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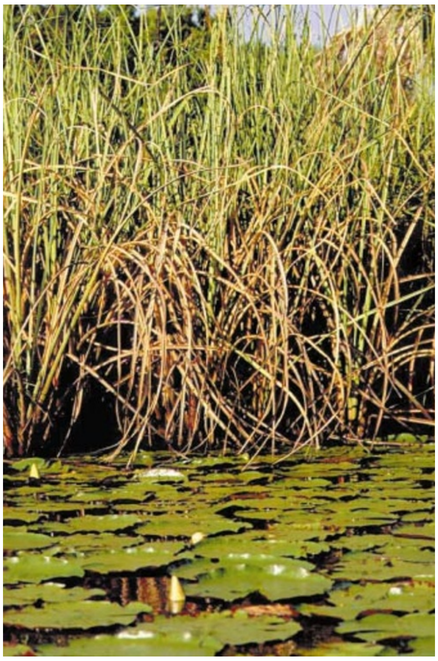

Wet and wild: loss of Everglades habitats threatens species such as the American crocodile (below).

Save our swamp

Florida's Everglades are the focus for the largest ecological restoration project yet attempted. But critics claim the present plan will fail to halt the wetlands' decline. Mark Schrope investigates.

In the 1920s, the southwards march of development in Florida ran up against the vast wetlands of the Everglades. Over the decades that followed, the construction of an elaborate network of levees, canals and dams allowed a boom in agriculture and population. Today, about half of the original wetlands are gone, and a large volume of water that once flowed through the Everglades is now diverted into the Atlantic and the Gulf of Mexico. Numerous plants and animals, such as the American crocodile, *Crocodylus acutus* are in dramatic decline, and wading bird populations have dropped to about one tenth of their former strength.

In December, as the world's media focused its attention on Florida's disputed election, the outgoing US president, Bill Clinton, signed a bill authorizing the first tranche of spending on a plan to rescue the Everglades. The Comprehensive Everglades Restoration Plan is billed as the largest ecological restoration project ever attempted. Its total cost, spread over two decades, is expected to reach $8 billion, with the state of Florida and the federal government sharing the tab.

The plan is largely the work of the South Florida Water Management District (SFWMD) — a state agency based in West Palm Beach — and the US Army Corps of Engineers. It calls for land to be bought and flooded to allow better storage and release of water through the ecosystem. It also aims to remove some barriers to flow, and build a water control network of pumps and water treatment and storage areas.

But among hydrologists and wetland ecologists, there is a growing consensus that the plan is seriously flawed. Scientific critics argue that, in focusing primarily on restoring historical depths of water, too little attention has been paid to patterns of water flow. They fear that the plan will allow substantial further degradation of the Everglades. And some marine ecologists are concerned that the plan could also threaten Florida Bay, further damaging its already fragile health.

Everyone agrees that there are no simple answers. Returning the Everglades to their natural state is not an option. The project's goal is instead to restore flow as much as possible while also considering the needs of local residents and farms.

Breach the barricades

The present plan would increase water movement through existing barriers, for instance by raising small sections of highways on to bridges, or cutting breaks into levees. At the same time, it would imitate aspects of historical flows using the water control network. The critics' central concern, based on recent studies of the Everglades' hydrology, topography and palaeoecology, is that too few barriers are being removed. "If you're going to restore that ecosystem," says Stuart Pimm, an ecologist at the University of Tennessee in Knoxville, "you have to let this free-flowing system be a free-flowing system."

These concerns stem in part from research by Christopher McVoy, a hydrologist with the SFWMD. McVoy has pieced together a picture of what the Everglades

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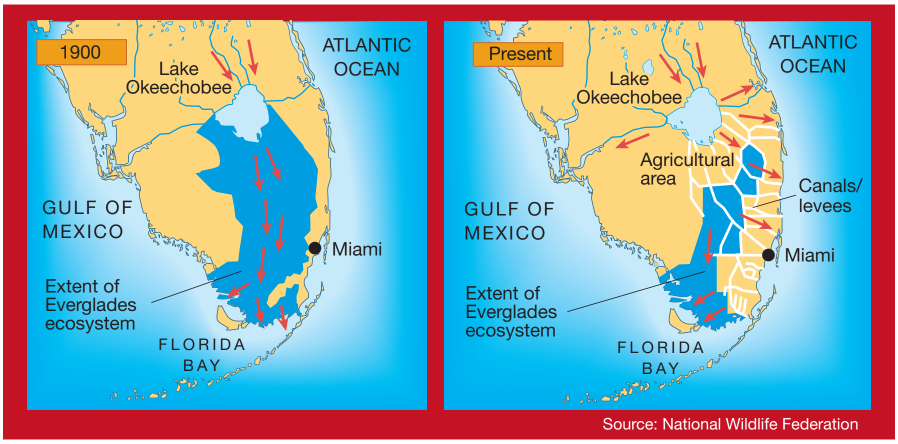

Before and after: about half of the wetland Everglades ecosystem has been lost to drainage.

were like before drainage began. Using historical sources such as aerial photos from the 1940s, he has compiled information about past topography and ecology[1].

McVoy's research indicates that the natural flow of water through the Everglades created a series of parallel ridges and sloughs, each about 500 metres wide and with a difference in elevation from ridge top to slough bottom of about half a metre. This pattern provided critical wildlife habitats. The drier ridges supported stands of sawgrass, *Cladium jamaicense*, whereas the sloughs were always flooded, maintaining an aquatic ecosystem. But most of this topography has now gone, and McVoy blames the reduction of free flow.

He and others believe that flowing water kept the sloughs from filling in by slowly transporting organic material downstream in particulate or dissolved forms. To test this hypothesis fully, continuous measurements of such transport at various sites in the Everglades are needed. But preliminary unpublished work by a team led by Daniel Childers at Florida International University in Miami has confirmed that fluffy particulates known as 'flocculent' organic matter are indeed found suspended in the Everglades' waters.

Other researchers have studied soil cores under a microscope, identifying pollen grains to see what type of vegetation dominated particular spots over the past several millennia[2]. They have found evidence for concentrations of sawgrass, characteristic of ridges, and water lilies, characteristic of sloughs, persisting in the same pattern for centuries at a time.

McVoy fears that this original pattern will continue to degrade under the present restoration plan, causing further loss of critical aquatic habitats and possibly allowing dense stands of sawgrass to dominate the ecosystem. He has pressed his point at conferences, building a growing ecological consensus behind the view that the restoration plan must be reworked. "He's been standing up and saying if we don't take out these barriers to flow, then we will continue to lose whole landscapes," says Robert Johnson, director of the Everglades National Park's South Florida Natural Resources Center in Homestead. "That's been a hard effort on his part, but I think the scientific community is responding well to what he's saying."

At the Greater Everglades Ecosystem Restoration Science Conference, held in Naples, Florida, last month, ecologists agreed that research to test McVoy's ideas should be a top priority. But it could take 20 years definitively to identify degradation of the natural topography resulting from implementing the plan as it stands — and the critical decisions must be taken now. "The best you can do is look at the pattern and think about the likely processes that formed it and make likely guesses," says McVoy.

Given the depth of ecologists' concerns, Pimm in January 1999 coordinated a letter to Bruce Babbitt, Secretary of the Interior. Signed by prominent scientists including Edward O. Wilson of Harvard University, the father of biodiversity research, it called for the restoration plan to be reviewed by the National Research Council (NRC), a branch of the National Academy of Sciences. Thanks in part to this letter, such a review is now underway, and the first of a series of NRC reports should be issued by the end of this month.

The architects of the plan defend their work. Tom Teets, project manager for the plan at the SFWMD, and Russell Reed, a senior civil engineer on the project with the Corps of Engineers, say that plans with more barrier removal were modelled, but they led to complications with excessive water or dryness in certain areas.

However, critics argue that options with more barrier removal were not given enough consideration and believe that any problems could be overcome. If the NRC panel backs their views, it will be difficult for the SFWMD and the Corps of Engineers to resist the calls for change. "One thing we always anticipated is constant peer review and interaction with the scientific community as the plan is developed," says Teets.

The rot sets in

Even if the arguments over removing barriers to water flow within the Everglades are resolved, another ecological controversy will remain. This centres on how much adding a large volume of freshwater to the Everglades will affect Florida Bay, into which most of the additional water will drain.

During the 1980s, it became clear that all was not well within the bay, which began to suffer from alarming die-offs of seagrasses — submerged marine flowering plants that stabilize sediments, provide a habitat for fish, crustaceans and molluscs, and are eaten by animals such as turtles and manatees. Blooms of planktonic algae have also become more frequent.

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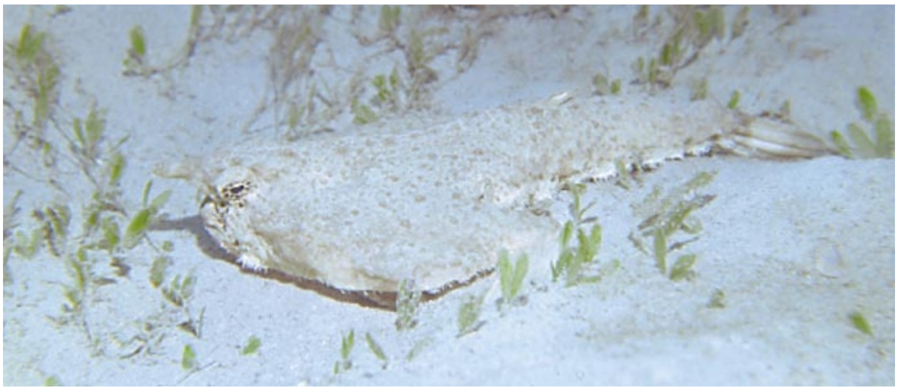
When the levee breaks: engineers are punching holes through some barriers to water flow.



HEATHER ANGEL/BIOFOTOS

Out to grass: a shortnose batfish (*Ogcocephalus nasutus*) rests among shoots of turtle grass.

The most widely accepted theory for why this has happened blames the reduction in freshwater flow from the Everglades caused by their drainage[3]. The idea's main proponent is Joseph Zieman, a coastal marine ecologist at the University of Virginia in Charlottesville. Historically, he argues, the bay experienced rising and falling inputs of freshwater, and hence salinity, depending on the rainfall in a given year. This variation in salinity supported a diversity of seagrasses.

Once the Everglades began to be drained and the water volume flowing into the bay plummeted, the salinity became more uniformly marine. This allowed a single species, *Thalassia testudinum*, or turtle grass, to take over. During droughts, Zieman argues, salinity now gets high enough in places to damage even the turtle grass. As the dead seagrass rots, releasing nutrients into the water, it feeds algal blooms that in turn block light and cause more seagrass die-offs. The loss of seagrasses also allows storms to churn up more bay sediments, which frees further nutrients to fuel the blooms.

Brian Lapointe of the Harbor Branch Oceanographic Institution in Fort Pierce, Florida, opposes this view. He believes the algal blooms stem in the first instance from elevated levels of nitrogen in water flowing from the Everglades, and that the blooms are responsible for seagrass die-offs.

Lapointe's ideas were long ignored, largely because the prevailing view has been that algal growth in the bay is limited by the amount of phosphorus present, not nitrogen. But in unpublished experiments, Carmelo Tomas of the University of North Carolina at Wilmington and his colleagues have shown that nitrogen can stimulate algal growth in samples taken from parts of the bay. And in a forthcoming paper[4], Lapointe documents events in the early 1990s when increased freshwater flows into the bay lowered salinity and raised nitrogen levels. This increased algal blooms and seagrass die-offs, even in areas where salinity was not a problem.

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Fragile: corals could suffer if levels of nitrogen in run-off from the Everglades increase.

Drain storms

Some marine ecologists believe that both Zieman and Lapointe have valid points. "I would say that most people would acknowledge that it's likely that salinity has been an important factor," says David Rudnick, an estuarine ecologist with the SFWMD. "But most scientists look at the whole picture and would say that nutrients have also probably been a factor."

This makes the impact of the Everglades restoration plan on Florida Bay difficult to predict. If salinity is the main problem, then an increase in the volume of freshwater entering the bay should help. But if nitrogen in run-off from the Everglades plays a significant role in the bay's ecological dynamics, then increasing the volume of water flowing into the bay could exacerbate the situation. The present restoration plan aims only to limit phosphorus levels, by controlling inputs from sources such as agricultural fertilizers and incorporating areas of wetland vegetation that will remove the element from the water through natural uptake.

Rudnick and his colleagues have found high levels of some nitrogen-containing compounds in water flowing from the Everglades[5]. But it is not yet clear how much of that nitrogen is natural and how much has arisen from human activity. Until 1998, Don Boesch of the University of Maryland's Center for Environmental Science in Cambridge chaired the Science Oversight Panel for the Florida Bay Program, a consortium of state agencies studying the bay's ecology. He says his group argued that there was a compelling need for more work to investigate nitrogen sources, as well as for systematic tests of the salinity and nitrogen hypotheses. He is frustrated that the agencies working in the bay did not make these studies a higher priority.

Rudnick says that Boesch's message has now been taken on board. "We definitely have more of a focus on nitrogen than we used to have," he says. "I think we will be in a better position to deal with this issue within the next two to three years." But there is little information about nutrient levels and the dynamics of the seagrass beds during the time before the problems were recognized. Given this, Boesch and Lapointe argue that there is an urgent need for experiments in controlled environments where the effects on seagrass of altering levels of nitrogen and salinity can be studied directly.

If a decision is eventually made to reduce the amount of nitrogen flowing into Florida Bay, it will be more difficult to accomplish than limiting phosphorus. But Lapointe argues that it could be done, for instance by incorporating algal aquaculture into water treatment areas — in essence creating contained algal blooms to soak up the nitrogen. "We should have been researching this for the past decade," he says.

Concerns about nitrogen do not end with Florida Bay. At least some of the run-off from the Everglades makes it through the Florida Keys, the chain of islands that extends from the end of the peninsula, and onto the coral reefs found on the Keys' Atlantic side. Lapointe firmly believes that nitrogen from the Everglades is contributing substantially to the decline of those reefs. Again, Lapointe fears that the Everglades restoration plan could accelerate this decline. "I think he really has something to say," says Phil Dustan, a coral reef ecologist at the College of Charleston in South Carolina, who recently completed a five-year study of Florida's reefs, finding an overall decline in coral cover of nearly 40% over that period[6].

As the restoration plan unfolds, other problems may emerge. And the performance of the plan's managers and their scientific advisers in wrestling with these issues will be watched keenly by ecologists planning restoration efforts elsewhere. "There's a long road ahead," says Robert Halley, a geochemist with the US Geological Survey in St Petersburg, Florida, who helped develop the restoration plan. "I think we'll stumble along the way, but we'll pick ourselves up." ■

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