PROFILE

# Profile of Daniel H. Janzen

**Tinsley H. Davis,** *Science Writer*

When Daniel Janzen gave his acceptance speech for the 1997 Kyoto Prize, he disappointed many people who had come to hear a preeminent biologist discuss iconic studies, from ant–acacia mutualism to seed predation (1, 2). "They expected a talk about science, but I'd switched to conservation," explains Janzen, DiMaura Professor of Conservation Biology at the University of Pennsylvania. Janzen, who was elected to the National Academy of Sciences in 1992, and his wife, tropical ecologist Winnie Hallwachs, have spent 35 years reframing the idea of national parks into that of collaboration between forests and societies. "The biology is easy, but we have to study society," explains Janzen. "For me, it's all human ecology." Together with thousands of partners, they have developed and expanded Area de Conservación Guanacaste (ACG) in Costa Rica into 168,000 ha of land and sea that, Janzen notes, protect 2.6% of the world's biodiversity, and are now using DNA barcoding technology to create a library of species (3).

## Chance Ant Encounter

Growing up in Minnesota in the 1940s, Janzen quickly became comfortable in nature. "I shot my first pheasant off the back steps, but I could get the bus off the front steps to the Minneapolis public library," he recalls. "I had the best of both worlds." The son of a wildlife management administrator, Janzen's fascination with the tropics began at the age of 14 on a butterfly-collecting trip to Mexico. In 1962, with a BS degree from the University of Minnesota and having entered the entomology PhD program at the University of California, Berkeley, Janzen returned to Mexico, looking for a thesis project. "In those days, rule number one for ecology graduate students was that you did all your own research," he says. "You were not part of a team or a lab."

Daniel Janzen and Winnie Hallwachs. Image courtesy of Maureen A. Donnelly (Florida International University, Miami, FL).

While out on a stroll, Janzen noticed a beetle landing on a nearby leaf and hastily departing after an ant ran toward it. Janzen thought nothing of the scene until he walked by the same plant again later and looked more closely. "There were ants all over the leaves and branches." He saw ants nesting in the acacia's hollow thorns. Janzen cut down two acacias, and took one home for further study. When he returned to the stumps a few weeks later, Janzen noticed severely eaten shoots sprouting from the stump whose trunk and ant colony he had dragged home. "A meter away, the other stump had a gorgeous shoot." The ant colony in the felled trunk had simply relocated to the stump. "I realized that I was looking at an experiment," he says. The beetle that caught Janzen's attention had retreated hastily because the ant colony aggressively defends its acacia home with venomous stings.

A comment at Janzen's thesis defense on this demonstration of mutualism between *Pseudomyrmex* ants and acacias in 1965 proved serendipitous: An audience member noted, "the ants were akin to chemicals in a plant (1)." His interest piqued, Janzen began research into plant defensive chemicals, resulting in multiple collaborations, such as that with chemical ecologists Arthur Bell and Paul Feeny. Together, they showed that L-DOPA, found in high concentrations in the seeds of Central American *Mucuna* vines, repelled armyworms and rodents (4).

## Mutualism in the Field

Through the late 1960s and into the 1970s, Janzen spent time at several institutions, ending up in the biology department of the University of Pennsylvania. "In those days, we all moved a lot." His focus on the Central American tropics remained constant, and it is in the forest that Janzen feels most at home, spending half of the year on fieldwork. "The field is a comfortable, friendly place for us," he says. In 1978, while working in Costa Rica, Janzen met fellow researcher Hallwachs.


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They married and continued what Janzen terms "hard core academics in a national park. We were not there to conserve it," he explains. "It was a safe place to do research, protected from development."

That view changed in 1985 when Alvaro Ugalde, a friend and then-director of Costa Rica's Servicio de Parques Nacionales, asked Janzen to produce an environmental impact statement on 1,500 miners illegally mining for gold in Parque Nacional Corcovado's protected rainforests. Janzen had never written an environmental impact statement. "I didn't understand much of that, but he asked me to go, so I did." Janzen arrived at a scene of devastation. He recalls thinking, "It's going to take me 15 minutes to write this environmental impact statement, but I've got a week, so I'll study the miners." The miners viewed the park as having no owners. "They were convinced they were doing no damage since they weren't hunting or cutting trees," Janzen says. He developed a plan that the government implemented, reassigning friendly staff to the park to raise awareness that mining was indeed illegal, and that they would be removed a year later. When the time came, Janzen recalls, only 272 miners remained, and they left peacefully.

Soon afterward, Janzen and Hallwachs were invited by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to comment on conservation of the dry tropical forests in northern Australia, which were largely unoccupied by people. Janzen recalls telling them, "If you want to keep this intact, you've got to use it and have it be productive." Returning to ACG, an area in Costa Rica's fragile dry tropical remnant forest on the Pacific coast, Janzen realized they needed to apply the same philosophy or risk seeing it disappear underneath advancing civilization.

## Saving the Dry Forest

The very concept of national parks, according to Janzen, is built on exclusion of people, and he has long felt that the real challenge is figuring out how to use forests without destroying them. Liliana Madrigal, then of the Nature Conservancy, approached Janzen after hearing his views in 1985. "She spent two hours educating me about the NGO [nongovernmental organization] world. That was the start right there."But," he says, "I still hadn't tried the idea out on the Costa Ricans." By early 1986, newly elected president Oscar Arias had given Janzen his blessing, noting, as Janzen recalls, that "if it didn't cost us anything, it sounded good to him." "We had a political free pass early on, which I didn't appreciate." Costa Rica's government, explains Janzen, is highly structured. "Working only from the bottom up, we never would have gotten anywhere."

The first step was to recruit new staff who lived in the area and possessed requisite skills. They used farmers as fire fighters and managers and resident staff as biology teachers, despite lack of official government qualifications. For the next three decades, Janzen and Hallwachs focused on facilitating staff and growing the park's boundaries. The question all along, however, has been how to create collaborations (5). "I call it 'biopolitics,'" he says. "Politics in the sense of understanding the legislative and emotive relations between the park and the people." The collaborations, including geothermal development and its resultant biomonitoring project that began in 2013, also serve as examples for other countries. "You don't produce much social capital by writing," he says. "Having real people see it as a real example is far more powerful."

## Decrypting Ecology

Janzen has continued to write, however. One of his most recent articles explores the structural basis for whiteness, which has no associated pigment, in a butterfly's wings. The work outlines different microstructural bases for whiteness in angle-dependent and angle-independent white spots on *Carystoides escalantei*, realizing that the spots are adaptations to the insects' low-light environment (6). Janzen's recent major effort is collaboration with molecular biologists to harness the power of DNA for species identification.

In 2003, Janzen and Hallwachs were invited to attend a meeting at Cold Spring Harbor Laboratories in New York. "We have a reputation of going to meetings and watching people and then coming up with cross-cutting, weird, and possibly meaningful ideas," he explains. "I knew the letters of DNA, but that was about it." Janzen, by then an inveterate student of human ecology, remembers watching the crowd fall mercilessly on Paul Hebert, a University of Guelph geneticist, who proposed identifying species with merely 650-bp snippets of mitochondrial DNA. Janzen and Hallwachs, however, were captivated by the realization of ideas Janzen had first encountered while reading 1950s science fiction in ninth grade.

To test the power of Hebert's idea, Janzen sent him a box of 16 butterflies, so similar, Janzen notes, that only he could tell them apart (and only because he had raised them). Hebert's DNA method identified the correct number of 12 species. Janzen, whose work in the Costa Rican tropics since the late 1970s had resulted in an enormous collection of voucher butterflies and moths, sent thousands more species of insects for DNA cataloging. "We just started pumping legs out to Paul," says Janzen, noting they have barcoded about 500,000 specimens of more than 45,000 species from ACG thus far.

In 2004, they published results showing that samples of a butterfly, *Astraptes fulgerator*, thought to be a single species, actually represented 10 different species (7). "That was the first paper that blew the lid off the taxonomic world," recalls Janzen. Further work revealed many more cases of so-called "cryptic species" that differ almost imperceptibly in appearance but have genetic and ecological differences, such as preferred food sources or microhabitats. A recent study of 100-year-old and newly reared specimens of *Udranomia kikkawai* butterflies revealed three genomically distinct, yet seemingly identical, species (8).

For 25 years, Janzen notes, his grant applications estimated 9,000 species of Lepidoptera in ACG. The number jumped to 15,000 after barcoding analysis. "The younger people tend to find this inspiring, while the older people find it terrifying." The technique reduces the reliance on morphological expertise and is exponentially faster. "We once sent 144,000 specimens to Paul," recalls Janzen. "All were discriminated within 6 months at a cost of $2.34 each." The technology is not yet widely affordable, but Janzen is determined to be ready when it catches up, focusing his work on cataloging as many species in ACG as possible (3, 9). "What we all can offer, along with Hebert's BOLD [Barcode of Life Data] informatics system as the public database, is the barcode library itself."

In the meantime, Janzen continues efforts to preserve the forest. The $400,000 prize money from the Kyoto Prize and other awards, such as the1984 Crafoord Prize, were starting points for subsequent land purchases. In 1999, ACG was designated a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site, and Janzen's current fundraising efforts are geared toward building an endowment to support staff who will safeguard forests by understanding them and their unique natural histories. "It becomes a people operation, not a biology operation," he says. "The goal is that the wild stuff is still here 1,000 years from now, and that it's allowed to be wild."


**1** Janzen DH (1966) Coevolution of mutualism between ants and acacias in Central America. *Evolution* 20:249–275.

**2** Janzen DH (1971) Seed predation by animals. *Annu Rev Ecol Syst* 2:465–492.

**3** Janzen DH, Hallwachs W (2016) DNA barcoding the Lepidoptera inventory of a large complex tropical conserved wildland, Area de Conservacion Guanacaste, northwestern Costa Rica. *Genome* 59:641–660.

**4** Rehr SS, Janzen DH, Feeny PP (1973) L-dopa in legume seeds: A chemical barrier to insect attack. *Science* 181:81–82.

**5** Janzen DH (2000) Costa Rica's Area de Conservación Guanacaste: A long march to survival through non-damaging biodevelopment. *Biodiversity* 1:7–20.

**6** Ge D, et al. (2017) Varying and unchanging whiteness on the wings of dusk-active and shade-inhabiting *Carystoides escalantei* butterflies. *Proc Natl Acad Sci USA* 114:7379–7384.

**7** Hebert PDN, Penton EH, Burns JM, Janzen DH, Hallwachs W (2004) Ten species in one: DNA barcoding reveals cryptic species in the neotropical skipper butterfly *Astraptes fulgerator*. *Proc Natl Acad Sci USA* 101:14812–14817.

**8** Janzen DH, et al. (2017) Nuclear genomes distinguish cryptic species suggested by their DNA barcodes and ecology. *Proc Natl Acad Sci USA* 114:8313–8318.

**9** Janzen DH, Hallwachs W (2011) Joining inventory by parataxonomists with DNA barcoding of a large complex tropical conserved wildland in northwestern Costa Rica. *PLoS One* 6:e18123.