Designing and Implementing Effective REDD + Policies: A Forest Transition Approach

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Introduction

Designing and implementing effective policies aimed at Reducing Emissions from Deforestation and Forest Degradation, known as REDD, and enhancing forest carbon stocks, known as REDD+, depends critically on a country or region's particular circumstances. The mitigation of climate change through REDD+ using contextually appropriate sets of policies and incentives requires matching variable circumstances with variable policy initiatives. This article argues that the concept of a forest transition (FT) is a useful lens through which to view the alternative forms that REDD+ policies might take at different times and in different settings.

The FT framework suggests that over time a country (or region) moves through three stages: 1. high forest cover and low deforestation ("core forests"), 2. accelerated deforestation and shrinking forest cover ("frontier forests"), and 3. stabilization and eventual reversal of the deforestation process ("forest-agricultural mosaics"). The FT is an empirical regularity, but not a deterministic prediction, because there are large variations between countries and also changing patterns over time (Mather 1992).[1] Extending this line of thought, because the drivers of changes in land cover, the substance of current forest policy, and the capacity to implement new policies all vary with the FT stage in which a country finds itself, one could argue that, to be effective, REDD+ policies should vary along this dimension as well. The more contextually appropriate the REDD+ policies, the easier it should be to implement them. The ease of

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[1]"Forest transition" is used in several ways in the literature. Some, including us, use it to represent the whole process or curve (see Figure 1) while others use it to represent the inflection point (i.e., the shift (transition) from deforestation to reforestation).

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implementation should in turn shorten the amount of time necessary to establish a REDD+ program of payments.

The FT is driven by a combination of socioeconomic and ecological changes associated with loss of forest cover, as well as policies that can, in part, be linked to forest scarcity. Over the last decade, the policy component of the FT has become increasingly important. In a global context of high food prices with the attendant political and economic pressures to expand cultivated areas at the expense of forests, the increases in forest cover predicted by the FT are unlikely to occur unless they are accompanied by policy interventions that provide incentives for landowners to retain or increase forests.

REDD+ is an international initiative that represents just this type of political intervention, seeking to value the carbon sequestered in forests and compensate landholders for the additional carbon sequestration (reduced emissions to and increased removals of carbon from the atmosphere) that occurs on their lands. REDD+ became part of the global climate change agenda at the climate summit in Bali in 2007 (United Nations Framework Convention on Climate Change [UNFCCC] 2007), and refers to local, national, and global actions that aim to reduce emissions from deforestation and forest degradation, and to increase removals through enhancing forest carbon stocks in developing countries (Angelsen 2009). Initially, REDD+ was expected to become part of a new post-2012 climate agreement, with significant international funding (mainly from carbon markets) to developing countries in a results-based system. Because the new climate agreement is still being negotiated, REDD+ actions are currently funded mainly through multilateral and bilateral aid initiatives that support national-level REDD+ policy reforms and hundreds of REDD+ projects at the subnational and local levels.

This article, which is part of symposium on the economics of REDD,[2] argues that applications of REDD+ should be contextually sensitive, tailoring the types of incentives and compensation available to the forest conditions in a country. For example, countries that have not experienced an FT (stage 1), like Suriname or Gabon, and still have large stocks of old-growth forests would focus incentive and compensation programs on the preservation of old-growth forests. Countries in the midst of rapid deforestation (stage 2), like Indonesia, would design programs to slow down high rates of deforestation. Finally, countries in the later stages of an FT (stage 3), with virtually no remaining old-growth forests, like El Salvador or Cote d'Ivoire, would develop programs that would incentivize and compensate landowners for allowing the regrowth of forests on their lands. In sum, we believe there is no one-size-fits-all portfolio of REDD+ policies. By situating REDD+ policies more explicitly in the FT framework, we hope to advance the intellectual agenda of Alexander Mather (2007), who argued for a more explicit recognition of the role of policies in FTs.

We begin in the next section by describing the concept of the FT, examining the drivers of forest cover dynamics, and discussing how policies affect these drivers of change. Next we examine challenges to the FT theory that have been raised in the empirical literature. Then we review the REDD+ policies that should, theoretically, be the most appropriate and effective at different stages of the FT. We conclude with a summary and brief discussion of the outlook for REDD+ policies.

[2]Kerr (2013) introduces the symposium and examines the economics of international policy to reduce emissions from deforestation and degradation; Lubowski and Rose (2013) discuss economic modeling insights and issues related to REDD; and Pfaff, Amacher, and Sills (2013) examine economic theory and empirical evidence concerning the impacts of domestic policies on forest loss.

The Forest Transition: Stages of Change in Forest Cover over Time

The notion of an FT was originally proposed by Mather (1992) and was refined by others including Mather and Needle (1998), Rudel et al. (2005), and Pfaff and Walker (2010). FT theory predicts a systematic pattern of change in forest cover in a country or region over time. Initially, a country has a high and relatively stable portion of land under forest cover. Next deforestation begins, and then accelerates, causing forest cover to decline. At some point, deforestation slows, followed by a point of inflection (i.e., from net deforestation to net reforestation) and a slow process of forest recovery. This stylized process is shown in Figure 1.

The FT is not a uniform theory, and, as noted by Mather (2007, 494), "forest transition theory is poorly developed." It is best viewed as a historical generalization about a recurrent pattern of change in forest cover over time. Mather outlined key elements of a theory in the early 1990s following a study of changing patterns of forest cover in five European nations during the nineteenth and twentieth centuries. Subsequent historical studies in non-European settings and then on a global scale established that this pattern, as depicted in Figure 1, characterized a wide range of long settled landscapes in the Americas and Asia (Rudel et al. 2005).

Other social scientists have tried to place the FT in a broader theoretical context (Perz 2007), arguing that it bears some resemblance to the literature on the environmental Kuznets curve. As a result, the FT has been criticized as an example of an unfounded "grand theory" with limited empirical support (Perz 2007). Some have used the FT as a conceptual framework for setting reference levels for forest cover change (baselines) for REDD+ (Meridian Institute 2009). Here we use the FT framework as a conceptual tool for matching bundles of REDD+ policies with forest cover conditions.

Stylized FT Stages and Their Characteristics

As shown in Figure 1, the FT suggests three stylized forest contexts or stages: 1. core forests (beyond the frontier), 2. frontier areas, and 3. forest-agriculture mosaics; cf. Chomitz et al. (2007). Depending on the purpose and empirical application, these stages can be further disaggregated (see Angelsen 2009; da Fonseca et al. 2007; Pacheco et al. 2011).

Table 1 presents the extent and characteristics of tropical forest biomes at different stages of the FT. The extent of core forest areas is particularly noteworthy because, contrary to the impression often conveyed in popular debates, these areas still represent a significant portion of the remaining tropical forests. Thus effective policies for stage 1 are important even though deforestation rates are lower.

The differences across continents are striking. Core forest areas comprise roughly half of the land area in Latin America and Africa, dominated by the Amazon and Congo basins, while they account for only 15 percent of the land area in Asia. Population densities in all three forest areas in Asia are much higher than the corresponding population densities in Latin America. Related to this, the remoteness of forests for the core and frontier forests is highest in Latin America. As we move along the FT curve, we would expect population densities to increase and remoteness to decline. This is supported by the data; in Latin America, for example, population densities are ten times higher in mosaic lands than in core forest areas.

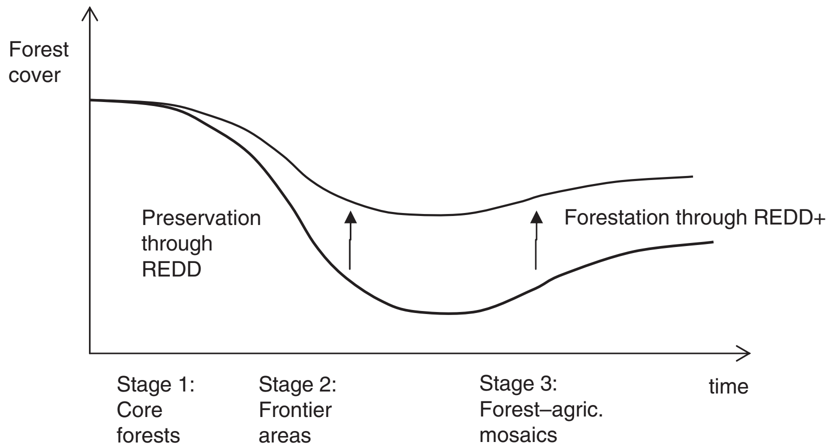

Figure 1 The forest transition with REDD+ policy interventions

Table 1 Areas and population densities for tropical forest biomes at different stages in the forest transition

	Core forests	Frontier areas	Forest-agriculture mosaics	Total
Area ('000 km^2)				
Africa	1,899	946	738	3,583
Asia	1,157	3,572	3,006	7,735
Latin America	5,105	3,569	2,468	11,142
Total	*8,160*	*8,089*	*6,213*	22,462
Population densities (persons/km^2)				
Africa	16.0	32.2	61.2	29.6
Asia	57.9	80.1	142.0	100.8
Latin America	2.2	11.8	22.0	9.7
Total	13.3	44.3	84.7	44.2
Share of area being remote (>8 hours of travel time to major city)				
Africa	64%	49%	25%	52%
Asia	49%	43%	23%	36%
Latin America	87%	55%	22%	62%
Total	76%	49%	23%	52%

Notes: Latin America includes Caribbean. Savannas are not included. Area refers to land area, not only forests. The table does not include savannas, which is a separate category included in the Chomitz et al. (2007) table, because these are less important from the perspective of carbon storage and REDD+ potential.

Source: Calculations based on Table 1.3 in Chomitz et al. (2007). These land cover figures are based on the Global Land Cover 2000 database of the European Commission Joint Research Centre; see Appendix B of Chomitz et al. (2007) for further discussions.

Table 2 presents a further characterization of forest areas based on social characteristics. Core forest areas are home to some of the poorest people in the world. Analyses of forest cover and census data throughout the tropics demonstrate a strong positive correlation between forest cover and poverty rates (Sunderlin et al. 2008b). A number of factors explain this association: poor access to public services and markets, low public investments, powerlessness, tenuous land tenure, and a related inability to capture potential forest rents.

Table 2 Social characteristics in the three main forest contexts

	Core forests	Frontier areas	Forest-agriculture mosaics
Social characteristics:			
Population density	Low	Low to medium	Medium to high
Market access	Low	Medium	High
Poverty	High	Mixed between groups	Medium to low
Land tenure	Insecure	Insecure	Fairly secure among larger landowners
Governance	Informal	Tenuous	Established
Opportunity cost of forest conversion	Low	Medium to high	High

Source: Partly based on Chomitz et al. (2007) and Pacheco et al. (2011).

Governance changes along the FT curve. Because remote forest areas are often outside the reach of state or federal governments, government agencies have limited capacity to enforce regulations and implement other measures. Local customary governance systems exist in some areas (e.g., village or tribal chiefs in parts of Africa) but not in others (e.g., large parts of the Amazon where formally recognized indigenous reserves are prevalent). Tensions between customary and statutory land rights systems have been a major field of investigation (e.g., Ensminger 1996; Fitzpatrick 2006; Schmink and Wood 1992), with overlapping rights systems creating conflicts, uncertainty, and resource degradation. This is particularly evident during the second stage of the FT, when land values increase, new stakeholders enter regions, conflicting claims are made, and landscapes are transformed rapidly (Rudel 1995).

Local capacities and incentives for forest governance are also likely to change with the FT. There has been a resurgence of community and indigenous forest management and rights in several countries throughout the tropics (Sunderlin et al. 2008). The number and strength of indigenous organizations have been increasing over time in both Latin America and Asia, resulting in a greater ability to launch counterclaims to external—often government-backed—land claims.

Drivers of the FT

The FT framework does not offer a unified theory of forest cover change. However, many explanations have been put forward about what drives the change in forest cover over time, varying in emphases between (1) "socioecological feedbacks," which are largely endogenous/autonomous responses based on forest scarcity and ecosystem degradation, and (2) "socioeconomic changes," which are processes that are largely exogenous to the forest sector (Lambin and Meyfroidt 2010). The distinction is illustrated by Rudel et al. (2005), who describe two major drivers of the FT: the forest scarcity path and the economic development path. Angelsen (2007) views deforestation as a race between agricultural and forest rents (in a von Thünen framework), with the forest scarcity path linked to higher forest rent and the economic development path linked to lower agricultural rent, mainly due to higher opportunity costs of labor (see Table 2).

In order to provide a deeper understanding of the drivers of the FT and incorporate the role of policies, we have further disaggregated the drivers into five categories.

Driver 1: Scarcity of forest products

Greater scarcity of forest products, caused by a combination of a shrinking forest stock and rising demand for forest products due to economic growth, can provide a strong stimulus for forest conservation, better forest management, and plantations. For example, the establishment of tree plantations in India has relieved pressures on nearby natural forests (Köhlin and Parks 2001). Another important study on India, by Foster and Rosenzweig (2003), finds that forest growth is closely linked to higher local demand for forest products. The feedback is primarily through markets, with scarcity leading to higher prices.

Governments can also strengthen the response by landholders through policies that stimulate tree planting to reduce the scarcity. For example, a concerted effort by the government of Niger during the early 1990s to assure farmers that they would own any trees they planted on their own lands led to a surge in plantings and a disproportionate increase in forest cover in southern Niger after 1995 (Reij, Tappan, and Smale 2010). In fact, the area of planted forests in Niger doubled from 2000 to 2010 (Food and Agriculture Organization of the United Nationals [FAO] 2010). The success of Niger's policy persuaded the United Nations to sponsor a similar effort in other nations bordering the Sahara (FAO 2010).

Driver 2: Scarcity of forest environmental services

A shrinking forest stock will reduce the supply of forest-based environmental services. Because, for the most part, markets for environmental services do not exist, people seek redress for the loss of environmental services in political arenas. Policymakers at all levels have responded to the loss of forest environmental services with policies that aim to stabilize and eventually increase forest cover. For example, after the destructive Yangtze River floods in China in 1998, which killed thousands and left millions homeless, the government initiated a series of policies to restore the forest cover including a logging ban and comprehensive programs for tree planting (Liu and Diamond 2008; Mather 2007). The perceived link between loss of forest cover and flooding was a major rationale for these policies. Mather (2007) also notes the parallel between recent events in China and nineteenth-century events in France and Switzerland, where alpine floods and erosion sparked government-sponsored forest conservation measures that contributed to the countries' FTs. A similar sequence of events occurred in the United States, where disastrous floods provided the political impetus for establishing the US Forest Service in 1905.

At the global level, current REDD+ efforts can be seen as a response to the reduced supply of the carbon sequestration and storage services supplied by forests, a direct result of deforestation and forest degradation. Again, a combination of higher scarcity and higher "political" demand for the services has increased their value. The architects of the REDD+ program aim to translate this increased global willingness to pay for environmental services into incentives for landowners to conserve their forests.

Driver 3: Diminishing agricultural rent from continuing forest conversion

Continued agricultural expansion into natural forests eventually slows down because the new lands brought under cultivation are more remote than lands converted earlier. For this reason, the new lands command lower agricultural rents. Classical economists focused on the diminishing agricultural rent due either to new land having lower fertility (the Ricardo approach), or new land being located further away, which results in higher transport costs (the von Thünen approach).[3] Both arguments continue to be valid; accessibility in terms of distance to roads is among the few factors that are consistently significant in regression analyses of deforestation (e.g., Andersen et al. 2002).

Market feedbacks can also slow down agricultural expansion. Introducing new agricultural technologies increases the profitability of converting forest land to agriculture, unless there are strong feedbacks in output markets (saturation effects that depress prices) or labor markets (labor shortage and/or higher wages) that reduce or completely offset the positive impact of higher yields on agricultural rent (Angelsen and Kaimowitz 2001). Thus localized output and labor markets can provide important feedbacks that accelerate arrival at the inflection point in the FT when deforestation gives way to reforestation. Conversely, greater trade and migration will weaken these feedback effects because they will dissipate over a much larger area, lessening their impact in any one area.

Such market feedbacks will not always contribute to forest cover stabilization. The feedback mechanisms just discussed assume diminishing returns to scale for the agricultural sector, which is not always the case. At early stages of frontier expansion, the development of downstream processing, infrastructure, and marketing are characterized by economies of scale, which further reinforces the deforestation process. For example, in Brazil, road improvements (paving) and new port facilities for agricultural exports created economic incentives for expanded beef and soybean production (Nepstad, Stickler, and Almeida 2006).

Government policies may also affect how lower agricultural rents translate into land use change; for example, governments may prevent market mechanisms from working. If the market had been left alone, yield increases in the American South during the 1935–1975 period would have depressed agricultural prices. But price support programs kept prices high, which discouraged farmers from abandoning marginal lands. In contrast, programs that expanded the national forest system in the South during the 1930s by purchasing cutover lands (extensive tracts of land that had been clearcut by the previous owners) ensured the return of these lands to forest (Rudel 2001).

Driver 4: Economic development and structural changes

The economic development driver includes several mechanisms. First, the growth of nonfarm sectors raises the opportunity costs of labor and reduces the supply of rural workers (see Table 2). Although they may lead to more mechanized operations, these changes are likely to increase farm operation costs overall. This dynamic varies greatly by region. The vigorous growth in the nonfarm and urban sectors of Asian and Latin American economies has pulled labor off the farm and induced farmers to abandon their least productive lands. Aide and Grau (2004) found a general pattern of upland reforestation and lowland deforestation in Latin America, supporting the argument that topography plays an important role in this dynamic, with farmers abandoning more remote sloped lands and continuing to cultivate flatter lower elevation lands close to roads. Similar trends may also characterize Southeast and East Asia. In contrast, in Africa, rapid population growth in urban centers, coupled with extensive land degradation in zones of export agriculture that have been abandoned, would imply continued

[3]See van Kooten and Folmer (2004) for a discussion of these two approaches.

deforestation of accessible old-growth forests to provide foodstuffs for urban consumers (Fisher 2010) and the slow emergence of scrub growth in abandoned and cutover districts.

Second, there may be systematic changes in the demand for agricultural products, which have significant implications for land use. Higher incomes and urbanization typically change the composition of food demand in favor of meat and horticultural products. Although horticultural products are typically provided by areas close to urban centers (due to their intensive cultivation and perishability), higher urban meat demand has been a major driver of deforestation in rural areas (Andersen et al. 2002; Shane 1986).

Third, economic growth leads to changes in the demand for forest products. For example, reliance on fuelwood declines as people begin to depend on so-called luxury energy sources like kerosene, gas, and electricity. This shift in fuel use, known as "the energy ladder," which societies climb as they move over time from a reliance on bulky fuels like wood and coal to more concentrated fuels like natural gas (DeFries and Pandey 2010), operates most visibly in societies that are undergoing urbanization, such as India.

The economic development driver assumes a closed economy in which changes in the local costs of wood, for example, are not offset by abundant supplies of imported wood. In an open economy, domestic agricultural commodity prices are strongly influenced by international markets. Thus it is not surprising that Foster and Rosenzweig (2003) find a positive correlation between forest growth and economic growth for closed economies, while the relationship is weakly negative for open economies (for the period 1980–1995). Similarly, migration across national borders may explain why some countries are experiencing an FT sooner than one would expect. For example, outmigration and subsequent increases in flows of remittance money from overseas have provided alternative sources of income and reduced the extent of cultivated areas in parts of Central America (Hecht et al. 2006).

Driver 5: Policy changes

Finally, shifts in government policies can influence landholder decisions that accelerate or delay the FT. For example, beginning in the 1960s, the Brazilian government established limits on the percentage of a landholding that could be cleared, created extensive protected areas (PAs), and issued logging concessions that mandated reforestation of areas after logging (Nepstad et al. 2009). Governments have also created tax policies that favor landowners who create forest plantations on cutover lands or other lands without trees. Tree tenure laws have been adopted to ensure that smallholders retain the value obtained from the sale of trees on their lands (Reij et al. 2010). Similar arrangements, often referred to as "forest reforms," have been enacted in Africa and South Asia to ensure that villages retain control over community forests (Sunderlin, Hatcher, and Liddle 2008).

In some respects, these forest reforms are endogenous processes in large-scale FTs. They usually have their origins in perceptions among policymakers that local supplies of forest have fallen to very low levels, causing deterioration in environmental services and growing scarcities of wood or other forest products. In other words, forest policy initiatives usually do not occur early in a FT. Rather they appear later (in stage 2) when forest losses and the growing scarcity of forests have become obvious to all parties, providing an impetus for reform efforts. The effectiveness of policy changes often hinges on the capacity of local governments to implement the reforms (Poffenberger 2006). By viewing REDD+ initiatives as part of these closely linked policy reforms, a broader political base for REDD+ can be created and the effectiveness of REDD+ policies enhanced.

The relative strength of the different driving forces varies over time. The growing scarcity of forest products (driver 1), fluctuations in agricultural rent (driver 3), and economic development (driver 4) play important roles in the transition from "core forests" to the "frontier." They reward individuals for their ability to exploit natural resources. As the destruction of the forests proceeds, environmental services deteriorate (driver 2), and the state, as the primary provider of public goods, becomes the locus of activity (driver 5). Both of these drivers play a prominent role in the transition from the "frontier" to the "forest-agricultural mosaic."

Empirical Challenges to FT Theory

There is now an extensive empirical literature on the FT. This literature challenges three features of the theory that need to be addressed if the FT is to be used as a framework for operationalizing REDD+ in context-appropriate ways.

Challenge 1: Beyond the forest–nonforest dichotomy

Although pure FT theory makes a simple distinction between forests and nonforest land cover, researchers have long noted a continuum between these two categories (Wiersum 1997). The intermediate categories vary with agro-ecological conditions and degrees of management and human use. These quasi-forests include degraded forests, agroforests, silvopastures (pastures with trees), forest plantations, farm forests, forest gardens, shifting cultivation systems, and wood lots (Aguilar-Støen, Angelsen, and Moe 2011; Lambin and Meyfroidt 2010; Michon et al. 2007).

There is a broad consensus that empirical studies must look beyond the FT theory's simple forest–nonforest dichotomy. As greater emphasis is placed on the environmental functions of forests including carbon storage and sequestration, finer land use/cover categories are needed to capture these environmental features of landscapes. The original FT framework ignores both the types of forest that expand after the point of inflexion and the environmental services they provide (Grainger 1995). Mather (2007) estimated that between a quarter and a half of the forest recovery seen in China, India, and Vietnam during the past two decades is in the form of plantations, which provide a more limited set of ecological services than natural forests. In densely settled rural regions, these types of intermediate systems can become the primary vehicle for an FT (Aguilar-Støen et al. 2011; Lambin and Meyfroidt 2011).

We see two barriers to including more varied land uses in the FT framework. First, there is no agreed-upon categorization of such intermediate systems, and any categorization is likely to be context specific. Second, the FT theory offers some broad predictions, and a more fine-tuned theory is likely to lose much of this general predictive power.

Yet REDD+ policies, whose primary aim is to reduce emissions, must take into account the different types of forests and land uses because the carbon loss per hectare due to forest clearing (known as "emission factors" in climate jargon) will differ. Failure to factor such differences into a result-based mechanism by applying a uniform payment per hectare of forest saved (i.e., by using the same emission factor) will actually result in more protection of *low* carbon landscapes than would otherwise be the case.

Challenge 2: Globalization and the scale of the FT

Early and most subsequent FT studies have used countries as their unit of analysis. This approach reflects both the availability of data and the presence of national scale drivers of the FT. When estimating the effects of REDD+ policies in the context of a particular FT, the appropriate scale of analysis may be either more localized contexts or more globalized processes. Sometimes political and economic forces operating on different scales combine to shape the FT. For example, forest conservation on the Pacific Coast of Costa Rica developed out of a synergy between high international demand for environmental services (biodiversity, tourism, and, lately, carbon storage) and (international) migration, coupled with the adoption of neoliberal national policy reforms (Kull, Ibrahim, and Meredith 2007). Perz (2007) suggests using a hierarchical approach in which land changes are viewed in a nested cross-scale framework. Given the unavoidable cross-scale challenges of implementing REDD+, this cross-scale approach facilitates its use as an interpretive tool.[4]

Undoubtedly, *local* ecological and socioeconomic conditions are important for the trajectory of the FT in specific forest areas, but *global* processes are increasingly shaping the forest conditions in particular countries. Increased trade in agricultural and forest products, growing cross-border investments, and increased international migration have all shifted the appropriate scale of the FT to more global levels. Recent studies of leakage (displaced deforestation and degradation) suggest that countries experiencing a transition from deforestation to reforestation offset a significant share of the forest regrowth through higher imports of wood and agricultural products. In a study of seven countries that had passed the inflection point, Meyfroidt, Rudel, and Lambin (2010) found that 22 percent of the increased forest area in those countries was offset by agricultural expansion and forest loss in the countries from which they were importing more wood and agricultural products. Similarly, international migration can spur an FT in the country of origin, by both reducing the labor force and substituting remittances for agricultural earnings (Schmook and Radel 2008).

Given these trends, it may become more appropriate to think in terms of a *global* FT, where in some regions or countries the forest cover will stabilize at very high levels while in others deforestation will continue until little forest is left. Some regions (exporters of agricultural and forest products) will be "facilitating" regions (i.e., characterized by high rates of deforestation over a long period of time) while others (importers) will be "transitioning" regions (i.e., quickly approaching the inflexion point of net reforestation) (Pfaff and Walker 2010). The global REDD+ mechanism currently being developed places a strong emphasis on avoiding deforestation in the large remaining tracts of tropical forests (i.e., avoiding the move from stage 1 to stage 2 on the FT curve in places with particularly carbon-rich forests). Once fully implemented, it could facilitate a global FT.

Clearly, the appropriate scale for thinking about a FT is the scale at which the drivers and policies of the FT are operating. As these drivers become increasingly globalized, it becomes increasingly important to undertake analyses of a global FT to complement the exclusively national focus of the original FT analysis. One implication of this trend is that the FT will be less pronounced, or perhaps disappear completely, in individual countries. For example, Cambodia is undergoing massive deforestation through illegal logging (an annual deforestation rate of

[4]In partial contrast to this view, Walker (2008) maintains that the FT concept was developed primarily to understand forest cover changes at larger, oftentimes national, scales.

1.3 percent during the period 2000–2010) while neighboring Vietnam afforests (+1.6 percent per annum) (FAO 2010).

Challenge 3: Policy drivers

Deforestation is increasingly driven by large commercial actors such as palm oil or soy companies or large-scale cattle farmers (Rudel 2007). Coalitions of these actors lobby the state for favorable rulings on concessions, taxes and subsidies, infrastructure projects, and military protection. However, their reliance on state services also makes them vulnerable to unfavorable shifts in policy. Change in Brazil's policy provides striking examples of these dynamics. In the late 1990s, organized groups of soybean growers in southern Brazil succeeded in getting the federal government to authorize a program of infrastructure improvements (Avança Brasil) that would facilitate the shipment of soybean crops overseas and at the same time open up new areas of the southern Amazon for deforestation. Following a spike in Brazilian deforestation rates in 2004, the federal government decided to enforce its rules against illegal land clearing though satellite monitoring. When landowners made too many illegal clearings, the federal government prohibited agricultural credits for all of the landowners in that municipality. The loss of access to credit proved very effective in curbing illegal deforestation (Camara 2010; Nepstad et al. 2009). While it remains to be seen if these policy shifts are part of a larger scale long-term FT in Brazil, they are a clear example of policy shaping the political-economic nexus between agribusinesses and federal government officials.

These political dynamics vary with the political context and change over time. Although it is hard to link policy drivers to specific FT stages, the political economy needs to be factored into any national-level analysis of forest cover change because large-scale commercial actors have the capacity to influence domestic policies and politically strong states have the power to reduce deforestation rates suddenly if they choose to do so.

REDD+ Policies

The key premise of this article is that the appropriate REDD+ policies depend on a country or region's stage in the FT. To use a market analogy, different FT stages have different *demands* for policies, as well as different capacities to *supply* them. This section discusses which REDD+ policies are most appropriate to pursue at different stages of the FT and identifies the challenges in applying them.

Matching REDD+ Policies to FT Stages

The initial idea of REDD+ was to create a multilevel (global-national-local) system of payments for environmental services (PES), and in that way incentivize and compensate all forest users (and potentially other decision makers as well) for the enhanced forest carbon services. Implementing a PES system poses significant challenges (see Pattanayak, Wunder, and Ferraro 2010 and Wunder 2007). These challenges include (1) defining the service (which involves measuring changes in forest carbon over time as well as setting baselines), (2) identifying the service providers (in a context of unclear and contested tenure), (3) finding mechanisms (market and nonmarket) to transform the global willingness to pay for forest conservation into hard cash, and (4) building institutions to handle information and money flows in a transparent manner. This has led Angelsen (2009) and Kerr (2013) to argue that REDD+, at least in the short to medium term, will have to include a broad set of policies.

The COP13 (the annual Conference of the Parties under the UN Framework Convention on Climate Change) agreement, which established REDD+ at the international level, insists on results-based actions after the implementation and evaluation of demonstration activities (UNFCCC 2007). In effect, the initial REDD+ "policies are experiments, [so] learn from them!" (Lee 1993).

Building on Angelsen (2010), Table 3 presents a typology of possible REDD+ policies and their expected effectiveness at the three main FT stages. The effectiveness ratings for the different policies are based on systematic reviews of the literature on tropical deforestation over the past two decades (including Angelsen 2010; Angelsen and Kaimowitz 1999; Rudel et al. 2005).

Policy 1: Institutions and broad policies to facilitate REDD+

Much of the REDD+ effort thus far has focused on so-called readiness activities, institutional and broad policy reforms that aim to facilitate more specific REDD+ policies but in themselves do not necessarily reduce deforestation and forest degradation. These readiness reforms include setting up national-level institutions to handle REDD+ policy implementation, as well as an independent agency for monitoring/measuring, reporting, and verifying (MRV) changes in forest carbon. Other broader reforms include decentralization of decision-making power and control over financial resources to lower level authorities (decentralization), measures to reduce corruption within the forest sector, and land tenure reforms (Angelsen 2009). Although all of these policies would presumably promote forest conservation, decentralization, for example, also runs the risk of handing over control to local factions intent on logging or clearing land (Tacconi 2007). In remote rural areas (stage 1), the economic incentive to clear land would be weak, suggesting that local control might, if anything, enhance the prospects for conservation because local livelihoods are based on the forests themselves (Rudel with Horowitz 1993).

Risk related to tenure insecurity has been found to increase deforestation (Bohn and Deacon 2000; Deacon 1999). Insecure tenure can lead to less land investment and more soil exhaustion, thus increasing the need and/or incentives for cutting down more forest to replace degraded land. However, in a situation where people lodge claims to land by clearing "empty" forests, a strengthening of land rights (obtained through forest clearing in the first place) can also stimulate deforestation. In this context, stronger land rights reduce the risk of losing the investment that land clearing represents (Angelsen 2007). In a study of property rights and deforestation in Nicaragua, Liscow (2005) concludes, "This study offers strong evidence that, contrary to many theoretical predictions, tenancy insecurity protects forests .... This result reveals the costs of creating better markets for land titling without creating any markets for the positive externalities provided by forests."

In contrast to institutions and broad policy reforms, the remaining policies in Table 3 aim to directly change the incentives to land users in three different ways: reduce the agricultural rent, increase the forest rent, and directly regulate land use.

Table 3 Possible REDD+ policies and their effectiveness at different FT stages

REDD policies	Core forests	Frontier areas	Forest-agriculture mosaics
1. Institutions and broad policies to facilitate REDD+			
National-level REDD+ institutions	++	++	++
MRV system	++	++	++
Governance and corruption	++	++	++
Decentralization	++	−−	−
Clarifying tenure and rights	++	++ (?)	++
2. Reduce (extensive) agriculture rent			
Depress agricultural prices	+	++	0/+
Support intensive agricultural sector	+	++	++
Reduce support to extensive agriculture	+	++	+
Reduce extensive road building	+	++	+
Create off-farm opportunities	+	++	+
More secure property rights to agricultural land	0/?	++	+
3. Increase forest rent and its capture			
Higher price of forest products	0	−	+
Secure property rights to forest land	0/+	+	+
CFM (capture local public goods)	+	+	+
PES (capture global public goods)	0/+	+	++
4. Direct regulation			
Protected areas	0/+	++	+
Concession policies	++	+	0
Land use zoning	0	++	++

Key: ++/+ (very) effective; −−/− (very) counterproductive; 0 limited/no effect or not relevant; ? ambiguous effect.

Policy 2: Reduce (extensive) agriculture rent

Although reducing the overall agricultural rent though discrimination against agriculture may not sound politically attractive, strong anti-agricultural and anti-rural policies can be found throughout the developing world (Krueger, Schiff, and Valdés 2003). Such policies have helped to conserve forests (Wunder 2003), but they also conflict with the objectives of enhancing food security and reducing poverty. More politically acceptable policies would involve targeted interventions, which avoid an increase in the rent of *extensive* agriculture but raise overall food production and farm income. Targeting *intensive* agriculture in areas that are at stage 3 can both pull labor out of extensive agriculture and boost output, which keeps agricultural prices low. Policies aimed at such targeted agricultural intensification, referred to as reduced emissions agricultural policy (REAP) by Rudel (2009), can include credit programs, subsidized fertilizers and seeds, assistance in marketing, and agricultural extension programs.

The recent REDD+ policy debate has drawn renewed attention to the role of agricultural technologies in reducing the pressure on forests (e.g., Wollenberg et al. 2011). The policy debate is often based on a simple food identity: (Population) × (Food consumption per capita) ≡ (Food per unit agricultural land) × (Agricultural land) (Angelsen 2010), which states that for a given population and food consumption per capita, any increase in the yield (food production per hectare) will reduce the agricultural land and thereby deforestation. This popular image of land-sparing agricultural intensification (Waggoner and Ausubel 2001, 241) can be highly misleading for several reasons: much agricultural production is not for food; countries trade; food per capita is not constant; some land expansion is not into forests; and changes in yields do not necessarily affect what is happening on the forest frontier (Angelsen 2010). A study across 10 crops and approximately 130 countries by Rudel et al. (2009) found no correlation between changes in yields and cultivated areas.

The von Thünen model contradicts the logic of the food identity, suggesting that higher (local) yields make it more profitable to expand agricultural land further (see Pfaff et al. 2013). In a collection of case studies on technological change in tropical agriculture and their impact on tropical forests, Angelsen and Kaimowitz (2001) suggest some ways out of the dilemma: (1) target intensive production systems and crops that are not directly responsible for forest encroachment because this might pull resources out of extensive systems; or (2) adopt labor- and capital-intensive technologies that have—in the context of labor and capital scarcity—a lower probability of leading to forest conversion. Technologies for rehabilitating existing agricultural land can also reduce the need to convert forests into new agricultural land. Overall, however, "trade-offs and win-lose between forest conservation and technological change in areas near forests appear to be the rule rather than the exception" (Angelsen and Kaimowitz 2001, 9).

Road building often presents policymakers with a win-lose menu of choices. Roads provide better market access for farmers and higher prices for their produce, but they also raise agricultural rent and make new forest areas more accessible (e.g., Nelson and Hellerstein 1997). However, roads are particularly important at the early stages of the FT to open up new areas for human activities (Weinhold and Reis 2008). At later stages, better roads can further stimulate agricultural intensification and economic development close to the roads, which reduces pressure for agricultural expansion into forests far from the roads (Sikor and Truong 2002).

Finally, economic development generally offers a win-win outcome by raising the opportunity costs of labor and thereby, ceteris paribus, reducing agricultural rents. Policies to stimulate nonfarm activities can, in general, be expected to take pressure off forests. An important exception might be in capital-intensive deforestation activities, such as the raising of imported breeds of cattle, where any stimulus to the local economy can provide the necessary capital for further expansion. In addition, beef is a luxury good whose demand increases rapidly when income rises.

As noted earlier, insecure property rights deter agricultural expansion, and the initial effects of more secure property rights spur investment and agricultural expansion at the expense of the forests. The longer-term effects of secure property rights, if any, have forest-conserving effects. Because owners no longer feel compelled to clear land to assert ownership, and their economic future is more securely tied to the land, they are more concerned with the long-term productivity of the land, which encourages them to conserve it and its associated water resources (Firey 1960).

Policy 3: Increase forest rent and its capture

The third set of policies listed in Table 3 seeks to increase forest rent and its capture, which is in line with the "forest scarcity path" of the FT. In this context, it is useful to distinguish between two types of forest rent: rent related to the production of forest products like timber (*extractive rent*) and rent related to the provision of environmental services (*protective rent*). An increase in the extractive rent has an ambiguous effect on carbon storage: depending on the context (including tenure conditions and the forest estate), it might lead to clearing and a major loss of forest carbon but also tree planting and better forest management. Higher protective rent, such as higher payment for the carbon services of forest, should yield unambiguously positive carbon outcomes.

Property rights determine the extent to which forest users capture the different forest rents. In an open access situation, where forest clearing and agricultural uses provide some land rights, there are limited incentives for farmers to factor forest rents into their decisions. Providing individual property rights would give forest users incentives to fully include the extractive rent. In a private property system, higher extractive forest rent will limit forest conversion and thereby increase forest carbon stocks.[5]

If property rights are moved up to the community level, the value of local environmental services (e.g., watershed protection) provided by standing forests should be factored into deforestation decisions. There is a large literature on community forest management (CFM) as an application of the common pool resources theory advanced by Elinor Ostrom (1990). CFM can provide a cost effective and viable management option (Somanathan, Prabhakar, and Mehta 2009), but achieving cooperative outcomes is difficult, particularly when the groups are large, heterogeneous, and poor, and the forest benefit flow unstable (Agrawal and Angelsen 2009). CFM can also reduce transaction costs, leakage, and adverse selection problems of other policies (e.g., in enforcing PAs or with communities rather than individuals the contract partner in PES schemes).

Direct payment for avoided deforestation was, as noted earlier, a key policy proposal in the early REDD+ debate. Despite the challenges of PES, it has been applied in some Latin American countries, notably Brazil, Costa Rica, and Mexico. Many of these are pilot programs, and a closer examination points to the inherent challenges of designing effective and cost-efficient PES schemes. For example, according to Kaimowitz (2008, 492) the PES programs in Costa Rica and Mexico are heavily oversubscribed, and "payments went largely to landowners with little inclination to clear or exploit their forests," which calls into question the additionality of these programs.

Policy 4: Direct regulation

The final set of policies enforces restrictions on forest use and land use planning through command and control. PAs, "one of the oldest and most reliable tricks in the conservation book" (Riketts et al. 2010), have demonstrated success in stopping land clearing but have been less effective in stopping degrading activities such as logging, grazing, and fire (Bruner et al. 2001). Although strictly protected forest areas experienced 70 percent less deforestation than all tropical forests between 2000 and 2005 (Campbell et al. 2008), it is important to examine the extent to which this was due to passive protection (PAs being located in remote and inaccessible areas), and whether some of the remaining protective effect is offset by more deforestation outside the PAs (leakage). Researchers have recently started estimating the passive effect, but leakage effects are harder to measure. Andam et al. (2008) find substantial passive protection for PAs in Costa Rica. Gaveau et al. (2009) estimated the deforestation rates in PAs in Sumatra

[5]The total forest carbon stock is the product of the forest area and the carbon density (carbon per hectare). Higher timber prices should, according to the standard Faustmann model, shorten the rotation period and reduce the carbon density (Amsberg 1998).

in the 1990s to be 58 percent lower than the rates in wider areas. However, this difference falls to 24 percent when they account for passive protection. In a global study, Joppa and Pfaff (2011) find that PAs reduce forest conversion in about 75 percent of the countries, but that controlling for land characteristics (passive protection) reduces the impact by 50 percent or more in 80 percent of these countries. Thus there appears to be an emerging consensus that PAs do reduce deforestation, although protection is not perfect (there is still forest clearing inside PAs), and that there is a medium to high degree of passive protection.

If implemented effectively, systems of national forests can create an interest group of concession holders focused on limiting the size of cuts and fostering regrowth within the concession boundaries (Veríssimo et al. 2002). Large-scale rubber plantations in Brazil, owned by tire companies, illustrate this type of arrangement. However, in general, the politics of forest and land allocation have favored exploitation rather than conservation, as in the case of Indonesia (Brockhaus et al. 2012).

Ecological or land use zoning has been implemented in Brazil (Mahar and Ducrot 1998) with the idea that by declaring heavily wooded, ecologically sensitive areas off limits for agricultural expansion, growth in cultivated areas would be steered toward areas with land that has already been cleared. Applied widely, such zoning would also be expected to raise the price of existing agricultural lands and thus contribute to the intensification of agriculture on these lands. However, implementation problems in Brazil have made it difficult to estimate the effectiveness of these schemes.

Key Policy Challenges and Recommendations at Different Stages

Combining the characteristics and drivers at the different FT stages and the REDD+ policy menu, the policy challenges and recommendations for REDD+ at the three FT stages can be summarized as follows:

Stage 1: Core forests

In core forest areas, the central challenge from a climate mitigation perspective is avoiding increased emissions of carbon dioxide. Thus a first set of policy recommendations would be what *not* to do to trigger a process of accelerating deforestation: build roads, establish large resettlements or agro-export schemes, support commercial projects (mining, hydro) with accompanying infrastructure, and so on. Avoiding the construction of publicly funded penetration roads is extremely important in this context because, once completed, they spur the construction of privately funded roads by investors in agricultural enterprises. Some of these projects may still be pursued for purposes of income generation, but they should be undertaken only when careful Forest Impact Assessments accompany the projects and the appropriate environmental countermeasures are taken.

Another important challenge at the first stage would be to clarify property rights in order to avoid land races, which occur when land is cleared with the primary purpose of establishing rights rather than for the productive use of the land, as has often been the case in the Amazon (Alston, Libecap, and Mueller 2000). In many contexts, strengthening the rights of indigenous peoples can provide an effective buffer against commercial forest encroachment, but these rights need to be enforced by local political authorities.

Establishing PAs may also have limited short-term impact because the degree of passive protection is high. That is, PAs tend to be located "high and far" from urban centers, where the threats of conversion are small (Joppa and Pfaff 2009). Because of the currently low opportunity costs, it will be easier politically to establish PAs. Moreover, establishing PAs in core areas can be viewed as a preventive measure and can assume a critical role over the medium to long term if or when the pressure on forest increases.

Land abundance gives few incentives to clarify property rights, but establishing such rights becomes critical if communities or individual forest users are to receive payments for forest conservation. The official UNFCCC definition of REDD+ includes forest conservation, which has resulted in disagreement in international REDD+ debates about whether this definition is just a means to avoid deforestation and forest degradation, or if it also involves paying for maintaining forest stock. The main argument against stock payments is their low additionality; the counterarguments are fairness ("do not just pay the high polluters") and the potential for higher future deforestation in these places.

Stage 2: Frontier areas

The main policy challenges at the second stage are, first, to dampen the extensive agriculture rent (which drives deforestation at this stage) and, second, to speed up and strengthen the emerging forces that eventually will stabilize the forest cover. Thus most of the policies outlined in Table 3 are relevant at this stage.

Frontier expansion has historically been driven by favorable government policies. For example, in El Salvador, the removal of agricultural subsidies and trade liberalization, combined with international migration and higher remittances, have led to a remarkable forest resurgence (Hecht et al. 2006). Brazil has experienced a 75 percent reduction in deforestation rates in the Amazon since 2004, which is due to a combination of factors including restrictions on agricultural credits (Camara 2010), the establishment of PAs (Soares-Filho et al. 2010), a decline in soy and beef prices between 2004 and 2006, and, finally, an appreciating real exchange rate that has made Brazilian soy and beef less competitive in international markets (Richards et al. 2012). In Africa, smallholder deforestation to grow staples like cassava for expanding urban populations, which is the region's chief source of deforestation (Fisher 2010), could not be controlled through credit restrictions because these cultivators are much less capitalized, so their need for credit is much lower.

Intensified peri-urban agriculture (i.e., the rehabilitation of abandoned peri-urban agricultural lands), as well as payments to smallholders for avoided deforestation, might be important components of a REDD+ program in nations with frontier forests. More generally, as suggested by Figure 1, the goal of a REDD+ system would be to shorten the period of time and the extent of the area in forested regions that experience frontier conditions. In a REDD+ world, the duration of deforesting of frontiers would be short and confined to small areas, and forest-agriculture mosaics would contain more forests than in earlier eras.

Stage 3: Forest-agriculture mosaics

The third FT stage is characterized by more well-established property rights, more well-developed markets, and a higher degree of market integration than in the early stages of the FT. Thus economic instruments such as taxes and subsidies are likely to be more feasible and the response more predictable. Well-established and secure property rights to land imply that market-based instruments like PES or PES-like schemes are more relevant.

In stage 3, policies that encourage tree plantings both around houses and in plantations would be an important component of a REDD+ program. Payments in this setting would be more for restoring environmental services (i.e., PES) than for preventing the loss of existing environmental services (as in stages 1 and 2).

Improved agricultural technologies, which at early stages tend to stimulate agricultural land expansion, can become an important element of government policies at this stage to allow for higher food production on existing agricultural land. The local pressure to clear remaining forests is likely to be lower, in part because not much forest is left, land is better demarcated, and alternative nonfarm livelihoods are more available. Higher production in stage 3 environments (e.g., the lowlands) can also take pressure off the forest in the uplands through general equilibrium effects in the output and labor markets (Shively 2001).

Concluding Remarks

This article has reviewed contextually appropriate policies and incentives to mitigate climate change through REDD+. At the first stage in an FT, these measures try to reinforce the preexisting passive preservation of forests. In stage 2, priority should be given to establishing boundaries and creating reserves to prevent the conversion of forests into agricultural lands. Policies that stimulate agricultural expansion should be avoided at this stage, even though such action may require difficult choices between climate and poverty objectives. In stage 3, the restoration of environmental services through PES measures would assume more importance.

Based on the arguments presented earlier concerning the influence of local forest stocks on REDD+ policies and using the regional classification of tropical forests (based on stocks of forests and drivers) developed by Rudel et al. (2005), we would expect the following regional variations in the REDD+ policy mix. In regions with abundant forests and limited market penetration and institutional capacity, such as Central Africa, policies would mainly consist of broad policies that influence agricultural and forest rents. In regions that have large areas with frontier characteristics, notably in Southeast Asia and South America, a combination of broad policies and direct incentives through PES or PES-like schemes would provide the policy menu. The same is true for West Africa and East/Southern Africa, although after decades of very high rates of deforestation (particularly in West Africa) these are not characterized as frontier situations. Direct regulations such as PAs, land demarcation, and secure land rights have a role to play in all of these contexts, but they also need to be tailored to respond to the local drivers of deforestation. Finally, Central America and South Asia are regions characterized by high population densities and a turning point (from deforestation to reforestation) in their FT, so direct incentives (i.e., PES) could assume a relatively more important role.

Initial REDD+ proposals focused on creating multilevel PES mechanisms, consistent with the textbook recommendation of "internalizing externalities." However, the implementation of simple ideas is rarely simple in practice. The challenges are formidable in terms of the politics (who and how to pay), the information requirements (measuring emissions and setting reference levels), targeting to ensure additionality, designing contracts that are incentive compatible, and building institutions that minimize the risk of mismanagement and corruption. Hence the focus over the past two to three years has shifted toward a broader set of policies that can be implemented under less restrictive conditions. Although it is too early to predict which REDD+ policies countries will pursue, our early observations suggest a strong emphasis on strengthening local-level institutions, engagement, and rights (various forms of CFM), agricultural intensification, and land use planning including PAs. PES schemes are mainly at an experimental stage, although many REDD+ pilot projects aim to produce verified emissions reductions and sell them in the voluntary carbon markets.

As with all major new policy initiatives, REDD+ is most likely to succeed through a graduated process of policy initiatives that first tries out policies individually and then in conjunction with other policies. This type of experimentation promises many failures, but also significant gains when the new policies reveal contextually appropriate ways to design and implement REDD+ programs.

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