showing a monkey a natural scene while recording from individual neurons in the animal's visual cortex.

Gallant's team creates "review" movies, which show the sequence of the scene's patches that fell in and around a neuron's receptive field as the animal looked around a natural scene. The team can play these movies back repeatedly to test the consistency of the neuron's responses. Their experiments already point to some intriguing effects that natural scenes have on the firing of individual neurons.

Gallant's team first characterized the responses of a neuron with gratings—a common form of artificial stimulus that looks somewhat like a small patch of corrugated tin roof—and then allowed the monkey to view a natural scene freely. Most of the neurons' responses to the natural scenes were muted compared to their responses to gratings. That was no big surprise, because previous work had shown that features that lie just outside a neuron's receptive field—and natural images are loaded with such information—tend to damp its response. The effect is thought to be caused by the activity of neurons that respond to those features. But additional work indicated that this neuronal interaction is more complicated than simple damping, says Gallant. Parts of the image outside a neuron's receptive field "are sculpting the responses of the neuron. They make the cell respond to fewer things, but the things it responds to, it responds to better." These effects are bigger than researchers had suspected from experiments with artificial stimuli, says Field. "Now that they seem to play a major role in the cell's activity," he adds, "we need a rigorous approach to actually finding out what they are doing."

Researchers hope that experiments with natural scenes will also help them solve the mystery of dormant neurons. "Periodically [you] record from cells that are just silent," says Field. Most often encountered in visual processing areas beyond the primary visual cortex, these inert neurons probably detect features or combinations of features that no one has thought of testing. Field and others hope that recording from the neurons while the animal views natural scenes will reveal features that make the neurons fire, providing clues to their normal roles. "If you use natural images, at least you are in a domain that the animal evolved to deal with," Gallant says.

Among those taking this approach are Dario Ringach and Robert Shapley at New York University. After finding neurons in the primary visual cortex of monkeys that didn't respond to any of the standard stimuli, Ringach tried movies. Where gratings and bars had failed, *Sleeper* and *Goldfinger* brought the neurons to life. "The most striking thing so far," says Shapley, is "that you can actually get responses from cells [that are silent] with the usual battery of tests." The finding means, he says, that you can check back to see what images were on the screen before, during, and after the moment when the neuron fired and look for patterns that may reveal what the neuron responds to.

The technique requires some intuition. For example, if a neuron seems to fire whenever there is red on the screen, Ringach reanalyzes the movie for when red is or isn't in view and checks whether there is any correlation with the neuron's firing.

But the associations may not be that simple: The neurons may be responding to combinations of features, and those combinations may be spread out in space or time. Such associations are unlikely to jump out at a human observer. "The real problem" says Ringach, is to use computer analysis to "tell what the cell is responding to without guessing." To scan all possible sets of events that might have triggered a neuron "isn't in principle impossible," says Shapley; "it just takes a lot of computing time."

Some neuroscientists, such as David Hubel of Harvard University, question whether the effort is worth it. Hubel, who received a Nobel Prize for his work using artificial stimuli to characterize visual neurons, argues that natural scenes are too complicated and too loosely defined to provide useful information about the mechanisms of vision. "It is all very well to say that there is something magic about a natural scene," he says, but it makes more sense to test the visual system instead with "more elaborate artificial scenes" that can be carefully designed and controlled.

"Nothing is magical about natural scenes," responds Gallant. "They are just another tool" to be used in addition to artificial stimuli, because they are useful in revealing adaptations our visual system has made to interpret the natural world. Eventually, Olshausen predicts, more neuroscientists are bound to find uses for this tool: "This is just the beginning. Five years from now, there will be entire sessions of the annual neuroscience meeting talking about natural images." **–MARCIA BARINAGA**

ECOLOGY

# The Great DOE Land Rush?

**The department is considering selling off land around its national labs that has been undisturbed for decades; these zones have become protected havens for wildlife and valuable locations for ecological research**

Since its creation in 1948, Oak Ridge National Laboratory (ORNL) in Tennessee has buffered itself from civilization with a natural security system: a tract of wilderness covered with oak, hickory, and pine forests. Ecologists have had a field day in Oak Ridge's 14,000-hectare protected zone—home to peregrine falcons, cerulean warblers, and 18 other rare animal species—and in similar swaths of wilderness surrounding six other Department of Energy (DOE) national laboratories. These zones have yielded data on everything from biological invaders to soil carbon levels that inform the climate change debate. "This land is incredibly valuable," says ecologist James Ehleringer of the University of Utah, Salt Lake City.

But these ecological havens are fraying at the edges. As part of an effort to cope with post–Cold War budget cuts, DOE has been quietly divesting itself of wilderness parcels no longer deemed essential to safeguarding the nation's weapons labs. So far, three labs have given up more than 1200 hectares (ha) of buffer zone to local governments and the U.S. Bureau of Land Management, which in turn have sold much of this land to developers for house lots, landfills, and commercial construction. Another 5200 ha may soon be put on the auction block. Scientists acknowledge that they have been slow to take up the cause. "These are federal reservations, and many researchers consider them inviolate," says James MacMahon, an ecologist at Utah State University in Logan. "I don't think it's on anyone's radar."

But the deals are setting off alarms among environmental groups. The Nature Conservancy (TNC), for instance, plans to complete a biodiversity database this month that documents roughly 1500 species, including rare or endangered animals and plants, in ORNL's buffer zone. This and other grassroots efforts are gelling into a campaign to persuade DOE to set aside as much of the buffer zones as possible for wildlife and research. "DOE should take stock of what it has before making any decisions" on land use, says Curt Soper of TNC in Seattle.

The disputes involve lands originally valued for their emptiness. Early ecological studies done in the buffer zones tracked the fate of radioactive waste dumped or leaked by the secretive labs, says Steve Hildebrand, ORNL's environmental sciences director. Then in the 1950s, outside researchers began discovering the lands as valuable spots to study broad ecosystem questions. "Scien-

tists came to collaborate, and the momentum grew," Hildebrand says. In 1972, DOE's predecessor, the Atomic Energy Commission, moved to protect such areas as wildlife and research refuges by designating the first National Environmental Research Park (NERP), at the Savannah River site in South Carolina. Over the next 20 years, six more parks were established (see map).

The parks quickly became a favorite haunt of ecologists. At the Idaho National Engineering and Environmental Laboratory in Idaho Falls, for example, researchers have compiled a stark picture of a non-native weed called cheatgrass, which has choked out sagebrush and fueled disastrous fires across much of the Great Basin. In the lab's buffer zone, cheatgrass is being held at bay by a hardy stand of native plants, says Jay Anderson of Idaho State University in Pocatello. "Our research shows just how much cheatgrass relies on overgrazed land, where you don't have these viable populations of native species," he says. And at Fermi National Accelerator Laboratory (Fermilab) outside Chicago, ecologists have spent 25 years restoring 500 ha of tallgrass prairie. The young grassland hosts research on how plants cope with grazing, for instance.

At ORNL, lab lands became a "field of dreams," says atmospheric scientist Dennis Baldocchi of the National Oceanic and Atmospheric Administration's office in Oak Ridge, attracting scientists who study climate change and nutrient cycling. One resource is a 30-year record of soil carbon levels at ORNL. One of only a few carbon histories taken in a southern temperate forest, the project offers insights into how carbon cycles between forests, soils, waters, and the air. "A lot of work on the carbon budget depends on long-term soil histories that you only get at sites like Oak Ridge," says Susan Trumbore, a biogeochemist at the University of California, Irvine. The National Science Foundation's Long Term Ecological Research sites provide similar data, she says, but many NERP studies have been running years or decades longer. What's more, Trumbore says, ORNL forests are protected from tourists, who sometimes disturb long-term experiments in national parks. Most projects in Oak Ridge's buffer zone are threatened by pending land deals, adds Pat Parr, ORNL's land area manager.

But some DOE officials argue that ecosystem studies fall outside the agency's purview. In a January 1997 audit, the agency's Inspector General (IG) asserted that DOE should stick to its central post–Cold War missions—stockpile stewardship, environmental cleanup, technology development, and research. The report recommended selling roughly a quarter of NERP lands—125,000 ha valued at $126 million—at ORNL, Idaho, and the Pacific Northwest National Laboratory in Richland, Washington. DOE managers agreed in principle, although they say that a higher, undetermined percentage of NERP territory should be kept. "We need a lot of that land," says Andrew Duran of DOE's field management office, partly because scattered patches are contaminated with radionuclides or toxic chemicals and are serving as test-beds for cleanup technologies. In response to the IG report, his office has asked each lab to assess how much land it needs.

Observers say the IG report essentially gives a green light to land deals. In Oak Ridge, city administrators have already received about 2400 ha of ORNL land for businesses, homes, schools, and other facilities. They hope to buy 3200 ha more. "We have to have room to grow," says Robert McDaniel, Oak Ridge city manager. The IG report deems expendable roughly 70% of the ORNL buffer zone used for research. Other labs have similar stories: At Los Alamos National Laboratory in New Mexico, 1800 ha—about 15% of the lab's land—could be transferred as early as 2001 to the county and to the Pueblo of San Ildefonso for commercial and residential use. In Richland, a 36,500-ha area known as the North Slope hangs in the balance, as congressional representatives squabble over the county's agricultural needs. And at Fermilab, county officials have aired the possibility of running a four-lane highway through wetlands on the 60-ha NERP.

The stakes are higher now that conservation groups have begun documenting the ecological richness in the buffer zones. Three years ago, the Audubon Society, TNC, and other organizations mounted a campaign to persuade DOE to refrain from selling the 30,000-ha Fitzner-Eberhardt Arid Lands Ecology Reserve at the Pacific Northwest lab, one of the few pristine shrub-steppe ecosystems left in North America and a hotbed for research on everything from Canadian geese and salmon spawning to air and groundwater quality. "To think that DOE would suddenly decide it was no longer important to protect those lands just boggled my mind," says Idaho State's Anderson. But the nature groups' strategy—writing editorials for local newspapers and organizing town meetings—paid off. Last year, DOE signed a contract with the U.S. Fish and Wildlife Service, which will manage the reserve as a wildlife refuge.

At Oak Ridge, TNC hopes its new database—which tracks roughly 400 animal and 1100 plant species, including rare migratory birds, salamanders, fish, and bats, on ORNL's 14,000-ha reservation—will spotlight the most vibrant areas in the buffer zone. Parr says the lab strongly advocates protecting the reserve for research. But others add that the labs face an uphill battle unless ecologists begin to raise their voices in protest. Says Janet Anderson, a DOE adviser, "It falls on [them] to support the integrity of these lands."

**–KATHRYN S. BROWN**

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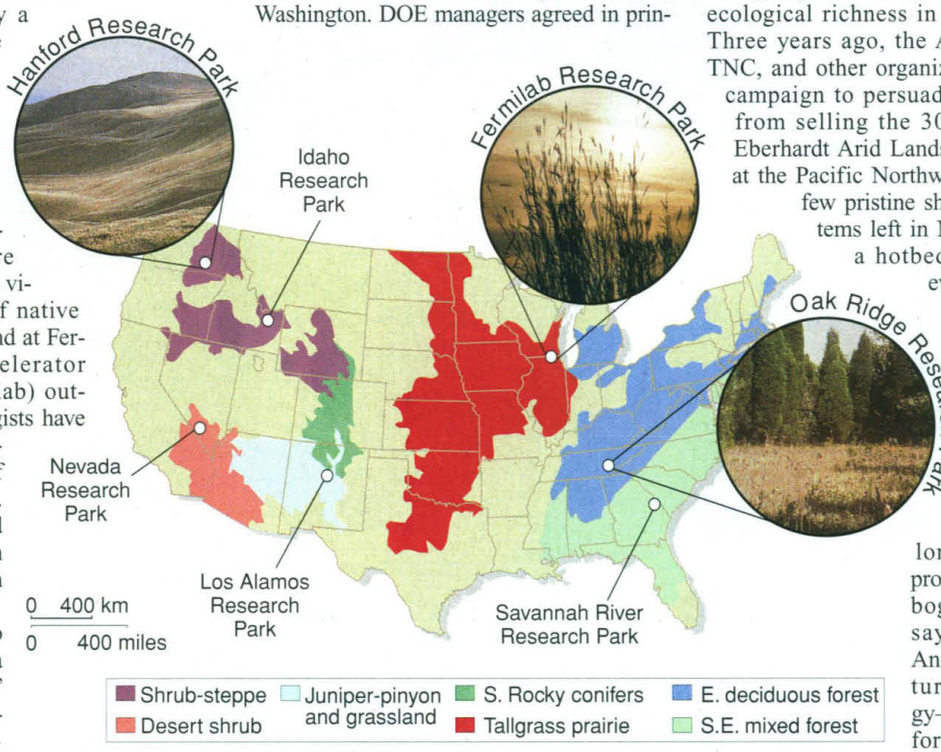


**Diversity.** DOE's research parks are set in a variety of ecosystems.

CREDITS: (CLOCKWISE FROM LEFT) THE NATURE CONSERVANCY; FERMILAB VISUAL MEDIA SERVICES; OAK RIDGE NATIONAL LAB; SOURCE: SREL