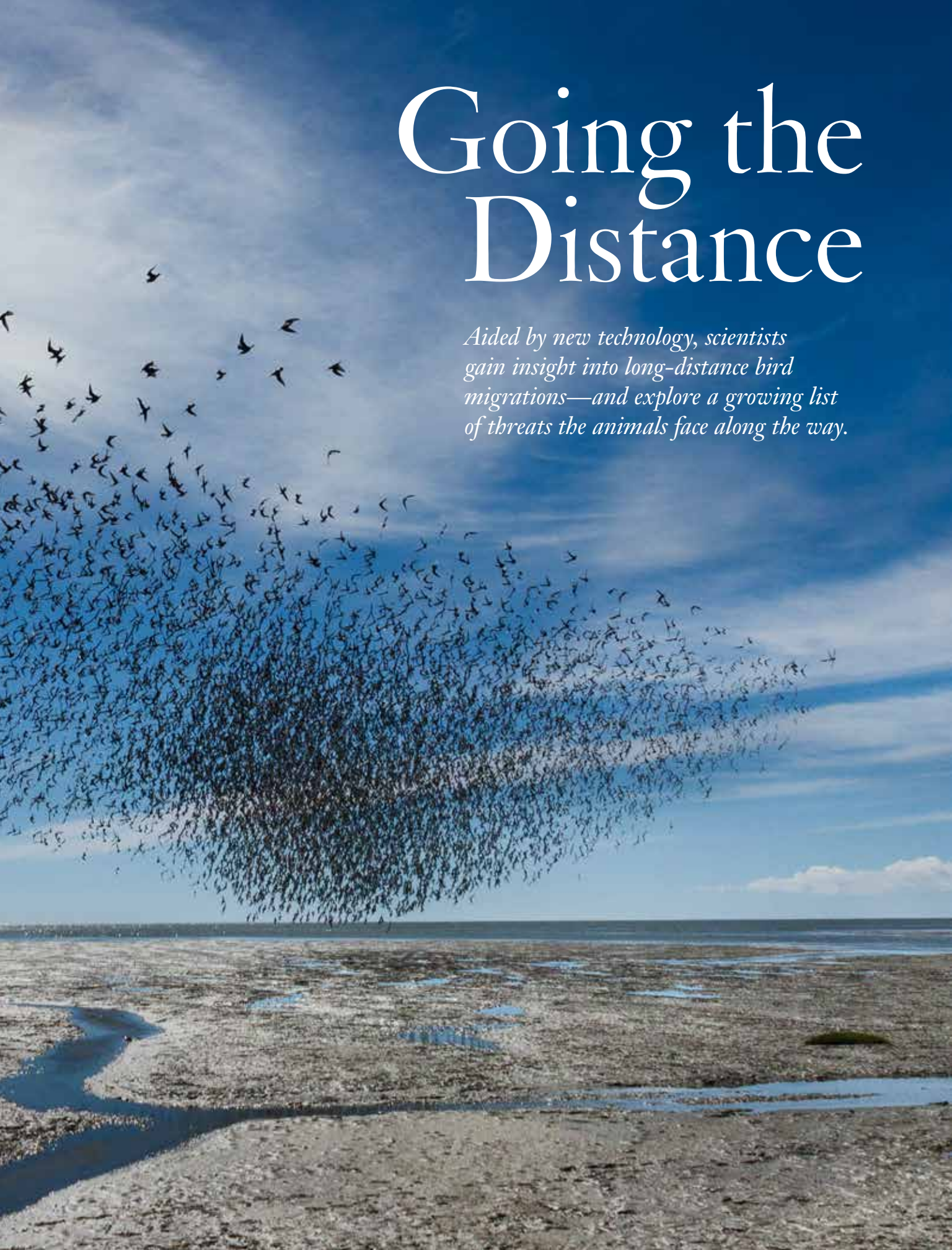
Hudsonian godwits, red knots and other shorebirds funnel into Tierra del Fuego near the southern tip of Chile, where they will spend the winter. The red knots have migrated more than 9,000 miles from their Arctic breeding grounds.

ANTONIO LARREA



Going the Distance

Aided by new technology, scientists gain insight into long-distance bird migrations—and explore a growing list of threats the animals face along the way.

By Barry Yeoman

KUZEYDOĞA SOCIETY (KUZEYDOGA.NET)

Just before afternoon thunderstorms blew into Turkey's Aras River Valley on a humid day in 2014, Joshua Horns held a great reed-warbler in his hand. The University of Utah conservation biologist and his colleagues had been monitoring the bird's migration using a tiny device, called a geolocator, strapped to its back. Earlier, Horns had spotted the warbler nesting in a swamp near the bird-banding station where he worked. He climbed into his waders and bushwhacked through the reed beds until the mud rose to his chest, then set up a speaker to broadcast a recording of the songbird's high-pitched call. Horns waited until the warbler chased the sound into a mist net. He quickly freed the bird, removed the geolocator, swapped in a new device and marveled at what would likely occur during the coming months.

ALAN MURPHY (BIA/MINDEN PICTURES)

BRAD WINN

Like many birds that migrate long distances, the cerulean warbler (left) and *rufa* red knot (below right) have declined significantly. To help stem such losses, scientists are mapping avian migratory routes using tiny tracking devices such as the geolocator affixed to this great reed-warbler (below left) in Turkey.

"Within one year, this bird is going to be in conflict zones in Syria," Horns remembers thinking. "It's going to be in coastal resorts in Yemen. It's going to be in tropical rain forests in Mozambique. It's going to see deserts and oceans and mountains. And if you're really, really, really lucky, this bird is going to undergo this 6,000-mile journey, then return to the exact same 20-by-20-foot square plot of land where you saw it 12 months before."

A banding-station volunteer snapped a photograph of that moment. It shows the warbler with its big brown head cocked to the right, looking into the shaggy-haired scientist's eyes. Horns returned the gaze. Then he let go.

Technology transforms research

The data carried on that warbler's back embody a transformation in how scientists study bird migration. New technology is helping researchers understand both where birds travel and why they make the dangerous journeys at all.

Such information couldn't be more timely. Migratory bird populations are in trouble globally, in large part because of human factors such as climate change and habitat loss. More than half of all neotropical migrant species—birds that breed in the United States or Canada during spring and summer, then fly to the Caribbean or Latin America for the winter—have shown steep losses over the past few decades, including the wood thrush, Canada warbler and cerulean warbler. In Europe, birds that commute up to thousands of miles to winter in sub-Saharan Africa are declining faster than those that stay home or travel shorter distances.

One key to stemming these losses is mapping the birds' migrations—not just the end points, but also the stopovers in the middle—and identifying the areas that need protection. "We need to know how to target limited conservation dollars," says Kristen Ruegg, an evolutionary biologist at Colorado State University.

As co-director of the Bird Genoscape Project, Ruegg is harnessing the genomic revolution to help identify those critical areas. By analyzing feather samples collected at bird-monitoring stations across the Western Hemisphere, she and her colleagues are identifying DNA markers that allow them to distinguish different populations within the same species and track their distinct migrations. So far, the project has amassed 250,000 feathers from more than 50 species and built population-specific genetic profiles of 14 North American migratory

Disoriented by the bright light, scores of birds heading south for the winter swirl in confusion—wasting precious energy—around New York City's Tribute in Light to victims of the September 2001 terrorist attacks. Today, volunteers monitor the beams so they can be shut off when large numbers of birds (visible here as white streaks) get too close.

bird species, from raptors to waterfowl to songbirds. She hopes to reach a hundred species by 2025.

The most talked-about innovations are lightweight tracking devices such as the geolocators Horns used in the Aras River Valley. As recently as 2007, scientists lamented that even the smallest gadgets were too heavy for most bird species. Since then, trackers have become 90 percent lighter—in Horns' case, less than half the weight of a dime. Some detect light and then use sunrise and sunset times to estimate a bird's latitude and longitude. (To retrieve these data, researchers must recapture the bird.) Others, miniaturized more recently, connect to GPS satellites. In some cases, scientists can access the data on these devices without removing them from the animals.

Of the 30 great reed-warblers Horns and his colleagues outfitted with light-detecting geolocators in Turkey, five returned and were recaptured over the next two years. Based on the data contained in their geolocators, he learned that during spring migration, the birds rest and refuel near the Red Sea coast before beelining across the arid Arabian Peninsula to the wetlands of central Iraq. The warblers cross the Red Sea at a narrow waterway called the Bāb al-Mandab Strait.

The birds' route "suggests that having good habitat before and after the ecological barrier of the Arabian Desert is very, very important," Horns says. "Otherwise, they won't be able to find the amount of food they need, or they won't be able to replenish their energy reserves enough to complete the migration."

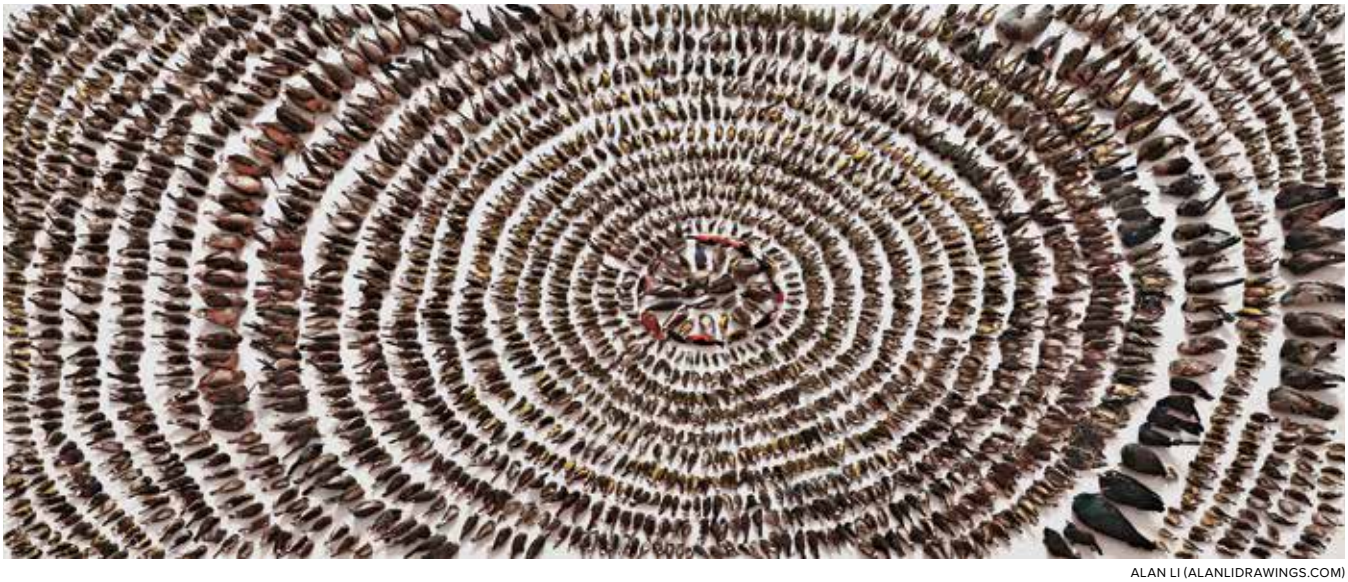
The area surrounding the Bāb al-Mandab Strait, however, like much of the warblers' migratory route, has little or no legal environmental protection. "So we have this perfect storm," Horns says. "We have lots of birds"—possibly more than a million—"migrating into a narrow geographic band and presumably relying heavily on the habitat there. But there's no real regulation to prevent that habitat from being degraded." His discovery has helped clarify where conservationists need to focus their work.

Though great reed-warblers themselves are not in danger, they serve as proxies for all African-European avian migrants that require wetland habitat. According to Horns' analysis, 54 of 80 bird species that live exclusively in wetlands are at risk of extinction. "By tracking this non-threatened species," he says, "we're able to find areas that are critical for other migratory wetland species that are either too small or too threatened to follow."

Why do birds migrate?

Along with *where* birds migrate, scientists have long been fascinated with *why*. The traditional explanation is that a bird, or a population, maximizes its own benefit by following the most abundant food and best nesting opportunities.

Others offer more innovative explanations. University of Michigan ornithologist Ben Winger suggested last year in the journal *Biological Reviews* that birds "travel long distances simply to stay in the same place." In other words, their migration patterns have evolved to return them efficiently to their established breeding grounds. "The first



ALAN LI (ALANLIDRAWINGS.COM)

Thousands of birds killed by crashing into buildings—from waxwings and woodcocks to warblers and bluebirds—are displayed by Toronto's Fatal Light Awareness Project to make the public aware of the problem.

LEFT: JOHN DE GUZMÁN

STOCK CONNECTION BLUE (ALAMY STOCK PHOTO)

Ignited to clear land, fire razes a rain forest in the Amazon (above), one of the most threatened habitats on Earth. Hundreds of bird species that breed in North America in summer, including the Canada warbler (right), seek shelter in tropical forests in winter. The warblers' numbers have fallen by 63 percent since 1970.

NWF PRIORITY

Fighting tropical deforestation

For more than 30 years, the National Wildlife Federation has worked to reduce deforestation in South America, whose forests and savannas not only house an astonishing diversity of year-round wildlife species but provide winter habitat for neotropical migrants: birds that breed in the United States or Canada, then fly to the Caribbean or Latin America for the cold months. To fight unsustainable agriculture and other actions driving deforestation, NWF collaborates with local partners and business leaders to craft solutions that help local communities, companies, wildlife and the environment. See: international.nwf.org.

to make a territory, or the first to lay eggs—oftentimes the young end up hatching with greater success and the parents produce more offspring," he says.

Pulling the lens farther back, macroecologist Marius Somveille, a postdoctoral researcher at BirdLife International, decided to consider all the world's birds part of a single system. He wondered why some birds migrate long distances, while others fly shorter distances and others not at all. "Can we explain them all together with a single model?" he asked.

To find out, he developed a computer model creating a simulated world that contained the same food distribution as the real one. This "virtual world" began birdless, and then Somveille introduced "virtual species" one by one.

He already knew that individual birds try to maximize their energy (food) intake while limiting how much energy they use to fly, reproduce and keep their bodies warm. They're also influenced by competition from other birds. "It would be better to live in a desert, alone, than to live in a very rich forest that's extremely crowded," he explains.

Somveille programmed his model to maximize energy efficiency. "Each species would have to decide whether to be a resident or whether to be a migrant and where to

ROBERT ROYSE

go," he says. When he ran the model, the results looked much like real-world migration patterns—and suggested that birds use migration to distribute themselves globally in a way that collectively maximizes energy efficiency. "I expected it to work, but not that well," Somveille says. He admits that his simulation is "crude"—for example, it doesn't include the intermediate stops a bird might make along the way. Modeling the full migration paths, and comparing them to GPS data from tracking devices, will be the next step, he says.

Perilous journeys

While scientists debate the reasons for migration, there's no doubt that these journeys are dangerous. For some species, up to 85 percent of all deaths occur as birds are traveling to their wintering or breeding grounds. Human activity is by far the greatest threat. Urban lights, for example, can disorient birds, which rely on starlight for navigation and on certain light frequencies for their internal compasses. In particular, intense light sources such as spotlights and sport stadiums can lure them off course.

"If they circle for five hours, then they've essentially wasted a whole night not moving anywhere and burning fuel that probably took at least a week to acquire," says Colorado State University ornithologist Kyle Horton. "Maybe that bird doesn't die. But maybe it's now a week behind in getting to its breeding destination. A delay of a week could have a big consequence on the success of a bird's breeding." Writ large, he adds, that "could depress bird populations."

A poster bird for migrants in trouble is the *rufa* subspecies of red knot, some of which migrate more than 18,000 miles a year between the tip of South America and the Canadian Arctic—one of the longest annual journeys made by any migratory bird. Federally listed as threatened, the large sandpiper is finding it harder and harder to survive dangers along its route—from oil spills in the wintering grounds to coastal development to a history of overharvesting horseshoe crabs in Delaware Bay, a migratory pit stop where the crabs' eggs are vital food for the birds.

What's more, rising sea levels and fiercer storms linked to climate change are swallowing up much of the red knot's coastal habitat. Climate change threatens other migratory birds as well. Scientists are concerned, for example, that migrants will no longer be able to coordinate their travel to take advantage of the foods they need to fuel the journeys.

"A lot of species have been using the same pathways and same timing for thousands of years, maybe millions," says University of Utah ornithologist Çağan Şekercioğlu, co-author of *Winged Sentinels: Birds and Climate Change*. "Especially in the spring, they will leave the tropics, where climate is still relatively stable, and then go to the temperate zone, where you have much faster climate change."

At higher latitudes, spring conditions are already arriving sooner. While species such as butterflies may be able to respond fairly quickly—by laying eggs earlier, for example—migratory birds that are coming from Central America, the Amazon Basin or the Andes "have no way of knowing that spring has come weeks earlier up in Minnesota," Şekercioğlu says.

Climate change has additional impacts, though none are fully understood or quantified. As scientists double down on research, they say we already know enough to sound the alarm. "More extreme weather events—more powerful hurricanes, more powerful snowstorms, rainstorms—are going to increase the mortality of migrating birds," says Şekercioğlu. "This is harder to study. But it is easy to predict."

Barry Yeoman wrote about the problem of ocean plastic pollution in the June–July 2019 issue.

» *Learn more about how climate change is affecting migratory bird species at nwf.org/shiftingskies.*