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REVIEW

Whither the forest transition? Climate change, policy responses, and redistributed forests in the twenty-first century

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Abstract Forest transitions occur when net reforestation replaces net deforestation in places. Because forest transitions can increase biodiversity and augment carbon sequestration, they appeal to policymakers contending with the degrading effects of forest loss and climate change. What then can policymakers do to trigger forest transitions? The historical record over the last two centuries provides insights into the precipitating conditions. The early transitions often occurred passively, through the spontaneous regeneration of trees on abandoned agricultural lands. Later forest transitions occurred more frequently after large-scale crisis narratives emerged and spurred governments to take action, often by planting trees on degraded, sloped lands. To a greater degree than their predecessors, latecomer forest transitions exhibit centralized loci of power, leaders with clearly articulated goals, and rapid changes in forest cover. These historical shifts in forest transitions reflect our growing appreciation of their utility for countering droughts, floods, land degradation, and climate change.

Keywords Forest gains · Forest transitions · Latecomer effects · Tree plantations

INTRODUCTION

The 'forest transition' is widely understood to be a historical generalization about the conditions under which European societies shifted from net deforestation to net reforestation during the nineteenth and twentieth centuries (Mather 1992; Mather and Needle 1998). It has the theoretical allure of capturing in a single concept a pattern of historically interconnected changes in land use with potential beneficial effects throughout the globe. If new policies could accelerate forest transitions (Lambin and Meyfroidt 2010), then the corresponding gains in forest size and carbon sequestration might slow climate change, stem biodiversity losses, and prevent a further deterioration in environmental services.

For this mix of intellectual and pragmatic reasons, the idea of forest transition resonated with land change scientists when Alexander Mather (1992) introduced the idea almost 30 years ago. While Mather used the idea to interpret changes in European forests, others applied these ideas to locales that differed dramatically from the Western European landscapes, places like the Ecuadorian Amazon (Rudel el al. 2002), the Mexican Sierra (Klooster 2003), Central America's highlands (Parés-Ramos et al. 2008; Redo et al. 2012), and mainland SE Asia (Zhang et al. 2017). Conceivably, these transition dynamics could explain forest cover change throughout the globe (Meyfroidt and Lambin 2011). Indeed, the most recent global assessment (Song et al. 2018) of forest cover change shows an increase in planetary tree cover from 1982 to 2016, a pattern that would be consistent with a global forest transition during the twentieth century. Distinct pathways through the transition have become apparent to analysts, some marked by extensive land abandonment as in northeastern North America (Foster 1992), others by large-scale tree-planting efforts as in China's interior (Zhang et al. 2017), and still others by flood-preventing reforestation of montane watersheds as in western Europe (Mather et al. 1999). A shift from net deforestation to net reforestation represented the common element in all of these processes of landscape change. The spatial extent of these shifts varied, sometimes characterizing nations, other times adjacent watersheds, and still other times regional clusters of contiguous nations.

As the prospect of disruptive climate change grew more likely, the appeal of a forest transition to policymakers

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increased because it promised through carbon sequestration in restored woodlands, to reduce greenhouse gas (ghg) concentrations in the atmosphere and, in so doing, limit climate change (Houghton 1999; Pan et al. 2011). Analysts began to contemplate how, through social movements and state actions, policymakers might be able to 'jump start' forest transitions.

With this question in mind, we reviewed the forms that forest transitions have taken during the last two centuries. The review begins with a discussion of three clusters of variables that appear to have been particularly salient in driving the early forest transitions. They are (1) decisions by farmers to abandon the cultivation of some lands and intensify cultivation on other lands, (2) tree planting by smallholders in places with few forests, and (3) crisis narratives that have prompted public efforts to expand forests in order to prevent flooding or to provide wood to vital industries.

To these recurring patterns in the extent and timing of forest transitions must be added a historical circumstance known as the 'latecomer effect' (Gerschenkron 1962) which asserts that the place of a transition in an historical narrative shapes the culture, organization, and speed with which it occurs. Participants in the first local or national transitions are 'pioneers.' Other transitions occur much later in a historical narrative, long after the first countries experienced a transition. Participants in these most recent transitions are 'latecomers.' Compared with the pioneers, participants in latecomer transitions exhibit exceptional clarity of purpose, wield concentrated power, and accomplish their ends faster (Gerschenkron 1962). Table 1 provides a short list of countries that have experienced these two types of transitions, with dates of onset and references to historical accounts of them.

Table 1 A historical typology of forest transitions

The pioneers, 1800–1980	The latecomers, 1990s -
Scotland (1900), Switzerland (1850), France (1860), Denmark (1800), NE United States (1840), SE United States (1935), Puerto Rico (1950), Mexico (1980), Madagascar (1970), Kenya (1970)	China (1998), Vietnam (1980–2000), India (1989), Kenya (1990s–2000s), Niger (1990s–2000s)

Here are the sources for each of the countries. The full citations for these sources are listed in the references for the paper. China (Mather 2007; Delang and Yuan 2015; Zhang et al. 2017); Denmark (Mather et al. 1998), France (Mather et al. 1999), India (Mather 2007; Nagendra 2010); Kenya (Holmgren et al. 1994; Tiffen et al. 1994; Maathai 2003), Madagascar (Kull 1998), Mexico (Klooster 2003), Niger (Reij 2014); NE United States (Foster 1992), Puerto Rico (Rudel et al. 2000); Scotland (Mather 2004); SE United States (Rudel and Fu 1996), Switzerland (Mather and Fairbairn 2000), Vietnam (Mather 2007; Meyfroidt and Lambin 2008b)

We outline this argument about the changing historical forms of forest transitions in four steps: (1) We describe the historical changes in societies and landscapes that precipitated the first wave of forest transitions, beginning in the nineteenth century and extending well into the twentieth century. (2) We outline the latecomer effect, a hypothesis about systematic differences between early and late transitions. (3) We describe the late, regional patterns of forest transitions that emerged during the last two decades of the twentieth century. (4) Finally, we explain how a plan for a global-scale forest transition, with the characteristics of a latecomer, has emerged as a crucial component in efforts to counter climate change in the twenty-first century.

HISTORICAL PATTERNS IN THE FIRST FOREST TRANSITIONS

Three persistent, but quite distinct patterns of change have accompanied the shifts from net deforestation to net reforestation during the nineteenth and the first three-quarters of the twentieth centuries. Discussions about these early transitions focused on changes in the local prevalence of trees or forests. Conversations about these shifts occurred within households, between farmers, and, at the largest scale, between officials in a national government. International influences did shape one set of early discussions about forest cover change in western Europe, as we outline below. A brief description of the dynamics that contributed to these early forest transitions follows.

Agricultural intensification and the spatial redistribution of forests

In the nineteenth and twentieth centuries, a recurrent pattern of changes, triggered by urbanization and industrialization, occurred across rural landscapes in Western Europe. Growth in the size and wealth of populations fueled an expansion in demands for foodstuffs that induced farmers to expand cultivated areas onto lands less suitable for agriculture. The expansion in agriculture accelerated deforestation. With the increase in cultivated areas, many farmers found themselves with a more diverse set of fields, varying in slope, accessibility, and soil fertility. Impoverished farm families worked many of these lands as tenant farmers, raising crops and livestock on infertile, rocky, and sloped lands. Over time, through a succession of harvests from these fields, land users became better acquainted with differences in the productivity and production costs of hill and valley fields and began to consider abandoning the less fertile fields (Mather and Needle 1998). At the same time, growth in industrial places of employment in cities induced many poor tenant farmers

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and small farmers to abandon agriculture or, at the very least, the less-productive, upland fields.

With selective abandonment of the less-profitable lands, farmers and their workers could devote more of their labor and agricultural inputs to the most-productive fields. This shift concentrated agriculture on the flat, accessible, machine-friendly fields in valleys. Mather and Needle (1998) refer to this process as 'agricultural adjustment to land quality.' It resulted in net reforestation because some of the abandoned agricultural lands reverted over time to forests. The relative ease of applying agricultural inputs like fertilizers to the remaining fields facilitated the further intensification of agriculture on these lands in subsequent years (Jadin et al. 2016).

A similar, global-scale dynamic reinforced these local changes in the characteristics of agricultural lands. Throughout the nineteenth century, frontier agriculture expanded in Canada, the United States, Russia, Australia, and Argentina (Lambin and Meyfroidt 2010). Large expanses of inexpensive, fertile, level land in these places became accessible. Settlers established claims and began to practice large-scale, machine-cultivated agriculture on these lands. Imports of large volumes of production from these countries depressed grain prices in Europe and made it impossible for many small-scale upland farmers in Europe to make a living from agriculture. Either they lost access to land through eviction or they abandoned their homesteads and moved to cities where they found work in new industrial enterprises.

The globalization of agricultural production continued into the late twentieth and early twenty-first centuries. Level, machine-friendly fields with longer growing seasons in places like Brazil replaced fields on sloped lands with shorter growing seasons in wealthy European societies. The abandoned fields in the wealthy, food-importing societies reverted to forests (Meyfroidt et al. 2010). The relative ease with which farmers have been able to incorporate increased use of agricultural inputs into the routines of cultivation on level, machine-friendly fields has reinforced these contrasting dynamics of a slow retreat from farming on sloped, temperate uplands and intensified cultivation on level, tropical lowlands (Nanni and Grau 2014). The intensification included an overall expansion in the size of fields and land clearings, as recently reported along active deforestation fronts in Southeast Asia (Austin et al. 2017a, b).

The low cost competition from overseas farmers, the intensification of local, lowland agriculture, and growth in urban jobs with higher wages convinced many European farm workers and farmers to abandon upland agriculture and, with government support, establish forests in the uplands (Petit and Lambin 2002).[1] These dynamics caused a spatial redistribution of forests (Redo et al. 2012; Jadin et al. 2016; Nanni and Grau 2017). To an increasing extent, forests grew in topographically rugged terrain (Aide et al. 2013; Wilson et al. 2017).

Small-scale tree planting

A second, persistent pattern of forest expansion occurred in settings where smallholders found sufficient value in forest products to expend the labor to plant trees around their homes. This practice generates a 'smallholder, tree-based land use intensification pathway' through the forest transition (Lambin and Meyfroidt 2010). Beginning in the 1960s, it occurred for at least three decades in parts of Kenya (Holmgren et al. 1994; Tiffen et al. 1994) and Madagascar (Kull 1998) where humans or droughts had practically eliminated local forests. In these settings, the price of wood rose; smallholders planted individual trees; agro-forestry spread, and some larger landowners established tree plantations. The planted trees, if they survived, produced modest local increases in the extent of forests (Lambin and Meyfroidt 2010). Deforestation followed by reforestation repeated the historical sequence of a forest transition, but the path to more forest cover did not entail spontaneously regenerating trees on abandoned fields. Instead, tree planting by smallholders along boundaries between farms or in woodlots gradually reforested the land (Kull 1998). Interaction effects between more extensive tree-planting and long-term trends like the redistribution of forests toward uplands certainly seemed possible in these places (Sikor et al. 2012).

State actions to expand forests

States played an important role in the early transitions. In part because the deforestation was often unprecedented, at least in the recent historical experience of nations, the consequences of it only became clear sporadically, often after extraordinary events created a crisis atmosphere. In

[1] The dynamics of land abandonment have also followed some anomalous, alternative paths. For example, land abandonment also drove a transient forest transition in Eastern Europe after the 1989–1991 collapse of the Soviet Bloc regimes, but in these settings the differential loss of state subsidies after the collapse shaped land abandonment patterns. Agricultural collectives located on prime agricultural lands experienced the largest losses in subsidies with the regime change, so much of the land abandonment and reforestation occurred on these prime, machine-friendly agricultural lands (Taff et al. 2010). As with the adjustment-driven patterns of forest cover expansion in Western Europe described by Mather, these eastern European increases in forest cover stemmed from shifts in political–economic arrangements that led to a kind of passive reforestation in which forests regenerated spontaneously on abandoned agricultural lands. With economic recovery after the collapse of the eastern bloc, farmers have reclaimed some of these abandoned lands and put them back into production (Kuemmerle et al. 2015; Meyfroidt et al. 2016).

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Scotland, sustained reforestation began after submarine warfare during World War I underlined the possibility that during wartime the wood for pit props used in coal mines could not be imported from overseas. With this prospect in mind right after World War I, British legislators created annual subsidies for landowners who reforested a portion of their lands. In the United States early in the twentieth century in the aftermath of floods, a crisis narrative emerged among legislators in which upland agriculture in the Appalachian mountains contributed to downstream flooding. The floods prompted the passage of the Weeks Act in 1911 that attempted to prevent further flooding by expanding national forests in higher elevations in the eastern United States (Shands 1992).

In some instances, a common crisis narrative spread among legislators in contiguous states. As early as 1800, French observers had noted a connection between upland deforestation and downstream flooding. Swiss officials, perhaps having read the French report, noted this connection between deforestation and subsequent flooding after floods during the 1830s, 1850s, and 1868. Both the French in 1860 and the Swiss in 1876 enacted laws to protect and restore high elevation forests in order to prevent downstream flooding. The Germans in neighboring Bavaria did the same thing during the late nineteenth century (Mather et al. 1999; Mather and Fairbairn 2000). While the isolated adoption of forest protection and expansion laws immediately after disasters seems common, this Franco-Swiss-German history suggests an alternative path to forest expansion through a regional wave of forest protection legislation. As we argue below, there are theoretical reasons to believe that a politicized, regional path to forest expansion may have become a particularly likely form for forest transitions during the twenty-first century.

POST-1980 FOREST TRANSITIONS: THE LATECOMER EFFECT

Countries that only recently shifted from net deforestation to net reforestation represent latecomers to the forest transition. Marx described the latecomers' position succinctly. For him, "the country that is more developed industrially only shows, to the less developed, the image of its own future" (Marx 1867). This famous statement is at best a 'half-truth' (Gerschenkron 1962, p. 6). It is true insofar as industrialization and urbanization unleashed a set of land-use changes in early industrializing places that recur in late industrializing places when they too industrialize and urbanize. It is not true insofar as the leaders in the later-to-industrialize regions initiate changes with the record of the early-to-industrialize regions from which to learn. This awareness of earlier examples distinguishes the latecomers from their pioneering predecessors.

This critique of Marx's claim originated with the mid-twentieth-century work of Alexander Gerschenkron (1962), an economic historian. He outlined what came to be known as 'the latecomer effect.' In its original formulation, the latecomer effect summarized differences in the historical conditions that propelled nineteenth-century industrialization, first in Britain and later in Germany. Industrialization in Britain occurred without conscious government strategies to accelerate it. By the mid-nineteenth century, it had endowed Britain with the capacity to churn out large volumes of valuable manufactured goods. German elites quickly came to appreciate the British accomplishment, and they decided to emulate them. To that end, German leaders launched an industrial development program to 'catch up' with the British in the late nineteenth century. Unlike the unself-conscious British industrializers of the early nineteenth century, the Germans consciously adopted industrialization as a societal goal, formulated programs to stimulate industrialization, and achieved higher rates of industrialization than the British had earlier in the century. Officials and observers in other countries took note of the German efforts and tried to copy them. By the 1940s, economists had formulated a bundle of industrial development policies for 'catching up' that any industrializing country might adopt.

A comparable pattern of change may have characterized some forest transitions during the twentieth and twenty-first centuries. In this historical sequence of events, the first forest transitions occurred without strong, centralized government direction. Some farmers took infertile, but rain-fed agricultural lands out of production, and these fields returned spontaneously to forests. Some states intervened to reforest upland watersheds in order to prevent downstream flooding or supply mines with pit props. These activities solved discrete problems and, in so doing, they reforested substantial areas, but they did not do so as part of a coherent and explicit government-led policy to reforest rural areas. Subsequently, observers and officials in some countries began to recognize the beneficial effects of this bundle of practices, and they proceeded intentionally in subsequent years to use state policies to accelerate the reforestation of rural areas.

The early histories of forest transitions influenced the latecomers to the transition in at least three different ways. First, the deleterious effects of deforestation in the first forest clearing countries made a case for trying to halt it earlier in the process in the latecomer countries. As noted above, a perceived connection between upland land clearing and subsequent floods in the adjoining lowlands of France and the United States spurred collective action. Politicians and foresters in the Far East initiated their

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reforestation programs with these earlier histories of floods and reforestation efforts in mind. As a result, East Asian officials pushed for and achieved turnarounds in forest cover trends, from decreases to increases in forest cover, while the land areas in forest in their countries were still relatively high. While the turnarounds in forest cover trends in early-to-transition societies like Denmark and Scotland occurred after forests declined, respectively, to 4% and 5% of all land, the turnarounds in forest cover trends in late-to-transition countries like China, India, and Vietnam occurred when they still contained, respectively, 17, 21, and 29% of their land areas in forest (Mather 2007; Wolosin 2017). Reliable data from twenty countries about the date of the turnaround and the extent of forest cover at the turnaround show a clear relationship between the two variables: the more recent a turnaround in forest cover trends, the more extensive the forest cover in a country at the time of the turnaround (Rudel et al. 2005, p. 26).

Second, the greater consensus among latecomers about the deleterious effects of deforestation on the commonwealth made an effective case for collective action to stem the land clearing, so states and NGOs, as the primary sources for collective action, figured more prominently in efforts to turn around forest cover trends in the latecomer transitions. For this reason, we might expect latecomer transitions to be more strongly state or NGO-led transitions. China has exhibited a prototypical latecomer transition. It launched the massive 'Grain for Green' reforestation program (Delang and Yuan 2015) after the Yangtze and Yellow River floods of 1998 made the argument about the contributions of upland deforestation to lowland floods more compelling. Indonesia has pursued similar policies of reducing deforestation in the uplands of Sumbawa in order to curb downstream flooding (Ansharyani 2018). In an attempt to assert more control over upland regions, the Thai government funded an expansion of forest plantations along with road building in northern Thailand during the 1980s and 1990s (LeBlond 2014). In sum, recent shifts from deforestation to reforestation have featured states that have intervened aggressively to promote forest expansion. Sometimes the state interventions have come in the form of inducements to expand forests on individually held parcels of land, as with the Grain for Green program, but in other circumstances, like the twentieth-century Thailand, states have expropriated lands and planted trees on them (LeBlond 2014).

NGOs, as well as states, have assumed leadership roles in recent campaigns. Through the Bonn Challenge of 2011 and the New York Declaration of 2014, international coalitions of NGOs and governments have made joint commitments to reforest millions of hectares of degraded lands. NGOs, organized either as third party certifiers like the Forest Stewardship Council or as groups of growers like the Roundtable for Sustainable Oil Palm Production, have created certificates that give growers access to high-priced markets for products produced through practices that encourage regrowth and forest preservation. Shade-grown coffee exemplifies this trend. Growers even adopt these regrowth friendly practices when the price markup from conventional to environmentally friendly markets is minimal (Rueda and Lambin 2013). Advocates of this sustainable commodity approach argue that shade-grown crops and secondary forests can share the same space in the tropics.

Third, the origins of latecomer efforts in states make it more likely that the scale of reforestation efforts would be large, the new forests would be monocultures, and the turnarounds would occur quickly because states would subsidize or pay participants to plant trees in large numbers of communities (Scott 1999; Mather 2007). In the case of France, one of the first countries to experience a forest transition, the change in forest cover trends emerged gradually throughout the nineteenth century. In the case of Vietnam, a pronounced change in forest cover trends occurred in only 20 years, from 1980 to 2000 (Mather 2007). Large-scale, state forest plantations played an important part in Vietnam's rapid, latecomer transition (Meyfroidt et al. 2008a, b).

Some dynamics characterize both early and late forest transitions. The redistribution of forests from lowland to upland terrain noted in observations of the first forest transitions also occurs in contemporary forest transitions (Aide et al. 2013; Nanni and Grau 2014). Globalization redistributes forest cover across nations and terrain in both processes. Globalization driven adjustment processes resemble the adjustment process discussed by Mather in his studies of nineteenth- and twentieth-century forest transitions, but they occur on a much larger geographical scale than Mather anticipated in his original formulations of the forest transition. For example, Jadin et al. (2016) demonstrate that a forest transition with overall environmental benefits occurred over the last three decades in Costa Rica when imports of agricultural commodities from more efficient farms in temperate North American landscapes replaced agricultural production from less efficient farms in the biodiverse, carbon rich tropical landscapes in Costa Rica. Kastner et al. (2014) found a similar pattern globally, with agricultural products flowing from high to low agricultural yield countries.

POST-1980 LATECOMERS: GLOBAL AND REGIONAL FOREST TRANSITIONS

The spread of forest transitions after 1970 from Europe and North America to tropical settings suggested that a global

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forest transition has emerged. A global analysis of land cover change by Song and his associates (Song et al. 2018) reports a pattern of net global reforestation between 1982 and 2016 that is consistent with the global forest transition idea. Net reforestation in the industrialized and temperate zone nations exceeded net deforestation in the tropical countries during this period. While these patterns are certainly suggestive of a global forest transition, the short time period covered by this study and the absence of global-scale historical records of a turnaround in forest cover trends makes arguments about a recent, global-scale forest transition more suggestive than conclusive.

At least two regional forest transitions have taken place during the last 40 years, one in Asia and the other in Africa. Both regional transitions exhibit the hallmarks of latecomer transitions and suggest changes from earlier forest transitions in their driving forces. The regional dimension of these processes also fits with the frequently under-appreciated regional dynamics in the political ecology of the Global South (Beckfield 2010). Topography, climate, agricultural practices, access to markets, and the availability of farm labor all vary regionally and figure centrally in the dynamics that govern growth or decline in the extent of forests, so it follows that the dynamics of forest transitions would follow regional lines (Song et al. 2018).

The forest transition in the nineteenth-century France, Belgium, Switzerland, and Germany followed regional lines (Mather and Fairbairn 2000). The distinguishing feature of these transitions is the spatial and temporal clustering of turnarounds in forest cover trends from deforestation and reforestation. An inexact, hard to document, but still evident 'availability heuristic' may have operated among policymakers, inducing them to adopt the land cover policies being pursued by people in neighboring jurisdictions (Dobbin et al. 2007). The late twentieth-century Asian and East African transitions followed these regional lines and, as argued below, conformed to the latecomer pattern outlined above.

Arguably, a mainland East and South Asian forest transition occurred during the last decades of the twentieth century. Between 1973 and 2000, South Korea, China, India, and Vietnam all pushed through radical reforms in their forest sector policies in the hopes of deterring additional deforestation and fostering net regrowth in forests (Mather 2007; Park and Yeo-Sang 2016; Wolosin 2017). The publicity surrounding these state-led efforts most likely encouraged elites in neighboring states to try comparable programs (Lambin and Meyfroidt 2010). These imitating impulses would cause forest transitions to cluster geographically. Crises might still trigger regional reform efforts, as the Yangtze River floods did in China in 1998. Officials in neighboring states would note the crisis-driven reform efforts next door and consider whether they too should embark on reforestation programs. In short, the crisis narratives would cross borders. The causal mechanisms spurring these mimetic-like processes remain undocumented, but they must involve the growing ease of international communication. More rapid and detailed communication at international meetings about the lessons of earlier reforestation efforts and the forest related activities in neighboring countries would presumably accelerate regional reform processes.

FAO figures on forest cover for 1980, 1990, and 2000 show turnarounds in forest cover or forest density trends in all four Asian countries during the 1980s and 1990s, so these figures provide tacit support for the idea that the forest reforms and other, concurrent trends spurred forest transitions in all four countries (Mather 2007; Wolosin 2017). Like most South and East Asia countries, all four countries contained densely populated rural areas with millions of impoverished peoples. The particulars of the reforms varied. South Korea sponsored nationwide tree-planting campaigns. India and Vietnam devolved power over forests to village councils. Vietnam and China instituted logging bans. China, South Korea, and Vietnam relied on tree planting as a primary means for fostering forest expansion. Vietnam also promoted agricultural adjustments that intensified cultivation on lower elevation lands in valleys served by roads (Sikor 2001; Mather 2007; Meyfroidt and Lambin 2008b; Wolosin 2017).

The timing of the Asian transitions suggests a 'wave' like adoption of state forest expansion programs consistent with a latecomer effect. Similarly, the relatively large amounts of forest still present in India, Vietnam, and China at the time of the reform suggest a shared understanding of the deleterious consequences of complete deforestation. In sum, the Asian forest transition exhibits the attributes of latecomer transitions: a self-conscious, planned pursuit of forest expansion, reforms initiated by central governments or a centralized campaign, and reliance on direct means of forest expansion, tree planting, that governments or campaigns could control. These attributes produced, unsurprisingly, relatively quick transitions from losses to gains of forest cover in South and East Asia.

In the late twentieth century, the Sahel and East Africa also saw a regional forest transition. Like South Asia and parts of East Asia, these regions contained large rural populations of impoverished peoples. In the more humid upland areas, farmers cultivated small plots of land, averaging one to two hectares in extent. The central governments were weak politically, so Asian-like, government-supported programs of reforestation did not occur, but several types of NGO-initiated programs did achieve widespread success. In the 1990s, a network of international NGOs working with government officials implemented tree tenure reforms in Niger and other states in the

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Sahel that secured smallholders' ownership of trees on their farms. With these reforms, the density of trees, some planted and others sprouting spontaneously, began to increase across a broad arc of Sahelian states (Reij et al. 2009; Reij 2014). On East African smallholdings, the planting of trees on smallholdings represented a long-standing practice, but it received additional impetus during the last three decades from tree-planting campaigns led by an NGO, the Green Belt Movement, headed by Wangari Maathai (Maathai 2003). More recently, the Green Belt Movement, working in concert with the United Nations and Western European NGOs, launched a worldwide 'Seven Billion Tree Campaign.' It capitalized on the preexisting practices of African smallholders and widespread international concern about deforestation to expedite additional tree planting on a tree-by-tree basis in small woodlots throughout the world. In the salience of the normative appeal, the centralization of the campaign in the Green Belt Movement, and the acceleration of tree planting during the campaign, the East African experience exhibits all the expected attributes of a latecomer forest transition. The recent scaling up of the East African campaign to a global campaign suggests that, at least in a normative sense, a global version of a latecomer forest transition may be emerging. We explore this idea below.

CLIMATE CHANGE AND STATE-LED FOREST TRANSITIONS IN THE TWENTY-FIRST CENTURY

As climate change has gathered force, the ecological feedbacks from it have become more obvious, and its consequences for the extent and health of forests have become more salient. Could the ecological feedbacks from the scaled-up human activity have driven both the extent and the form of forest transitions at both global and national scales (Chazdon et al. 2016)? In some boreal locales, global warming may have recently encouraged forest expansion (Song et al. 2018). Conversely, declines in the snow pack at high elevations in the western United States have contributed to a recent upsurge in forest fires in the region (Allen et al. 2009; Abatzoglou and Williams 2016).

At the same time that these ecological feedback effects from global climate change have become more conceivable as drivers of forest cover trends, the human mobilization through states and NGOs to compel a transition from deforestation to reforestation has become more concerted internationally. The comprehensive plans to spur reforestation have come out of planning processes set in motion through the Conference of Parties (COP) meetings sponsored by the United Nations Framework Convention on Climate Change. This process culminated at the 21st COP in Paris in 2015 where national governments presented plans for Intended Nationally Determined Contributions (INDCs) to a global effort to reduce greenhouse gas emissions.[2] A substantial number of countries proposed to meet their emissions reduction goals by accelerating the sequestration of carbon through an expansion in the size of forests. In effect, officials from a wide range of nations promised at Paris to implement state-led forest transitions. INDC plans from China, India, Vietnam, Papua New Guinea, Uganda, and Cape Verde all pledged emission reductions through forest expansion and an associated acceleration in carbon capture by forests (http://cait.wri.org/indc/#/profile). To this end, coalitions of states and NGOs have created institutional mechanisms to help landowners capture carbon, the most prominent of which are REDD + (Reducing Emissions from Deforestation and Degradation) programs that pay landowners for the carbon sequestration and other environmental services (PES) provided by the forests on their lands (Sunderlin et al. 2014). These plans for forest expansion, while not mandatory, appear to have the potential to grow into an internationally coordinated forest transition program. Collectively, they constitute a plan for a global, state-led forest transition. The similarity of INDC plans within regions suggests that countries made commitments with an eye on what other, neighboring country commitments looked like (http://cait.wri.org/indc/#/profile).

Civil society, in particular through fora like the United Nations, has over the same time period become more mobilized to pursue forest and landscape restoration. In 2010, the United Nations' Convention on Biological Diversity adopted the Aichi Targets that committed nations to slowing biodiversity losses through reduced deforestation and expanded forest restorations. Number fifteen of the United Nation's newly adopted Sustainable Development Goals, 'life on land,' commits UN members to sustainable forest management. The Bonn Challenge and the New York Declarations by nations and NGOs express these commitments in quantitative terms. Signatories to the Bonn Challenge promise to restore 150 million hectares of degraded forest lands by 2020. The New York Declaration on forests by nations and NGOs promises to cut the deforestation rate in half by 2020. Corporations have recently committed their organizations to this collective effort, promising to adhere to deforestation neutral production processes (Curtis et al. 2018).

Where would the states find the lands to reforest? As noted above, agriculture continues to move downhill to

[2] The WRI-CAIT website (http://cait2.wri.org/pledges/#/profile) contains summary descriptions of each country's plans for emissions reductions. These plans frequently describe reductions to be achieved through increases in carbon sequestration in expanding forests.

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level lands that make it easier for farmers to use machinery and apply inputs like fertilizers. The prevalence of uplands still in cultivation, likely to be abandoned, and able to regenerate varies from region to region. Tree planting in degraded, upland sites seems quite possible. The state-led forest transitions in Asia in the late twentieth century emphasized expansion in tree plantations, and the affinity between state-led efforts and tree planting in degraded or treeless areas seems likely to persist in future plans for forest expansion (Barney 2008; Van Holt et al. 2016).

CONCLUSION

While the idea of a forest transition suggests a predictable pattern of land use and cover change during socioeconomic development (Redo et al. 2012), the socioecological contexts in which the transitions have unfolded during the last two centuries have changed dramatically, so we might expect corresponding changes in the drivers and pathways of forest cover change. Many of the first forest transitions occurred passively when farm workers left for cities and forests regenerated on the abandoned agricultural land. More recently, forests have reappeared intentionally, planted by governments eager to forestall flooding or recuperate degraded lands. Most recently, the rationale for intentional forest expansion has expanded to include climate stabilization. Table 2 summarizes this argument. It describes the shifts in the social and ecological drivers of forest transitions across three historical periods.

The hypotheses offered above about the twenty-first-century forest transitions remain to be confirmed by more detailed comparative historical research, but, if they are confirmed by future investigations, several implications about the expanded forests would follow. If planted forests become more prevalent during the twenty-first century, they would change forests in significant ways. While spontaneous secondary forests resemble simplified versions of the old growth forests they replaced, planted forests depart from spontaneous old growth forests in radical ways. They contain much less biodiversity, dominated as they are by monocropped pine or eucalyptus trees. If governments establish these forests to sequester carbon, the new, planted forests might do so more rapidly than spontaneously generated forests. If we plant a growing proportion of forests, their spatial distribution may change, with more of them appearing in formerly pasture dominated landscapes in countries like Uruguay, China, or South Africa. While the spread of forest plantations intends to alleviate one problem, climate change, it aggravates other problems. It diminishes biodiversity (Bremer and Farley 2010; Austin et al. 2017a, b). It also can create environmental injustices if the reservation of extensive areas for wood production displaces indigenous peoples who lived on these lands prior to the creation of the plantations (Alywin et al. 2014).

Table 2 Drivers of forest transitions: nineteenth–twenty-first centuries

	Nineteenth, early to mid twentieth century forest transitions	Late twentieth century regional forest transitions	Twenty-first century forest transitions
Land use changes	Spontaneous regeneration; More montane forests	Spontaneous regeneration; More montane forests; More planted trees	Spontaneous regeneration; More montane forests; More forest plantations
Political mobilization	Elites intervene to protect forests	Latecomers; Regional political mobilization	Latecomers; Global political mobilization
Ecological feedbacks	Floods ↓	Floods ↓	Floods ↑, Droughts, Fires

Following the hypothesis about the latecomer effect outlined in the preceding pages, the transition to these redistributed forests would take a particular form. More so than the earlier forest transitions, it would entail extensive state, NGO, and even corporate-led political mobilizations. As with all large-scale political mobilizations, issues of burden sharing among organizations intent on meeting their mitigation targets could mark these plans for reforestation. Environmental justice issues would emerge if poor nations and communities feel compelled to devote agricultural lands to carbon absorbing forests without compensation. Trans-scalar land use planning that brings together local, national, and international officials could provide an institutional means for resolving some of these issues about the extent, location, and financing of the new forests (Rudel and Meyfroidt 2014).

As would be expected of a large-scale political mobilization, the leaders of this transition would argue for it. A global forest transition may or may not be under way, but, like other latecomer processes, it has become normative to advocate for it. For this reason, the global forest transition, at present, is as much a normative formulation as it is a verifiable phenomenon in landscapes. The command structure of the agreed upon forest transition would feature a centralized, global effort at landscape change devoted to reducing ghg emissions through coordinated actions by states, corporations, and NGOs. Finally, as implied by the foregoing remarks about recent state-led transitions, the planned pace of a global, latecomer transition would be

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faster than the previous transitions. In these last two respects, its global structure and its rapid pace, a latecomer global forest transition would be commensurate with the rapidly accumulating challenges of climate change and biodiversity loss.

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