The African Gray parrot is a talkative, intelligent, and sensitive animal, seen by some bird lovers as the perfect mix of brains and beauty. Its mimicry is renowned: Say something aloud and it may echo your words in a squeaky, somewhat mechanical voice. If a rainforest animal could express its own thoughts, would it warn us about the perils of global warming? “Heeey, wake upppp! You’re destroying the plannnnnet!” No one knows, of course, if parrots notice climate change or even associate human words with their meanings. However, in an inadvertent, nonverbal sense, rainforest birds like the African Gray parrot are already relaying an important message about global warming through their tropical diseases.
Using birds as research models, San Francisco State University assistant professor Ravinder N.M. Sehgal is helping to provide evidence that environmental change may be fostering the emergence of new diseases all over the world. By testing hundreds of varieties of birds in the African rainforest, Sehgal is attempting to connect deforestation—which contributes to accumulating greenhouse gases—and the rising incidence of tropical diseases worldwide.
Since 1975, the World Health Organization has reported the rise of over 30 diseases new to medicine. The list includes AIDS, Ebola, Lyme disease, toxic Escherichia coli, a new hantavirus, and a range of antibiotic-resistant organisms. Ancient diseases such as cholera, tuberculosis, and malaria are making strong resurgences, as well. Scientists now see evidence that human-modified land changes, including many that contribute to global warming, are primary causes in many of these infectious disease outbreaks.

With this research, Sehgal says, the team hopes to present evidence that deforestation and other causes of global warming are, indeed, increasing the appearance of new diseases and the infection rates of older diseases.

Sehgal, a biologist in the SF State Department of Biology, does field research in the African rainforest. In areas where people have disrupted natural forest habitats, Sehgal measures the prevalence and spread of diseases by sampling bird populations. Scientists have found that birds serve as excellent animal models because they are susceptible to diseases similar to our own yet have none of the socio-economic and cultural patterns that can complicate human research.

Sehgal encounters many forms of habitat disruption, including
deforestation, new farms, irrigation, and urban expansion, all of which can impact the rainforest ecosystem. Deforestation, the most widespread damage, eliminates habitat for wildlife, changes their remaining environments, and alters their food supply. Such alterations touch off a devastating chain of events that compels species to interact with different sets of organisms than they did before. When trees disappear, for example, mosquitoes that once fed on insects living in trees are then forced to feed on other species, including humans. The rise in diseases may stem from the way organisms are adapting to utilize alternative hosts—a process called “host-switching”.

To understand host-switching, imagine that you have a dog whose coat is inhabited by fleas. If you were to disrupt his routine nightly habitat by removing his bed and taking away his favorite sleeping spot, he might jump on your bed and sleep next to you. Some of his fleas would probably hop off of him and land on you. Host-switching is a bit like this but with an added detail: Imagine that those fleas were once able to survive only on your dog’s coat, but now have adapted to living on your skin, sucking your blood, and transmitting their bacteria to you, their new host.

Sehgal suggests that deforestation may be causing actual host-switching in birds that inhabit the African rainforest, and that this phenomenon could be increasing the spread of malaria. At the heart of Sehgal’s research is this question: By changing host-specificity, could bird parasites be switching to other hosts and transferring new diseases or spreading old ones?

**According to ecologists, deforestation destroyed 20 percent of the world’s tropical rainforest between 1960 and 1990.**

Sehgal has studied several types of bird malarial, some specific to particular hosts such as the Olive sunbird, some not. Sehgal thinks that understanding the mechanisms behind host specificity may help explain why tropical diseases are spreading. “Most of the time,” he explains, “malaria doesn’t kill birds. We are studying it because it’s a good model system and we can look at proteins involved in host-specificity.” Details of protein structure in a malaria parasite may shed light on why it infects a particular host—like the Olive sunbird—but then changes and becomes capable of transmission to other species.

Like Sehgal, thousands of biologists and medical researchers worldwide study malaria because it exacts a monstrous toll on humanity. According to researchers at John Hopkins School of Public Health, malaria remains a constant threat to more than 40 percent of the world’s population and kills 1.5 to 3 million people annually. A physician can usually treat a patient if diagnosis comes at an early enough stage. Many cases of malaria, however, are fatal because good medical care is unavailable in remote regions of Africa, Thailand, India and Indonesia. In other cases—including Sehgal’s own aunt in India—patients have access to treatment but fail to seek it out soon enough because they mistake their symptoms for influenza or other conditions.

Historically, French physician Charles Louis Alphonse Laveran first identified the *Plasmodium* parasite that causes malaria in 1880. British physician Ronald Ross later discovered that mosquitoes are the
vectors that transmit the parasite to humans. Ross was the first scientist to use birds as a model for the study of disease transmission, and his work on malaria earned him the Nobel Prize in medicine in 1902.

Sehgal’s own work builds on this research tradition, but, of course, uses modern molecular techniques and also incorporates ecological and conservation data. Sehgal first became interested in conservation during his postdoctoral work with Dr. Tom Smith at the Center for Tropical Research at SF State (now at UCLA.) Immersed in library studies of parasites and blood-smear analyses, Sehgal sought to find the connection between bird parasites and environmental changes. This opened the door to broader questions about the impact of deforestation on disease.

In 2005 Sehgal and several research assistants from SF State journeyed deep into the African rainforest to search for evidence of the premise that higher rates of infectious diseases would exist among bird populations in areas slashed by deforestation. After one arduous hike 30 km into the Cameroon jungle, Sehgal and his research team set up camp. They conducted an assortment of tests such as capturing birds in mist-nets, analyzing blood smears, and measuring morphological differences between individual birds. Back in the lab, they used the data to study the interrelationships of disease vectors, natural hosts, and their environments.

On other trips, Sehgal and colleagues gathered blood samples from bird species that have a wide distribution throughout Africa: the Ivory Coast, Ghana, Uganda, Cameroon and Equatorial Guinea. With samples of pigeons, sunbirds, and songbirds, they were able to track different strains of malaria and measure changes caused by land degradation.

Sehgal continues to collaborate with other scientists at the Center for Tropical Research now at UCLA. The work is part of a multidisciplinary team funded by the National Science Foundation and their Ecology of Infectious Disease Program. The UCLA team is trying to quantify how land disturbances promote disease. They are trying, Sehgal explains, to first measure the degree of host-switching that may occur in various habitats, compare the rates of diseases such as malaria over time in areas with profound changes to natural habitats, and then predict the likelihood that parasites will switch to new hosts in those altered habitats. With this research, Sehgal says, the team hopes to present evidence that deforestation and other causes of global warming are, indeed, increasing the appearance of new diseases and the infection rates of older diseases.

So far, the evidence has been surprising. While the incidence of human malaria has increased in deforested areas, there appears to be a decrease in bird malaria. Why would this be?
“We were expecting to see lower prevalence in the intact forest and higher prevalence in deforested areas. With humans you do find more malaria in the deforested areas but with birds we’re seeing less malaria in deforested areas,” says Sehgal. Researchers believe this may be because disease vectors such as mosquitoes are preferentially feeding on humans rather than birds in the deforested areas. This is simultaneously lowering the rates of bird malaria but raising the rates of human malaria.

According to UCLA epidemiologist Shira C. Shafir, ecologists can already see the impact of environmental changes on these different species. Referring to a “malaria line,” she explains that, in the past, in mountain areas where malaria is endemic, the disease was not transmitted above a certain altitude because temperatures were too cold for disease-carrying mosquitoes to survive. Now, however, with rising average temperature, mosquitoes are surviving at elevated altitudes and this malaria line creeps higher into the mountains, leading to a higher incidence of malaria in previously unaffected populations. “This is one of the greatest global burdens of our times,” exclaims Shafir.

The link between global warming and deforestation is well-documented. Since the beginning of the 20th century, the rate of deforestation has grown rapidly. According to the Food and Agricultural Organization (FAO) of the United Nations, Nigeria lost 79 percent of its old-growth forests between 1990-2005. This conversion of forested to non-forested land for purposes of logging or pasture creation has resulted in a degraded environment and decreased biodiversity. According to ecologists, deforestation destroyed 20 percent of the world’s tropical forest between 1960 and 1990. Estimates of deforestation within tropical rainforests range from about 53,630 to 120,000 square kilometers lost each year during the 1990s. Ecologists predict that at this rate, all tropical forests could disappear by the year 2090. “Aww-wkkkk!” the African Gray parrot might rasp, “All gone by 2090!”

Ravinder Sehgal’s biggest challenge is trying to tackle so many diseases in so many areas with so much disruption. “With such a complex set of variables—climate, species, and land areas—it is hard to get a large-enough sample size of birds with all these various features,” says Sehgal. The other factor is time. “This could take lifetimes to understand.”

In the same breath Sehgal adds, “But Africa is losing 5 percent of its rainforest every year.” He is personally convinced that deforestation is causing rising disease rates. His greatest hope is that proving the link between deforestation and rising human malaria could provide a visible, tangible, self-interested reason for people to begin reducing rainforest destruction. African rainforest birds are echoing this message with their rates of malaria, but are we listening?