Everglades Rebound From Andrew

The wetlands will recover from the hurricane, but threats from urbanization, from agriculture, and–ironically–from the Endangered Species Act pose tougher problems

HOMESTEAD, FLORIDA—Looking down from a National Park Service helicopter, it's apparent that Hurricane Andrew delivered a solid blow to the Everglades when it passed through the heart of the largest U.S. wetland on the morning of 24 August. Mangroves on the western edge of the Everglades were stripped bare, and in some areas 160-mile-per-hour winds splintered 75% of the trees. The central grasslands look as they always do, but the hundreds of oblong tree islands look as if Godzilla had used them for stepping stones: trees flattened, shrubs smashed, alligator holes muddied.

But to researchers who gathered in early September to conduct a post-hurricane survey, the view out the window of the helicopters was reassuring as well as sobering. Andrew spared the southern quarter of the Everglades, and 20 days after the storm, surviving trees and shrubs were already sporting new growth, painting the area pale green. Alligator trails were prevalent, and flocks of great egrets, tricolored herons, great blue herons, roseate spoonbills, and other wading birds scattered at the sound of the approaching helicopter. Deer rutted, manatees swam offshore from the mangroves, and the hawks known as snail kites continued to pluck apple snails from the tops of the tall sawgrass.

PATRICIA COULFIELD/ANIMALS ANIMALS

JOE ALPER

Restricted diet. The snail kite, a hawk found in the Everglades, eats only one food: the apple snail. Remains of a snail kite's meal are shown at right. The kite is an endangered species whose future poses problems for the Everglades—because the Endangered Species Act focuses on individual species rather than on ecosystems.

"The system took a good shot, and certainly it will take some time to recover fully, but this isn't an eco-catastrophe by any stretch of the imagination," said Marty Fleming, senior research biologist with the Park Service. That resilience may be expected of an ecosystem that has evolved in an area prone to hurricanes. More disturbing to ecologists who were present to view the trail of the hurricane is that Andrew's destruction laid bare chronic problems—ecological and political—for the future of the Everglades.

The key issue is water: Since the 1920s the exploding urban population and farming have diverted more and more of the water needed to keep the Everglades wet. A surprisingly unanimous coalition of government agencies, local interests, and ecological groups wants to restore the Everglade's water supply and preserve its biological health. But here's the rub: How to do it? And when that question comes up, it brings with it a devilish conflict between preserving single species and preserving the ecosystem as a whole. The Endangered Species Act is the main policy mandate for ecological planners in the Everglades. Yet what is best in the short-term for individual endangered species—such as the snail kite—may not be best for the ecosystem in the long run. Scores of interviews with ecologists, conservation biologists, and policy makers suggest that this contradiction springs up in every area of U.S. environmental planning. And there is an emerging consensus that broader ways of thinking about ecological problems—rooted in the latest scientific thinking about ecosystems rather than individual species—are badly needed.

"In the Everglades we have over a dozen endangered or threatened species, each with varying needs that aren't necessarily compatible, within a changing ecosystem," said David J. Wesley, Florida supervisor for the U.S. Fish and Wildlife Service. "As an ecologist, I would argue that the best solution is to restore the Everglades as a functioning ecosystem, and in the long-run, that will benefit all the wildlife there. But as an official of the agency that oversees the Endangered Species Act, I have to consider the effects these changes will have on those species that are endangered at this moment."

Many of those effects stem from the complexities of water supply and flow. Until the 20th century, water moved through the Everglades in a huge, slow-moving sheet. Water spilling out of Lake Okeechobee in the north took nearly a year to flow through one of two grassland rivers: Taylor Slough, which flowed to Florida Bay, and Shark River Slough, which emptied into the Gulf of Mexico. Both rivers took an eastward path through what is now the western parts of suburban Miami before turning south or west.

During the rainy season, lasting from May through October, water overflowed the sloughs and flooded the outlying grasslands, providing a crucial part of the basis for this rapidly changing ecosystem. Fish, the most important resource for wading birds and alligators, colonized these areas, which ecologists call "short hydroperiod wetlands," and reproduced rapidly. When the landscape dried during winter and spring, the fish congregated in ever-smaller pools, providing easy pickings for predators. Since the sloughs remained wet all year, a base population of fish remained, ready to spread out when the rains returned in summer. Other predators and prey, such as the snail kite and the apple snail (on which the bird feeds), also found strategies for adapting to the seasonal flux in water levels.

Rolling back the waters. That was the pattern for millennia. But in 1905, the newly elected governor of Florida, a man with the imposing name of Napoleon Bonaparte Broward, began to implement a campaign promise to drain the Everglades to provide more room for building and development; since then, an ever-expanding system of canals, dikes, and levees has severely altered nature's dynamic hydrology. By the time Everglades National Park was created in 1947, half the ecosystem had been converted to urban or agricultural use, and of the remaining 80,000 km^2, only 60% was within the

park. The remainder came under the jurisdiction of a government agency with a distinctly different purpose: the South Florida Water Management District, whose mission is to supply water to Miami and the largely corporate farms in the Everglades Agricultural Area (EAA) surrounding Lake Okeechobee, and to protect those areas from flooding during the rainy season.

Today, the northern half of the Everglades is little more than a collection of diked pools connected by canals. Water released from the pools flows down the canals, eliminating any chance for the rain-driven sheet-flow that once made the Everglades what they were. The result: Few of the short hydroperiod wetlands, once the region's hallmark, survive in the north. In the southern half of the region, by contrast, the hydrology is closer to the pre-urban norm, but there is not enough water flowing through the sloughs to create more than a small fraction of the short hydroperiod marsh needed by the system's wildlife.

And that is a situation that perturbs ecologists. "Ideally, there should be an extensive area of short hydroperiod marsh that dries out over 5 to 10 months, depending on the rainfall in a given year, and that stays dry once every 10 years," said Stuart L. Pimm, professor of ecology at the University of Tennessee and a member of a blue-ribbon scientific panel put together at the Park Service's request earlier this year by the Audubon Society to evaluate the Everglades' ecology. "Instead," says Pimm, "the limited short-hydroperiod areas dry down over just a few months and stay dry 1 year out of 3."

One of the ironies of Hurricane Andrew is that it actually recreated an approximation of the original ecosystem. Andrew's predicted arrival prompted the Water Management District to release large quantities of water into the Everglades to prevent farms in the EAA from flooding. As a result, the view from the post-storm survey chopper showed, for the first time in years, large areas of wet grassland on either side of Shark River Slough.

The report from the Audubon panel is due out this fall, but *Science* has obtained a prepublication copy. It agrees with the consensus in the ecological community that recreating rain-driven sheet-flow is the key to solving most of the Everglades' ecological problems. And, if that is done, it could be a major aid in eliminating another problem: two exotic plant species that are destroying key habitat areas.

At least one of the species—*Melaleuca quinquinervia*, an Australian eucalypt—is directly related to the water-flow problem, because the plant was introduced in the 1920s to help dry out the Everglades. It has by now colonized about 100,000 acres and has recently begun taking over the neighboring Big Cypress National Preserve. At the same time, the shrubby *Schinus terebrinthinus*, or Brazilian pepper, moved into the park from the Miami suburbs and now covers about 100,000 acres of what were once mangrove in the west and pineland in the south.

Both species are essentially weeds, producing dense, monotypic stands that choke out any growth beneath them; both thrive under the altered hydrologic regime. But neither will grow if there is at least 6 inches of standing water at the time of seed germination, a condition that would exist in most years in a restored Everglades. "This would not only stop the spread of these exotics, but give us an opportunity to get rid of the stands that already exist," says biologist Fleming of the Park Service.

Turning on the tap. Restoring something like the original water flow would also greatly benefit the nesting population of wading birds, a central component of the park's fauna that is currently dwindling rapidly. At present, 300,000 wading birds winter in the Everglades, but in summer only about 20,000 to 30,000 make their nests there, compared to as many as 500,000 in 1910. The key to the decline may be the altered water pattern, which eliminates the optimum conditions for nesting.

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Unwelcome immigrant. *Melaleuca*, an Australian eucalypt introduced into the Everglades in the 1920s, has colonized 100,000 acres—pushing aside native plants.

But in spite of a remarkable unanimity of opinion—including the Audubon Society and the scientific community, the Park Service, the U.S. Fish and Wildlife Service, the Army Corps of Engineers, the South Florida Water Management District, and most local interests—that an improved water flow is crucial to the ecosystem in the park, restoring that flow has not proved simple. A surprising problem has been the single-species approach mandated by the Endangered Species Act.

Several agencies started down the road to restoring the original hydrology in 1989, when Congress enacted the Everglades National Park Protection and Expansion Act. The act provided funds for adding 107,600 acres to the eastern side of the park, land critical to restore normal flow through the Shark River and Taylor Sloughs. Beyond that, the act directed the Army Corps of Engineers to work with the Park Service to "restore the natural hydrological conditions within the park."

Thus commanded by Congress, the National Park Service, the Army Corps of Engineers and the Water Management District worked to develop a plan for restoring something approaching the original pattern of water flow. There was only one objection—but it was critical. In February 1990, a U.S. Fish and Wildlife Service biologist, who has since been transferred to Maine, determined that the plan could harm the endangered snail kite and therefore issued a "jeopardy opinion" under the Endangered Species Act. The result: Planning came to a halt.

The sticking point was that, in changing the hydrology, the restoration plan would drain a large, flooded field on the park's northern border that has become the snail kite's favorite feeding ground, because the standing water forces the bird's only prey—the apple snail—to crawl onto the tall sawgrass, offering an easy meal. Draining the area would force the snail kite to search elsewhere for food, and that could cause short-term problems. Park Service biologists counter, however, that the kite frequently moves around the Everglades as local apple snail populations rise and fall.

The Park Service was stunned by the jeopardy opinion. Even biologists at the Fish and Wildlife Service disagreed. To resolve the controversy and get the derailed plan back into operation, the agencies agreed to convene an independent scientific panel. And to avoid the delays involved in government organizations, they called on the National Audubon Society.

After reviewing the available data on snail kite behavior, and the jeopardy opinion, the panel concluded the problem was more bureaucratic than biological. Specifically, the panel saw that the emphasis on a single endangered species could put the ecosystem on which that species depends at risk. "The very nature of the process leading to the jeopardy opinion was likely to create problems," says panel chairman Gordon H. Orians, a University of Washington zoologist. "The parties involved couldn't exchange ideas or explore the various scientific hypotheses regarding the snail kite's feeding habits or habitat re-

quirements of its sole prey, the apple snail. In short, the whole process worked against both the snail kite in particular and the Everglades in general."

In fact, the Audubon panel concludes that studies cited to support the jeopardy opinion were flawed and that, while maintaining the status quo could produce short-term benefits for the snail kite, it would probably cause serious problems in the long run. "The only way to protect the snail kite, and the other endangered species in the Everglades, is to gradually restore the entire system," said Orians.

The report stressed that restoration must begin immediately. Sugarcane and citrus farms in the area are becoming less productive and some are already going fallow because land in the region has lost much of its topsoil and is subsiding at a rate of several inches a year. As a result, real estate prices have fallen. The Water Management District has already purchased some of the land, but the panel expressed fears that in the future farmers may try to have their land zoned for commercial or domestic development to increase its resale value. If this should happen, and prices shoot up to the point where the government cannot afford to purchase the land, "the overall goal of restoring the hydrology of the area cannot be accomplished."

Another critical recommendation in the Audubon panel's report is to separate Miami's water supply from the Everglades. The greater Miami area gets much of its water from wells sunk within the Everglades, but since the city lies above a "superbly permeable aquifer," it should be possible to recharge that aquifer with water that is currently being dumped out of the Lake Okeechobee drainage area into the Atlantic Ocean in the name of flood control.

Ecologists are hoping that publication of the Audubon panel's report this fall will help jump start the stalled restoration plan. If so, it will remove clouds over the future of the wetland that are darker than any brought by Hurricane Andrew. But beyond the Everglades, the report, with its emphasis on the entire ecosystem and multispecies management, could provide a model for other threatened natural areas. By staying within the provisions of the Endangered Species Act and at the same time preserving overall biodiversity, that plan could help to realize a goal that is bound to become increasingly important in environmental policy in the years to come.

–Joe Alper

GENE THERAPY

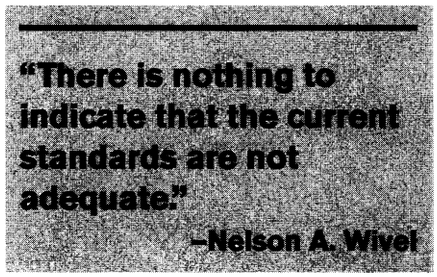
Monkey Tests Spark Safety Review

Since early this year, the Food and Drug Administration (FDA) has been grappling with two key questions about the safety of human gene therapy: What is the chance that the "vectors," the crippled viruses used to transfer genes to human patients, could cause disease? And how should researchers who regularly use those vectors test them to make sure they're safe? These questions have always hovered in the background of experimental attempts at gene therapy, but late last year they took on added urgency when studies at the National Institutes of Health (NIH) showed that certain viruses, which might contaminate the vector preparations, can cause cancer in monkeys.

In the wake of those studies, unconfirmed reports began flying that the FDA was about to stop approving new gene therapy protocols until the safety questions were resolved. FDA is now trying to scotch those rumors: "There is no moratorium," says Gerald V. Quinnan Jr., deputy director of the FDA's Center for Biologics Evaluation and Research. "We are still reviewing new protocols and INDs (investigational new drugs) as we get them. The routine approach to [safety] testing will continue to evolve with time, but there is no big new problem with gene therapy."

Quinnan's declaration means practitioners in the embryonic field of gene therapy can breathe easily, at least for the moment. But the debate over safety hasn't gone away. Indeed, questions about safety testing dominated the 13-14 September meeting of the Recombinant DNA Advisory Committee (RAC), the NIH group charged with reviewing new gene therapy protocols.

The objects of concern are the laboratory cell lines that produce the hobbled mouse retrovirus used to transfer genes to human beings. Ordinarily, the viruses from these cells are not capable of reproducing ("replication competent," as virologists say), but occasionally the cells do produce virus particles capable of replicating and causing infection. RAC and FDA require testing to ensure that vector preparations are free of infectious virus. But even if a small amount of replication-competent virus got through, researchers have long believed there was little risk. The reason: Experiments in the mid-1980s, in which NIH scientists intentionally injected infectious mouse retroviruses into healthy monkeys, suggested that the viruses weren't capable of causing disease.



But last year, Arthur Nienhuis, chief of clinical hematology at the National Heart, Lung, and Blood Institute, got different results. In Nienhuis' lab, three of eight rhesus monkeys involved in an NIH gene transfer experiment developed lymphoma, a cancer of the lymphatic tissue. The monkeys had been treated with a preparation known to contain viable viruses, but on the basis of the previous studies, Nienhuis' group assumed they were harmless. FDA took the results seriously. "When Art Nienhuis' monkeys got lymphomas, that was the first data which said replication-competent virus can be pathogenic," said FDA's Paul Aebersold. "These data necessitated a rethinking of viral testing."

That rethinking has already begun at the companies that want to pursue gene therapy experiments. On 13 September, FDA officials met with scientists from Gene Therapy Inc., (GTI) a Gaithersburg, Maryland, biotech company that has submitted several protocols for new gene therapy experiments. As a result of the safety concerns, GTI proposed adding several sensitive tests for infectious virus.

Despite the concern over Nienhuis' results, NIH and FDA experts agree that none of the nearly 30 humans who have received genetic transfers worldwide has been harmed. "There is no indication of any human risks," said Aebersold. "None of the patients have shown any problems which could be attributed to the fact that they had [gene] marked cells or genetically transduced cells." RAC director Nelson A. Wivel adds: "There is nothing to indicate that the current standards are not adequate."

In discussing the recent events, FDA officials have adopted several different tones. Some have tried to downplay the intent of the FDA's review. "It was not meant to throw a scare into the industry about dangers to the patients," said FDA scientist Phil Noguchi. "We are just smarter than we were a few months ago." Aebersold, on the other hand, concedes that "if Art's experiment had been done 3 years ago, we might have had a different timetable for the initiation of gene therapy. Additional testing would have been required from the beginning."

But since the results weren't available 3 years ago, the reconsideration must be done in midstream. The RAC has put the issue on the agenda for its December meeting, and FDA is still deciding what safety tests it will require. FDA sources predict the internal discussion on that issue should be complete in a month.

–Larry Thompson

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