# One Earth

## Perspective

# The Global Forest Transition as a Human Affair

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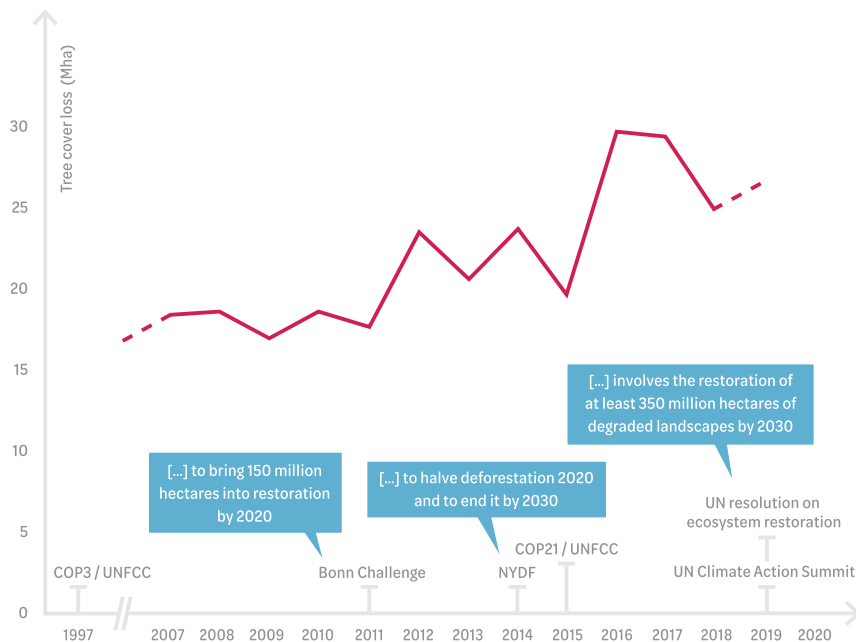https://doi.org/10.1016/j.oneear.2020.05.002

Forests across the world stand at a crossroads where climate and land-use changes are shaping their future. Despite demonstrations of political will and global efforts, forest loss, fragmentation, and degradation continue unabated. No clear evidence exists to suggest that these initiatives are working. A key reason for this apparent ineffectiveness could lie in the failure to recognize the agency of all stakeholders involved. Landscapes do not happen. We shape them. Forest transitions are social and behavioral before they are ecological. Decision makers need to integrate better representations of people's agency in their mental models. A possible pathway to overcome this barrier involves eliciting mental models behind policy decisions to allow better representation of human agency, changing perspectives to better understand divergent points of view, and refining strategies through explicit theories of change. Games can help decision makers in all of these tasks.

## Introduction

Forests across the world stand at a crossroads. Climate change[1] and land-use change,[2,3] both end points of larger and complex chains of cause and effect, will shape their future. Although changes in climate and land use are not independent from each other,[4] the underlying processes work at different time-scales: decades to centuries for changes in temperature and rainfall patterns against years and sometimes months for agriculture conversion, infrastructure development, logging operations, and political regime shifts.[5] Agriculture is the main driver of deforestation.[6,7] Net deforestation in the tropics dominates[8] with various regional drivers:[9] ranching and soybean expansion

**Figure 1. Detected Tree-Cover Loss and Institutional Timelines**
Despite demonstrations of political will and global efforts, tree-cover loss continues unabated. No clear evidence exists to suggest that these initiatives are working (data by Global Forest Watch; tree-canopy density > 30%).

abated and are reaching a critical point.[23] No clear evidence exists to suggest that the current restoration initiatives are working (Figure 1). Despite corporate commitments, commodity-driven deforestation persists,[9] and new evidence suggests that targets, e.g., 10% of the government pledges to the Bonn Challenge, were set without consideration of the biophysical capacities of the system.[24] Successes here and there do not register at the global scale, and at best they tell the story of battles won but of a losing war.

Why are policies designed to halt deforestation and increase restoration of forest landscapes apparently missing their target? We hypothesize that a key reason for ineffectiveness lies in a failure to recognize the agency of the many stakeholders involved—their capacity to act independently and to make their own free choices—and the adaptive capacities of the systems we seek to steer. Landscapes do not happen; we shape them. They are the result of the sum of individual actions and decisions made by all stakeholders and the interactions between these and the biophysical processes.[25] Forest transitions in the Anthropocene are primarily driven not by ecological processes but by social processes, including policy and economy, and social behaviors. When forest transitions happen, they are the result of a change in the way humans govern and manage ecosystems. From the smaller community of hunter-gatherers to the largest corporations, it is only and always humans who make decisions.

Agency is a blind spot in our decision-making processes and a possible reason why global policies and initiatives to halt forest degradation and foster restoration fail. In this Perspective, we suggest a possible pathway to overcome this weakness. We first introduce two widely applied theories (forest transition and sustainability transition and transformation) and then elaborate on the reasons for policy failures. We then propose a radically new approach, where we discard the assumption that it is feasible or necessary to work toward achieving a common vision for transformation. We propose a method that allows decision makers to align forces despite different and sometimes opposing values and worldviews without the necessity to find beforehand a "common vision." The core of our approach rests in the elicitation of the mental models used by decision makers, a necessary step that allows for a better representation of human agency in them. Games can represent these models and be designed to portray the needs, constraints, and aspirations of the stakeholders they refer to. Such games, when played, allow the self-actualization of the decision makers who play them.

in Latin America,[10–12] subsistence agriculture in Africa,[13,14] and small-holder farming linked to industrial plantations in Asia.[10,15] According to Global Forest Watch, annual tree-cover loss reached 29.7 million hectares globally in 2016, a 51% increase since 2015. In the tropics, 12 million hectares—an area the size of Belgium—were lost in 2018 alone.[16]

Multiple initiatives worldwide—including the Convention on Biological Diversity (CBD), Aichi Target 15,[17] the United Nations Framework Convention on Climate Change (UNFCCC), Reducing Emissions from Deforestation and Degradation (REDD+),[18] the Bonn Challenge, the Rio+20 land-degradation neutrality goal,[19] and Sustainable Development Goal (SDG) 15[20]—all had stated ambitions to reverse these trends. Sixty percent of the 500 most influential companies in forest-risk supply chains have made deforestation commitments in one form or another.[21] The New York Declaration on Forests, Initiative 20×20, the African Forest Landscape Restoration Initiative (AFR100), and similar initiatives seek to restore deforested and degraded land. The Bonn Challenge Barometer of Progress reports that 47 countries are pledging more than 160 million hectares for Forest Landscape Restoration through voluntary, non-binding initiatives, and 43.7 Mha were reported as being restored.[22] More recently, the World Economic Forum launched in February 2020 the 1t.org project, a global initiative to grow, restore, and conserve one trillion trees around the world. They join other similarly named initiatives (Plant for the Planet, the Trillion Tree Campaign, and Trillion Trees) aiming to unite governments, civil society, companies, and private individuals in a global-scale nature-restoration movement. Despite repeated failures to meet many earlier targets and leaving aside the possibility of ulterior motives held by leaders and representatives, these efforts show that the stated collective ambition to preserve forests remains strong (Figure 1).
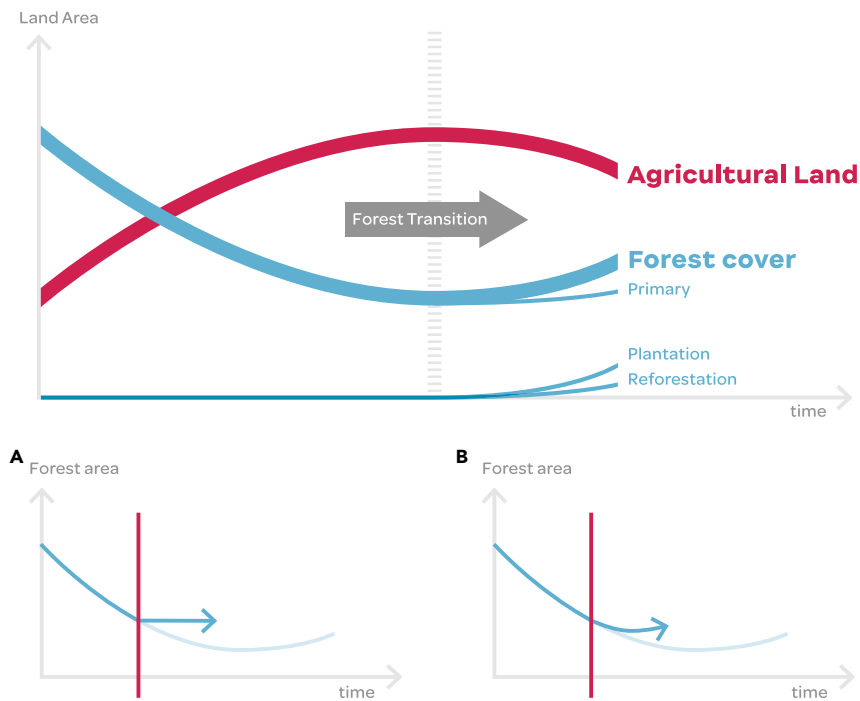
Despite the demonstration of political will and global efforts, forest loss, fragmentation, and land degradation continue un-

**Figure 2. The Forest Transition Theory, Deforestation, and Forest Landscape Restoration**

Forest transition theory is a description of the changes that a landscape—initially a country—undergoes when its forest cover stops shrinking and starts expanding amid growing human population, 2013Forest transition theory is a description of the changes that a landscape—initially a country—undergoes when its forest cover stops shrinking and starts expanding amid growing human population, increased technical capacities, and changing cultural values. With agricultural expansion as the major driver of forest loss, the curves of forest area and agricultural area complement each other. The expansion of remaining forests, forest landscape restoration, and active plantation programs explain the recovery of forest area. The forests at the end of the process are different from those at the beginning. Policy interventions can speed up or slow down the transition. A policy to reduce and stop deforestation can at best flatten the curve (A). Forest landscape restoration can potentially redress it up to the maximum ecological potentialities of the locality (B). Halting deforestation and restoring landscapes are equally needed for operating the transition. Modified from Rudel et al.,[27] Lambin and Meyfroidt,[28] and Mather.[29]

## Common Theories of Transitions
### Forest Transition Theory

Forest transitions—defined as regional-scale shifts from a shrinking to an expanding forest area—serve as a heuristic framework for conceptualizing forest landscape change (Figure 2). This framework distinguishes three distinct phases where (1) fragmentation, (2) deforestation and degradation, or (3) restoration and reforestation are the main processes shaping the landscape (but see Bogaert et al.,[26] who classify fragmentation as a case of deforestation and note that fragmentation and deforestation can continue even as restoration occurs). This trend is represented with the forest transition curve,[27,28] a theoretical construct that maps changes in forest cover area for a given region or nation over time.[29] The theory has shortcomings. Forest quality is not well represented, and degradation, if it is higher in the second phase of the transition, can happen all along the forest transition curve. The forests that return are not necessarily the same as those that disappeared in structure, composition, and function.[30] Other limitations of the theory include how it defines forests, the explanations it offers to the transition, and its generality.[31] Despite these, the forest transition theory remains one of the foundations of current thinking on forest landscape change.[32–34]

### Sustainability Transition Theory

A multi-level perspective (MLP) of nested scales is commonly used for modeling socio-technical transitions[35–38] and has been used in forest-governance contexts for analyzing conditions across policy levels.[39–41] It identifies three analytical levels (Figure 3). The macro level (1) includes the broader political and socio-economic trends, values, and normative landscape. The meso level (2) consists of the current socio-technical regimes, rules, and routines that define the "way of doing things at the

moment," e.g., the production system including rules and actors from industry, policy, science, and users. The micro level (3) consists of niches where experimentation with novel technologies, practices, and policies, collectively referred to as innovations, takes place. In niches, innovations are shielded from regime influences,[42,43] but over time experimentation can be expanded to "spaces where networks of actors experiment with, and mutually adapt, greener organizational forms and eco-friendly technologies."[44] The MLP does not correspond to specific scales. Rather, it can be applied to different scales ranging from regional to national and local depending on the analytical context. The MLP also describes under which conditions a stable regime could radically change through a "regime shift."[45] A shift is possible when novel practices mature, gain traction through economies of scale, for example, and replace dominant practices in the regime.[46,47] Examples of successful transitions come foremost from sectors with a strong technological character, such as electricity systems,[48–50] "green" cars,[51,52] biogas,[53] and sustainable housing.[44]

Because of economies of scale, the costs of innovations can be considerably reduced over time, making them much more competitive against conventional practices. However, in sustainable agriculture, e.g., in coffee agroforestry systems,[55] economies of scale are not easily created. In the case of sustainability, transitions happen only when sufficient pressure is put on the normative landscape to create opportunities to adopt innovations. Therefore, the transitions are unlikely. The example of coffee is telling. Despite policies and agendas, agroforestry coffee is in decline globally.[56] Should the transition happen, in coffee or in other sectors, it would still have the potential to create inequality if the interests, needs, and constraints of small-scale producers were left aside, pushing them out of the system.[54,57–59]
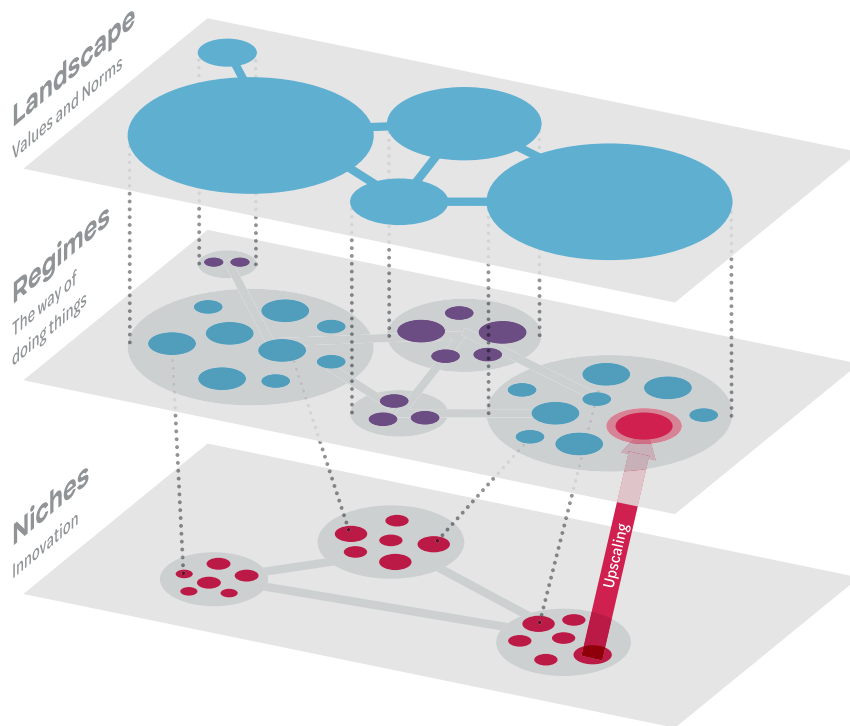
**Figure 3. The Multi-level Perspective Theory Framework**
The landscape represents the norms and values that shape our collective enterprise. The regimes capture current rules and processes that define "the way of doing things." Innovation happens at local scales in niches protected from competition. According to this theory, the upscaling of innovation by change agents can create regime shifts, redefining how we do things, but this requires pressure from the landscape level. This figure depicts a point in time where a novel practice has gained traction and regime shift is just starting. Note that "landscape" here does not refer to the physical landscape. Adapted from Geels.[54]

mine whether a transition will occur.[70] These choices and actions are driven by economic factors and markets; policies; social norms, rules, and beliefs around land use and management; the assets accessible to the agents making the decisions; and ultimately, their free will and agency (Box 1). In the end, we all make choices and decisions with different levels of power and effectiveness, and these decisions shape either the landscapes or the decisions of those who shape them.[71]

Social groups actively fabricate their knowledge and versions of reality through everyday interactions. Actors work within biophysical constraints, regulatory structures, complex social networks, and power imbalances that invite, discourage, or forbid certain actions. Individuals are not passive rule followers but actively create, use, and reproduce social norms—the unwritten rules to which people adhere.[73] The individual's understanding of the norm might be accurate or not. Further, different individuals might share the same understanding or not. They make their decision on the basis of the information available to them, their capabilities, and their compliance to the norms, laws, and policies or their capacity to evade enforcement and tolerate risk. Thus, before forest changes are observed on satellite imagery, the trends are first socially constructed by actors holding expectations that might or might not be based on correct perceptions of physical realities or laws, norms, and individual capabilities. Understanding social perceptions, rules, and norms is therefore essential to driving social, and ultimately ecological, change.[74–76]

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has stressed the importance of inclusive valuation.[77] Its regional assessments highlight how diverse values and value systems shape interactions between people and nature, including the use, management, and conservation of nature's contributions to people.[78,79] They describe how incorporating a diversity of social values into decision-making processes can contribute to successfully designing and implementing effective conservation and sustainable use plans, as well as to achieving the SDGs.[79,80] Values—as well as the current emotions, preferences, and personalities of decision makers or the characteristics of options[81]—drive decisions.[82] Therefore recognizing the role and personal contexts of local decision

## Reasons for Policy Failures
### System Lock-In
Systems have memory[60] that conditions what possible future states the system can take. Path dependency describes the notion that the pathways the system can take are bounded by a "corridor of the possible" beyond which certain states are impossible and certain decisions appear unthinkable.[61] Once a system is engaged in a certain pathway, continuation in the same direction becomes more probable—a lock-in is in place.[62]

Existing market and land-policy distortions underprice the use of natural resources, making business-as-usual production systems more competitive in the short term.[63] Innovations to tackle forest loss and degradation are generally based on policy instruments (e.g., certification, payment for ecosystem service schemes, and offset requirements[64–66]) that are designed to internalize environmental costs and are, hence, more expensive to implement than the alternatives. For example, forest-management certification was promoted as a market-based solution to the failure of public policies to protect forest resources.[64,67] However, its adoption has been limited, especially by forest communities, by the costs involved. Where adopted, it has promoted and shaped sustainability transition processes by introducing new concepts in national policy arenas.[40,68] Simply scaling up the current forest-certification models, however, will not lead to a regime shift. A focus on macro-level processes is required.[69] The challenges facing forests, particularly tropical forests, usually originate from outside of forests and the forestry sector.[9]

## People and Their Values and Beliefs
Ultimately, human actions and behaviors—migrating in or out, investing in tree planting, and allowing land to lie fallow—deter-

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**Box 1. Case Study: Mount Elgon, Uganda**

*Geography.* Mt. Elgon is a solitary extinct volcano straddling the Uganda-Kenya border (4,321 m) and is located at 01°07′06″N and 34°31′30″E. Below the Afroalpine and ericaceous zone (from about 3,200 m), there is an Afromontane zone and an Afromontane rainforest zone. The forests and higher-elevation areas are protected by a national park, and nearly all land within 20 km is under small-scale cultivation or grazing. Population densities, ranging between 300 and 1,000 p/km$^2$, are high.

*History.* Mt. Elgon was first established as a forest reserve (1929) for timber and water-catchment values. Pine plantations replaced some forest in the north (1955), and neighboring people settled inside the reserve. In 1968, forest management in Uganda was centralized, and reserve boundaries were officially demarcated. Under President Idi Amin (1971) and Milton Obote (1978), most forests were encroached by (small-scale) farmers. Starting in 1987, efforts to restore forest on Mt. Elgon were implemented, first through a forest-restoration program and then through increasing the level of protection of the forest to that of a national park (1993), evicting and/or resettling forest residents, and cracking down on illegal forest uses. In the 1990s, collaborative approaches to forest management were introduced in an effort to reduce conflicts between park management and local residents and improve conservation outcomes. Overall, these interventions have halted forest-cover loss and even led to some restoration (see figure below). However, forest restoration was successful in only a few places; renewed clearing sometimes reversed initial success, and restored cover is often highly degraded. Overall recovery is limited, and conflicts are still very common. Forest conservation on Mt. Elgon in Uganda is a classic illustration of a wicked problem.

*Forest Transitions on Mt. Elgon.* The figure below shows nested forest-transition curves for Mt. Elgon in Uganda between 1960 and 2009 for the whole forest zone (magenta line) and split among sub-areas. These show the balance of factors supporting forest conservation and forest loss. The study found that single drivers of forest change failed to explain the historical changes on Mt. Elgon, especially for forest recovery. Instead, it found that local forest-cover trajectories on Mt. Elgon were determined by actions driven by local historical cultural preferences around land and forest use; over time, these interact with changing contexts of markets and market access, conservation policies and their expression in terms of access to resources, and external political interference (see figure below). For example, in the first phase, population pressure and wealth drive forest clearing, but later there is recovery in wealthy densely populated areas but forest loss in poor, relatively low population areas.

Attempts to drive forest recovery on Mt. Elgon have not sufficiently recognized the social norms and beliefs that govern people's actions. For example, in one area, strong traditional forest-use rules broke down after the area was declared a national park, and forest that had resisted previous drivers of deforestation started to be degraded. Efforts to reduce conflict and forest loss through forest-resource use agreements have mixed results. They generally do not sufficiently meet people's needs or give them adequate ownership and are therefore often used as opportunities to access the forest for more destructive activities, as illustrated by field assessments in this study. The relationships among stakeholders on Mt. Elgon are characterized by distrust.

Mt. Elgon illustrates how forest transitions are embedded in social transformations and the importance of understanding these in order to drive social and therefore ecological change. For example, on Mt. Elgon, with its enormous population pressure and strong claims on forest resources, conservation managers might have to radically change their perceptions on forest conservation and accept lower levels of forest intactness that balance longer-term minimum conservation needs with meeting local needs for ecosystem services.

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makers and decision influencers in fostering (or preventing) forest transitions is key to understanding how to support and promote forest recovery. However, there is more at stake than values.

The systemic shifts required for the forest transition to happen are unlikely to follow from a gradual change in values held by decision makers. They demand rapid large-scale behavioral transition that will occur only if social norms change.[83] We resist changing our values because these define our identity.[84] Awareness-creating activities aimed at changing values will meet with limited success unless they are targeted at young people whose identities and values are not yet crystallized.[85]

Actions are driven by values as well as by beliefs.[86] We make decisions on the basis of what we want (our desires) filtered by what we think will happen (our beliefs).[73] Whether these beliefs are justified is not of primary importance. The "illusion of understanding," a set of overly simplistic, unjustified assumptions about complex and uncertain topics, proves to be a powerful driver of action.[87] However, the closer our mental
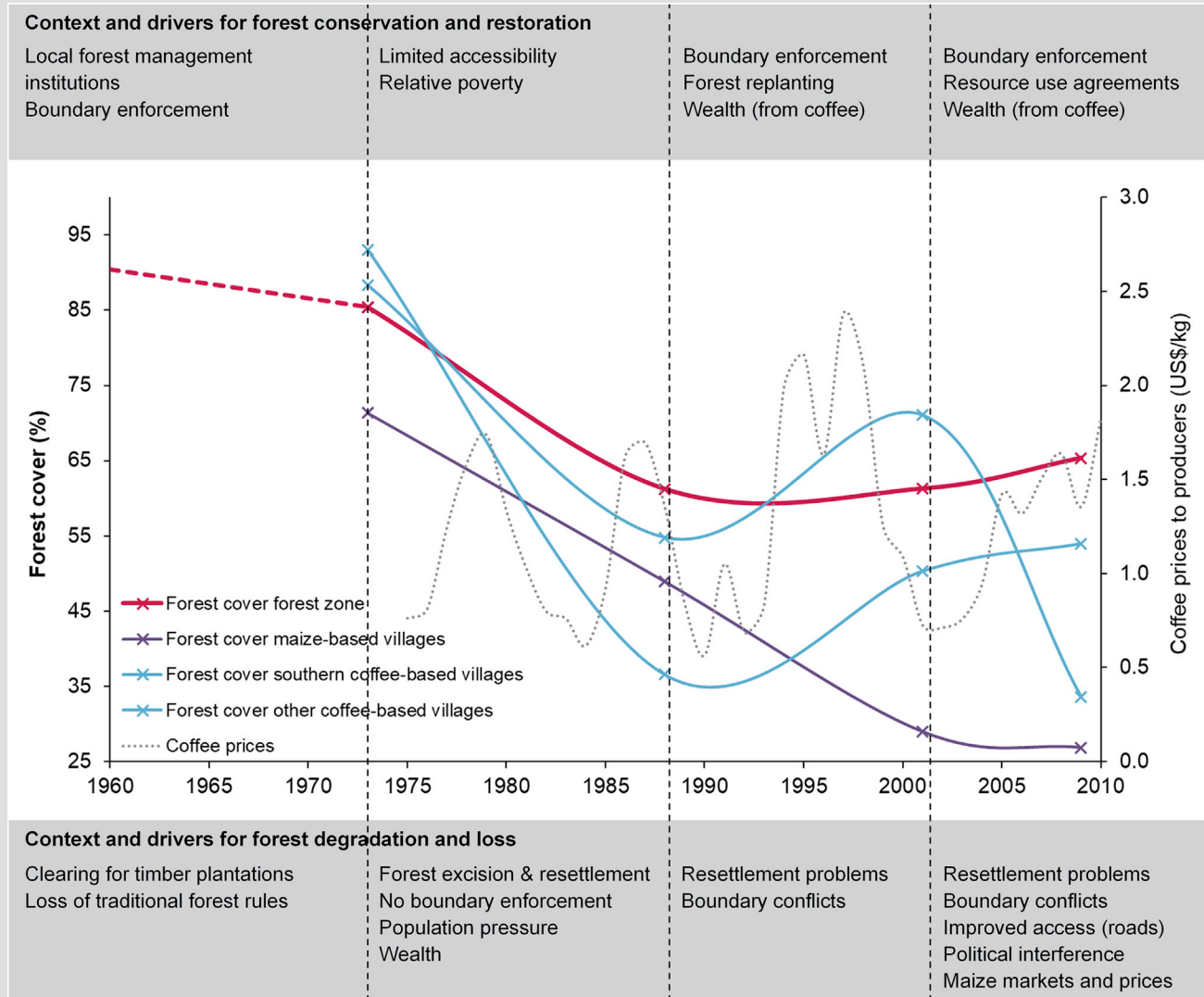
models are to the actual network of causal links that shape the landscape, the smaller the gap between the intended consequences of our actions and their effective impact will be.[73] In addition, whether correct or incorrect, our expectations of others' behaviors and attitudes influence our behavior. When people prefer to act like most others, beliefs can be self-fulfilling.[88] Changing the expectations of what others will do can then create abrupt shifts in behavior and trigger a chain reaction.[83] The pathways connecting actions and beliefs are two-way avenues.

### Bringing about Radical Transformations
We propose that it will be very expensive, perhaps even futile, to invest in trying to change the values of decision makers in order to bring about forest transitions or any other systemic environmental transformations. Developing a common vision of what the world should be will be difficult, exhausting, and possibly impossible if the values held are at loggerheads. More importantly, it is not required.

**Box 1.** *Continued*

**Context and drivers for forest conservation and restoration**

| Local forest management institutions | Limited accessibility | Boundary enforcement | Boundary enforcement |
|---|---|---|---|
| Boundary enforcement | Relative poverty | Forest replanting | Resource use agreements |
| | | Wealth (from coffee) | Wealth (from coffee) |



**Context and drivers for forest degradation and loss**

| Clearing for timber plantations | Forest excision & resettlement | Resettlement problems | Resettlement problems |
|---|---|---|---|
| Loss of traditional forest rules | No boundary enforcement | Boundary conflicts | Boundary conflicts |
| | Population pressure | | Improved access (roads) |
| | Wealth | | Political interference |
| | | | Maize markets and prices |

This figure shows forest-cover change for the entire forest zone of Mt. Elgon, Uganda (magenta line), and within 2 km of villages adjacent to the park (blue and purple lines). The split among different groups of villages reflects a broad focus on either coffee or maize for income and, together with other contextual factors, aids our understanding of local variation in forest-transition trajectories and their contribution to the overall forest-zone curve. Southern villages are presented separately to illustrate the reversal of a forest-regeneration trend among traditionally coffee-focused villages in the south. Underlying drivers considered include, among others, prices and markets for major crops, national-level politics, population, and changing conservation policies. Modified from Sassen et al.[72]

For collaboration between agents to emerge, they do not need to agree on a common objective or shared vision. It is sufficient that they agree on how the world works and how it could change.

### Agreeing on How Things Are

We propose that a path less trodden for policies and interventions is to provide reasons for people shaping the landscape or shaping the decisions of others in the landscape to change the expectations they hold about what others will do or how the ecosystem will respond.[83] It means working on creating agreement around a common understanding of how things are (descriptive approaches) instead of focusing on how things should be (normative ones). It means asking how the system works so people provide mechanistic explanations rather than asking them the reasons of the positions they defend.[87] Asking *how* instead of *why* allows three things happen:

First, people can relate to their empirical knowledge of the system and feel secure if their own perception of reality is represented adequately in the discussion.

Second, exposure to the realities perceived by other parties will lead to surprises, given that one's point of view is suddenly shifted. In so doing, we create the conditions for epiphany learning (EL) to happen. EL occurs when agents suddenly and dramatically alter their behavior.[89] EL is different from reinforcement learning, prevalent in the decision-making literature. In cases such as the ones we outline here, learning happens all at once. The neurological pathways leading to such epiphanies have yet to be understood.[89]

Third, when no trust exists between parties, a common description of how things are (independently of the values we attach to them) serves as common entry point for building agreement. Trust is critical in collective action,[90] but it is not given and is possibly overrated.[91] The processes we advocate do not require altruism or trust between parties. Nor do they void the necessity of strategic foresight by all parties: intelligent, organized, and often powerful resistance to environmentally motivated change is an important feature of most environmental issues.[92] They do require pragmatism and sound methods such as the ones we expose below to be successful.

What role can science play? One of the classic roles assigned to scientific research is ontological. Society expects science to generate new knowledge that will change our understanding of what the system actually is, establish trends, ascertain new orders of magnitude. This is akin to exploring the "what" of forest landscape change. The map of intact forest landscapes[93] played such a role. By giving a precise definition to an until then fuzzy concept and proposing a first map outlining their extension and location, the authors created a new viewpoint on forests and a new layer of information. In doing so, they initiated a policy transformation that led to the integration of new forest-management requirements by the Forest Stewardship Council and their adoption by certified operations 6 years later.[94] The estimation of the number of trees on Earth[95] had a similar impact by transforming the Billion Trees campaign into the Trillion Trees campaign, when decision makers involved in that initiative realized the magnitude of the processes they wanted to influence. More recently, the estimation of Earth's tree-restoration potential played a similar role by changing the public perception of the value of forest as a natural climate solution.[24]

Understanding the changes in forest cover, as well as measuring whether and to what extent forests are degraded or expanded, is therefore crucially important for putting topics on the agenda. A descriptive framework that quantifies and monitors the status of forests should in principle be able to contribute to modifying individuals' perceptions and evolving social norms toward a more unified vision and thus reduce false understanding of individuals in a group. However, given that definitions of forests are political statements, simply agreeing on what to monitor already proves a challenge.[96] Ontological research and quantitative monitoring frameworks are needed but are not sufficient for creating the transformations we call upon.

### Becoming Self-Aware

A theory of change (ToC) and other similar approaches make it possible to document and examine assumptions, causality, and the steps along a project-development pathway.[97] They do so by articulating the hypotheses that underlie potential pathways to change and making anticipated cause-effect relationships explicit. A ToC focuses attention appropriately on *how* the system works as opposed to *why* it should work in a certain way. Such a reflexive process improves the chance of designing and implementing successful projects.[98–100] The participatory nature of a ToC development and refinement is key to success.[98,101]

The widespread use of a ToC both as a process and as a product in the development of policies and projects tackling deforestation, forest degradation, and reforestation would contribute to more realistic long-term goal setting and allow for learning and adaptive management. It facilitates transparency on collective beliefs and reveals differences in the assumptions among stakeholders.[102] If framed not as a normative issue but as a description of the status quo, the use of a ToC helps stakeholders who might not all agree on an overarching objective to smooth the way for reflection and shared negotiation of common or compatible goals and solutions.[103] As a dynamic process, the ToC can support the collective testing of assumptions within the intervention.[98] As outcomes begin to be realized, the ToC revisits both the logic and the assumptions of the policies and projects to ensure that change is taking place as intended. A key aspect of the process is to strengthen stakeholder ownership and continuously revisit pathways of change while ensuring that the scenarios produced are relevant to policymakers and practitioners.

Understood as such, a ToC thus outlines a strategy for achieving a stated objective.[99] It is first developed on the basis of the mental model of the decision makers.[104] It necessarily includes statements on the expectations of how stakeholders will respond to initiatives. Through the process of revisiting it, the mental model can be refined. With a ToC thus come two keys for success: the elicitation of mental models that allow self-awareness of those undergoing the process and the design of a learning process that allows the models to be refined.[99]

Flaws and inaccuracies in the mental models, however, will be costly, create delays, or even foster opposition. This process is often referred to as "muddling through," an expression used in policy development, administration, and landscape management.[25,105] There are ways to fast track the process of testing and validating one's mental models. They involve engaging actively in scenario construction. The essence of such prospective analysis is to explore possible futures[106] rather than to predict what will happen. The aim is to highlight the forces that drive the system to make better decisions today about the future.[107] However, the complexity of the landscapes we address defies the cognitive capacities of most of us. As with a game of chess, with its $10^{120}$ estimated variations,[108] it is easier to explore the behavior of a system by using a board and pieces than to play with a blindfold. We suggest that games, as models of strategic situations, can help here too if only we can convince decision makers to play them.[109,110]

### Learning by Playing

In a game, the outcomes of an action depend on the interactions between one's decision, the decisions of the other players, and the rules of the game. A game is therefore a model of a strategic situation.[111] Games are adaptable to different viewpoints and can represent different roles, information, and power asymmetries. Their development and manipulation help people cope with complexity.[109] Games can be developed to help us
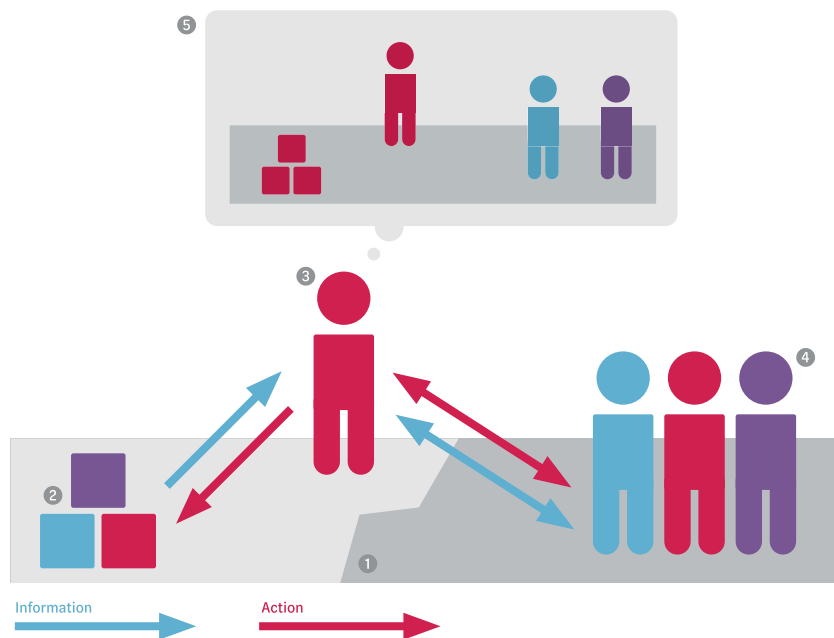
**Figure 4. Agent-Based Model Framework**
The games we develop use the basic architecture common to most multi-agent systems but are applied to landscape and natural-resource management. A first layer details the physical landscape and its heterogeneity (1). Resources, including ecosystem goods, are present in this landscape, and each resource has its own sub-model to describe its dynamics (2). Stakeholders are represented as agents and have different qualities of life, access to capitals, knowledge, and skills (3). Stakeholders manage the land and the resources according to their needs, capacities, and aspirations. In addition, stakeholders are embedded in a policy, social, and institutional environment made of other agents (4) with whom they interact and that contributes to shaping their strategies. The crucial element is the mental model of the agent (5) and her perceived environment, which will condition the choices she makes. Adapted from Ferber and Weiss.[114]

understand landscape changes and map environmental conflicts.[112] Based on the companion-modeling approach,[113] their design involves the collective elicitation of the mental models that underlie decisions and the transformation of these mental models into a game that will serve as a tangible and adaptable boundary object (Figure 4).

Developed through participatory processes, a game can represent all the crucial actors, resources, processes, and interactions—ecological, social, economic, and political—relevant to the discussion.[114,115] Such a game is then understood as the combination of tokens (what the system is), a set of commonly agreed-upon rules (how the system works), and players.[116] Playing the game lets stakeholders confront their understanding of the system with the narrative presented by the game. The game poses challenges to the players, responds to their decisions, and invites them to think strategically. They can then pitch their strategies against those of the other players and against the engine of the game—the core rules that define what is possible and what happens. This process acts as a reality check of the assumptions that participants have.[116] It allows creating consensus on how the system works; when participants agree, the rules represent the system that they are familiar with. Games enable stakeholders to share and confront their perceptions to better grasp the complexities of the system, to explore alternative futures in a low-risk environment, and to negotiate new forms of collective action.[117] The insights gained can then be translated into real life first as a refined ToC and then as actual policy propositions. This is the process that negotiators of the Forest Stewardship Council Regional Working Group for High Conservation Value Areas experimented in August 2017 in Brazzaville. They used MineSet, a game developed to explore the links between mining and logging activities, to agree on the definition of regional indicators for intact forest landscapes.[118] The game allowed all participants to create a common understanding of a system they thought they knew. Going back and forth between reality and

the game enabled discussions that were more constructive. Using the board, rules, and tokens as a tangible model to represent situations, counterfactuals, scenarios, and their consequences brought clarity to their narratives. Preceding the negotiations with a game session allows the game to become a tool for establishing an inclusive, engaging, and constructive dialog and facilitate the negotiation process, leading to an agreement when none was previously in sight.[119]

Any method that confronts mental models through the construction of boundary objects would contribute to the same objective. Why should we focus on games particularly? Because to overcome the cognitive biases that prevent changes to our mental models, there are few better ways than to force people to take a new vantage point and to look carefully at what can be seen from that point.[112,117] When faced with a situation that is beyond their control yet in a safe environment, participants become alert, a state that makes it easier for them to reflect and learn.[120] Games thus play the role of the third key to success by providing tools and methods to improve the participants' capacity to learn and placing their own agency center stage.

Outlining the land-use futures and pathways of change requires the identification, definition, and testing of policy innovations and new business models through scenario development. These must then be transposed to the system to help foster the transition. Decision makers engaged in this process need to map policy innovations and business models that suggest alternative pathways away from business as usual by challenging the existing regimes of forest governance. They can look for innovations that aim to challenge the incumbent regime, introduce change to existing practices, and provide alternative pathways. Given that forest governance is fragmented across jurisdictions and includes multiple actors, the identification can span from local levels to international politics. This can require national arrangements[121–123]—including governance instruments by state, markets, and civil society—as well as hybrid modes of governance and public-private partnerships, such as logging concessions and co-management of resources.[124] It can also influence social-private partnerships, such as community "conservancies"

and payments for ecosystem services.[125,126] Identifying synergies between various policy innovations and business models can strengthen policy environments that foster transitions.[127]

Besides identifying policy innovations and business models, decision makers need to identify the individuals, groups, or organizations that can be influenced to achieve the transition.[128] The selection of boundary partners will most likely target a wide range of actors involved in land-use sectors, including firms, investors, users, non-governmental organizations, and various government agencies. Although we advocate change through collaboration and co-creation through exploration of common futures and changed expectations, changing the status quo and the existence of intelligent opposition could also require actors who employ destructive change strategies, such as confrontational campaigns and demonstrations.[129] All of these processes enter in the revision of the ToC. By then, the journey to transformation will already be well underway.

## Conclusions

Landscapes are shaped by a multitude of interacting factors acting on different spatial and temporal scales. Climate and land use are two end points in long and complex causal chains that influence forests globally. Forest-cover loss and forest degradation have negative impacts on biodiversity and the provision of ecosystem services originating from forest systems. They are essential for millions of forest-dependent communities. They contribute to the likelihood of emerging infectious disease. They reduce the capacity of forests to contribute to climate mitigation through carbon sequestration. To counteract deforestation, global initiatives and policy instruments have been created. Yet forest loss continues. Deforestation happens because locally, and in the short run, it is the most logical and rewarding course of action. Doing what is rational depends upon the context one is in, and land-use change is no exception. These negative impacts are balanced by the extraction of timber and other goods originating from the forests, the allocation of more space to agricultural production and infrastructure, and the ensuing economic and social benefits. The gains to be made from deforestation outweigh the negative impacts—at least in the short term and for the subset of stakeholders who actively engage in clearing and degrading forests. Unless the context changes, decisions are unlikely to change. Yet, the context itself is shaped by the biophysical processes and by the decisions of others. More specifically, this is a function of what we understand of the biophysical processes and of the expectations we have on the decisions of others.

This self-referencing process leads to a self-reinforcing pattern of landscape change that can be broken by an abrupt change in perceptions about how the world works. Fostering forest transitions thus requires decision makers at all levels to better understand their own perceptions and values, as well as those of the other stakeholders involved. This is first a call to introspection, and it is true for all decision makers be they working fields, sitting in a minister's office, or sitting on a board. The higher the power of the decision maker, the more pressing the need. Until this happens, policies risk continuing to target the wrong stakeholders for the wrong reasons.

We have highlighted the three keys that can unlock this radical change: (1) gaining self-awareness of the mental models of how the system works and including better representations of human agency in them, (2) adopting a process to revise and improve these mental models through a participatory process such as the ToC, and (3) using games and other boundary objects that decrease cognitive obstacles to learning and prevent self-actualization. In adopting this approach, decision makers will directly address human agency, the Gordian knot at the root of deforestation and forest degradation. We need that to design more meaningful and effective strategies and policies.

## AUTHOR CONTRIBUTIONS

This article builds on the ideas of C.A.G. S.S. led the writing. C.A.G., S.S., V.G., R.V., S.W., C.K., M.S., B.R., H.M., B.N., and J.R. wrote the initial draft. C.V., F.T., J.O., V.G., H.S., F.Q., P.O.W., J.F.B., M.B.A., and J.G. reviewed the initial draft. C.A.G. and P.O.W. conceptualized the figures.

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