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REPORT

The Tropical managed Forests Observatory: a research network addressing the future of tropical logged forests

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Abstract

While attention on logging in the tropics has been increasing, studies on the long-term effects of silviculture on forest dynamics and ecology remain scare and spatially limited. Indeed, most of our knowledge on tropical forests arises from studies carried out in undisturbed tropical forests. This bias is problematic given that logged and disturbed tropical forests are now covering a larger area than the so-called primary forests. A new network of permanent sample plots in logged forests, the Tropical managed Forests Observatory (TmFO), aims to fill this gap by providing unprecedented opportunities to examine long-term data on the resilience of logged tropical forests at regional and global scales. TmFO currently includes 24 experimental sites distributed across three tropical regions, with a total of 490 permanent plots and 921 ha of forest inventories.

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Introduction

While deforestation in the tropics remains a major environmental issue to be tackled (Hansen et al. 2013), forest degradation deserves more attention from a broad range of stakeholders concerned about social and ecological well being. Degraded forests are a major component of tropical landscapes (Laurance et al. 2013); over half of all tropical forests have been cleared or logged, and almost half of standing primary tropical forests, up to 400 million ha, are designated by national forest services for timber production (Blaser et al. 2011). The portion of tropical forests managed for timber extraction, hereafter referred to as 'managed forests', will therefore play key roles in the trade-off between provision of goods and maintenance of carbon stocks, biodiversity and other services. However, so far, most of our understanding of tropical forest yields is from plot networks located in old-growth undisturbed forests or in secondary forests, while the dynamics of managed forests at the regional and continental scale remains poorly studied (Cho et al. 2013).

Monitoring of managed forests is important for myriad reasons, including the need to understand their roles in the global carbon cycle and the trade-offs between environmental impacts and human benefits. With regard to these trade-offs, the results of monitoring can be used to design silvicultural treatments that mitigate any deleterious impacts of forest use and enhance the resilience of forest subjected to unavoidable impacts so as to maximize the conservation values of those forests (Sist et al. 2008; Putz et al. 2012). Moreover, given that forest management practices, forest structure and dynamics differ widely among tropical countries and regions, assessments of the impacts of different practices are needed at regional and continental scales to inform policy (Sist et al. 2008).

To address the challenge posed by tropical forest management, 20 research institutes are now collaborating on studies on the effects of logging and post-logging silviculture on forest structure, productivity, biodiversity and carbon fluxes at large spatial and temporal scales. These efforts resulted in the creation of the Tropical managed Forests Observatory (TmFO), an international network that merges information from experimental sites across South America, Africa and South East Asia. TmFO aims to address the data and knowledge gaps by promoting collaboration among institutions that monitor permanent plots in managed tropical forests, some of which were established by foresters many decades ago. These institutions house irreplaceable and unique data on logged forests from before CO_2, temperature and precipitation regimes reached contemporary levels. TmFO's guiding questions include: (i) how resilient are tropical forest structure, function and composition to logging; (ii) how do forest responses to logging and other silvicultural treatments vary across regions and continents; (iii) what are the trade-offs between financial viability and environmental sustainability of commercial logging; and (iv) what is the role of silviculture in forest conservation?

Presentation of the network

TmFO currently comprises 24 experimental sites located in nine countries across three main regions (Fig. 1): Amazon Basin (11 sites, five countries); Congo Basin (six sites, two countries); and South East Asia (seven sites, two countries). A total of 921 ha of tropical managed forests spread over 490 permanent sample plots (PSP) are inventoried (Appendix S1). Among them, 59 control plots (12%) are in undisturbed forests. TmFO spans a large gradient of logging intensities (5–60% of above-ground biomass removed) and silviculture practices (reduced-impact logging, conventional logging and post-logging silvicultural treatments). These features offer unique opportunities to investigate post-logging dynamics over a wide range of conditions, up to those that were heavily degraded by high-intensity unplanned logging.

Given that TmFO's plots were established by different organizations, often with different purposes, there is some variation in data collection protocols, but all the PSPs: (i) are located in tropical forests with a total area inventoried $\geq$ 1 ha; (ii) have all trees at least $\geq$ 20 cm DBH measured and botanically identified by experts; (iii) have a mean annual rainfall $\geq$ 1600 mm; (iv) have consistent information on logging treatments (e.g. number of stems harvested and biomass removed) and logging impacts (e.g. logging damage assessment).

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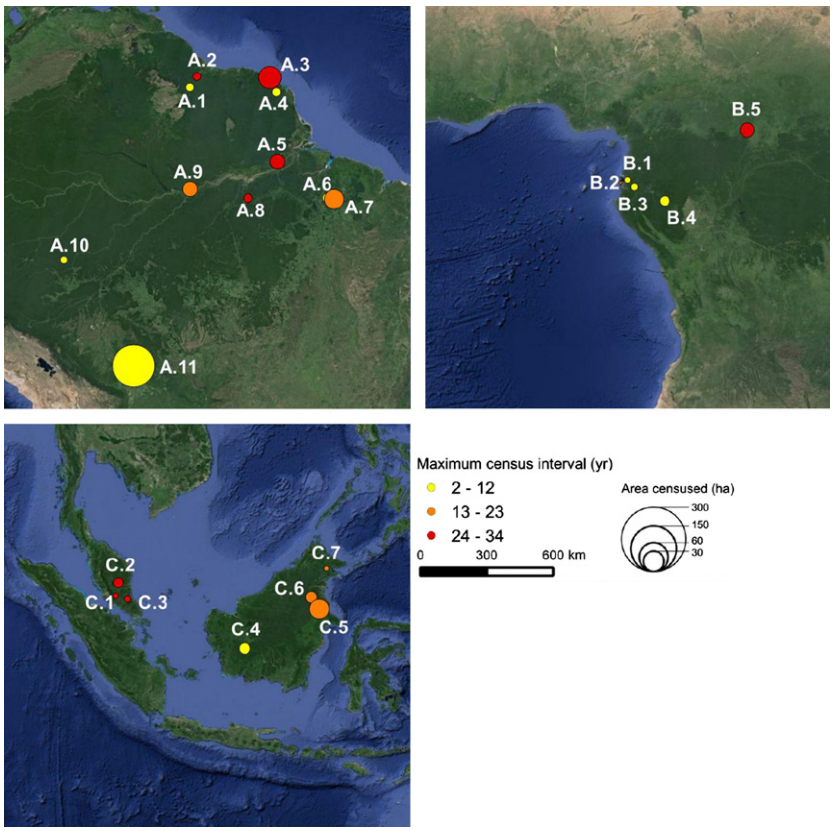

Fig. 1. Plot locations of TmFO (A.1: Iwokrama; A.2: Celos; A.3: Paracou; A.4: Tortue; A.5: Jari; A.6: CIKEL; A.7: Paragominas; A.8: Tapajos; A.9: Itacoatiara (MIL); A.10: Tabocal; A.11: La: Chonta; A.12: Moju; B.1: Aboun; B.2: Mondah; B.3 Monts de Cristal; B.4: Milole; B.5: Mbaiki; C.1: Pasoh; C.2: Tekam; C.3: Lesong; C4: PT Erna; C.5: STREK; C.6: Malinau).

While the majority of the plots are in tropical wet forests (22 sites with annual precipitation > 1800 mm), research sites in Bolivia and in the Central African Republic are in semi-deciduous tropical forests (Appendix S1). The quality of the botanical identification is exceptionally good, with most stems identified to the species level at most sites, offering the opportunity to explore changes in forest composition at least at genus level. The length of post-logging monitoring ranges between 2 and 35 yrs, with most plots having a least one pre-logging measurement (17 out of 24 sites). Among other benefits, pre-logging inventories reduce the risk of pseudo-replication at sites that lack truly replicated plots (Ramage et al. 2013). The total number of trees currently included in TmFO is estimated at *ca.* 300,000, representing almost three million measurements.

While logging intensity and practices are important factors in the trade-off between commercial production and environmental services provision, accounting for biotic and abiotic differences among sites is also important. The large range of environmental conditions encompassed by TmFO will allow regional and pan-tropical investigation of forest responses to logging in the context of climate change. Nevertheless, some geographical gaps remains (Fig. 1), especially in the western Amazon and Africa, but efforts are underway to spread TmFO in those regions.

Another major goal of TmFO is to favour capacity-building and data management in partner institutions. To do so, TmFO acts as an exchange platform for researchers involved in the Observatory. In order to respect data ownership and ensure equitable co-authorship, no raw data are shared among researchers. The management and intellectual property of a given data set resides exclusively with scientist(s) or institution(s) that own the data. For each site, one to two site leaders have been identified to coordinate TmFO's activities, such as computing the required summary data (i.e. biomass or stem density ha^{-1}, diversity indices) and performing relevant analyses (see www.tmfo.org for more details on data management policy). All research questions and protocols of data analysis are discussed, developed and agreed upon by all researchers. Once these participatory steps are achieved and summary data are produced, a collaborative regional analysis is performed among TmFO researchers.

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Conclusions

With its extensive spatial (pan-tropical) and temporal (up to 35 yrs) coverage of post-logging forest dynamics, TmFO offers unique opportunities to address the resilience of tropical forests to anthropogenic disturbances and climate change, and their potential interactions. TmFO fills the gap in the tropical forests science community betweemen secondary and undisturbed natural forests. TmFO is supported by the Sentinel Landscape program of CGIAR (Consultative Group on International Agricultural Research) Forest Tree and Agroforestry Research Programme. This financial support has allowed for the organization of meetings to define research questions and for technical workshops to perform uniform data analyses related to the agreed upon research questions. TmFO is an open network, and scientists, institutions and NGOs interested in the resilience of managed tropical forests are most welcome.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Main characteristics of the 24 experimental sites of TmFO.

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