Up Front

Follow the Songbird

Isotopes tell a tale of bird migration and may help with efforts to conserve natural habitats.

Field biologists have long been trying to discover exactly where migratory animals go on their seasonal journeys. In a world of rapidly vanishing habitats, such insight would help those trying to protect sensitive lands. With more than 20 percent of the world's forests having disappeared in the past 300 years, habitat loss ranks as one of the biggest threats to wildlife, especially migratory birds, which rely on two locations—a winter and a summer home—for shelter and food.

Dustin R. Rubenstein, currently a Cornell University graduate student in behavioral ecology, concentrates on migratory songbirds. These small, hard-to-observe creatures are especially vulnerable because many of them depend on large, uninterrupted tracts of forest to survive. The challenge for field biologists, says Rubenstein, an HHMI predoctoral fellow, has been overcoming the "needle in the haystack" limitations of traditional capture-and-recover field studies; thousands of birds may be captured and fitted with leg bands, but only a few are ever recovered once they complete their migratory journeys.

As an alternative, Rubenstein, 25, in collaboration with Dartmouth College biologist Richard T. Holmes and Stanford University geochemist C. Page Chamberlain, started monitoring stable isotopes—alternative forms of chemical elements—that exist naturally in the environment. They capitalized on a technique, pioneered by Chamberlain, that uses the "chemical signature" of stable isotopes locked in birds' feathers to tell where a bird has been spending its time.

The stable isotopes of elements such as carbon, hydrogen, sulfur and strontium form durable patterns in the soil that vary predictably from place to place and can thus serve as tracers. Taken up by plants, isotope signatures are subsequently expressed in the insects that eat the plants and, ultimately, in the birds and other animals that eat the insects. "You are what you eat," says Rubenstein. In birds, these signatures manifest themselves in the chemical makeup of the feathers and thus can serve as natural markers for where a bird has been. By sampling a single tail feather from a captured bird or even a museum specimen, scientists can identify where a bird lived. The isotopic signature reflects the latitude at which the bird has been living and where it grew new feathers.

As a Dartmouth undergraduate on an HHMI research internship, Rubenstein helped orchestrate one of the first comprehensive studies using stable isotopes to ferret out the closely held secrets of a particular migratory songbird, the black-throated blue warbler—a species that summers and breeds over a deep swath of eastern North America (from Ontario to Georgia) and winters in the Caribbean. In the process, he and colleagues discovered "the astonishing fact that warblers from different breeding regions have distinct migratory patterns"—a discovery that not only revealed a previously unknown migratory behavior of the black-throated blue warbler in particular but, by extension, raised the possibility that many other migratory songbirds might behave in the same way.

Their findings, published in the February 8, 2002, issue of *Science*, showed that the warblers that summer in northern sections of North America tend to winter in the western Caribbean and those that summer in the southern United States winter in the eastern Caribbean islands.

To learn where the migrating birds were coming from as they traveled south for the winter, Rubenstein and his colleagues first determined the isotopic pattern found in

DANIEL FAZER (MAP), COURTESY OF LARRY MASTER/NATURESERVE

THERE IS A SEASON **Black-throated blue warblers (right) that spend their summer breeding time further north, between Michigan and New Brunswick, Canada, tend to winter in the western Caribbean. Warblers that summer as far south as Georgia migrate to the eastern Caribbean islands for the winter.**

MICHAEL GREENLAR

Dustin Rubenstein studied the isotope signatures in thousands of warbler feathers. He hopes his work will expose the impact of deforestation and habitat loss.

feathers of birds whose breeding locations were known. They then compared those signatures with the isotopic signatures extracted from birds of unknown breeding location caught in their wintering grounds.

"Isotopes have been used [before] to study bird migration, butterfly migration and fish migration," says Rubenstein. "Our study, however, was the first really comprehensive one that sampled birds from across a species' entire breeding and wintering range." It illustrated the technique's promise not only for field biology but also for conservation—by linking declines in regional summer populations to environmental change occurring where the birds spend their winters. "Variable rates of deforestation and habitat loss on the different Caribbean islands may affect some breeding populations more than others," says Rubenstein. The severe deforestation occurring in Haiti, for example, is thought to be contributing to the decline of the black-throated blue warbler's southernmost breeding populations (those birds that spend their summers in Georgia and North Carolina), which usually migrate to the more easterly islands of Hispaniola—where Haiti is located—and Puerto Rico for the winter.

The stable isotope method as used by Rubenstein "is a way to investigate in some detail where some birds are spending the winter," according to Kevin J. McGowan, a researcher at Cornell University's Laboratory of Ornithology. "It's surprising what we don't know about the wintering ranges. For a lot of birds, we just don't know where they go. It's impossible to watch these behaviors unfold across the surface of the globe, and when we get access to tools like this, it really helps us out."

Rubenstein, Chamberlain and Holmes believe that their recent work sets a standard for other studies that seek to reveal the hidden lives of wild animals. And Rubenstein's contribution, say his senior colleagues, notably transcended its original purpose as a senior thesis at Dartmouth.

"When Dustin came on board, he was facing a tremendous amount of work, much more than a traditional thesis would require," says Chamberlain. "The number of analyses on one species—numbering in the thousands—is unprecedented, and without him pushing to do this, the study never would have been done. It's the kind of work that was Ph.D. quality."

To publish in *Science* as an undergraduate was testimony to the quality of the work, note both Holmes and Chamberlain. For Rubenstein, the achievement was a kick, he says, but he adds, "It's somewhat daunting since this was my first paper. I hope I haven't peaked this early in my career."

—TERRY DEVITT