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Tracking the dynamics of human modified tropical forests in Borneo

David Coomes (1), Matheus Henrique Nunes (1), Tom Swinfield (1), and Gregory Asner (2)

(1) Cambridge University, Plant Sciences, Cambridge, United Kingdom (dac18@cam.ac.uk), (2) Department of Global Ecology, Carnegie Institution for Science, 260 Panama Street, Stanford, CA 94305 USA

Asian forests are under substantial threat, particularly from conversion to oil palm plantations and intensive logging. Few regions have seen such rapid and extensive transformation as the island of Borneo, where 163 thousand square kilometres (30%) of forest were lost between 1973 and 2010 and even greater areas were logged. Tracking changes in carbon stocks associated with land conversion processes is difficult with optical remote sensing, but repeated surveying of landscapes with airborne LiDAR provides high-resolution maps of carbon density change resulting from tree growth and death processes. Here, we use LiDAR surveys made in 2014 and 2016 to estimate changes in carbon density across 300 km2 of highly heterogeneous human-modified landscape in Malaysian Borneo. We show that oil palm plantations accumulated carbon at an average rate of 1.98 Mg/ha/year while degraded forests that were not logged between the two surveys accumulated 2.8 Mg/ha/year of carbon. Set against these gains, 18% of the forested area was intensively logged between the surveys, which reduced carbon stocks by 62%. Riparian forests surrounded by oil palm plantations represented 5.7% of the forested area and 70% of these riparian strips were wider than 30 m, exceeding requirements under Malaysian law. Riparian areas surrounded by large forest fragments gained 8.2 Mg/ha/year, but those surrounded by oil palm plantations grew by only 0.34 Mg/ha/year. Fragmentation had discernible influences on forests up to 580 metres from edges. Overall, carbon stocks declined by 6% as a result of logging and fragmentation. The study provides evidence that the current policies towards riparian forests have not been effective, that oil palm plantations create edge effects regardless of the plantation age and that logging is the main factor contributing to carbon emissions. We demonstrate the power of repeated airborne LiDAR to uncover carbon dynamics at multiple spatial scales in heterogeneous human-modified tropical landscapes