Warming streams have cascading impacts in the Amazon

October 14 2014, by Amy Mcdermott

Farmland and forest in stark contrast. Credit: Marcia Macedo

Water carried by the Xingu River winds through Northern Brazil. It cuts across 1,200 miles of protected rainforest before joining the mighty Amazon and surging toward the sea.

Although the Xingu snakes through a mosaic of federally protected land,

its headwaters do not. The multitude of small streams that feed into the Xingu at its source are largely unprotected.

The Xingu's headwater streams once babbled through lush forest, but today they are increasingly surrounded by cattle ranches and cropland. As the landscape changes, so do the streams. And as the streams change, so could the whole Xingu River.

In 2013, ecologists from Columbia's Earth Institute, the Woods Hole Research Center, the Woods Hole Marine Biological Lab, and Brazil's Instituto de Pesquisa Ambiental de Amazonia, published new research in the journal *Philosophical Transactions of The Royal Society*, examining the effects of increased agricultural development on streams at the headwaters of the Xingu, in Mato Grosso, Brazil.

The researchers focused specifically on water temperature, because it directly affects stream health, and because common agricultural activities (including streamside deforestation and small-scale damming) are responsible for a warming trend.

Stream temperatures were measured for 12 sites throughout the 109,000 square mile upper Xingu watershed over a period of 16 months. Researchers found that streams in agricultural areas were significantly warmer (by three to four degrees Celsius) than those sheltered by forest.

Aerial view of a changing landscape. Credit: Paulo Brando

Normally, native vegetation shades streams, keeping them cool. But when riparian zones are deforested for agriculture, native trees are often replaced with shorter pasture grasses and crops. Streams are left exposed, facing the full brunt of the sun.

Higher water temperatures are bad news for sensitive aquatic organisms, which often thrive in a narrow temperature range. "Most aquatic organisms can't regulate their body temperature relative to the environment," explained Dr. Marcia Macedo, a landscape ecologist and lead researcher in the 2013 study.

"In general, higher temperature means shorter development time and

higher metabolism, so you need more resources to survive." As their world warms, stream animals must adapt to their changing environment, and many can't keep up.

Exposed streams are not only warmer; they're also brighter. Removing forest cover allows more light to reach a stream, which can drastically change the types of aquatic plants and animals able to live there.

In addition to deforestation, the unregulated damming of small streams also changes these fragile ecosystems. When streams are dammed to form drinking ponds for cattle or for small hydroelectric turbines, there are potential effects on fish movement and downstream populations.

Streamside deforestation. Credit: Marcia Macedo

"Although these are small streams and small watersheds, they are a representative pathway for the whole region," says Macedo. "This is all happening upstream of big reserves where people do fish. There's a big sports fishing operation in the region and there are indigenous people who rely on fish too… we don't really understand how it will play out in the bigger river, but we expect that it does."

Headwater streams and downstream ecosystems are intimately linked. "These small streams represent about two thirds of the entire stream network, so although they're small, they're many," Macedo explains. "And widespread change in the biogeochemical cycling and nutrient inputs at the small stream scale is going to cascade up and have impacts at a larger scale." Protected areas that don't account for the movement of water and aquatic organisms can't necessarily protect everything they intend to. This study highlights the importance of responsible land use on private property outside of protected areas, because unprotected headwater streams will ultimately flow downriver to impact protected ecosystems.

What can be done? As Earth's population grows and demand for food increases, tropical agriculture will only expand. But do farms need to come so close to the water's edge?

Dams disrupt the flow of headwater streams. Credit: Vania Neu

Results of this study imply that intact forest acts as a streamside buffer, keeping water temperatures cool and stable. Leaving forests intact along riverbanks may be one way to reach a happy medium between agricultural development and stream health.

Today, farmers are legally required to conserve 80 percent of their private properties, including 30 meters of forest around their streams, as undeveloped forest reserve. Prior to this study, these laws were based largely on conventional wisdom, but little work had been done to quantify the impact of streamside forests on stream health in the tropics. Education and enforcement of the law were problematic because tangible gains of streamside forest hadn't been illustrated in local

systems. This study is a first step toward better education and management practices to enforce and expand the protection of streamside forests, headwater streams, and the larger Xingu River.

Provided by Columbia University