Elishebah Tate-Pulliam *received both her Bachelor's degree and Master's degree in Biology from Cal State University, Long Beach. She was a member of the inaugural "African-American Scholars" cohort awarded by the Aquarium of Pacific in 2021. After defending her Master's Thesis, Elishebah has been volunteering, and working as a Research Assistant at the aquarium. Tate-Pulliam's goal is to educate students in urban areas about the importance of wetlands and environmental awareness.*

Bhavya K. Magdziarz *is a freelance visual communication designer and illustrator, with a growing interest in natural heritage and diversity.*

Further Reading

Estes, J. A., J. Terborgh, J. S. Brashares, M. E. Power, J. Berger, W. J. Bond, W. J. Carpenter et al. 2011. Trophic downgrading of planet Earth. *Science* 333(6040): 301–306. https://doi.org/10.1126/science.1205106

Eisenberg, C. 2013. *The wolf's tooth: keystone predators, trophic cascades, and biodiversity*. Washington DC: Island Press.

Kareiva, P., S. K. Attwood, K. Bean, D. Felix, M. Marvier, M. L. Miketa and E. Tate-Pulliam. 2022. A new era of wolf management demands better data and a more inclusive process. *Conservation Science and Practice:* e12821. https://doi.org/10.1111/csp2.12821.