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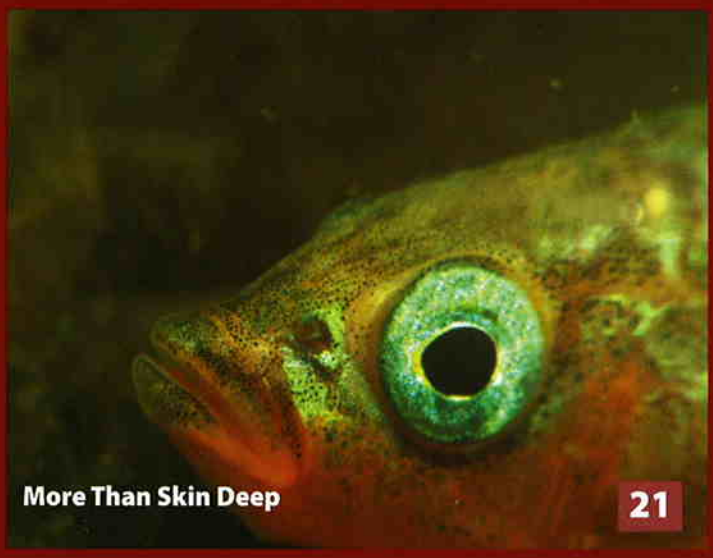

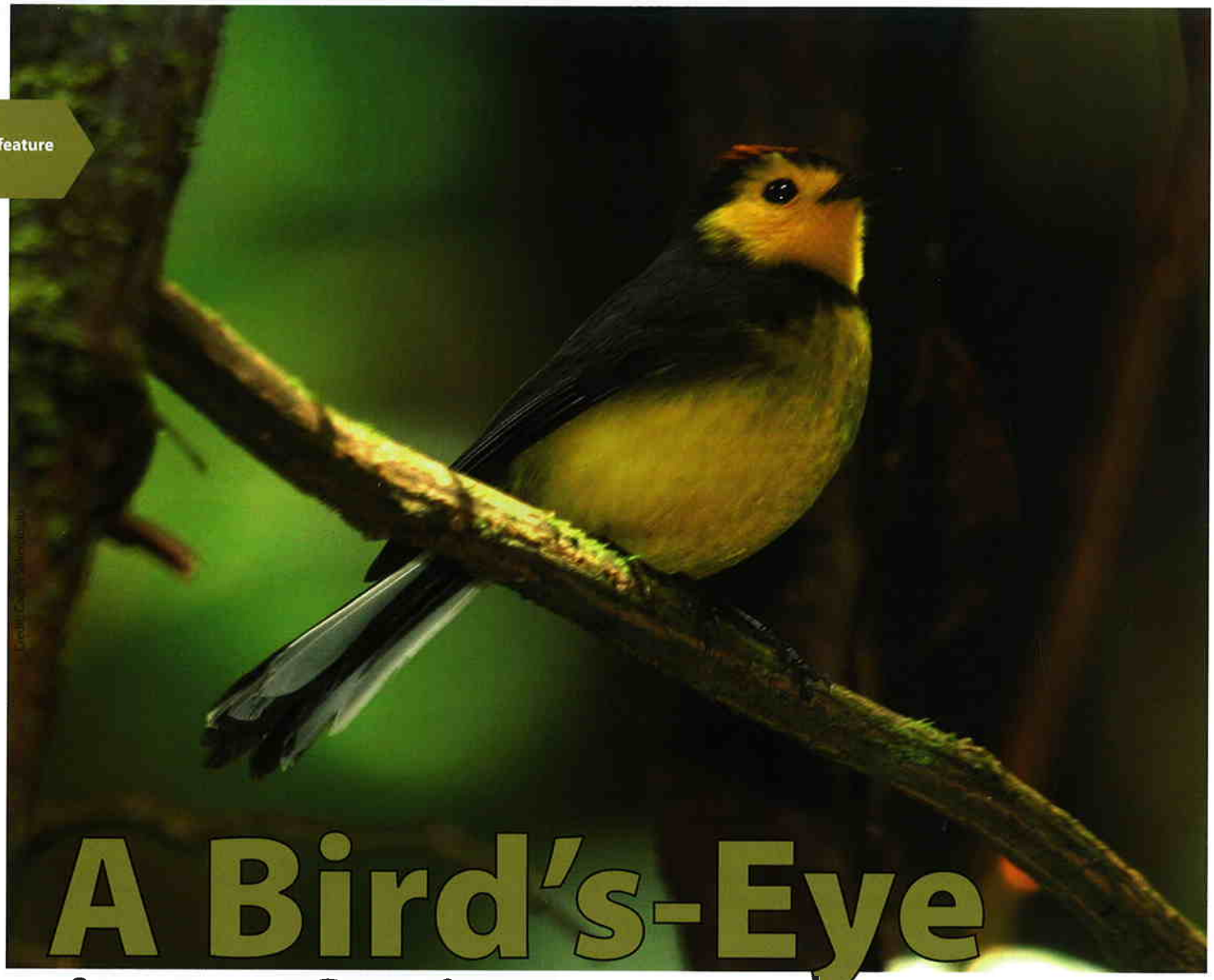

A Bird's-Eye View of Climate Change

Models Indicate Bird Extinctions Rise with Global Temperatures and Habitat Loss

by Rachel Adams

Humans have the rare ability to live at extreme elevations, ranging from 400 meters below sea level at the Dead Sea to 6,000 meters above sea level in the Qinghai-Tibetan plateau. Birds, on the other hand, cannot tolerate the variation in climate across such a broad elevational range and instead tend to occupy an elevational range of about 2,000 meters. To meet specific temperature and precipitation requirements in the face of global warming, many plants and animals are shifting to higher elevations. These shifts make the species vulnerable to extinction, and models by Stanford scientists published in the February 2008 issue of *Conservation Biology* show that as the world continues to warm and lose native habitats, bird extinctions will become more common. In the worst-case scenario, nearly one in three landbird species worldwide could be extinct by 2100.

The Connection between Elevational Range and Extinction Risk

Soon after Cagan Sekercioglu, Ph.D came to Stanford in 1998 as a senior scientist for the Center for Conservation Biology in the Department of Biology, he began to accumulate what he calls "the most extensive bird ecology database in existence." The database now contains over 600,000 entries, and it continues to grow. It is now an excellent resource for both basic science and conservation efforts, so much so that Birdlife International has requested to collaborate.

The breadth of the database also makes it a powerful tool for exploring new patterns, including the observation that a narrower elevational tolerance is correlated with a higher extinction threat. Both are associated with limited habitat. Sekercioglu recalls, "I did not set out to show a large number

(left) The Collared Redstart (*Myioborus torquatus*) lives in cloud forests in the mountains of Costa Rica and western Panama. The unique habitat in which it lives has already shown shifts in elevation, and the bird itself may soon follow this shift. (below) The Rainbow-billed Toucan (*Ramphastos sulfuratus*), which has the most colorful beak of all the toucans, is the national bird of Belize, but has a broad geographic distribution from southeastern Mexico to Venezuela. While it is normally restricted to lower elevations, it is already moving upwards to the montane forest habitat and competing with native species there.

of birds were under threat of extinction. Instead, I wanted to use the database to look at the ecological consequence of bird extinction, and this striking pattern emerged."

Modeling the Effects of Climate Change on Landbirds

Sekercioglu teamed up with Stanford climate change specialist and Biology Professor Stephen Schneider, a former Geographic Information Systems guru from the Center for Conservation Biology John Fay, and a Duke University Ph.D. student and former Stanford co-term Scott Loarie to model how the elevational range limit of bird species will shift due to anthropogenic changes on the earth. They used predictions of global warming recently generated by the 2007 Intergovernmental Panel on Climate Change (IPCC). Additionally, the authors included estimates on habitat loss under different scenarios produced by the Millennium Ecosystem Assessment. Lastly, the authors incorporated different physiological responses, such as heat tolerance, of the birds to elevational shifts.

Their model combined these predictions in unique ways to test sixty different scenarios. The goal was to approximate the number of landbird species, representing over 85% of all bird species that would become extinct or threatened with extinction as a result of change in elevational range limits. The estimated number of extinctions by 2100 ranged from 100 extinctions with the least surface warming to 2,500 in the worst-case scenario. Landbirds at risk of extinction stretched from 1,770 to 2,650 species, compared to 1,615 species at risk today. Overall, with the intermediate scenario of 2.8°C surface warming, about 2,150 species would be threatened and another 400 to 550 bird species would go extinct, with the spread depending on the amount of habitat loss.

Responses to Climate Change Vary by Habitat and Species

The detrimental effect of a combination of climate change and habitat loss is partly explained by the shape of mountains. Since mountains narrow at the top, the higher in elevation you move, the less land area there is at that elevation and consequently the more restricted your geographic area becomes. "A 2-meter strip at the top of a 100-meter tall pyramid covers about 1% of the area of a 2-meter strip at the bottom," explains Sekercioglu. "Even if a species retains its elevational breadth, it will occupy an increasingly smaller area as it moves up a mountain."

Also, geography often does not provide a higher place to go: a lowland bird in a flatland may have no mountain nearby to climb. Likewise, some highland birds are restricted to isolated mountains, and environmental conditions in lowlands may prevent movement to other suitable habitats.

Additionally, not all bird species will respond the same way to a changing climate. Sekercioglu notes, "I have recently shown that migratory bird species are less likely to go extinct than sedentary birds because high mobility provides a way out if a species' habitat becomes unsuitable." In the model's intermediate scenarios, 5% of non-migratory bird species were predicted to go extinct whereas only 1% of migratory ones were predicted to meet the same fate.

Climate change also differentially affects birds with different feeding strategies. Generalist feeders utilizing a wide resource base may be more likely to shift their elevational range independent of other organisms. On the other hand, specialist species require specific plant and animal species for resources, and their shift in elevation may depend on these resources making the climb before or along with them. Both situations break up interacting communities, furthering disturbance and the risk of extinction.

Sekercioglu's database clued him into a previously unrecognized pattern: the narrower a species' elevational tolerance, the more likely it was to be threatened. In fact, the elevational range accounts for 97% of the reason that a landbird species may be currently at risk of extinction. A similar correlation between a species' geographic range and extinction risk had long been known, but Sekercioglu's finding identified another way to tag bird species under risk of extinction. In actuality, elevational range and geographic range are correlated, in that they are related to how broad a resource base the bird species utilizes.

The Mayas and Aztecs called the Resplendent Quetzal (*Pharomachrus mocinno*) the "god of the air." Found in the highland forest from southern Mexico to Panama, it is a species that will be affected by climate change and shifting habitats. In the Monteverde Cloud Forest in Costa Rica, researchers have already documented a drying of the quetzal's montane forest habitat.

Conserving Land and Species

Sekercioglu and his co-authors have conducted some of the first research examining the relationship between climate change and habitat loss. Whereas global warming may alter the elevational range which meets a species' particular requirements, habitat destruction could prevent suitable alternatives; few models have considered both factors simultaneously. The study found that the direct loss of habitat amplifies the constriction of suitable habitat brought about by climate change. For example, under the model's highest degree of temperature change, that of 6.4°C, the number of extinctions nearly doubled depending on the extent of habitat loss.

For most of the bird species, extermination does not appear to loom on the horizon. In fact, two-thirds of the species predicted to become extinct in the next 100 years are currently not even tagged as threatened. Although there is limited evidence for an evolutionary response in birds to climate change, for the vast majority of species, adaptation to an Earth altered by global warming may not occur quickly enough to prevent extinction.

Halting the "Escalator to Extinction"

Sekercioglu paints the picture of an "escalator to extinction." He explains, "Many bird species with a broad elevational range are at the base of the escalator. As the range narrows the bird species moves onto the escalator. As a warming climate and the loss of habitat continues, the bird species moves farther up the escalator, becoming more threatened, until it gets off the escalator by going extinct."

Despite the dire predictions, not all hope is lost. The model shows a non-linear effect of climate change: the difference in the number of bird extinctions between 4 and 6°C is much greater than the difference between 1 and 3°C. At low temperatures each degree of warming projected a loss of about 100 species whereas at high temperatures the loss is 500 species for each degree of warming. Therefore, Sekercioglu argues, the conclusion that the effects of global warming are already inescapable, that the escalator is in motion and cannot be stopped, is a faulty one. He emphasizes that "even a reduction of 1°C can make a huge difference." **S**

Rachel Adams is a graduate student in the Ecology & Evolution section of the Department of Biological Science. Her mandolin classes are going quite nicely.

To Learn More

For more information, visit Dr. Sekercioglu's website: **http://www.stanford.edu/~cagan/main.html**