ECOLOGY

Much-Studied Butterfly Winks Out on Stanford Preserve

It might not be as big or as flashy as some of its cousins, but the bay checkerspot butterfly is among the most studied insects in science. Since 1960, when a young Stanford biology professor named Paul Ehrlich first took to the hills at the university's Jasper Ridge preserve, his sights set on *Euphydryas editha bayensis*, textbooks and scientific papers have been aflutter with checkerspot findings and theories. But last year, for the first time, graduate students engaged in the annual bay checkerspot count at Jasper Ridge came back empty-handed. After a long decline, it appears that the insect, which was officially listed as a threatened species, has disappeared from the same Stanford grasslands where the studies began. "The loss of the study population is a huge, huge thing because of the amount of information there was on that population," says Daniel Simberloff, an ecologist at Florida State University (FSU) in Tallahassee. "It was really sort of a classic."

This local extinction isn't a certainty yet. Scientists at Stanford's Center for Conservation Biology say there's a remote chance that an odd *E. editha bayensis* may be spotted on the ridge this March. But the possibility of a Jasper Ridge local extinction has raised some entomological eyebrows. Ehrlich and others at Stanford chose to watch the population die off, saying more could be learned from watching it disappear than from intervening to try to save it. As Stanford biologist Dennis Murphy puts it, "We [decided to] observe the demise unimpassioned."

That choice has reverberated in the ecology community. Some observers, including ecologist David Wright, who oversees endangered invertebrates at the U.S. Fish and Wildlife Service in Sacramento, California, wonder whether the wealth of information about the Jasper Ridge population might have justified efforts to revive it. And he and others say the controversy highlights a dilemma that many ecologists studying endangered species eventually face. "Increasingly, if we don't intervene, we will be watching our study materials disappear," says Wright.

Stanford scientists have observed the checkerspot since at least 1934 on the 485-hectare Jasper Ridge biological preserve, which is owned by the university and contiguous to the main campus. The preserve is now an island in a semisuburban sea, one of the few places in northern California where one can still find native grasses growing on stony, inhospitable, "serpentine" soils. Development is just one reason for the loss of serpentine grasslands. The invasion of exotic species and the cessation of livestock grazing also have reduced the habitat available to dependent species, including the bay checkerspot, which feeds on *Plantago erecta*, the California plantain, among other native plants. Even in this refuge, the checkerspot was confined to some 2 hectares of serpentine grasslands.

PHOTOS BY ED NELSON/JASPER RIDGE BIOLOGICAL PRESERVE

Local loss. Bay checkerspot butterfly in adult *(above)* and larval *(right)* stages.

Over the decades, checkerspot observations have yielded a treasure of entomological information. "It's pretty amazing where Ehrlich's initial study has taken us," says Stuart B. Weiss, a Stanford postdoctoral fellow who has been studying the bay checkerspot since 1978. Ehrlich first counted the butterflies during their spring flight season in 1960. His discovery that they lived not as a single population but as three distinct populations (labeled G, C, and H) helped upset some ideas of the day about population dynamics. Observations of the butterflies and their host plants have helped scientists better understand coevolution, or the complementary evolution of closely interacting species. "There are very few organisms we know as much about as *Euphydryas editha*," Ehrlich says. "And the more we learned, the more we became humble about what we didn't know."

During the droughts of the mid-1970s, the number of Jasper Ridge checkerspots nosedived. In 1980, Murphy petitioned the U.S. Fish and Wildlife Service to place the butterfly under the protection of the Endangered Species Act (ESA). And in 1987, it was listed. During the interval, a previously unknown cache of hundreds of thousands of checkerspots was discovered to the south of Stanford near San Jose on land slated to become a landfill. The landfill developer, Waste Management Inc., agreed to set some of the property aside as a checkerspot preserve.

Ironically, the protection of the Kirby Canyon butterflies south of San Jose helped seal the Jasper Ridge populations' fate. During the 1980s and the early 1990s, as the Jasper Ridge checkerspot populations staggered along, the Stanford biologists—mindful of the large pool of checkerspots at the new Kirby Canyon preserve—"agreed that we would just watch [the Jasper Ridge population] go belly up," Murphy says. "The idea was, here's an opportunity to actually watch the extinction process," says Weiss. The ESA required nothing different: The act prohibits harming protected species, but does not require that actions be taken to save them.

Stanford biologists tick off a host of factors that could have contributed to the checkerspot's decline. First, there was the science itself. In the early 1980s, a massive mark and recapture study affected nearly every butterfly in the preserve, Weiss says. "It's concluded that we hurried the extinction of the population in area G and the rate at which C went extinct by sampling butterflies," Ehrlich says. Then, there was the decision to remove cattle and horse grazing from the preserve in the early 1960s. Murphy, who has studied the checkerspot for 20 years, says, "There's no question that the removal of grazing up there contributed" to the butterfly's demise. Other events such as an inadvertent malathion spray in 1981 and local pesticide use may also have taken a toll.

But ultimately it was bad weather and lack of topographic diversity that did in the butterfly, say Weiss and others. Confined to the ridge's small areas of serpentine grasslands, the bugs didn't have enough habitat choices to survive California's tempestuous climate. The plants on which the butterfly larvae feed wither early on warmer slopes, later on cooler slopes. Without adequate habitat variations to choose from, the butterflies died off. "It's sort of the Goldilocks effect," says Weiss. "It has to be just right."

Indeed, that realization was part of the intellectual payoff of watching the bay checkerspot's slow slide toward extinction on Jasper Ridge, says Ehrlich. "My conclusion early on was that there were several large patches of suitable habitat which should be more than enough. That conclusion was dead wrong," says Ehrlich. "What this adds is that it isn't just [total] area that matters. The topographic diversity of the habitat" is "an absolutely critical factor" as well, he says, as is "the timing of

the plants, when they dry up."

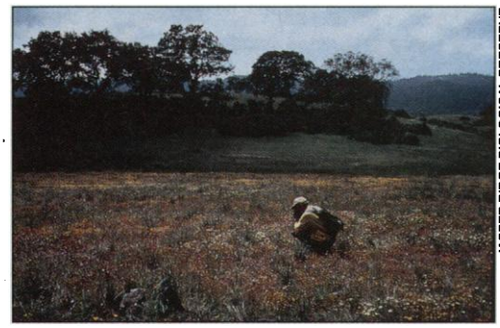
But news of the loss of the Jasper Ridge checkerspot has highlighted for many the question of when, if ever, scientists studying a shrinking population should intervene to save it. "That's very controversial," says FSU's Simberloff.

The Fish and Wildlife Service's David Wright, for one, thinks more could have been done to help out the Jasper Ridge checkerspot, given its status as a threatened and much-studied species. "I don't intend this as a criticism of Stanford, but I regard this as a wake-up call... for anyone interested in conservation." He says that "if a population has survived at a location for tens of thousands of years, it likely has the reproductive capability to recover from environmental vagaries"—if given a helping hand. Wright suggests that researchers might have experimented with increasing the amount of habitat available to the butterflies by restoring grazing or controlled burns or weeding part of the reserve.

By most accounts, the case for intervening is strongest when the threatened population is genetically distinct. Murphy says that concern doesn't apply to Jasper Ridge, where "there were no unique alleles." Ehrlich concurs, saying that the vast reserve of Kirby Canyon checkerspots is "very similar" to the Jasper Ridge populations. But Susan Harrison, an associate professor of environmental studies at the University of California, Davis, who did her graduate work with Ehrlich and Murphy on the Kirby Canyon checkerspots, asserts that "nobody really knows the answer to that because the studies weren't done." Comprehensive genetic studies of *Euphydryas* populations along the western United States were done in the late 1960s and early 1970s, but used a method which has since been shown to be unreliable, says Alan Launer, research associate at Stanford's Center for Conservation Biology.

Reed Noss, a population extinction expert and professor at Oregon State University in Corvallis, says that whether to intervene "really depends on the management goals for a particular area." Small populations "have a high chance of going extinct," he says, and "from a metapopulation standpoint, it probably doesn't matter" if the Jasper Ridge butterflies have disappeared because of the reservoir of bugs at Kirby Canyon. But where a whole species is winking out, and efforts to protect habitat haven't been effective, interventions may be warranted. "If a species is really on the brink, and we see that an intervention can be done, we have an obligation to do that, just ethically," he says.

Watching the Jasper Ridge checkerspots disappear was an important research opportunity, Murphy contends. "Watching this population hang on at about a dozen individuals was one of the more enlightening aspect of our study of the species," he says. Indeed, says Ehrlich, "just trying to keep *Euphydryas* going on Jasper Ridge would give us less information" than observing the extinction.



JASPER RIDGE BIOLOGICAL PRESERVE

Serpentine splendor. Native grasslands on Jasper Ridge during spring bloom.

Either way, the question of observation versus intervention is "something the community needs to discuss more," says Wright. He also would like to see *Euphydryas editha* back on Jasper Ridge. "I want to work with them to reintroduce the butterfly to Jasper Ridge. If there are special permits that are needed, I'm more than happy to put that on my list of priorities."

Ehrlich and Murphy share Wright's enthusiasm for a reintroduction. "We will be trying a reintroduction," Ehrlich promises. But Murphy notes a possible snag: "Stanford is very sensitive to the legal implications of putting the butterfly back in the habitat. Stanford now has grasslands that are free of listed species. If they wanted to build on these habitats, they frankly could."

And while Stanford has no plans for construction on Jasper Ridge, says Stanford spokesperson Janet Basu, it isn't planning to reintroduce the checkerspot butterfly, either. "It looks like the reintroduction won't happen, at least [not] in the short term. ... There's been no forward action on this," Basu says.

Come mid-March, graduate students will again be taking to Jasper Ridge to search for the checkerspot. If none are seen, then the extinction will be official. "It's the loss of a symbol, and it's another example of population extinction," mourns FSU's Simberloff. "You now have more and more examples of a depressing trend."

–Ellen McGarrahan

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BIOCHEMISTRY

Photons Add Up to Better Microscopy

The first view through the light microscope opened up the cellular world for 17th century biologists. Now, a new kind of microscope could do the same thing for the world of biochemistry, letting 20th century biologists follow molecules in real time within living cells.

On page 530, applied physicist Watt Webb and his colleagues at Cornell University in Ithaca, New York, describe how they tapped photon physics to view a key brain chemical called serotonin inside living cells. The significance of the achievement goes beyond serotonin, however. Webb's method, which uses the additive energies of multiple photons to excite fluorescence from molecules that previously couldn't be observed without damaging or killing the cell, should open new vistas for any biologist interested in tracking specific molecules in tissue.

SARAH CRITTENDEN/UNIVERSITY OF WISCONSIN

Rainbow microscopy. Two proteins (red, green) and DNA (blue) fluoresce in a two-, four-, and eight-cell nematode embryo.

The technique will enable researchers to probe deeper into cells and to monitor molecules in living samples much longer than previously possible, Webb says. Joseph Lakowicz, a biochemist at the University of Maryland School of Medicine in Baltimore who is also developing new fluorescence spectroscopy techniques, agrees: "Webb has really changed the paradigm of microscopy."

In current microscopic methods, biologists often visualize cellular components by tagging them with molecules that fluoresce when excited by light of the correct wavelength. But the fluorescence technique is limited because many dyes and cellular components, such as proteins, fluoresce only when excited by short-wavelength, high-energy photons that can overheat the cell or drive toxic chemical reactions. In addition, because the entire sample is illuminated, stray