doi:10.1111/j.1467-9493.2006.00235.x

Monitoring and modelling tropical deforestation: Introduction to the Special Issue

Douglas O. Fuller and Rinku Roy Chowdhury

Department of Geography and Regional Studies, University of Miami, Miami, Florida, USA

Correspondence: Douglas O. Fuller (email: dofuller@miami.edu)

This Special Issue of the *Singapore Journal of Tropical Geography* derives from a set of papers on remote sensing and forest governance in Indonesia, presented at a workshop held at the Center for International Forestry Research (CIFOR) in Bogor in June 2004. The workshop assembled experts in forestry, geography and biodiversity conservation to examine the ways that imaging satellites such as Landsat are shedding new light on problems and processes associated with tropical deforestation. Although the workshop mainly focused on some of the major drivers of this process in Indonesia, the issues of illegal logging, fires and the establishment of industrial plantations are common to many other parts of the tropics where forests have been converted to other land uses, often at rates that merit global concern (Sidaway & Teo, 2005).

Although alarm bells have been rung some time ago to warn against the consequences of tropical deforestation (e.g. loss of biodiversity and ecological services, air pollution from fires, climate change), the scope of the problem remains an area of active study and debate. As a tool for detecting change in forest cover, satellite imagery increasingly determines how we measure and monitor loss of tropical forest. More pertinently, the increased availability of inexpensive imagery coupled with increased computer power since the early 1990s has facilitated the diffusion of new information among a wide range of actors in civil society. This has the potential to revolutionize forest governance by improving transparency in the forestry sector in particular, and in land use policymaking more generally, by making available information that some central governments and large landowners have guarded quite closely. Although this Special Issue explores some of the limitations of existing satellites for mapping forests, with relatively new sources of satellite imagery (e.g. MODIS or Moderate Resolution Imaging Spectrometer), near real-time monitoring of tropical deforestation is starting to become as much a reality as the monitoring of hotspots from vegetation fires has been for over a decade. Thus, with an evolving constellation of orbital and geostationary satellites, we should expect operational monitoring of land use and land cover change (LULCC) in the tropics at more frequent intervals and at finer spatial resolutions. The improved ability to observe changes at finer temporal and spatial scales is likely to translate into major advances in predictive capability that will be helpful for understanding changes in land use dynamics.

Over the past decade, a dominant approach to understanding LULCC dynamics is to link data available from satellite imagery to ancillary information in order to model the underlying drivers of landscape transformation. Efforts to quantitatively link land cover to theorized driving forces of change are not novel; for instance, earlier statistical models linked regional or national land cover metrics (e.g. per cent forest cover) to demographic and other factors (e.g. population density, rate of economic growth). The greater temporal and spatial resolution currently afforded by satellite imagery thus allows a finer spatial lens through which to view such dynamics. When corresponding fine-scale or disaggregate data on biophysical or socioeconomic drivers are available, LULCC models

may yield rich insights – in identifiable patterns of regional landscape change and their local variability, and which driving factors explain changes at what scales.

For many regions of the tropics where data are scarce and spatially referenced data even more so, satellite imagery may provide valuable sources of ancillary information beyond the land cover component. For instance, land cover classifications may be used in Geographic Information Systems (GIS) to generate additional spatial data layers recording infrastructure and distance to the closest road networks. Collectively, LULCC models aim at a multiplicity of goals. For example, 'mining' of available satellite and ancillary data to identify empirically the most significant factors driving change; testing specific hypotheses about the role of biophysical or socioeconomic processes and how they affect land cover and landscape patterns; examining the effect of changing spatial scales on model results and consequently our understanding of change at multiple scales; predicting spatial locations and quantities of change based on model runs, or projecting LULCC into the future based on model-derived relationships, and, usually, some informed assumptions on whether these will hold into the future.

This Special Issue includes six papers that address various aspects of forest monitoring and land-use modelling with remote sensing. The contribution by John Baker and Ray Williamson explores the global rise of 'image activists' who have emerged mainly in the nonprofit sector over the past few years. This label applies not only to analysts working in the humanitarian, relief and arms control sectors, but increasingly also to those working in the environmental arena, where nongovernmental organizations play a vital role as watchdogs and promoters of nature conservation. In particular, Baker and Williamson highlight how various forms of remote sensing have been and are being used to detect and monitor illegal logging and other potentially illicit forms of LULCC. The second paper, by Douglas Fuller, reviews how different forms of remotely sensed imagery, including those from optical sensors and radar, have been used to map and monitor different forest cover types in the humid tropics. Fuller also outlines the limitations of current sensors for mapping tropical forest and how such systems can support operational monitoring schemes to inform key decision makers and stakeholders in tropical countries such as Indonesia, where transparency and reliable information have been lacking for at least 20 years.

These two broad thematic papers are followed by two more technical contributions that examine land cover change trajectories in two parts of Kalimantan (Indonesian Borneo). The first of these, by Rona Dennis and Carol Colfer, uses a series of Landsat images spanning two major El Niño events (1982–83 and 1997–98) which spawned numerous fires and produced massive damage to the forests of Borneo and Sumatra. Their analysis reveals a rapid transition in the East Kutai District of East Kalimantan, from dense forest cover pre-1983 to a landscape dominated by degraded forest, grassland, industrial timber and oil-palm plantations. Interestingly, the most rapid change in their study area occurred after the fall of the Suharto New Order regime in 1998 and the devastating fires of that same year. The paper by Trigg, Curran and McDonald deals with West Kalimantan and the use of Landsat Enhanced Thematic Mapper Plus (ETM+) imagery for continued monitoring of Gunung Palung National Park, where illegal loggers have felled large areas of forest inside the protected area boundary over the past decade. In particular, the analysis by Trigg *et al*. shows that degraded post-2003 Landsat ETM+ imagery caused by the failure of scan line correction (SLC-off) can be used to obtain accurate estimates of forest cover to support continued monitoring of Gunung Palung and other protected areas in the tropics.

The final two papers in this Special Issue address more explicitly some of the drivers

of LULCC in the tropics. The paper by Luca Tacconi and Yayat Ruchiat examines the use of fire in Nusa Tenggara Timur (NTT), eastern Indonesia, where the climate is more amenable to seasonal biomass burning than in the humid forests of Borneo. They provide evidence that farmers and livestock managers use fire intentionally to promote grassland development and reliable fodder sources. In other words, they act rationally to preserve their livelihoods and maximize their incomes, despite the damage that fire may cause to forests nearby. Interestingly, similar studies of fire-derived landscapes in Borneo are cited, which suggest that local people often prefer anthropogenic grassland to closed forest as it provides more options for small-scale cultivation of cash crops such as pepper. In the final paper, Roy Chowdhury discusses some key characteristics of spatially explicit LULCC modelling approaches and applies one such model to understand the drivers of LULCC in the southern Yucatán in Mexico. She uses a multivariate logistic regression model to evaluate the relative importance of biophysical and census-derived socioeconomic variables in driving regional deforestation between 1987 and 1996. The analysis reveals biophysical and locational contexts such as soils, elevation, forest type and distance to infrastructure to be the most important determinants of the spatial location of deforestation at the regional scale.

Taken as a whole, these six papers present a range of perspectives on monitoring and modelling the process of tropical deforestation. While remote sensing cannot replace detailed field studies of the causes and consequences of deforestation, the data and tools of remote sensing and geographical information science increasingly favour open access to information, and shed new light on how and why people and societies are modifying forests throughout the tropical world. Most crucially, once in public view, such information can be, and has been, used to influence and properly enforce forestry policy in particular, and land use policy more generally, in tropical environments where the rule of law has sometimes been weak and forests have disappeared at rapid rates over the past 20 years.

Acknowledgement

We wish to acknowledge the generous support from the Center for Ecosystem Science and Policy (CESP) of the University of Miami and CIFOR which helped to fund the workshop on 'Remote Sensing and Forest Governance in Indonesia: Increasing Transparency and Accountability', held in Bogor, 24–25 June 2004.

Reference

Sidaway JD, Teo P (2005) Editorial: lessons in geography. *Singapore Journal of Tropical Geography* **26** (1), 1–3.