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Tree cover transitions in tropical landscapes: hypotheses and cross-continental synthesis

Forest transition theory was primarily developed to explain the process of decline (deforestation) and recovery (regeneration) of forest area in both temperate and tropical areas. Most forest transition theory literature use national statistics on forest cover, which refer to a diverse range of tree cover types. As qualitative change between tree cover types is a prominent aspect of the regeneration process, the term 'tree cover transition' may be a more appropriate and useful identification.

It seems that 'trees' were relegated when the world moved its focus to 'forests' as part of the climate debate. The term 'forest' is first of all an institutional marker; there are forests without trees and trees outside forests. Moreover, debates about forest transition have often tried to replace time as the primary X-axis with macroeconomic variables that indicate the changing roles of forest areas once economies develop. However, in the context of tropical countries, the existing hypotheses lack agency- and context-specific explanations. While the logarithm of human population density accounts for 70-80% of variation in the national forest cover fraction, forest transition points can occur at almost any population density and forest cover fraction (Figure 1). They seem to be more likely, however, in countries that already had above-average forest cover in relation to their population density. The identified limitations of forest transition theory include the loose definition of forests (combining primary, secondary and planted forest types), a lack of detail about the forest cover dynamics involved, including its spatial and (multi-)temporal scales, and few explanations of context-specific transitions (Perz, 2008).

Tree cover transition and the underlying hypotheses

Tree cover in landscapes changes in quantity, quality and spatial pattern—and therefore in function—along the forest transition pattern of decline followed by return of trees in a non-linear fashion (Figure 2a). The same total amount

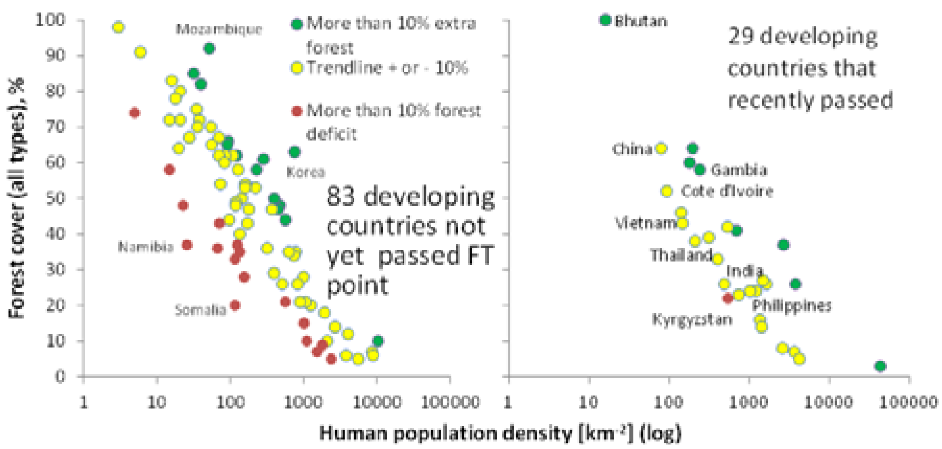

Figure 1: *Relationship between human population density and percentage forest cover at the national scale, with indication of countries that are more than 10% above or below the average trend, and distinguishing between the countries before (left) and after (right) a reported increase in national forest cover (forest transition (FT) point); based on the dataset found in Kothke et al. (2013). The graph on the left shows countries that have not (yet) reached the FT point; the graph on the right shows those that have, at the population density and forest cover shown.*

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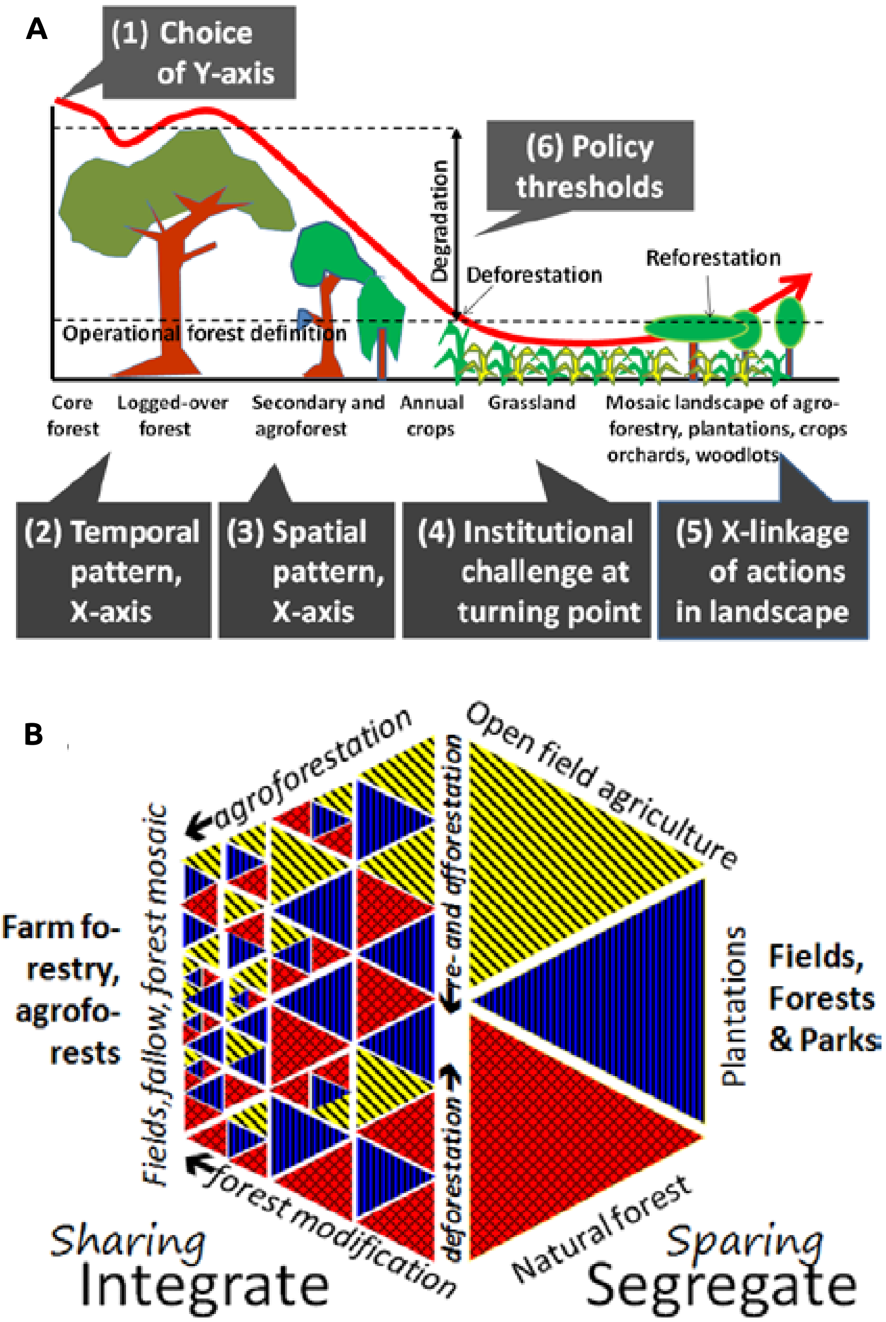

Figure 2: *Tree cover transition in the landscape (a), and spatial pattern of different land use types associated with the sharing versus sparing approaches, respectively (b).*

of natural forest area, open field agriculture and tree (crop) plantations, respectively, can be arranged in an integrated or segregated spatial pattern (Figure 2b) using both land sparing and land sharing approaches to achieve the multifunctionality that local communities want and/or need. Tree cover is best described as a spatially and temporally dynamic continuum, with trees— established spontaneously or planted. Land use policies, however, dissect this continuum into a forest versus non-forest dichotomy; this tends to give undue weight to a forest definition, which is a major challenge to both the fairness and efficiency of policy implementation (van Noordwijk *et al.*, 2012a).

In a global comparative study of the dynamics of forests, trees and agroforestry (FTA) by the CGIAR research program, we framed 12 hypotheses related to the multiple versions of a tree cover transition to test under the CRP 6 FTA program. The hypotheses span a full circle that connects actors, underlying drivers and leverage points, as well as consequences, stakeholder evaluations and opportunities to manipulate points of leverage (Figure 3).

As specified in hypothesis 4, an increase in desirable types of tree cover is often triggered by a transition from forest to agrarian rules of land tenure, due either to generic policy reform or to location-specific reclassification of land.

Until recently European Union rules assumed that trees and agricultural land use were incompatible, but changes that allow and encourage trees and crops to be combined on the same land unit, are now forthcoming.

'Resilience' (to certain environmental risks and events) has become a popular concept, but it remains difficult to quantify and study. It may be more fruitful to focus on the related concept of 'buffering' (for example, are insurance premiums being paid? Are wetlands and overflows that buffer river flow retained?) as this can be assessed continuously, while resilience is only expressed in response to calamities. Trees have always been valued for their microclimatic buffering roles and, more contentiously, they are often considered to have a positive meso-climatic role as well (van Noordwijk *et al.*, 2013).

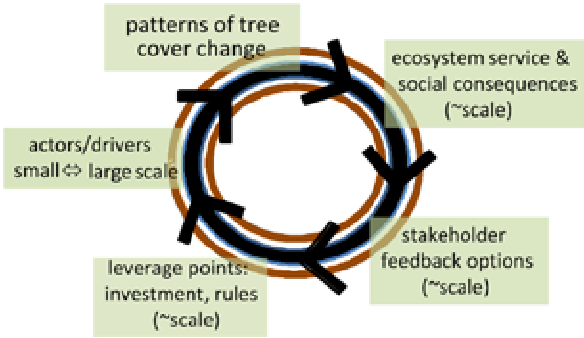

Figure 3: *Logical loop linking patterns of tree cover change to consequences, stakeholder feedback, leverage points, influencing drivers, actors and, ultimately, tree cover change*

Main hypotheses:

		Hypotheses
1.	Basic forest transition hypothesis	Tree cover in landscapes shows a forest transition pattern of decline followed by recovery.
2.	Population density and welfare hypothesis	Tree cover transitions in time show that an increase in human population density is linked to a decrease in natural forest cover.
3.	Spatial forest transition hypothesis	The spatial pattern of tree cover expanding outwards from centres of human habitation show more than a coincidental resemblance to the temporal dynamics of hypothesis 2 (Dewi et al., 2013). (On the often misunderstood "agroforestation" phase, see Fairhead and Leach, 1995.)
4.	Agroforestation or tenurial reform hypothesis	Institutional change from a forest focus to an agrarian regime of tenure and control is essential for supporting the transition from decline towards increase and recovery of tree cover (Akiefnawati et al., 2010).
5.	The 'sparing' hypothesis	What happens in one part of the tree cover transition is linked at the driver and/or actor level to other parts of the landscape (leakages). (Lusiana et al., 2012; van Noordwijk et al., 2012b). Sparing can be a positive opportunity to protect trees.
6.	The driver change hypothesis	Drivers of tree cover transition are space/time dependent and knowledge of past drivers in a particular landscape cannot be directly extrapolated to predict future changes; there may, however, be more predictability in the succession of drivers.
7.	Trade-off hypothesis	Land use types that are part of the tree cover transition differ in their effectiveness in provisioning and environmental goods and services (Santos-Martin and van Noordwijk, 2011; Villamor et al., 2011).
8.	Integration, buffer and resiliency hypothesis	Tree cover of all types and at all stages is positively associated with buffer functions in an ecological, social and economic sense, with the spatial pattern and degree of integration linked to human resilience and adaptive capacity in the face of climate and market variability (Figure 1b) (Nguyen et al., 2013; van Noordwijk et al., 2013).
9.	Diversity of stakes hypothesis (including gender specificity)	Appreciation of tree cover and its associated ecosystem services varies according to gender and ecological knowledge (Villamor et al., 2013; Villamor and van Noordwijk, 2011).
10.	'No silver bullet' hypothesis	Feedback mechanisms from beneficiaries of (certain types of) tree cover to drivers/agents can take multiple forms and produce various outcomes (rules, incentives, suasion, investment in value chains and technology, and so on) (Jackson et al., 2012; Lopa et al., 2012; van Noordwijk et al., 2012a). Context-specific feedback is most effective.
11.	Negotiation support hypothesis (including gender specificity)	The dynamics of tree cover changes can be influenced by multi-stakeholder negotiation support processes that recognize the diversity of knowledge, perceptions, stakes, power and influence (Villamor et al., 2013).
12.	Impact pathway hypothesis	Public discourse on aspects of tree cover transition and the relevance of interventions follows a policy issue cycle (Clark et al., 2011; Minang and van Noordwijk, 2013).

The analysis of tree cover change in current landscapes is often part of negotiation support, rather than decision support science (Clark *et al.*, 2011), as multiple stakeholders have different claims to the legitimacy of their knowledge and interpretation of a complex reality. Rather than having a single 'footprint' value, many commodity value chains have a wide management swing potential (Davis *et al.*, 2013). An 'issue cycle' is occurring, in which new issues are constantly being framed and proposed, with only some reaching the level of wider public and policy concern and fewer still reaching the stage of policy solutions. The role of scientists varies with the phase of the cycle. While 'impact pathways' are more easily framed for mature issues with imminent solutions, science plays at least an equally important role in the early sifting of new concerns, and in recognising which issues merit of further exploration.

Global comparative landscape networks

Tree cover transition is considered to be a unifying concept encompassing issues related to livelihoods, landscapes and governance. A global comparative network of landscapes where the socio-ecological, economic, political and institutional aspects of tree cover change are closely monitored can help to produce a salient, credible and legitimate perspective on issues at all stages of the policy cycle. A global network of landscapes like this is utilized in the on-going research programs of the various institutions involved in the CGIAR's Sentinel Landscapes Project in Cameroon, India, Indonesia, Malawi and Vietnam, together with scientific contributions from partner institutions in West Africa, particularly in Burkina Faso, Ghana and Mali (Figure 4).

We welcome further partnerships and cooperation in this effort to combine local, national and international scientists and stakeholders seeking solutions based on the functions of tree cover in multifunctional landscapes, replacing the current emphasis on form and formal forest definitions.

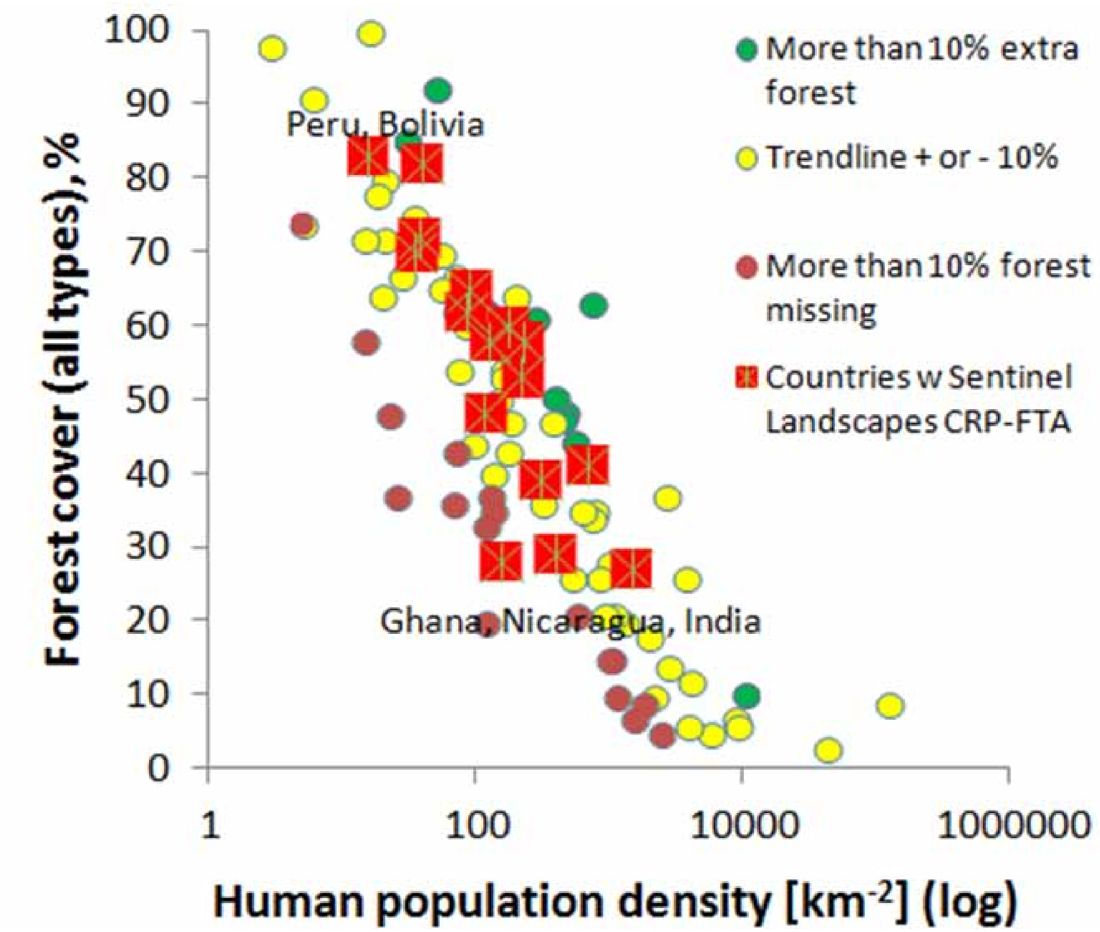

Figure 4: *Countries included in the network of Sentinel Landscapes studies by the CGIAR research program on forest, trees and agriculture (CRP-FTA).*

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