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Extreme weather events provide window for scientists studying Amazon climate change

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A fisherman and his sons return from a good day of fishing for tambaqui, one of the Amazon's most high-value fish species dependent on the floodplains. Credit: Virginia Tech

Three extreme weather events in the Amazon Basin in the last decade are giving scientists an opportunity to make observations that will allow them to predict the impacts of climate change and deforestation on some of the most important ecological processes and ecosystem services of the Amazon River wetlands.

Scientists from Virginia Tech, the Woods Hole Research Center, and the University of California, Santa Barbara, funded by NASA, are collaborating with Brazilian scientists to explore the ecosystem consequences of the extreme droughts of 2005 and 2010 and the extreme flood of 2009.

"The research fills an important gap in our understanding of the vulnerability of tropical river-forest systems to changes in climate and land cover," said the project's leader, Leandro Castello, assistant professor of fish and wildlife conservation in Virginia Tech's College of Natural Resources and Environment.

The huge study area encompasses 1.7 million square miles, the equivalent of half of the continental United States.

In addition to historical records and ground observations, the researchers will use newly available Earth System Data Records from NASA—satellite images of the Amazon and its tributaries over the complete high- and low-water cycles.

NASA is funding the study with a $1.53 million grant shared among the three institutions.

"Amazon floodplains and river channels—maintained by seasonal floods—promote nutrient cycling and high biological production, and support diverse biological communities as well as human populations with one of the highest per capita rates of fish consumption," said Castello.

The researchers will look at how the natural seasonality of river levels influences aquatic and terrestrial grasses, fisheries, and forest productivity in the floodplains, and how extreme events such as floods and droughts may disturb this cycle.

"We are confident that deforestation and climate change will, in the future, lead to more frequent and severe floods and droughts," said Michael Coe, a senior scientist at the Woods Hole Research Center. "It is important that we understand how the Amazon River and ecosystem services such as fisheries are affected so that we can devise mitigation strategies."

Amazonian grasses, sometimes called macrophytes, convert atmospheric carbon to plant biomass, which is then processed by aquatic microorganisms upon decomposition.

Tambaqui is a fruit-eating fish species known to taste like the fruits it eats; its taste varies throughout the year depending the seasonality of the fruit ripening. Credit: Virginia Tech

"Terrestrial grasses grow during the short window when water levels are low, sequestering some carbon, and then die when the floods arrive, releasing the carbon into the aquatic system," said Thiago Silva, an assistant professor of geography at São Paulo State University in Rio Claro, Brazil. "They are followed by aquatic grasses that need to grow extremely fast to surpass the rising floods and then die off during the receding-water period."

"Although most of the macrophyte carbon is released back to the atmosphere in the same form that it is assimilated, carbon dioxide, some of it is actually exported to the ocean as dissolved carbon or released to the atmosphere as methane, a gas that has a warming potential 20 times larger than carbon dioxide," said John Melack, a professor at the University of California, Santa Barbara.

Researchers will measure plant growth and gas exchange, and use photographs from the field and satellites.

Two other Amazon resources—fisheries and forests—are important to the livelihood of the people of the region.

"We will combine water level, fishing effort, and fish life-history traits to understand the impact of droughts and floods on fishery yields," said Castello, whose specialty is Amazon fisheries. "Floods in the Amazon are almost a blessing because in some years they can almost double the amount of fish in the river that is available for fishermen and society."

The fishery data include approximately 90,000 annual interview records of fisheries activities on the number of fishers, time spent fishing, characteristics of fishing boats and gear used, and weight of the catch for 40 species. The hydrological data include daily water level measurements recorded in the Madeira, Purus, and Amazonas-Solimões rivers.

The researchers will examine the potential impact of future climate scenarios on the extent and productivity of floodplain forests—those enriched by rising waters, called whitewater river forests, and nutrient-poor blackwater river forests.

For example, extreme droughts may reduce productivity due to water stress and increases in the frequency and severity of forest fires. Prolonged periods of inundation, on the other hand, may decrease productivity or increase mortality due to water-logging stress.

"We will evaluate these responses for the first time at a regional scale using remotely sensed indicators of vegetation condition and fire-induced tree mortality to measure the response of floodplain forests to inter-annual flood variability and extreme climate events," said Marcia Macedo, a research associate at the Woods Hole Research Center.

Researchers will measure tree litter dry weight, depth of flooding, tree height and diameter, and stand density. They will also use photographs and satellite images.

Previous research has focused on Amazon upland forests and the potential impacts of deforestation, fire, and drought. The research team will compare new greenhouse gas simulations to previous simulations.

"Our research informs large river ecology globally because natural flowing rivers like the Amazon are rare these days, and most research to date, being done in North America and Europe, has focused on degraded systems," Castello said.

Castello will coordinate fisheries analyses working jointly with consultant Peter Bayley of Oregon State University and Nidia Fabré and Vandick Batista of Universidade Federal do Alagoas, Brazil.

Macedo and Coe will perform hydrological analyses, and Macedo will work with consultant Bernardo Flores of Wageningen University and Universidade Federal do Rio Grande do Norte to complete forest fire analyses.

Laura Hess of the University of California, Santa Barbara will lead forest productivity analyses. Melack will work with Silva on macrophyte productivity analyses.

Provided by Virginia Tech

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