# Carbon cycling in the peat swamp forests of Borneo

February 29 2016, by Kelsey Damrad

MIT grad student Alison Hoyt studies the carbon cycle of Borneo's tropical peat swamp forests. These forests store a huge amount of carbon in underground peat soil, which can be up to 20 feet deep. Credit: Alison Hoyt

Imagine a two-hour boat ride through the dark waters of the Mendaram

River, a humid hike through flooded forest floors, and weeklong camp outs without Internet or phone access.

For Department of Civil and Environmental Engineering graduate student Alison Hoyt, this experience is threaded throughout her last several summers researching the hydrology and carbon cycling of the peat swamp forests of Southeast Asia. Her work in the lab of Professor Charles Harvey is part of a collaboration between MIT and Singaporean researchers—the Singapore-MIT Alliance for Research and Technology.

"It's certainly an intense experience to work in a forest where the ground surface is completely flooded," Hoyt says. "It makes practical life tricky, but it's also incredibly exciting. There were times we had to use our boat as the kitchen and even eat dinner standing in water."

Hoyt first explored tropical forests when her family moved to Costa Rica as a child. This sparked her interest in working in the tropics. After completing her undergraduate work at Yale University in environmental engineering and physics, she proceeded to join the Department of Civil and Environmental Engineering (CEE) at MIT as a graduate student in hydrology.

Tropical peat swamp forests are being drained and deforested at an alarming rate. The dry peat burns, causing fires and haze across the region. Credit: Alison Hoyt

For the past several years, she has trekked to the inner depths of Southeast Asia to study the implications of draining and deforesting tropical peatlands as they are converted to oil palm and acacia plantations. She recently spoke with CEE about her work:

## Q: What are the real world implications of your research?

A: Peat is an incredibly organic soil that forms over thousands of years.

A defining characteristic of tropical peat swamp forests is that the ground is completely flooded throughout the majority of the year. This means that decomposition of roots, branches, and leaves is very slow—so slow that fallen roots, leaves, and branches slowly accumulate over time, creating a thick layer of peat soil. In the field sites where I am working, both in Brunei and Indonesia, this layer of soil has been accumulating for nearly 3,000 years, and is over 15 feet deep.

Currently, due to the scarcity of land in coastal regions and a high demand for palm oil, many peatlands are being drained and deforested to satisfy the need for agriculture and oil palm plantations. When this occurs, this rich soil burns, and thousands of years' worth of accumulated carbon is released into the atmosphere, mainly as $CO_2$.

The devastation of tropical peatlands has implications at a variety of scales. At a global scale, the drainage of peatlands is a major source of $CO_2$ to the atmosphere, equivalent to 1-3 percent of total global emissions from the combustion of fossil fuel. On a local scale, the drained peat is an excellent fuel for fire. The fires are mostly started by people trying to clear the land and then the peat soil itself catches fire causing it to burn out of control. Once a peat fire begins, it can burn on this rich soil for months, particularly during the dry season. This results in a heavy haze throughout the region each summer and fall. Neighboring countries are also subjected to this unhealthy air quality.

## Q: What opportunities have you had to delve deeper into your research?

Alison Hoyt collects water samples for analysis. Credit: Alison Hoyt

A: Although people acknowledge that tropical peatlands are releasing a lot of carbon into the atmosphere, it's not very well known exactly how much and which types of land uses release the most carbon.

During my time in [CEE], I've had the chance to work at a protected forest site in Brunei. This site is remote and relatively inaccessible, so to get there we have to drive, take a boat, hike in several hours with all of our equipment, and finally camp out at the site for up to a week at a time. As it's a swamp forest, the ground is completely flooded and the journey to the site is an adventure in itself.

This past summer, I conducted fieldwork in Brunei looking at a pristine, intact tropical peat swamp forest as a way to study the ecosystem in its natural, undrained state. This particular fieldwork focused primarily on methane—a very important greenhouse gas released from wetlands in their natural state and much more potent than CO2. My team and I were looking to discover how much methane is being released as well as the source of the methane. We also hope to better understand how these peatlands are different from those in North America and Europe.

Overall, we are studying these peatlands in their natural state and then comparing that to what happens to the carbon cycling when they're drained and deforested. During past fieldwork in Borneo, my research focused on CO2 emissions—a greenhouse gas released when the peatlands are drained. When these peatlands are drained, the water table is lowered. This introduces oxygen to the peat, causing it to decompose and release CO2 to the atmosphere. My team and I were looking at the relationship between water level and CO2 emissions, and confirmed that they are strongly linearly correlated.

It's been a privilege to work with such a large and diverse team. We have people from many different disciplines working at our field site—everything from biology, to hydrology, geochemistry, and paleoclimate. I really enjoy this project because it provides me the opportunity to employ both hydrology and geochemistry to explore a pressing environmental challenge.

## Q: What's the next step for you in your work?

A: In the next part of my PhD, I plan to focus on subsidence. After peatlands are drained, the peat's ground surface actually starts to sink. Right now this is being measured in a few places, but there are no widespread projections or data on the speed at which this is happening. Our preliminary work has indicated that some of these peatlands are sinking very rapidly—in some places as fast as 10 cm per year! Unfortunately, most of these peatland areas are in coastal regions, so if this rate of subsidence continues it will create a threat for flooding over the next 50 years or so. The rest of my project will utilize remote sensing and satellite imagery to create large-scale regional maps that highlight the rate of subsidence and future flooding projections.

The skills I've gained in [CEE] are applicable to many other research questions. For example, I recently started working on a project in Siberia studying carbon cycling in permafrost soils and how that relates to climate change. I hope to continue to explore related research questions—both during and after MIT.

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