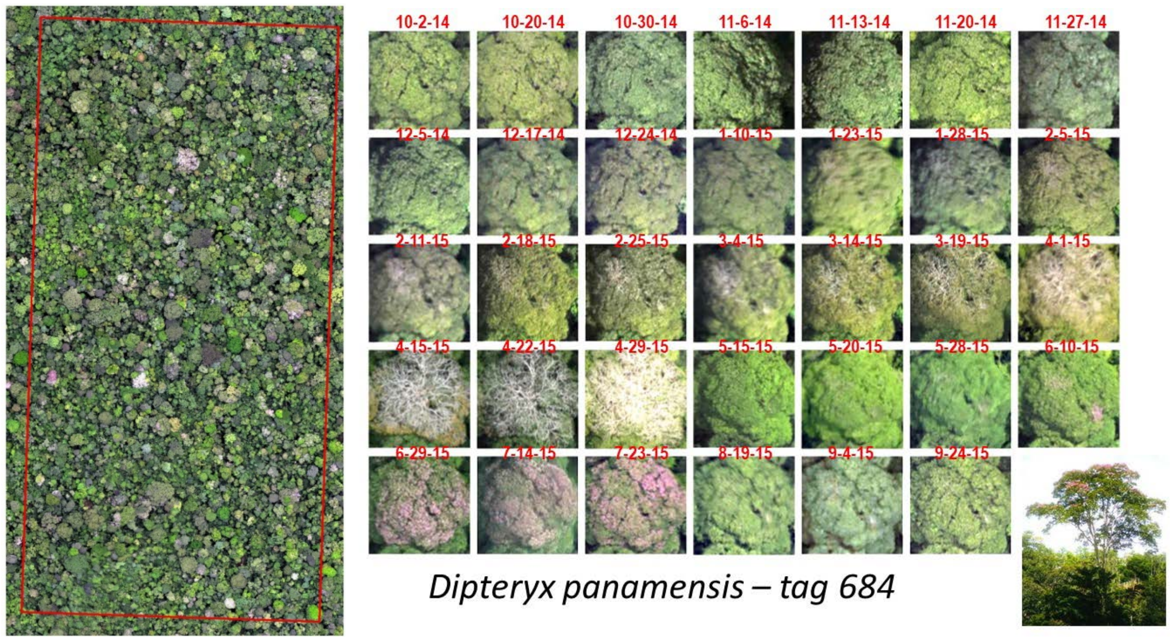
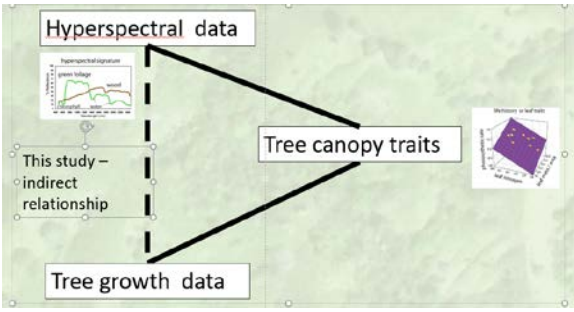
Tropical Forest Phenology

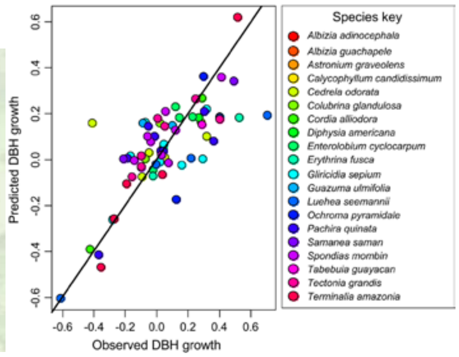


Tropical forest phenology - the patterns of leaf flush, leaf drop, flowering and fruiting - are important for the carbon and water exchange, plant-animal interactions, decomposition, and other ecosystem processes in this critical ecosystem. Unlike temperate forests, which generally have deciduous trees that drop leaves for the winter or evergreen trees that keep leaves year round, tropical forest species display a huge range of phenological patterns that we think respond to patterns of soil and atmospheric moisture, light, day length, temperature, herbivory and other biological interactions. Synchrony in phenology is limited among species, and even within species. Quantifying patterns of phenology among and within species is difficult with field work because of high species diversity and the obscured view of the top of the tropical forest canopy, and challenging with satellite data because of high cloud cover, smoke and haze.

Near-surface remote sensing, from unmanned aerial vehicles (UAVs) and tower-mounted cameras, view the top of the canopy below cloud cover and can help us understand the phenology of tropical trees. UAVs in particular can cover enough different tree crowns to quantify the variation within and among tree species and potentially understand their environmental drivers. Starting in 2014, our team has collected wall-to-wall images of the Barro Colorado Island 50-ha forest dynamics plot in Panama to quantify how species vary in their phenological patterns. Ongoing work focuses on (1) producing quantitative metrics of phenology from images that are taken in varying lighting conditions, (2) scaling up patterns of phenology from individual crowns to landscape patterns detectable from satellite data (3) analyzing the environmental drivers of individual species phenology and their relationship to leaf traits and (4) using this information to improve models of ecosystem function.

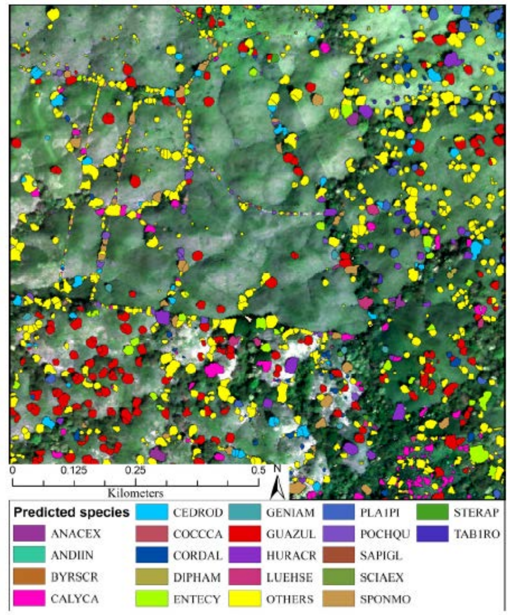
Remote Sensing of Tree Growth





Hyperspectral images, which quantify light reflected from the earth's surface in hundreds of narrow wavelength bands across the energy spectrum, have become an important tool for quantifying ecosystem structure and composition, and for monitoring ecosystem health. Indeed, hyperspectral techniques can identify species, including exotics, quantify the chemical composition of vegetation and indicate plant stress and disease. These vegetation properties can lead to differences in plant growth and performance through time. Because hyperspectral data can successfully quantify vegetation characteristics that control tree growth, we hypothesize that a single hyperspectral image may be able to discriminate individual trees and species that are growing at different rates. We have demonstrated this proof-of-concept (hyperspectral discrimination of tree growth rates) in a multi-species reforestation trial in Panama and are now exploring (1) what traits allow the link between hyperspectral reflectance and growth to be successful and (2) if this approach can also work at broad array of sites, including locations in the National Ecological Observatory Network.

Contribution of trees to ecosystem services of tropical agricultural landscapes



Agriculture is a large and increasing land cover in the tropics. Many agricultural landscapes in the tropics retain significant tree cover in the form of small forest fragments, riparian forest strips, live fences and isolated trees. In large-scale scale assessments of ecosystem function, biodiversity and carbon, the landscape is often divided into forest and non-forest (agriculture) with little understanding of how trees in non-forest classes contribute to ecosystem services. With this project, we are quantifying the contribution of agricultural tree cover to biodiversity, aboveground biomass and other ecosystem services in the highly deforested Azuero peninsula in Panama. We combine high resolution remote sensing with field data and models to identify tree species and quantify biomass with a focus on linking field and image data on individual trees, rather than estimating biodiversity and biomass on pixel or plot-scales. We hope to link this detailed understanding of tree distributions on the landscape to identify areas most suitable for reforestation, and/or that may need interventions link tree planting to assist reforestation. Furthermore, we have coupled the analysis of biophysical drivers of reforestation with knowledge of organizational support for environmental improvement to help identify where scarce intervention resources can best be deployed.

Amazon Dams Network

Hydroelectric dams are being built in the Amazon basin at an accelerating pace. While providing electricity for growing national economies and export to other nations, these dams have tremendous impacts on river hydrology, sediments and aquatic organisms including fish communities. Changes in the environment, in addition to the building of the infrastructure itself, lead to intensive and ongoing impacts to communities in the vicinity, upstream and downstream of the dams. I help lead the Amazon Dams Network, a transdisciplinary group of researchers and practitioners from the University of Florida, universities from other parts of the U.S. and Amazonian countries, the US Geologic Survey (USGS) Glen Canyon Adaptive Management Program, international governmental agencies and non-governmental organizations, indigenous peoples and other stakeholders impacted by dams. The goals of this network are

- to conduct and coordinate research on the environmental and social impacts of hydroelectric dam development in the Amazon
- share knowledge, perspectives and experience among academics, decision-makers, stakeholders and others related to dam impacts on people, water and forests
- encourage cross-site learning about adaptive management of Amazon dams, the Glen Canyon dam on the US Colorado River, and dams throughout the world
- foster collaboration that leads to inter- and trans-disciplinary research on Amazon dams
- improve the planning, management and mitigation of dams in the Amazon via developing improved information on social-environmental impacts and via enhanced communication among stakeholders, decision makers, and researchers

My lab group is particularly interested in the direct (reservoirs destroy forests) and indirect impacts (people displaced by dams clear land for new homes and livelihoods) of dams on the terrestrial environment. Infrastructure development, such as road-building, is known to be a key driver of deforestation in tropical areas, but hydroelectric dams have been largely overlooked as a threat to tropical forests. My lab group is particularly interested in the impacts of altered hydrology on riparian forests in the Amazon and on the impact of the transmission line network on forests.