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## To Save Its Canal, Panama Fights for Its Forests

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MIRAFLORES, Panama - A freighter slides slowly into the first of the Miraflores Locks, red, orange and white cargo containers stacked six or seven high on its deck. Gates swing shut and the lock begins to drain, water flowing into the lock below.

A few minutes later, when the water levels are equal, gates at the other end of the lock swing open, and the ship moves into the next chamber. Once again, water drains, gates open and the ship and its tons of cargo head out to the Pacific Ocean.

Something else is moving, too - about 26 million gallons of water, the amount that drains from the Pedro Miguel and Miraflores Locks each time a ship goes through them to or from the Pacific. The same amount drains into the Atlantic when ships pass through the Gatún Locks on the other side of the isthmus. So each trip through the canal, or lockage, means 52 million gallons of water. On a busy day, there may be as many as 40 lockages.

The water comes from Gatún Lake, one of the largest artificial lakes in the world, created during construction of the canal.

The canal depends on the lake and its water, and they in turn depend on the health of the surrounding watershed forest. But in the last few decades, half of it has been lost to logging and slash-and-burn agriculture.

Panamanians know what will happen if they cannot maintain an adequate supply of water for the canal. In the drought winter of 1990-91, lack of water forced canal operators to curtail lockages to fewer than 30 a day, something no one here is eager to repeat.

Although Panama City is a major financial center now, by some estimates the canal and its associated businesses still contribute 40 percent or more of the nation's economy.

And if Panamanians vote to upgrade or expand the canal, an issue they are expected to confront in a referendum this fall, the reliability of Gatún Lake's water supply will be even more crucial.

"We need the water for the functioning of the canal," Reyna Carrillo, a guide at Miraflores, recently told a group of visitors. "Without the water, we would be the biggest ditch in the whole world."

The Panama Canal Authority and an array of scientists are working together to study Gatún Lake's hydrology, to restore its watershed and to teach the people who live there the importance of preserving it.

Gatún Lake is fed chiefly by the Chagres River, which was dammed during the construction of the canal. It straddles the isthmus at the canal's highest elevation, and part of the canal runs through it.

Water per se is not its problem. The Chagres drains a tropical jungle where it rains 10 feet or more each year - about three times as much as it rains in Seattle or New York, and in theory more than enough to keep the locks operating at capacity.

But the rain does not fall steadily year-round. Most of it comes from May to December, in brief but intense downpours. An inch in an hour is ordinary, and six inches in a day is hardly unheard of. Rain falls so heavily in Panama that early canal builders described storms as turning the air to water.

On forested slopes, much of this water soaks into the ground and feeds slowly into watershed streams and then into Gatún Lake.

But deforested slopes cannot absorb heavy rains.

Floods of water run off into the lake, overflow Gatún Dam and run out to sea - useless for lockage. Meanwhile, eroded sediment ends up on the lake bottom, reducing its storage capacity.

One consequence is apparent to those who traverse the Gatún Lake portion of the canal.

Between the town of Gamboa and Barro Colorado Island, a dredge anchored offshore drills into the lake bottom, sucking up excess sediment and pumping it through long pipes to shore.

The resulting turbulence fills the lake with so much silt that people nearby who rely on it for drinking water have to filter it or use bottled water instead. But the dredging helps maintain the lake's capacity to store water.

Columbus and his men were the first Europeans to see the towering forests of the Chagres River basin, with their 1,500 species of trees, some of them growing more than 100 feet tall, and the howler monkeys and toucans and other creatures that inhabit them. Another Spanish seafarer, Juan Corzo Serna, wrote about them in 1524, according to Stanley Heckadon Moreno, a sociologist and research associate at the Smithsonian Tropical Research Institute in Panama.

"He is our first witness to the land," Dr. Heckadon said. "He describes it as a monumental forest."

Despite the building of a railroad across the isthmus in the 19th century, the completion of the canal in 1914 and the military buildups of World Wars I and II, the watershed forest was more or less intact until about 1950, Dr. Heckadon said in an interview.

But by then the United States had built a highway across the isthmus, from Panama City north to Colón.

"Pretty soon we ended up with 3,000 kilometers of trails built by loggers and followed by cattlemen and slash-and-burn farmers," Dr. Heckadon said. In the Chagres basin and in the watershed on the other side of the canal, thousands of acres fell to their machetes and chain saws.

When the treaty turning the canal over to Panama was negotiated in the Carter administration, "there was a belief 'now this area is ours, we can go in there,'" said Luis A. Alvarado Kinkey, a hydrologist

who is environmental division manager for the canal authority, known as A.C.P., its initials in Spanish. "There was a lot of influx from the interior. They started cutting down forest to build pasture at an alarming rate."

Panamanians were such assiduous practitioners of slash-and-burn agriculture that some here began to joke bitterly that they must be born with machetes in their hands.

Deforestation peaked in the 1980's, said Dr. Robert F. Stallard, a geologist at the Smithsonian research institute in Panama who studies the hydrology of the watershed. By 2000, when Dr. Heckadon and his colleagues completed a study using satellite imagery and ground surveys, they found 53 percent of the watershed forest had been lost.

Today travelers who fly over the isthmus see a patchwork of forest and pasture.

The Panamanian government first recruited Dr. Heckadon to examine the issue in the 1980's, when he formed a study group of scientists and technical experts to evaluate the health and future of the watershed. "One of the main conclusions was the absolute national imperative to protect the surviving forests," Dr. Heckadon said in an interview. At the urging of the study group, Eric Arturo Delvalle, then the country's president, established Chagres National Park, which covers about 250,000 acres or about a third of the canal watershed. "I think on that day he bought the insurance policy on the Panama Canal," Dr. Heckadon said.

But things did not go well. Much of the 1980's was "a lost time," Dr. Heckadon said, when Panama was under the de facto control of Gen. Manuel Antonio Noriega and deforestation continued. Even after the United States arrested General Noriega in 1990, conditions were initially unsettled and Chagres and smaller watershed parks were not adequately protected.

But then things began to change. Dr. Heckadon, who became the nation's first environment minister, said one important step came when leading Panamanian bankers decided to stop financing cattle ranchers who cut down forest for pasture. "That withdrew the oxygen of the fire of slash and burn," he said. And with the canal turnover in 1999, government agencies acted again to expand protected watershed areas.

Now, Mr. Alvarado says that only negligible amounts of watershed are lost each year to deforestation. But others say that official agencies do not have enough money or staff to patrol the parks as closely as they wish and that, as a result, logging and burning is continuing, even if on a smaller scale.

"With the chain saw these guys can do anything," Dr. Heckadon said. "They look at a mahogany tree and they cut it on the weekend, saw it in slabs, get it on someone's pickup. It's a problem."

Dr. Stallard said: "There are constant threats on the park boundaries. There is always chipping at some border."

So the canal authority and other agencies have also begun community efforts to educate rural Panamanians about the importance of preserving the forest landscape. "We now employ people the old canal would never imagine it would - social workers for example," Mr. Alvarado said. "We work with the communities. We work with the schools."

Meanwhile, efforts are also under way to restore damaged landscapes. A.C.P. has begun a program

called the Native Species Reforestation Project - a cooperative arrangement with the Smithsonian, the Yale University School of Forestry, the International Development Center at the Kennedy School at Harvard and other universities and agencies to study ways to protect the canal watershed and restore its native vegetation.

The scientists are learning as they go, because little is known about reforesting tropical rain forests, said Dr. Mark S. Ashton, a professor of forest ecology at Yale. Dr. Ashton said in an e-mail message that scientists hoped to restore the landscape in ways that protected the watershed, enhanced biodiversity and identified trees and other plants that could be grown and harvested sustainably, replacing slash-and-burn farming as a source of income.

But the effort, known by its Spanish acronym, Prorena, is complicated by the presence of an invasive and persistent form of a grassy plant called wild sugar cane or paja blanca (*Saccharum spontaneum*).

Dr. Stallard said biologists first spotted this grass in the canal area in 1978, and since then it has established itself in huge stands.

The plant, apparently an immigrant from Asia, has tenacious roots that hold the soil, an advantage in preventing soil runoff. But it grows aggressively and crowds out potentially useful native plants. "It might prevent erosion, but it does not have any other use," Mr. Alvarado said. So the authorities here want to remove as much of it as they can.

For many in Panama, the success of these and other efforts to protect the canal watershed means more than the money - \$65,000 for an average toll - for ships passing through the canal.

"People came from all over the world to make this dream possible," Ms. Carrillo tells visitors at the locks at Miraflores.

But, she reminds them, "Even when the Americans were here, if they had cut the forest we would have no canal today."