Joshua Tree National Park.
Photo: Jarek Tuszyński, 2009 | Wikimedia Commons

The Science of Seeing

Scientists on the Front Lines

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Marine biologist Tim Gordon could have decorated the walls of his childhood bedroom with posters of superheroes, star athletes or scenes of Hollywood-movie mayhem. Unlike many of his peers, however, he chose to surround himself with images of candy-colored coral reefs.

So candy color is what Gordon expected to see when he finally got a chance to conduct research on Australia's Great Barrier Reef in 2016. Reality, however, looked nothing like the pictures he remembered. In 2016 (and again in 2017), the Great Barrier Reef, one of the world's seven natural wonders and a UNESCO World Heritage area, experienced widespread coral bleaching caused by warming ocean temperatures. But it wasn't just the absence of color that unnerved Gordon as he surveyed the blanched corals in his study sites. It also was the silence. "A reef should be noisy" with the crunching, chomping, popping and scraping sounds of its numerous residents, he observed in a 2020 *ScienceNews* article. "Instead of documenting nature's wonders, I was documenting its degradation."

"One of the penalties of an ecological education is that one lives alone in a world of wounds," wrote Aldo Leopold in *Sand County Almanac*. Since Leopold penned these words in 1949, the challenges for the ecologically educated—environmental scientists like Gordon—have intensified. Planetary wounding has become more pervasive and egregious as climate change accelerates. And the trauma has deepened for those reporting from the front lines of the war on nature. Many scientists now spend their careers cataloguing its casualties in real time—with no end in sight.

But they are no longer suffering alone and in silence. Gordon, for example, teamed up with fellow scientists Andrew Radford and Stephen Simpson to daylight the emotional toll of their work in a 2019 issue of the prestigious journal *Science*. Their letter—"Grieving Environmental Scientists Need Support"—hit a nerve. Dozens of scientists responded with gratitude, praising the trio for their "emotional honesty."

The letter argues that biologists face unique challenges when it comes to environmental degradation. Science professionals, for example, are expected to check their emotions before entering the field lest they compromise the objectivity of their data collection and bias the results. But this "pervasive illusion that scientists must be dispassionate observers," they posit, "is dangerously misguided." Researchers often develop a deep bond with their study organisms. When they sicken or die, the loss is as deeply felt as that of a loved one. The

Roots 12 and fungi on vellum | Juniper Harrower

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Jtree forest on handmade paper.
Juniper Harrower

expectation of detachment only compounds the work-related stress.

But even when ecogrief is acknowledged, there are "few opportunities to address this grief professionally," they say, unlike "other professions in which distressing circumstances are commonplace, such as health care, disaster relief, law enforcement, and the military. In these fields, well-defined organizational structures and active strategies exist for employees to anticipate and manage their emotional distress."

That often leaves scientists to their own devices when it comes to navigating the trauma of climate change. Their stories can be heartbreaking. For some, however, the journey through ecogrief has also led to heartening breakthroughs. Juniper Harrower is one of them. A desert ecologist and director of the Art+Science Initiative at the University of California, Santa Cruz, her work exemplifies the emotional challenges faced by environmental scientists—and the ingenuity of their responses.

I first encountered Harrower's work in fall 2020 when I spent a month as an artist in residence at Joshua Tree National Park. Ever since camping out in a "forest" of Joshua trees several years before, I dreamed of spending long, uninterrupted hours once again in their company. These quirky yuccas with their shaggy arms akimbo

Joshua Tree at night | Photo:InceptedNoggin, 2017 | Wikimedia Commons

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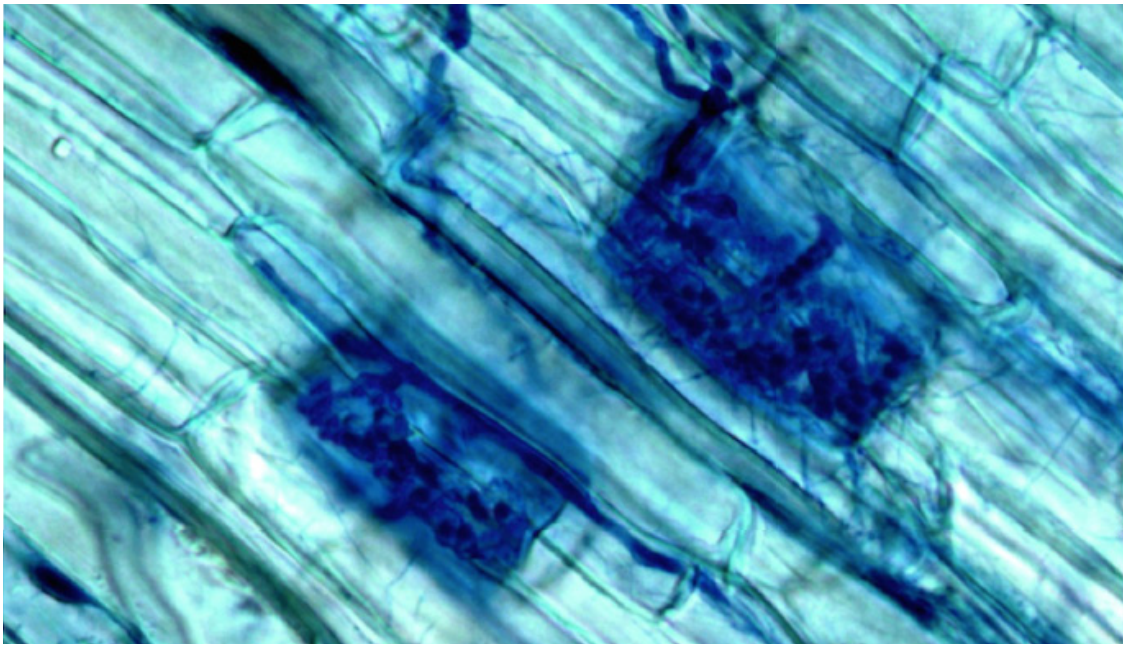
against the turquoise desert sky reminded me of exuberant Sufi dancers. Like the tall saguaros in my own Sonoran Desert, they seemed to have a kind of sentience. The opportunity to live for an extended period of time among them in their namesake park was, well, a dream come true.

Harrower had been part of the previous year's cohort of resident artists and her focus on Joshua trees caught my attention. Even more intriguing was this: her work as an artist drew on her research as a scientist.

As a doctoral student in biology at UC-Santa Cruz in 2015, Harrower encountered reports warning that warming global temperatures could compromise the long-term survival of Joshua trees in the park. Within less than a century, the science predicted that viable Joshua tree habitat would shrink to a mere two percent of its current range. The news hit home—literally—since she grew up just outside the park boundary. "That area of the desert and the Joshua trees specifically," she recalls in an interview, "played such a big part in forming my identity as a person that the climate threats felt like a personal attack."

So Harrower decided to focus her Ph.D. research on developing a more fine-grained understanding of the impact of climate



Mycorrhizal fungi in Joshua tree roots.
Photo: Juniper Harrower, 2018.

change on the relationships between Joshua trees and their critical partners, chief among them the yucca moth (*Tegeticula antithetica*). Joshua trees rely on these minuscule insects for pollination. The moths, in turn, depend on the trees' fruits and seeds as food and nurseries for their young, a relationship of mutually assured survival that has endured for millions of years. She also sampled the soil in which the plants grew, becoming the first to identify the 36 species of beneficial mycorrhizal fungi that live in association with the roots of Joshua trees. These mycorrhizae scavenge moisture and nutrients from the soil in exchange for photosynthetic sugars from the trees, helping the plants grow faster, stronger and more resistant to pathogens.

Harrower surveyed Joshua trees and their partners in three regions of the park: low, mid and high elevations. Her data revealed that both Joshua trees and their symbiotic moth partners flourished only within a narrow band of mid-elevation habitat. But under climate-change scenarios, these now-prime habitats are expected to become too hot and dry for the plants, forcing them to migrate to cooler, moister reaches in the park's higher elevations. The long-term survival of Joshua trees in these upper zones, however, depends on the ability of their pollinating moths to journey alongside them, an unlikely scenario since the tiny, peppercorn-sized insects are poor fliers.

To further complicate matters, Harrower's research showed that the makeup of the mycorrhizal communities also varied by elevation. The fungal networks in the mid-elevation habitats, like the pollinating moths, would require transplantation to higher ground. Harrower's prognosis was bleak: without human intervention the ancient relationship between Joshua trees and their symbiotic partners could be severed, causing these iconic plants to become extinct in the park within 100 years. But even with assisted migration to higher ground, questions remained: Would the linked trio of trees, moths and mycorrhizae be able to adapt to their new circumstances?

Harrower's grief over the uncertain future of Joshua trees was intensified by the fact that she was pregnant and gave birth to her first child, Jack, midway through her fieldwork. Riding in a backpack, he often accompanied her on research forays. One day as she and Jack stood in a study plot, Harrower suddenly realized: "Here I am collecting all this data, and I've got this brand-new little baby with me. Within a 100 years all the trees could be gone from this place where I'm working, and that's just

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basically his lifetime. I'll be gone by then, but what's it going to look like at the end of my son's life? It just felt so heavy and sad and overwhelming," she recalls.

Desperate to process the emotional implications of her scientific discoveries, Harrower received permission from her dissertation committee to expand the traditional deliverables of her science Ph.D. to include a suite of multimedia art projects. She began by painting a series of richly imagined scenes from the desert's subterranean realm, in which the mesh of plant roots threaded with their fungal partners were rendered in sumptuous brocades of earth-toned hues. Embedded in this rhapsodic beauty were both menace—and hope. Portions of the canvas, for example, were slashed and then stitched together with needles harvested from the leaf tips of actual Joshua trees.

Hey JTree project.
Juniper Harrower | https://www.heyjtree.com

In addition to the paintings, Harrower created an online "dating" site called *Hey JTree*. Mimicking the human marketplace of romance, it features compelling profiles of individual plants created by writers and musicians along with GPS coordinates and a list of pertinent scientific data. The goal of *Hey JTree* was to create a platform that would help the public "fall in love" with individual Joshua trees and thereby become more proactive about supporting climate-change solutions.

Among the most resonant in Harrower's suite of creative deliverables, however, was her stop-motion animation, *A Joshua Tree Love Story*. In it Harrower as a young scientist with her long black curls stuffed into a cap trudges through the desert carrying her infant in a backpack. The animation chronicles the various stages of Harrower's field work while Baby Jack, against the soundtrack of his actual giggles, explores the desert floor with her bug net. In other scenes, they lie side by side deep in sleep under the stars. At the close of the animation, Harrower digs up Joshua tree seedlings and directs Jack's attention to the

Stills from *A Joshua Tree Love Story*

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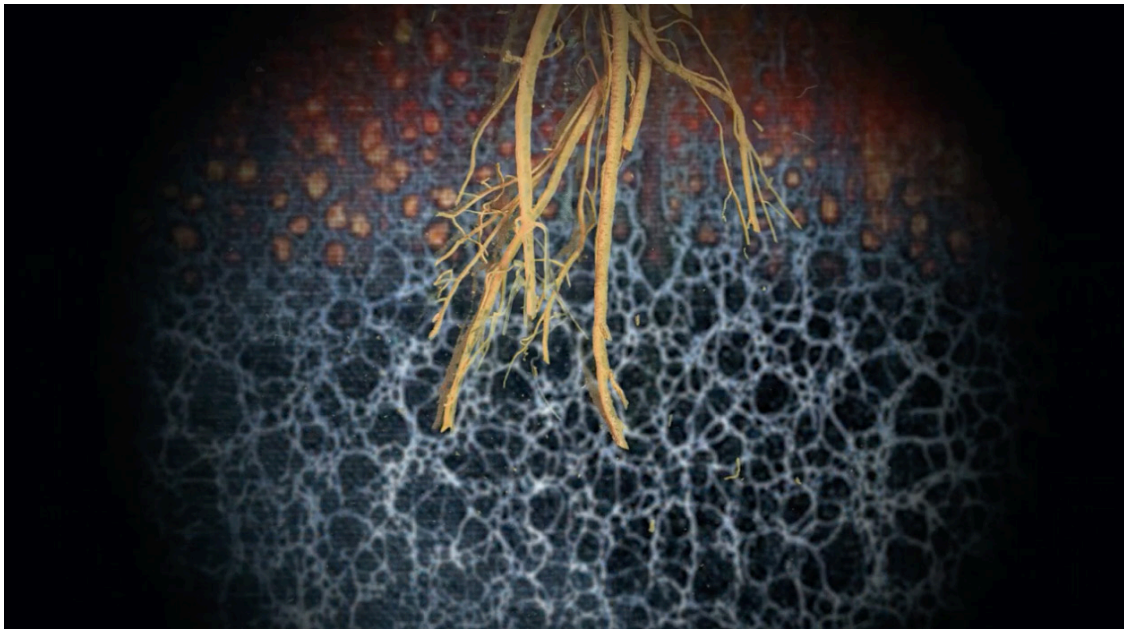
mountains on the horizon where they will be replanted. Skipping forward nine decades in time, the film concludes with Jack, now an old man with white hair and beard, climbing the mountain that his mother pointed out to him as a baby. Along the way, he ponders an old photograph of himself as an infant in his mother's backpack. Then he breaks into a smile as the scene opens up to reveal that Jack is surrounded by desert tortoises and birds. Beside him too are yucca moths and blooming Joshua trees, evidence that the assisted migration of Joshua trees to higher elevations was successful.

Harrower has screened the animation, exhibited her paintings and lectured widely on her scientific research, winning national media attention from such outlets as *National Geographic*. But raising awareness of the plight of Joshua trees has done more than warm hearts and fire up the resolve of desert lovers. The Center for Biological Diversity cited some of her research in its recent petition for legal protection of Joshua trees under the California Endangered Species Act. On September 22, 2020, the California Fish and Game Commission agreed to temporary protections for the plant pending the outcome of a yearlong



A Joshua Tree Love Story (https://www.youtube.com/watch?v=6elejGlqsuA).
Stop motion animation short by SymbioArtlab and Juniper Harrower

review of the latest science. If the ruling becomes permanent, Joshua trees will become the first species in the state to be protected due to climate threats.

Harrower is gratified that her research has contributed to efforts that will help Joshua trees persist on the landscape for the next generation of desert lovers. Her success, however, is as much due to her work as an artist as it is an environmental scientist. Completing a science Ph.D. is a stressful undertaking. “Everybody gets burned out at some point,” she observes. But today’s environmental scientists must cope with the added challenge of ecogrief. Innovative educational projects, like Harrower’s melding of art and science, could offer new models for helping students to manage their emotions while engaged in the rigors of field research. “If I hadn’t been able to incorporate the art part, I might have just left grad school. But having the art component really saved me,” Harrower reflects. “It gave me a way to humanize all the science.” ×

We would appreciate your feedback on this article:

Still 'moth pollination' from *A Joshua Tree Love Story* (https://www.youtube.com/watch?v=6elejGlqsuA).
Stop motion animation short by SymbioArtlab and Juniper Harrower