

announcement that the Lunar Prospector spacecraft had detected significant amounts of hydrogen—presumably from water—above the dark regions of the poles. But those early investigations probed just a meter or two into the lunar soil.



**SHADOWED CRATERS** at the lunar south pole—in particular, craters Shoemaker and Faustini—returned blank stares from ice-seeking radar, dashing hopes for easy access to moon water.

Campbell's team used the Arecibo radar to penetrate more than five meters into the floors of several small shadowed craters near the moon's north pole and into Shoemaker and Faustini craters at the south pole. When the observatory detected weak radar echoes, the researchers concluded that they must have been encountering only lunar rocks and dust, which absorb most of the beam.

Campbell admits that he was disappointed not to find thick ice deposits, but he points out that his team's results in no way imply

that the moon is ice-free. Crystals as big as golf balls could be common components of the lunar soil, he explains, and they would be invisible to radar. The problem is that the crystals may well be snowflake-size or smaller, and harvesting them from other lunar material would be more challenging and costly than excavating blocks of ice.

Discovering slabs of ice below two meters would also have implied that the total supply of lunar ice was considerably greater than the best current estimate of 10 billion tons or more. That may sound like a lot, but it's really just a small lake's worth, notes Alan B. Binder, founder and director of the Lunar Research Institute in Tucson, Ariz. Lunar visitors could face tough decisions about how to conserve a very limited resource, Binder says.

Some researchers still insist that ice sheets may exist in places where no one has looked. Last year physicist Ben Bussey of Johns Hopkins University and his colleagues reported that the moon's cold traps might cover twice the area cited in

previous estimates. Bussey also suggests that substantial deposits may exist in the floors of many impact craters that cannot be viewed from Earth.

No one seems to quibble that the next step is to take a closer look. NASA is already considering a mission that would probe the floor of a shrouded crater and send samples back. And with China and the Bush administration both discussing ambitious plans for manned lunar missions, astronauts may soon get a chance to see for themselves.

## GETTING THE MOON ALL WET

There's no doubt that the moon gets its water from an external source, and water-laden comets often get the credit. But recent computer simulations indicate a less obvious origin: the sun. Hydrogen ions carried in the solar wind constantly pelt the lunar surface and occasionally hook up with oxygen atoms that are abundant in moon rocks. Most of the fledgling H<sub>2</sub>O molecules break apart and escape into space, but some hop along the lunar terrain until they freeze inside sunless craters near the poles. There icebound hydrogen could constitute about 4 percent of the rocky soil—more than enough to account for the 1.5 percent hydrogen that Lunar Prospector detected in 1998.

## ECOLOGY

# When Blade Meets Bat

UNEXPECTED BAT KILLS THREATEN FUTURE WIND FARMS BY WENDY WILLIAMS

**T**he interaction of bats and wind turbines is emerging as a major and unexpected problem in northern Appalachia. From mid-August through October 2003, during the fall migration period, at least 400 bats died at FPL Energy's 44-turbine Mountaineer

Wind Energy Center on Backbone Mountain in West Virginia.

The bats apparently died by colliding with the wind turbines, but why so many animals were killed at this particular site remains a mystery. The public outcry over these num-

bers threatens to delay or halt construction of some of the additional several hundred wind turbines planned for the tristate region of West Virginia, western Maryland and south-central Pennsylvania.

Steve Stengel, a spokesperson for FPL, which is based in Juno Beach, Fla., says the company is cooperating with federal biologists to study the problem of bat kills at Mountaineer. "We don't know exactly why it happened," he states. "We're moving quickly to find out as much as we can." Some scientists believe that the migrating bats may not be using their echolocation when the collisions occur. Others speculate that the wind turbines may be emitting high-pitched sounds that draw the bats to the site. Still others suggest that the animals may be getting caught in wind shear associated with the turning turbines.

West Virginia biologists have identified the majority of the 400 bats that were recovered from the Mountaineer site—mostly common species such as red bats, eastern pipistrelles and hoary bats. "What's scary," remarks biologist Albert Manville of the U.S. Fish and Wildlife Service, "is that we may be finding only a small percentage of what's been killed." That is because bats are very small and difficult to find in the field; also, scavengers could discover the bat corpses before researchers do.

At issue is the length of time that wind-energy entrepreneurs are devoting to preconstruction wildlife studies. The Fish and Wildlife Service issued voluntary siting guidelines last summer, indicating that a census of wildlife activity should precede the building of a wind farm. Some biologists feel that such a census should last two years, although some energy companies believe this length of time to be excessive. (The guidelines are voluntary because in many cases the federal agency has little enforcement power unless an endangered or threatened animal is actually killed.)

Concerned that the endangered Indiana bat may be at risk at FPL's 20-turbine wind

project in Meyersdale, Pa., wildlife advocates are threatening legal action. They allege that thorough habitat studies were not done in advance of construction at Meyersdale.

A letter last October from a bat biologist hired by the project's builders would appear to back them up. Pennsylvania State University's Michael R. Gannon spent two days last spring looking for bat caves on the future wind-farm site. He suggested that Indiana bats may use the site as a summer habitat and noted that at least a summerlong study might



**WHEN GREEN ENERGY** meets red bats, the mammals seem to lose. Some wind farms are finding this species of bat, as well as many others, dead on their properties. Such discoveries could threaten planned wind farms and force revisions in the way turbines are sited.

be appropriate. But industry biologists disagreed, Gannon says. "A two-year study should have been conducted prior to the installation of the turbines to determine the potential risk to bats," he wrote in his letter. "Unless and until these data are available, it should be assumed that this site is a flight path of the Indiana bats and that Indiana bats will be killed.... Data that are available indicate this as a very likely scenario."

FPL, which bought the project during development, still wants more information. "We are reviewing the matter," Stengel comments, "and after our review we will respond, if appropriate."

*Wendy Williams, based in Mashpee, Mass., writes for Windpower Monthly, an international news magazine.*

## NEED TO KNOW: BAT WATCHING

Bats have been killed at other wind turbine sites across the nation, but nothing on the scale of the recent Mountaineer incident has yet been documented. Keeping the bats away from the turbines means finding out just exactly how and why the bats are killed. One key could be infrared cameras, says James A. Simmons of Brown University, an expert on bat echolocation: "You have to watch the collisions occur. Because of the difficulty of seeing them, an infrared camera is the only way to do that." Merlin D. Tuttle of Austin, Tex.-based Bat Conservation International agrees: "There may be simple ways to solve these big problems, but first you have to take a look."