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Special Issue
Migration

Current Conservation carries the latest in research news from natural and social science facets of conservation, such as conservation biology, environmental history, anthropology, sociology, ecological economics and landscape ecology.

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editor's note

Cover art **Harikumar Nair**

Time may be an abstraction, but we all have our ways of marking its passage—whether it's with the Gregorian calendar or cyclical changes in temperature and precipitation. We dedicate the final issue of 2021 to migratory species, who, through their seasonal movements across distances great and small, fill us with wonder and serve as a reminder that everything is interconnected.

Awe-inspiring as they are, animal migrations all over the world are under severe threat. The delicate balance of this phenomenon—which evolved gradually over vast evolutionary timescales and independently across several taxa—is being disrupted by ongoing habitat loss, overexploitation of migratory species, and anthropogenic climate change. The fact that migratory animals pay little attention to political boundaries only makes their conservation that much more challenging.

Still, there are things worth celebrating, such as rapid advancements in technology that are helping us better understand migratory patterns and routes, enabling more robust decision-making as well as transboundary cooperation. Read on for a diverse collection on 'Migratory species conservation' curated by Editors Eduardo Gallo-Cajiao and Kartik Shanker. We end on a light-hearted note with Kartel Shockington in the year 2084, where only vegans remain.

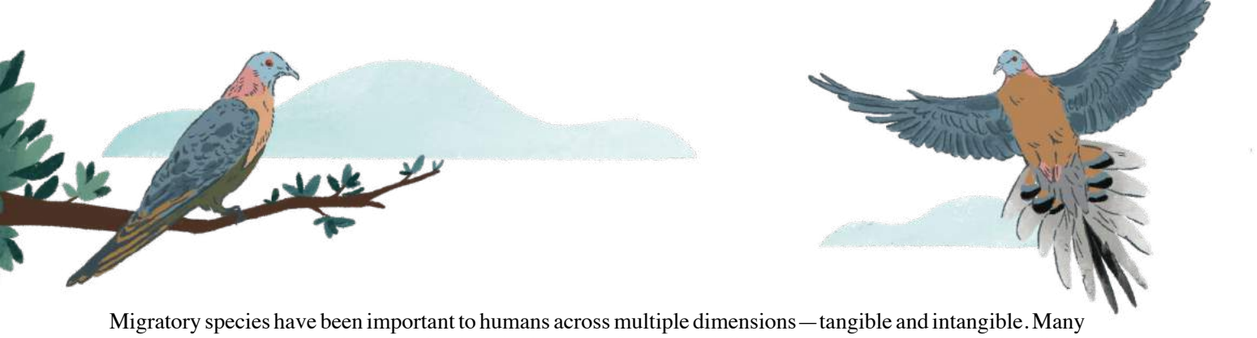
— **Devathi Parashuram**

Conserving animals on the move

Authors **Eduardo Gallo-Cajiao & Kartik Shanker** | *Illustrator* **Malvika Dwivedi**

From frantic wildebeests crossing the Mara River in East Africa, to the lofty flight of bar-headed geese over the Himalayas and the frenetic upstream run of sockeye salmon in the Cascade Range of North America, migration defines the life of many animals around the world in the skies, oceans, rivers, mountains, as well as plains. This life strategy entails cyclical, predictable, and seasonal patterns of movement through which individual animals complete their life cycle at separate places that can range from short to extremely long distances. For instance, while the Christmas Island red crab migrates just over 4 km between terrestrial and marine environments in the Indian Ocean, the Arctic tern completely shifts hemispheres by flying from the Arctic to Antarctica and back in a 17,000-km journey each way.

Migration has evolved independently across a wide range of animals, including crustaceans (e.g., lobsters), insects (e.g., butterflies), fish (e.g., tunas), reptiles (e.g., sea turtles), birds (e.g., raptors), and mammals (e.g., whales). This suggests that migration is advantageous—animals are able to maximise their survival by exploiting ephemeral yet superabundant resources, as well as avoid unfavorable environmental conditions, including harsh weather and predation, at critical stages of their life cycle, such as breeding. This seasonal tracking of favourable conditions thus usually leads to movement in large aggregations, creating one of nature's greatest spectacles.



Migratory species have been important to humans across multiple dimensions—tangible and intangible. Many migratory species are exploited as food, as in the case of commercially harvested tuna species, and caribou, which are harvested for subsistence purposes. On the other hand, a well-known case of non-consumptive use of migratory species is ecotourism. For example, the migration of humpback whales along the coasts of virtually all continents creates many job opportunities through whale watching tourism. Additionally, migratory species provide important ecosystem services through transport of nutrients and interactions with other species across different environments. For example, Pacific salmon, which spend most of their lives in the ocean, are important fertilizers of carbon-rich and climate-regulating temperate rainforests, as their mass migrations to spawn in inland waterways results in tons of nutrient-rich carcasses that are shuffled on the forest floor by hungry animals, such as bears. Some of the close connections between humans and migratory species have unsurprisingly become embedded in cultural expressions, such as festivals. For instance, Colombia's upstream migration festival or '*Festival de la Subienda*', is held in a small city on the shores of the Magdalena river to celebrate the bounty brought by the migration of multiple fish species of commercial and subsistence importance.

Despite their apparent abundance in many cases, migratory species cannot be taken for granted. North American skies that were once darkened by large roving flocks of passenger pigeons are now just part of a cautionary tale. This species used to migrate between nesting areas in the Northeastern United States, moving as far south as Florida during winter. However, overhunting and habitat loss drove them to extinction by the early 1900s. The story of the passenger pigeon looms over us once again, with many migratory species currently at risk of extinction. Examples include the saiga antelope, the orange-bellied parrot, and the American eel, amongst others. Similar mechanisms seem to be at play in the decline of these species. Depending upon their migratory patterns, habitat loss can have disproportionate effects on populations as they congregate in large numbers at specific sites during their life cycle. Likewise, managing harvest can be very challenging as individual animals often straddle multiple political jurisdictions with different regulatory contexts, potentially leading to overuse.

Recognising these impacts, efforts have been underway to conserve and restore populations of migratory species. These strategies require cooperation and coordination between people, organisations, and governments along their migratory routes. Within this context, multiple international agreements have been developed with a focus on various groups of migratory animals. Examples include the Convention on the Conservation of Migratory Species (CMS), the Inter-American Convention for the Protection and Conservation of Sea Turtles, the Polar Bear Agreement, the Agreement on the Conservation of Populations of European Bats, and the China-Russia Migratory Bird Agreement. Some of these mechanisms have been supplemented by local governments and non-governmental organisations, such as the Network of Urban Nature Reserves of Patagonia, which works on migratory shorebird conservation to support hemispheric conservation efforts in the Americas. Arrangements of cooperation and coordination have enabled the deployment of specific on-ground actions for conserving migratory species, such as the construction of overpasses across highways to allow the safe passage of pronghorn during migration south of Yellowstone National Park in western North America. Additionally, trans-frontier systems of protected areas have been established to secure the habitat of migratory wildebeest and zebra in East and Southern Africa.

Conserving migratory species remains a challenge; however, there are reasons for hope. As researchers continue to unveil long-unknown migrations through the use of ever improving tracking technology, policy makers are better informed to decide where conservation efforts are best rolled out. Likewise, this very information is being adopted by environmental educators and advocates to build narratives that mobilise public and political support based on the amazing journeys of these animals. In line with these ideas, Current Conservation decided to throw the spotlight on migratory species with this special issue, as they are incredibly important, are in peril, and require specific conservation approaches.

This special issue includes a wide breadth of contributions from various perspectives, regions of the world, ecosystems, and groups of animals. We open with an article by Sahas Barve on the ecology and physiology of birds that migrate between places at extremely different elevations, demonstrating their marvelous adaptations. We are then transported to Mexico, where Kirsten Lear explains how migratory bats play a key role in culturally and economically important landscapes. Beyond their biology and roles in ecosystems, migratory species also bear important cultural significance in their own right, as shown with cranes in South Asia in a captivating piece by David Hecht. The role of technology in studying animal migration is absolutely critical, and its development and use is reviewed by Jared Stabach. Along these lines, Rob Harcourt takes us on a personal tour of exciting field work to study the movements of seals in Antarctica. Finally, we end with some delightful storytelling by Kate Mansfield and Liliana Colman, who help us experience migration through the eyes of a sea turtle. We hope this collection of articles sparks further interest in, and support for, these marvelous travelers.

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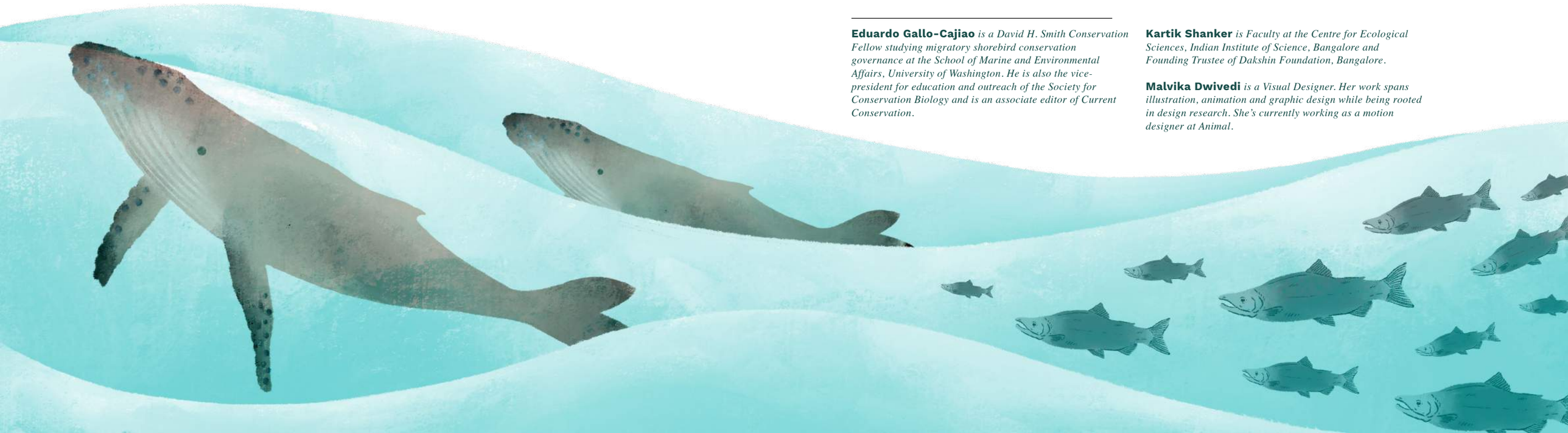
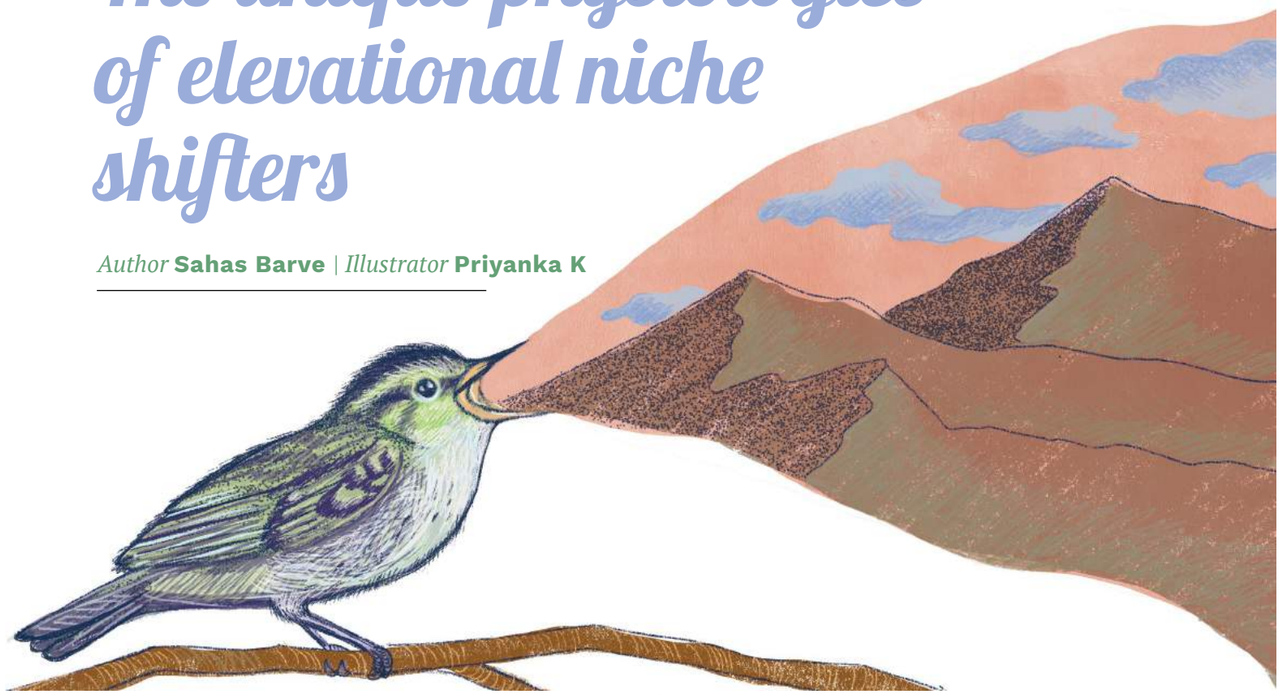


The unique physiologies of elevational niche shifters

Author **Sahas Barve** | *Illustrator* **Priyanka K**



As a kid growing up in Mumbai, I often played on the beach. Our football would sometimes disperse a flock of white birds with grey wings sitting by the water. Those birds were brown-headed gulls, winter migrants that are commonly seen around water bodies throughout peninsular India. But they are part of an elite class of only 92 species worldwide (less than one percent of over 10,000 bird species) that show what scientists—Jessie L. Williamson and Christopher C. Witt—call Elevational Niche-Shift Migration (ENSM). ENSM is a special kind of migration where birds not only move seasonally between locations, but also these locations have over 2000 metres (6600 feet) of difference in elevation. Those brown-headed gulls eating chips and *gathiya* (Indian snacks) that you drop on the beach are doing something incredible every year, flying over the Himalayas to breed on the Tibetan plateau.

Thousands of species of birds spend their summers in their breeding habitats and migrate significant distances to their non-breeding or winter habitats every year. Some species, like the bar-tailed godwit, make epic 12000 km non-stop flights, and even the tiny 4-gram ruby-throated hummingbird flies from Canada to Central America and back every year. But almost all migratory species' breeding and non-breeding habitats are at low elevations (for example, the Indian pitta). ENSM species, on the other hand, migrate between summer and winter habitats that are very different in elevation and, thus, over 20 percent different in their oxygen availability. Moreover, most spend their summers breeding in the more hypoxic (low oxygen) high elevation habitats where all activities—flying, maintaining body temperature, feeding, avoiding predators—are much more energy intensive than at lower elevations. Talk about high achievers!

After collating information on the migration ecology of thousands of birds, Williamson and Witt discovered that ENSM species are spread out across the avian tree of life. Songbirds (such as finches, warblers, and flycatchers) comprised the biggest single group, but sandpipers, gulls, cranes, pigeons, and hummingbirds are also some species with ENSM movement. Each clade has independently evolved this extreme lifestyle, which is especially concentrated in birds of the Himalayas and Tibetan plateau.

For any oxygen-breathing animal, enduring such a 20 percent change in oxygen availability is quite significant. High elevation organisms (including humans in the Ethiopian highlands, Tibet, and the Andes) have several modifications to their physiology that increase their ability to extract oxygen from the air. These include changes in the breathing pattern, blood circulation, blood chemistry (increased hemoglobin concentration, increased size and number of red blood cells), etc. However, high elevation adaptations come with a cost if you don't live in a high elevation environment, such as highly viscous blood due to the increased red blood cell counts, making the blood more difficult to circulate. So, having high elevation adaptations in a low elevation environment for many months of the year creates a dangerous animal-environment mismatch.

The scientists suggest two models to explain how ENSM evolved: 1) High elevation habitats may match the winter ranges of these birds in temperature and habitat, or 2) Himalayan birds may also have evolved ENSM as their summer breeding habitats slowly rose up in elevation over millions of years, giving them the time to adapt.

Williamson and Witt argue that ENSM species may achieve these feats of physiology by not having a specialized high elevation or low elevation system, but rather a highly flexible physiology. This would give them the ability to quickly change their body to survive in a new environment, thus helping them cope with these extreme changes twice a year. Given the handful of ENSM species worldwide, it appears though that this physiological flexibility is difficult to evolve and a lot remains to be studied.

So the next time you see a brown-headed gull, grey wagtail, greenish warbler or common sandpiper, know that they may be common birds, but under the hood they are incredible animals!

Further reading:

Williamson, J. L. and C. C. Witt. 2021. Elevational niche-shift migration: Why the degree of elevational change matters for the ecology, evolution, and physiology of migratory birds. *Ornithology* 138(2): ukaa087.

Sahas Barve *is an evolutionary ecologist and a Research Fellow at the Smithsonian National Museum of Natural History.*

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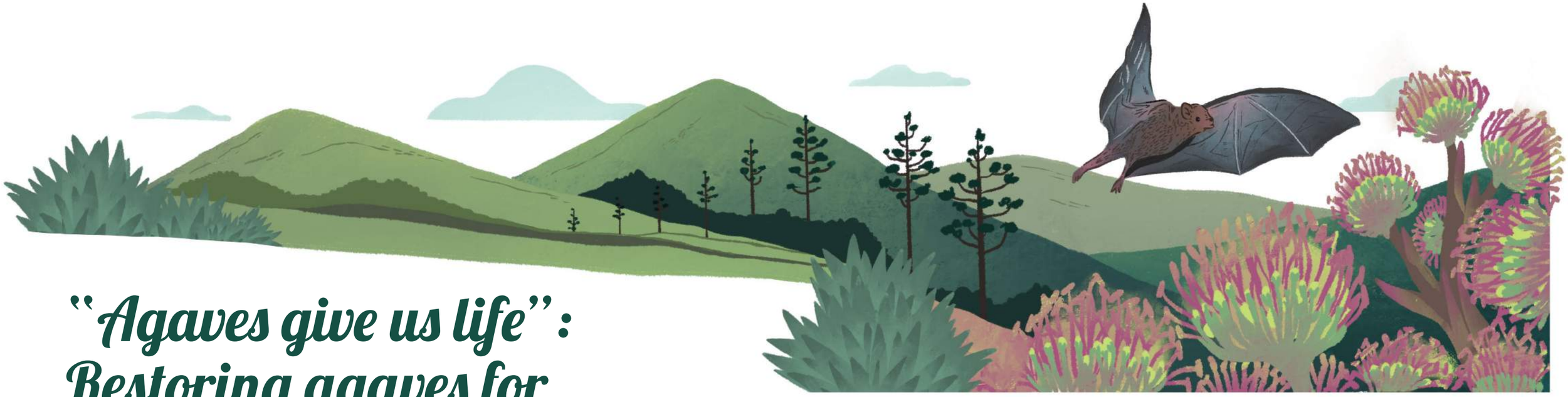

"Agaves give us life": Restoring agaves for bats and people

Author **Kristen Lear** | *Illustrator* **Malvika Dwivedi**

The moon rises above the jagged mountains, casting a soft, pale light on clusters of towering agave stalks and their branches full of flowers. A gentle breeze sways the flowers and the pungent odour of the sweet nectar wafts towards us as we sit, silent and waiting, by the agave. We hear a soft whoosh by our heads. Suddenly our infrared camera screen comes alive with frantic activity as a group of seven small, brown bats flit up to the flowers in rapid-fire succession. A split second is all each bat needs to lap up the sugary nectar that fuels their nightly foraging bouts. They continue their aerial feeding dance for several minutes, until they decide it's time to move on to the next agave patch. They will continue this pattern throughout the night, taking periodic rests among rock outcrops or their roosting caves, where they groom, socialize, and rest.

These hungry bats are endangered Mexican long-nosed bats (*Leptonycteris nivalis*). Undertaking a spectacular 1200-km annual migration, pregnant females leave the mating cave in central Mexico to seek out a handful of maternity caves in northern Mexico and the southwestern United States, to give birth to their single pup. Males stay behind in bachelor colonies.

Mexican long-nosed bats, along with their close relative the Lesser long-nosed bat (*Leptonycteris yerbabuenae*), feed on the energy-rich nectar from agave plants in the desert and mountain ecosystems they call home. Not quite as graceful or able to hover as hummingbirds, they get covered in yellow pollen during their rhythmic feeding bouts. They move among agave patches throughout the night, spreading this pollen near and far. Able to carry and disperse pollen over 50 km in a night—much farther than most birds or insects—these bats are critical to connecting agave populations, helping maintain their genetic diversity and ultimately increasing resilience to threats, such as pest and disease outbreaks.

However, these nectar-feeding bats aren't the only players that have a close relationship with agaves. Another key player? People.

Agaves and people

The next afternoon as the bats are tucked away in their cave, I take a walk with Armando, a Mexican farmer whose family lives in a communal *ejido* in the mountains of Nuevo León. We stroll through his *parcela*, the agricultural plot where he and his family grow corn, beans, and other crops. He stops along the fence line at a two-metre-tall agave with a large hole carved from the centre. Bending over, he scoops a cupful of cloudy liquid from the hole: *agua miel*, or "honey water", the sap of the plant. I taste the liquid: it's sweet but with a very plant-like taste. "Agaves are the sustenance of the ranch," he says.

Like Armando, many rural *ejidatarios* (farmers) across Mexico harvest and use agave plants to obtain traditional beverages like *agua miel* and *pulque* (fermented *agua miel*); to distil liquors like tequila and mezcal for sale in local, regional, or even international markets; to feed to livestock, especially in times of drought; to serve as "living fences" that keep livestock out of crops or to delineate property boundaries; and to retain soil and prevent erosion on hillslopes and along roadsides. Agaves sustain their livelihoods, allowing them to retain their homes and ties to the land even when other livelihood sources, such as livestock and farming, let them down. With increasing periods and severity of droughts and increasing desertification in Mexico, drought-tolerant agaves offer a lifeline for many families.

Armando points down to the base of the agave at several small baby agaves, called *hijos*, growing from the mother plant. These *hijos* are clones, underground offshoots that are genetically identical to the mother plant. Like their mother, they too will eventually shoot up a massive flowering stalk and offer nectar to bats and

other animals. Clonal reproduction offers a safeguard to the mother plant in the event that seed production through pollination is not successful. For many agave species, sexual reproduction through seeds helps maintain genetic diversity, while clonal reproduction can help maintain population numbers.

In fact, Armando explains that for many agave species, proper "castration" of the mother plant—hollowing out the centre of the plant to create the hole where the *agua miel* collects—stimulates production of clonal *hijos*. This provides the harvester with new baby plants that they can then transplant as living fences or for future harvest. Thus, harvest of agaves, combined with sustainable ranching practices, can be an important way to safeguard agave populations for future use by people.

The importance of agaves for bat migration

When agaves are left to flower, they provide an important food source to nectar bats and are pollinated in turn, thus completing the cycle that benefits bats, agaves, and people. Rural communities throughout Mexico, as well as private and government lands in the U.S., are important stepping stones along the bats' migratory route, connecting critical roosting caves with a path of foraging resources.

Back at the agave we had monitored the night before, the vibrant yellow flowers are beginning to shrivel in the sun and heat. As agave flowers shrivel across the landscape, the bats move along on their migration. Flower death does not, however, signal the end of the agave's life cycle. The pollinated flowers soon become ovular fruits, with hundreds of tiny black seeds nestled inside. These fertilized seeds give the plant an opportunity to pass on its legacy in the form of new seedlings, if they successfully germinate.

Native to deserts and semi-arid habitats and with over 250 species worldwide, agaves have been part of cultural landscapes for over 10,000 years. However, agave populations and the habitats where they occur are being lost to various threats, such as expansion of agriculture, unsustainable ranching, urban development, and climate change. Loss of agaves affects both the migratory bats and the people that rely on them. Efforts to restore agave habitat are being undertaken by organizations like Bat Conservation International. Through diverse partnerships with NGOs, state and federal agencies, industry partners, and local communities across the southwestern United States and Mexico, Bat Conservation International is promoting agave planting, sustainable agave use, and other land use practices that support both threatened bat populations and human livelihoods.

Naturally dispersed by wind and water, tiny agave seeds get a helping hand from Bat Conservation International's partners. By propagating and nurturing the seeds into little seedlings for planting back in the wild, these agaves get a new chance to grow tall on the landscape and once again feed the bats and provide sustenance and livelihoods to people. Exclusion of restored areas from herbivores helps ensure the plants' survival. Community training in sustainable agriculture and ranching practices helps ensure that communities can make a living from their land long into the future. Long-term community conservation agreements ensure that the agaves are protected until they flower and that restoration efforts are co-designed in ways that benefit the communities. Market-based initiatives like the Bat Friendly™ Tequila and Mezcal project, launched by Dr. Rodrigo Medellín of the Universidad Nacional Autónoma de México and David Suro of the Tequila Interchange Project, work with liquor producers to certify agave farms that let five percent of their crop flower for pollinating bats.

These efforts to restore and protect a "nectar corridor" for migratory bats and communities require bi-national collaboration between Mexico and the U.S., bringing together people and linking ideas across a vast landscape. I think back to my walk earlier with Armando and recall a statement he made that couldn't be truer or more motivational: "For us the agave is so noble that it gives us life." Agaves do indeed give us life. But it's not just us—agaves support a wealth of healthy ecosystems and wildlife species, some of them migratory. It is our responsibility to protect and restore agave habitats before it is too late and species like the Mexican long-nosed bat are lost forever.

Further Reading

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Bat Conservation International. 2020. Boosting bats by restoring Mexico's agaves. https://www.batcon.org/article/boosting-bats-by-restoring-mexicos-agaves/. Accessed on October 5, 2021.

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Songs and signals on the wings of cranes

Author **David M. Hecht** | *Illustrator* **Harikumar Nair**

We wait as the sun disappears behind the darkening mountains, the chill of winter settling into our bones without the warm beams of daylight enshrining the high-altitude wetland valley. The only sounds are our gentle breathing—making clouds of vapour illuminated by a rising moon—and the distant trumpet of black-necked cranes flying towards their roosting ponds. Deep in the winter of the new year, we listen as they move invisibly through the cover of night: gentle rustles of dark grey and black feathers and a quiet ripple of icy water as they land together. Gangtey-Phobjikha valley has long been blessed with the presence of the revered Thrung Thrung Karmo, as black-necked cranes are known in Dzongkha and Monpa languages. These birds are winter migrants from the Tibetan Plateau where they breed, finding refuge in the warmer, wetland valleys of the Kingdom of Bhutan, Ladakh and Arunachal Pradesh in India, and parts of southern China.

Our team of scientists have been brought together by a single goal—to successfully capture and attach satellite transmitters to several black-necked cranes for a long-term study on their migratory patterns and movement ecology. The odds of success would feel immensely stacked against us, were it not for the collective wisdom and expertise of this team of crane scientists from Bhutan's first and oldest non-governmental environmental organization, The Royal Society for the Protection of Nature (RSPN), and Crane Conservation Germany (Kranichschutz Deutschland).

As we sit quietly in the dark, listening, waiting for any sign that the capture set-up has been successful, the distant histories and memories of this place envelop me. For how many centuries has this protected valley sheltered Thrung Thrung Karmo and other migratory waterbirds from the harsh winter months of Tibet—the roof of the world? Here, where they are warmed by lower elevations and the welcome hospitality of the Bhutanese people that have called this valley home for generations. Many residents of Gangtey-Phobjikha consider the black-necked crane to be heavenly birds, divine messengers, and reincarnations of Bodhisattvas1. For many farmers, it is considered a blessing of good harvest for the year should migrating cranes land and dance in their fields of potatoes, turnips, barley, and buckwheat. Still others claim migrating cranes circumambulate the central monastery three times before descending into the valley in the winter, and again while ascending out of the valley on their way to their spring breeding grounds on the Tibetan Plateau.

Rubbing my hands together for warmth, waiting in the darkened silence, I dwell on the many connections that have formed through the centuries between cranes and mountain communities, manifest in paintings of cranes on the walls of traditional farmhouses; cranes ornately carved into the eaves of the wooden gateway of Gangtey Goenpa, the central monastery of the valley; stories of cranes threaded into traditional dances and woven into songs that mimic their characteristic call: Thrung Thrung, Thrung Thrung. I am reminded of one such traditional Bhutanese song, shared with me many years ago by my friend and colleague, Jigme—the guiding voice of this field excursion, who is in turn a leader in crane conservation and research in the country. I sit next to him as we wait some more through the night, a gentle wind blowing around us, sweeping through the expansive valley, covered in frost, when this song loops in my mind:

[1]Bodhisattva, wylie (byang chub sems dpa'), [awakening being] is a being on the path of enlightenment for the sake of others

Ja dhi thrung thrung karmo
Me mang gi aro
Sho tsel nga la yar dang
Jangchub shing gi patra
Tharing jangla me dro
Me mang gi aro
Ling thang kor nay lok wong
Jangchub shing gi patra
Pang gi lhabja gongmo
Me mang gi aro
Phayul mindhu ma sung
Jangchub shing gi patra
Regu tho ray tho tsay
Me mang gi aro
Lhabja gong moi Phayul
Jangchub shing gi patra

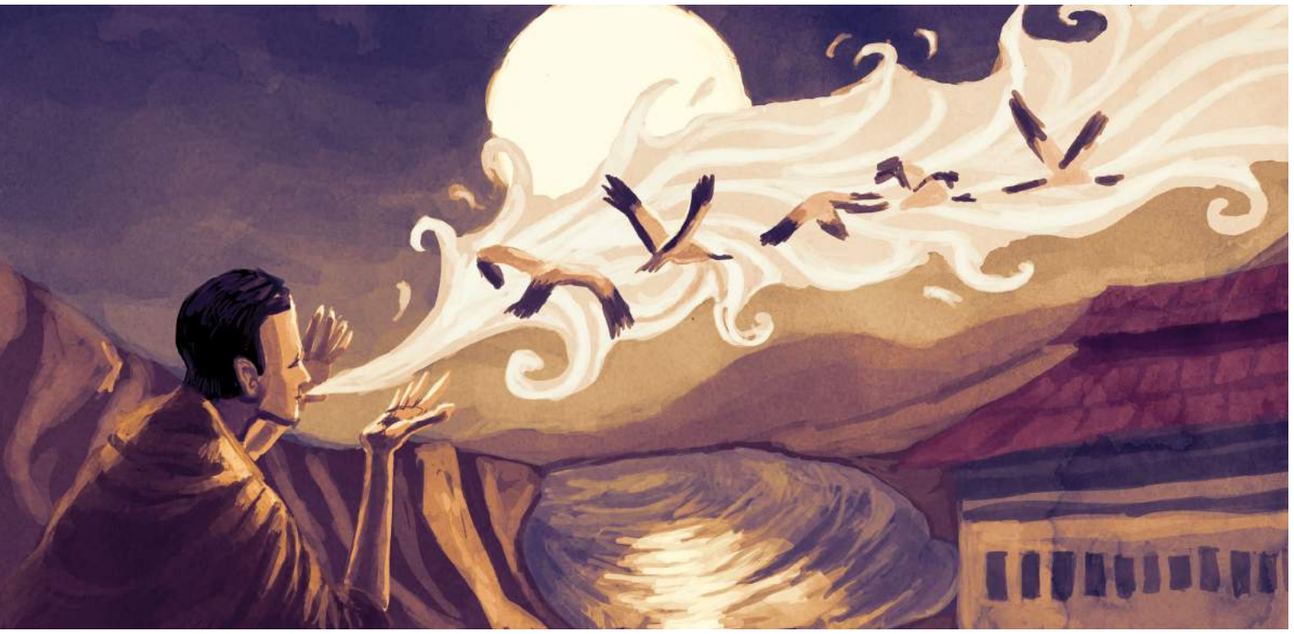
Black-necked cranes
Favoured friends of the people
All feathers rise up
As if carved of the Bodhi tree
Will not fly far
Favoured friends of the people
Will come back from Lithang
As if carved of the Bodhi tree
Birds on the earth
Favoured friend of the people
Don't say there is no
home/native place
As if carved of the Bodhi tree
Higher up in the mountains
Favoured friends of the people
So it is the home/native place
of the bird
As if carved of the Bodhi tree[2]

[2]Translated from Dzongkha to English by Tandin Wangmo

This song of antiquity, amongst many others of its kind, marks a long history between the people of this Kingdom and the cranes, which migrate from areas such as Lithang in Kham Province, Tibet. This region, which is intricately tied to Tibetan Buddhist histories and living traditions, was the birthplace of the Seventh and Tenth Dalai Lama. As I sing the song silently like a mantra in my head, I recognize its reminiscence to a verse, attributed to the Sixth Dalai Lama, Tsangyang Gyatso, frequently taken as a reference to his commencing rebirth: "Oh white crane, lend me your wings, I'm not going far and away, I'll return through the land of Lithang, and thence, return again." Inscribed in both this poetic verse and traditional song are geographical and historical linkages to Eastern Tibet. Each is animated by the migration of the world's only alpine crane species, the black-necked crane, traversing across the Eastern Himalayas through centuries of song, dance, and recorded tradition.

The moon is high in the sky now, casting a silvery glow across the valley floor. Still, no sign of movement from the roosting cranes. Jigme keeps a watchful eye through the darkness, as I stay lost in thought. Another story enters my mind, shared with me by Sonam, a Bhutanese cultural scholar and friend. He tells me of a 17th century religious teacher who lived in this very valley we wait in now: Tendzin Lekrpai Dondrup, the Second Gangteng Trulku[3] (born in 1645). Unable to return to Tibet to see his precious teacher, reportedly the Third reincarnation of Pema Lingpa[4], Tendzin wished to send a message. In his melancholic reverence, he sings a song to the black-necked cranes of the valley, asking them to carry his message of respect to his master as they fly back to Tibet, high over the green mountain passes, when the winter frost thaws.

A distant splash breaks my concentration. Our group jumps to attention as we realize that a roosting crane may be caught. We rush off into the night, wading through the ice-laced waters and frosted wetland grasses, to spot an adult crane perfectly held by a leg hold—a time-honored trapping practice, perfected over many years by crane researchers around the world. The hold is released as Jigme cradles the crane gently under his arm. He walks slowly back across the wetland to the field truck, where he kneels in front of the team, a crane tucked safely at his side. The crane is fitted with a solar-powered transmitter—a small device as big as a bundle of incense sticks—that connects to the global cellular network and communicates geographic positions at regular intervals. This device, a humble, microchipped messenger, will tell us precisely where this crane goes, by sending regular signals along the path of their upcoming spring migration to Tibet. As we release the crane to rejoin the others, into the peaceful embrace of night, I am filled with gratitude for the many ways in which we tell our collective stories, and for our world's many messengers—the songs and signals that are sent upon the wings of the crane—in the present century, those that have passed, and those still to come.



[3]Trulku, Wylie (prul sku), is a reincarnate custodian in a lineage of Tibetan Buddhism, often recognized as the rebirth of a previous practitioner.

[4]Pema Lingpa was a famous 15th century Bhutanese saint and revered discoverer of spiritual treasures, or Terchen, Wylie (gter chen)

Whether through old songs, narrative verse, or solar-powered transmitter, the black-necked cranes are indeed our precious predecessors, hosts of the skies and the valleys, well-deserving of our reverence. As we drive home to warm beds and peaceful dreams, I am transported to an interview conversation held six years ago with the current Gangtey Khenpo—head of the central monastery of the Gangtey-Phobjikha valley. I had asked him about the significance of cranes in this place, and he replied: "Actually, the land is sacred, and the cranes are noble creatures... The cranes are enlightened, they are also found in heaven. They are very noble, show kindness, help each other, and are very compassionate. They are different from the other birds. They can fly high up, like an airplane… one of [our] foreign disciples did research on this. He wrote a letter on the neck of the crane, and that crane was seen again [far, far away]."

Perhaps it is the majesty of these magnificent, migratory birds that has fostered such goodwill and inspiration through the generations, and why many dedicated individuals have worked tirelessly to protect critical habitats within their migratory flyway—a route regularly used by large numbers of migrating birds. We see ourselves in them, in their strength, ability, grace, fidelity to place and partner. If we learn to hold their many stories and embrace diverse ways of telling them—across culture, language, discipline, and time—perhaps we can better serve them, as they serve us.

As a conservation social scientist, these memories paint for me a living tapestry—by song and by satellite—of cranes as messengers. Messengers that speak to the richness that can be illuminated when science embraces multiple ways of transmitting knowledge to inform conservation decision-making. It's an achievable goal that can be equitably and inclusively accomplished in partnership with indigenous peoples and local communities. If we choose to listen, these types of historical connections and animating stories can be found threaded through just about everything. And if we do more than listen, we will realize they can add depth, dimension, and meaning to our growing scientific knowledge base through collective environmental and political action. Stories, precious messages from our predecessors, improve our capacity to understand the world's many challenges and complexities. If we work together in partnership with communities who hold generations of storied expertise, then we will be better positioned to know, conserve, and protect migratory species, like the *Thrung Thrung Karmo*.

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Tracking the past, present, and future use of technology to save global species migrations

Author **Jared Stabach** | *Illustrator* **Anushree Vaze**

From hiking in the forest to navigating to the best slice of pizza in New York City, GPS technology has transformed our everyday lives and become a mainstay in our travel and business sectors. For wildlife researchers, GPS technology has been nothing short of revolutionary. The first living being tracked from space was an elk, fitted with a cartoonishly large tracking collar by pioneering wildlife researchers Frank and John Craighead near Jackson Hole, Wyoming in February 1970. Dubbed 'Monique the Space Elk' by the national media, Monique's rudimentary collar weighed a whopping 10 kg (the weight of an average car tyre), cost roughly USD 25,000, and boasted an average positional error of approximately 50 km^2 (about 10,000 football pitches).

Today, some 31 Global Positioning System satellites encircle the earth, providing geolocation information to GPS receivers almost anywhere with unprecedented precision (within 2–10 metres or better in optimal conditions). At the same time, the weight, storage capacity, and cost of GPS tracking devices have all improved significantly. These advancements have allowed for an increasing diversity of species—from meadowlarks to blue whales—to be tracked for days, months, or years at temporal resolutions (hours, minutes, or seconds) that would have seemed unimaginable during initial experiments so many decades ago.

Countless discoveries have been made thanks to data collected via GPS. Researchers have mapped the migratory pathways of ungulates across the North American intermountain west, estimated the area requirements of Mongolian gazelle—an astounding 11 times the size of Yellowstone National Park, revealed the importance of collective decision-making in gregarious primates, and assessed the role of long-term memory in how marine and terrestrial mammals select resources. These findings illustrate a brief snapshot of the breadth of research being conducted by scientists globally using GPS and highlight the importance of this technology in spurring scientific discovery.

Nearly concurrent to the development of GPS technology, earth scientists were also looking to the stars to better understand our changing planet. The recent launch of Landsat 9 in September 2021 marks an almost 50-year record of earth observation, with satellites capturing the entire surface of the earth every eight days at roughly 30-metre spatial resolution. Importantly, these data have been made freely available to the global science community, promoting a surge in earth science research and discovery. Data collected from successive satellite missions has led to a better understanding of agricultural productivity, changes in land-cover, forest health, water quality, climate, and even variation in the size of the polar ice cap. By linking these remotely sensed data sources and their derivatives with animal tracking data, researchers have appropriately taken advantage of the vast quantity of information now available to conduct global-scale analyses. These activities are providing an improved understanding of the range of conditions that are driving changes in the persistence of long-range species migrations and most recently, are providing insight into how animals are responding to reductions in human activities resulting from COVID-19 restrictions.

This ability to monitor shifts in animal movement at large spatial scales is increasingly important as anthropogenic pressures drive the alarming loss of animal migrations globally. The Cornell Lab of Ornithology, for example, estimates that nearly three billion migratory birds have been lost since 1970, representing a 28 percent decline in bird abundance over the past half-century. Studies led by researchers from Utah State University also show that large-bodied herbivores may be at the highest risk of extinction, with barriers from development further limiting the ability of animals to move and acquire the resources required for survival. These findings are concerning on many levels, but perhaps most importantly because animal migrations facilitate the redistribution of energy. The hooves of approximately 1.3 million migrating wildebeest, for example, aerate the soil with every step, circulating nutrients contained within their feces throughout the ecosystem, forming the foundation for ecological food webs and giving rise to diverse biological communities and burgeoning local economies.

To address the mounting challenges of these declines, researchers have joined forces to encourage information sharing and increase the diversity of species being tracked. As an example, researchers at the Max Planck Institute of Animal Behavior initiated Movebank in 2007, a free and online digital archive for tracking data that now contains nearly three billion tracking locations from over 1,000 species. More recently, initiatives like the Migratory Connectivity in the Ocean (MiCO) and the Global Initiative on Ungulate Migration (GIUM) have (literally) begun putting migrations on the map, with the aim of engaging policy makers and government officials with data highlighting actual movement pathways from tracked animals, to inform decision-making processes.

Still, much work remains to be done to increase the range of species that can be monitored effectively. Current GPS tag weight limits are around 5g, far too heavy for around 70 percent of birds and 65 percent of mammals that call our planet home. Various developers are pushing on this weight limit boundary, with low power GPS tags now as small as 1g that work for short periods—weeks or potentially months, if the frequency of data collection is reduced to less than a few points per day. Scientists associated with the ICARUS initiative are pushing on these restriction thresholds by developing a solar powered tag that could collect hourly data for multiple years, transmitting data on individual animals to a low-orbit receiving antenna attached to the International Space Station. Others, such as non-profits like Smart Parks, are taking advantage of technological spillover and working with a growing community of scientists and engineers to openly share their designs, creating new cost-effective solutions. Continuing to push these technological boundaries offers promise in increasing our understanding of migration, with fine-scale data that can be incorporated into analyses to assess species responses to human-driven environmental change.

These new data streams, however, are complicated in nature and require a unique set of skills to analyse. As a result, collaboration is again necessary to facilitate the sharing of new skills and ideas, often from other disciplines like physics or computer science, to 'crack the code' and develop tools that make use of the fine-scale data being collected. The Continuous-Time Movement Modeling framework represents a good example of years of development by quantitative ecologists working together globally, all the while aiming to democratise tools to the broader scientific community through user-friendly interfaces and specialised trainings (i.e., AniMove).

To save animal migrations from disappearing altogether, researchers must continue to push on these technological and analytical boundaries. In addition, researchers will need to broaden collaborations with other researchers, with officials in government and non-government organisations, and with members of local communities where studies are focused. Saving migratory routes will require researchers to connect with audiences beyond traditional academic outlets to provide results in a format that will inspire policy makers and the public to preserve and protect this invaluable phenomenon. Institutions could facilitate this process by evaluating employee contributions to outreach and communication as part of annual performance reviews. At the same time, researchers could create engaging learning opportunities for students by developing lesson plans with educators to showcase the near real-time tracking data being collected (such as the annotated track of a female pronghorn known to researchers as 700031A, as she traverses a diverse land-use matrix in central Wyoming). Indigenous knowledge about contemporary or even extinct migrations could also be incorporated into analyses where data are lacking. Lastly, training the next generation of scientists with the new tools that are being developed is also critical, inclusive of funding opportunities to facilitate trainings in countries where access to resources is more limited. If COVID-19 has taught us anything, it is that global communication networks are allowing us to communicate across continents and time zones like never before. While virtual meetings and seminars are no substitute for developing long-term relationships with partners, they do offer more cost-effective means (and a reduced carbon footprint) to build the required set of skills to analyse data with partners globally.

While the field of movement ecology is a relatively young discipline (formalised in circa 2008), tremendous opportunity exists to build upon promising early achievements. Future studies will likely focus on broadening the historically narrow emphasis on tracking single taxa and individuals, with greater attention on ecosystem-wide interactions between different species. Technology has certainly helped spur this revolution forward, but saving these migrations will require an explicit focus on collaboration between local and international institutions, necessitating scientists to step beyond their comfort in academic dialogue to use data collected to impact decision-making processes and better engage the public. As shown effectively by the Census of Marine Life's Tagging of Pacific Predators (TOPP) project, migration knows no political boundaries. Therefore, saving migrations requires government officials at the highest international levels to develop agreements of mutual interest to find ways to facilitate connectivity across rapidly changing land and seascapes.

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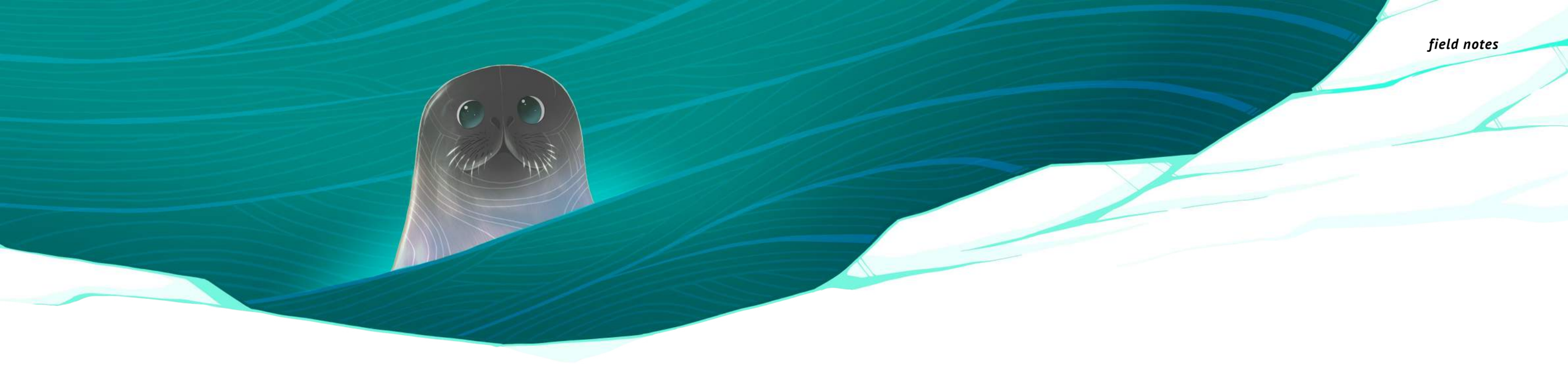

An icy life: Tracking the Weddell seal for conservation and environmental understanding

Author **Robert Harcourt** | *Illustrator* **Adwait Pawar**

I rise from my bunk and stagger to the mess for coffee and to check the ambient conditions at Scott Base. This New Zealand base is nestled on the southern side of Ross Island, nearly 78°S of the equator. It is late February and the first sunset of the year is soon approaching. I check the weather station—outside it is a balmy -10°C, but most importantly the wind is less than 15 kmph. This means that we should be able to safely head out on to the sea ice without risking drifting away, as strong winds can break up the ice. The team gathers at the Hagglund (a Swedish track truck that handily floats) after a hearty breakfast. Dressed in multiple layers we head down from base, over the transition (the point at which we cross from driving over land to driving on the ice) and towards a cluster of black dots moribund on the ice. As we trundle along, windows fogging, the excitement is palpable. Soon, the black dots grow to large mounds, and a few heads turn briefly to inspect our approach.

We have arrived. We are parked amid a group of moulting Weddell seals, the southernmost breeding mammal on earth. These beautiful 400 kg plus animals have large, oversized brown eyes for gathering light deep under the sea ice, disproportionately small heads and big fat tummies. Their large round shape is a product of their several centimetre-thick blubber layer, which keeps them warm in this most extreme of environments, whether sleeping exposed on the ice to katabatic winds that send freezing air down from high on the Antarctic continent, or hundreds of metres deep in the subzero polar waters. They are lazing around moulting last year's coat, in readiness for the coming darkness of winter, when the sun doesn't rise again until spring and they must forage under the ice for fish and other prey, building reserves for the coming breeding season. Many of the females are pregnant and will spend many hours hundreds of metres below the sea foraging in the darkness, only returning to pup the following October.

Antarctic seals and threats to their habitat

Weddell seals are pinnipeds—a group of 33 fin-footed species of carnivorous, semi-aquatic mammals, many of which are migratory, that includes true seals, eared seals (fur seals and sea lions), and the walrus. Female Weddells number around 200,000. All seals give birth out of the water, either on ice or land, but feed at sea. True seals, such as Weddells, feed their young for a relatively short period (from a few days to a few weeks), mate and then may disperse widely across oceans remaining at sea for months. The five species of Antarctic seals—Weddell seal, Ross seal, crabeater seal, leopard seal, and southern elephant seal—show a variety of migratory patterns. Crabeater, leopard, and Ross seals give birth on the pack ice, which forms around the continent each year. Thus, they remain pelagic, feeding below the drifting ice, although leopard seals are also often found near their prey, at penguin colonies. At the other extreme, elephant seals disperse widely from the subantarctic islands they breed and moult on, migrating at times more than 1000 km away to feed in Antarctic waters. Weddells, on the other hand, breed on the fast ice—the ice 'fastened' to the continental edge—and then disperse to various extents into the seas around their natal areas. This migratory behaviour is what we are here to investigate.

Antarctica and the Southern Ocean are critical components of the world's climate and weather systems. Amongst all continents, Antarctica is the farthest from the equator, as well as the coldest, windiest, and driest. Each winter the sea freezes around it to cover a total area of about 14 million square kilometres. The combination of a circumpolar ocean with the massive freezing and melting of the ice shelves and the extreme cold and dynamic atmosphere, drive interactions that have global implications. It is the most remote of all continents and the only one not permanently inhabited by humans. Yet, even here at the end of the world, there is evidence of anthropogenically-driven climate change playing out in a complex manner, but with effects predicted to grow over the next century, and many implications for, amongst others, these beautiful Weddell seals.

Beyond climate change, human pressures within the region are managed through international cooperation, which is imperative for pinniped conservation given their long-range movements. Within the Southern Ocean, toothfish are not only a valuable fishery, but also form an important prey base for Weddell seals as well as for killer whales and sperm whales. Since Antarctica has been named a continent for science, activities there are managed carefully to comply with the Protocol on Environmental Protection to the Antarctic Treaty, also known as the Madrid Protocol. Thus, fishing is also carefully regulated and scientific monitoring of its impacts on other predators is a unique feature of management in the region. Moreover, the Commission for the Conservation of Antarctic Marine Living Resources uses an ecosystem-based management approach that includes establishing a network of Marine Protected Areas in the Southern Ocean. This showcases the importance of international cooperation for the conservation of seals, as they often travel between areas under various political jurisdictions.

Tagging Weddells

So here we are, standing on the sea ice, careful not to approach too close to the ice edge. We are on a brittle surface and even though metres thick, the ice can break away and float off into the Ross Sea in a frighteningly swift manner. We drill holes through the ice to measure the ice thickness and make sure we don't fall through as we work, and we stake out safe areas to work using flags on bamboo poles. We check the seals for their moult status, as we will be attaching tags that measure the sea temperature, salinity and depth, as well as their location, and send us ocean profiles of all these parameters throughout the winter. These tags have transformed our understanding not only of these beautiful animals but of their environment and how it is changing.

Our research here is twofold. First, as a collaboration between Australia's Integrated Marine Observing System and our New Zealand cousins at the National Institute for Water and Atmospheric Research, we are assessing the impact of fishing in the Ross Sea Marine Protected Area on Weddell seals by tracking their movements and foraging behaviour through the winter. Second, it is part of a huge global initiative, the Global Ocean Observing System, that is monitoring the world's oceans. Seals like these Weddell seals and their cousins, the elephant seals, have provided over 70 percent of all ocean profiles south of 60°S. These tags send us information through satellites to our warm and comfy offices as our seals roam freely across the Southern Ocean and dive deep to feed in areas extremely difficult, dangerous and expensive to get to with ships during the harsh Antarctic winter.

We find a suitable candidate, a fat, freshly moulted female with the tell-tale shiny stripe of new hair down her back. We carefully approach and pop her into a hoop net, quickly inject a sedative, then release her and move away stealthily, allowing the sedative to act and for her to fall back to sleep. As there are no land predators, Weddell seals are relatively calm in our presence. Many of her compatriots have given us but a cursory glance and fallen back to sleep, and she quickly does the same. When our veterinarian gives us the signal, we approach, place her in a sling below a tripod, hoist her up to get a body weight, lower her back to the ice, and work quickly to collect all our necessary biological samples. We then clean the fur on her head and glue the transmitter to her head, making sure not to let it move out of position as the quick dry glue sets. She will proudly wear this hat until she moults the following October, giving us positions and ocean profiles right throughout the winter and allowing us to track her movements up to 1000 km north of where we stand.

The information we have gathered is critical to understanding the effectiveness of Marine Protected Area boundaries and fishing zones, but also provides us with so much more. This research allows us to see what sort of habitat these animals prefer, and by tracking animals from three different areas of Antarctica, we have shown that movements and habitat preferences are shaped by their local environments. Once they have moulted, our seals disperse. Some do not move very far, and may stay within a few kilometres of where they were tagged throughout the winter, feeding in shallow water over the continental shelf. Others will disperse up the coast and then venture out into the pelagic zone, roaming far into the winter ice, foraging pelagically, all the while preferring areas of high ice concentration. Whether stayers or roamers, all keep to areas of high ice density—perhaps as a way of avoiding their key predator, the killer whale. As more Marine Protected Areas are proposed, this sort of data should allow us to predict how effective they may be for protecting these animals and their prey. At the same time, the oceanographic data and in particular the many ocean profiles are incorporated into, and therefore improving, the models which bodies, such as the Intergovernmental Panel on Climate Change (IPCC), are using to predict future climate change.

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Migrations through the eyes of a sea turtle

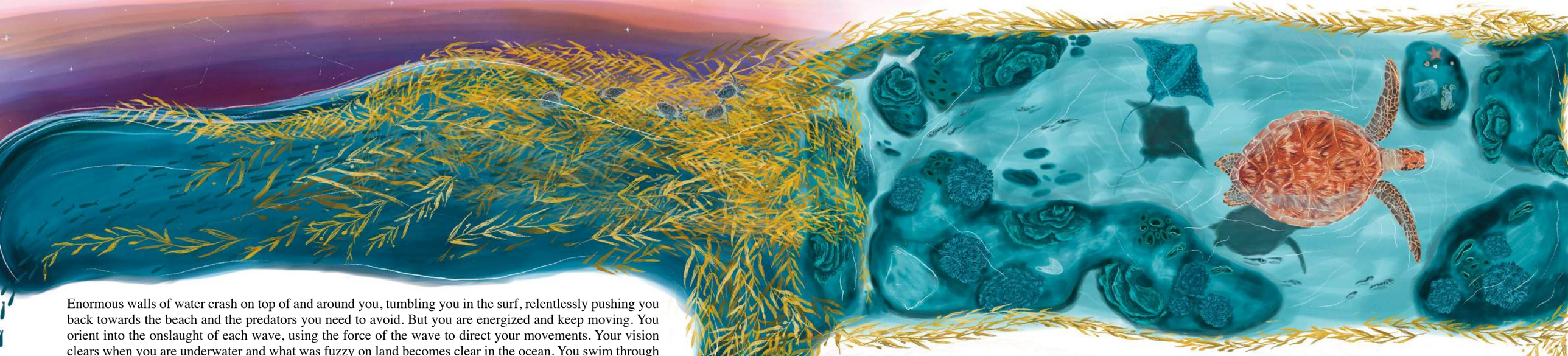
Author **Kate Mansfield & Liliana Colman** | *Illustrator* **Upasana Chadha**

If you are reading this, you are likely a human. We humans are terrestrial beasts—we live on land and we can learn to swim, but we require air to breathe. Through our skin, we can feel changes in air or water temperature, the wind blowing, and even water currents nudging or pushing against us. We can hear a range of sounds, taste with our tongues, and communicate with our voices. We are also visual creatures—we can see a spectrum of color, and use color and light to communicate with each other. As humans, we experience the world through sensory windows unique to us; hence, it is easy for us to forget that other creatures may experience and sense the world in very different ways.

Now imagine that you are a sea turtle hatchling, smaller than a deck of cards. You are so small you can easily fit in a human hand. You slowly become aware of your surroundings—you are in a closed dark space. You feel movement around you. The temperature drops a little and that movement becomes more frantic. Something gritty gets in your eyes and many leathery appendages hit your face and body. The temperature drops a little more and you feel a sense of urgency—to move, to climb up through a collapsing substrate. As you climb, it feels like you are swimming through something thick that you can't quite grasp, like trying to climb up an escalator that is going down. You suddenly emerge from your collapsing hole with other small beings just like you, all boiling out onto a beach at night.

You are on your own now.

Everything looks blurry; there is darkness behind you and a faint glow of light in front of you. You are drawn to the light. You also develop a sense of place—you imprint on the Earth's magnetic field, taking note of this location because it will be important sometime in the future. You may have a sense of where you must now go. You start to move and crawl, crawl, *crawl* towards this brighter horizon. The moon and the stars are reflecting in the ocean. *There* is where you must go. To get *there* you may encounter rocks, hills, and valleys you must traverse—some of these are far, far larger than you. It takes time and every second you spend crawling towards the bright horizon you are in danger. Large strange creatures may try to attack and drag you away. They have claws and beaks. They are much stronger and faster than you. If you are lucky, if you are quick, and if you persist, you reach the ocean.



Enormous walls of water crash on top of and around you, tumbling you in the surf, relentlessly pushing you back towards the beach and the predators you need to avoid. But you are energized and keep moving. You orient into the onslaught of each wave, using the force of the wave to direct your movements. Your vision clears when you are underwater and what was fuzzy on land becomes clear in the ocean. You swim through the surf into surface waters that rise and fall with less urgency. You keep swimming, swimming, *swimming* at the sea surface. Your lungs are so small that you can't afford to remain at depth for long. You swim through the sunrise and a day of sunshine that heats your shell and your body, helping to quicken your movements. Then sunset, cooling through another night of darkness. As you swim, large creatures appear below you or swoop down at you from above. You use up your energy reserves, energy from the yolk that gave you life in your dark egg, to swim, swim, *swim* away from these new predators. Swimming into deeper waters that hopefully offer you safety. You must reach those waters before your energy reserves are exhausted.

As you swim, swim, *swim*, you encounter a change in the water—a physical force that pulls at you. You are near the end of your energy reserves and you can't fight the force. When you finally give in to this pull, allowing your body to move and drift with the water, you find that you travel faster and you can rest a little. You have encountered a surface current that helps you move away from shore, away from the near-shore predators, the hungry birds and fishes that are interested in eating you as an afternoon snack. As you ride the current, this oceanic highway, you encounter some floating algae—brown and tangled, it traps water at the surface of the ocean, wrapping you in warmth. You climb on top of this algal mat and finally rest.

You are safe.

This new home buoys you as you travel. The sun rises and sets, rises and sets. At night, overhead you are surrounded by a bowl of darkness with the twinkling lights of the stars, and the glow of the moon. This new home continues to slowly drift along the oceanic highway. Sometimes, in the middle of the ocean, the winds start to blow, causing the waves to get larger, crashing on top of you and your algal home. When this happens, your home starts to break up—bunches of algae float apart from each other, diminishing your safe, warm, food-filled algal home until it is scattered over kilometres of ocean.

You realize that you generally know where you are in the world—you were born with the ability to sense the Earth's magnetic field—you have an internal "map" sense, similar to an internal GPS or compass. So, when you feel the temperatures dropping too much and your body and limbs start to slow down due to the cold, or when you start traveling to places that are too far to the north or south, away from waters where you are most comfortable, you *know* you must move, and travel back to the safety that is ingrained in your understanding of where you are and where you should be. And if you are lucky, you are able to find more of the brown, floating algae that provides warmth, food, and safety from predators lurking—swimming and circling—below your perch on top of the tangled habitat. While you drift with the algae, you bask in the warmth of the sun. This warmth makes you hungry and you find plenty of food lurking in the tangled algal mats you call home. You are cold-blooded; the more you eat and the warmer you are, the faster you grow—outgrowing the jaws of those predators who live and wait, hungry, just below you.

The years pass.

You have grown larger than a dinner plate or even a toilet seat. You find you can dive deeper and deeper, relying less and less on the sea surface as a place of safety. You can now hold your breath longer and you find that you are able to outswim and outsmart some of those predators that lurk in the waters beneath. You need more and more food to sustain your larger size—food that isn't available in the quantities you require in the open ocean. These resources are thousands of kilometres away, in those treacherous, predator-filled coastal waters that you first encountered as a hatchling. So, you slowly make your way back. Perhaps you use your innate compass sense and your "GPS superpower" on your return journey, or perhaps you simply follow the currents. You are bigger now, no longer the snack-size of a deck of cards, making it harder for other creatures to eat you.

As you transition back to coastal habitats, your diet changes and you start spending more time at depth, diving through different temperature layers searching for food on the seafloor. You no longer nibble on the small creatures found hiding in floating algal habitats offshore. If you are a green sea turtle, you may become a vegetarian—a coastal lawnmower, grazing on seagrasses and algae found growing in shallow coastal waters. If you are a loggerhead, then *you* become the terror of the same creatures that once would have eaten you! You develop a taste for crabs, those scary creatures that once chased you as a hatchling. You discover that your powerful jaws are built to crush and you start feeding on whelks, horseshoe crabs, and other crunchy creatures. But the abrupt changes to your diet combined with diminished resources or polluted waters can stress your body. You may get sick, or become infected with a virus that causes tumors to grow on your skin. You might have hitchhikers join you on your travels. Algae or barnacles may grow on your back, or little crabs, leeches, and other small creatures may make a home on your body. Too much algae or too many creatures may slow you down, making it harder to swim through the water.

From your oceanic home, you have migrated to coastal foraging grounds—areas along the shallower continental shelf waters or closer to land within bays, lagoons, and rivers. Some of these foraging grounds may be too cold for you in the winter, so when the temperatures drop at the end of the summer and the days grow shorter, you become restless and feel the need to swim, swim, *swim* out of the cooling waters. You may spend the winter on the edge of warmer currents within deeper shelf waters. You bide your time, waiting for the seas to warm in the spring so you can follow the warming temperatures back to the productive foraging grounds you visited before. Back to the bays, lagoons, and rivers that provide a banquet of prey for you during the warm months, making the winter wait worthwhile. You face a number of threats in these coastal habitats. Human activities are *everywhere*; any time you travel between habitats, you swim through a gauntlet of fishing gears, boats, and unhealthy waters that assault you and your senses. Over time, the once-abundant food in your foraging areas may become scarce, causing you to spend more and more energy searching for the resources that will help you grow, grow, *grow* to maturity.

Decades pass.

If you are clever and fast enough to avoid the increasing human presence in your coastal home, you mature into an adult female, ready to reproduce. Your growth slows, your hormones change, and you feel the urge to migrate back to those beaches that you crawled down decades before as a hatchling. You feed, feed, *feed* in anticipation of your reproductive migration—fuelling up for the long journey back to your natal beaches, because you know you won't eat again until much later. You might use your "GPS superpower" once again to return to the region you "bookmarked" in your brain when you were a hatchling. To the same beaches that your mother, your grandmother, sisters, and cousins all return to every few years, to find mates and to lay eggs.

During your journey, you bump into male turtles who will court you by gently biting the back of your neck and rear flippers. Those that you like, you will choose as your mate. You have your pick; more than one is successful in getting your attention! Those that you don't like, you treat them like any other predator and try to swim away or hide from them on the seafloor. And then, when you are "home", back in your natal waters, you prepare to leave the ocean and return to the beaches where you once hatched. When the sun goes down, you swim towards shore, getting pushed by the waves towards the beach, where you emerge from the water and slowly drag your now enormous body across. Your vision blurs and things are not as clear to you as they are underwater. The beach is different than you remember. More lights. You get a bit confused, unsure of where to go once on the beach. There are many artificial lights glowing on the beach and you aren't sure if you should be scared of or attracted to them.

The beach is different than you remember.

There are more signs of humans and the creatures that humans attract—raccoons, dogs, coyotes, even armadillos. Your perception of the beach environment has changed now that you are an adult female turtle. What once were rocks, hills, and mountains are now small shells or ripples in the sand made by human footprints or human vehicles. The beach is smaller, due to human development and storm erosion. You *need* to find a suitable place to lay your eggs. Somewhere that the eggs will be safe and protected from terrestrial predators, high tides, and beach erosion. You will dig, dig, *dig* your nest patiently, slowly. You carefully lay your eggs, then cover, cover, *cover* them. You will leave them there on the beach, incubated by the sun and the warmth of the sand, until your hatchlings emerge, just like you did many decades ago. You will repeat this process for more than a month, returning to lay more eggs every week or two.

When you lay your last nest of the season, you start the long migration back to the foraging grounds you know, where you will find food to recover from the excitement of the last several months. You will remain on these foraging grounds for a couple of years. Banking more energy to make the long migration—the remigration—back to your natal, and now nesting beaches to mate, and lay more eggs before once again returning to your foraging grounds to refuel.

Over the decades, it becomes harder and harder to find the food and energy you need to make this mating and nesting migration. You once only needed two years to refuel, but now it may take you three or four years to bank the energy needed for the long trip home to your natal beaches. And over the decades, you notice that there are more and more changes to those nesting beaches—more erosion and habitat loss, obstacles like seawalls appear, blocking your path up the beach to lay your eggs. It now takes you even more time and energy to find safe places to lay your eggs; you may not have the energy to nest as many times as you once did.

Sea turtles have been following this life-long pattern of migration and movement across varied habitats for millions of years and you are no different. You continue to repeat the cycle of foraging, migrating, mating, nesting, migrating, foraging until you are too old, or until the threats from humans make it impossible for you to continue. Or, perhaps, until humans realize how their actions and activities may make you work harder, harder, and *harder* to achieve your basic life goals: to survive, to thrive, and to reproduce.

There is a human idiom that states before you judge someone, you should walk a mile in their shoes. What if we humans tried to swim a mile, or thousands of miles with your flippers? We humans are terrestrial creatures and experience the world differently than sea turtles; we lack the same sensory "window" and capabilities to sense and experience the world as turtles do. Sadly, humans can't sense the Earth's magnetic field and we don't have an innate sense of place. Like the young, oceanic stage sea turtles, we, too, must remain close to the sea surface to breathe. We can sometimes feel layers of temperatures when we wade into the ocean, or be buffeted by currents. But we do not have to swim thousands of kilometres to reach our destinations, so we may not realize that there are hidden highways, currents, within the oceans that can help a turtle travel from one place to another. And we may not realize that our actions add up over time, over the lifetime of sea turtles, making their lives so much harder. Maybe, if humans could better understand and imagine what sea turtle lives are like, it is then possible to define effective conservation measures to better protect them from the gauntlet of human activities that turtles encounter over the course of their long, long, long lives.

Further Reading

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WRITTEN AND PRODUCED BY

KARTEL SHOCKINGTON

VISUAL EFFECTS BY

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It is the year 2084.

The word has successfully rid itself of all non-vegetarian, pescatarian, lacto-vegetarian, ovo-vegetarian, lacto-ovo vegetarian, and other contrarians. Only vegans remain, led by their Supreme Leader, Wonald Vegan. The only butcher shops are in the museums of horror. Fishing fleets have been converted into game parks. Poultry and dairy farms lie vacant, and grass, unleashed from the pressures of herbivory, runs amok.

Wonald Vegan was a meat-store truck driving man. He was the head of the chunky chicken (coo clucks) clan. But one day, he had a dream, or maybe it was a vision. Anyhow, it had funky colours and harps. He saw the souls of a million slaughtered animals. He heard the voices of those clamouring to be saved. He hears them still.

Now he rules with a steely eye. No one is allowed to so much as look askance at an animal. Anywhere, anyhow. Birds chirp, fish jump, and frogs frolic. They need no longer fear the hungry human. A world without butchery and pain. Or domestic animals. Since they were no longer needed, the last one died in 2069. In an Orwellian twist, pigs survived.

Wonald Vegan rules with a vengeful verb. His language police ensure that no one says things such as 'Can you flesh that out?' or 'I've got a frog in my throat' or 'Get the monkey off your back'. If the 'cat has got your tongue', then in all fairness, it must literally be so. And of course, you cannot 'let the cat out of the bag', because the very thought of a cat in a bag can unleash mobs. And, needless to say, it cannot 'rain cats and dogs'. You are not allowed to 'chicken out', 'pig out', 'go the whole hog' or 'horse around'. You cannot under any circumstances 'take the bull by horns', and the worst offence is, undoubtedly, 'to kill two birds with one stone'.

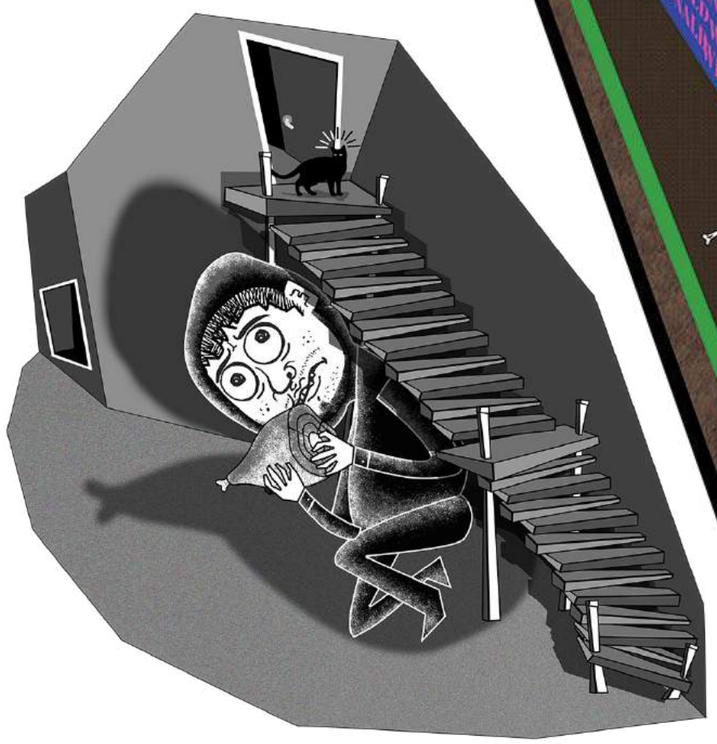
But all is not milk and honey. Because those, of course, are banned. There are many groups that think Wonald's way doesn't go far enough.

The most vocal are the **fakefoodians**, a cult that demands that cruelty to plants must stop. Given all the advances in transgenics and tissue culture, most food can be grown in the lab. Lab cultured food such as 'Beyond beans', 'Impossible potato', 'Benevolent banana', and 'Can't believe it's not tomato' have become the vogue.

Their last press release said, "As we very well know, plants have feelings too. With every slaughtered soy, with every culled cob, with every crying onion, the universe loses an ohm of its resonance. Stop breeding them, stop eating them, stop killing them. Stop it, stop it, stop it now!!!"

And then, there are the **pillpopperians**, a miniscule caucus who believe that all manipulation of living things must stop, including in the lab. They hypothesize that nutritional demands can be reduced to capsules and tablets. They deduce that this will make the world a better place. Their motto is 'Food is falsifiable'. They are a pill.

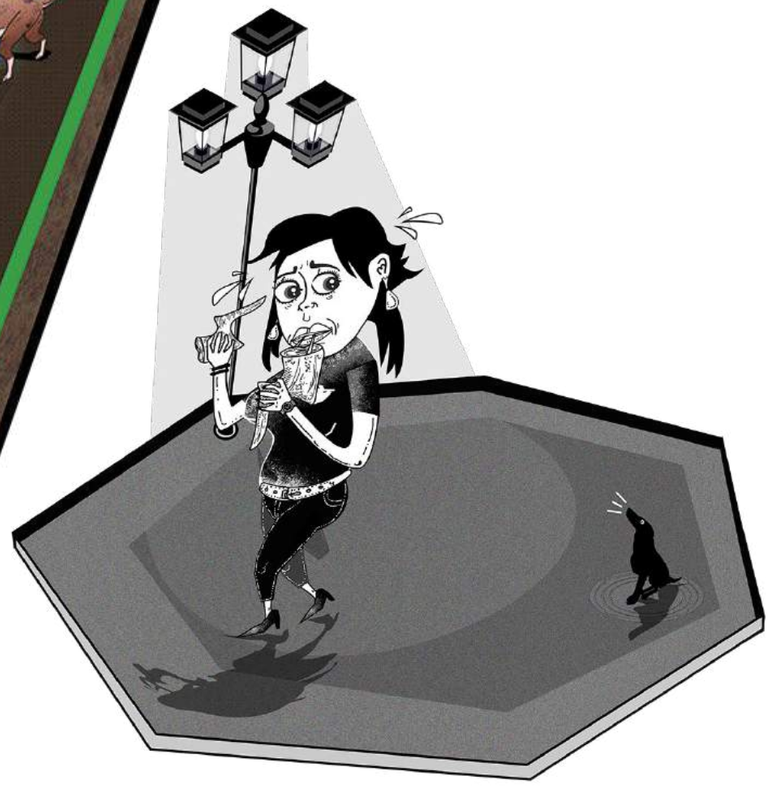
In a far-flung corner are some **freshbytairians**, a commune that genuinely believes that one can survive on love and fresh air alone. Fights break out constantly between the love faction (heart-throbs) and the fresh air fraction (airheads) about how much of each is required. But these don't last long, as they run out of energy pretty quickly.



Another problem exists. In this world, animals are still allowed to kill each other. One clique thinks this is wrong. The **antipredatorians** have been campaigning for (a) the genetic modification of all predators, or (b) the supervised extirpation of all predators. An extreme subgroup that fights for universal plant rights argues for the extirpation of all animals.

And some are just confused. There is a contingent who flip-flop between cults, caucuses, communes, and cliques. They have been variously described as irksome, exasperating, maddening, and vexatious. The **calendarians** have a specified belief system for each day of the week.

But none trouble the Great Wonald as much as the **meatheists**. Different camps of these primitive tribes are believed to live deep in forests, where some have learned to hunt, fish, farm, and brew their own booze.



Wonald's blood boils when he thinks of them. We managed to acquire a transcript of a conversation between Wonald Vegan and his trusty sidekick, Franny Fruitloops, as they plan a definitive campaign to shut them down.

Wonald's World may be here to stay.
Or maybe there will be another revolution.
Or then again, perhaps this is the end, my friend.

Kartel Shockington *is a failed comic book creation with special powers of rapid hair loss. He sometimes appears as Kartik Shanker, and at other times as Dan Brockington.*

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